Stargate

Making Star Trek Real
Jack Sarfatti
Internet Science Education Project

Foreword

"The future, and the future alone, is the home of explanation."
Henry Dwight Sedgwick[i]

"Sarfatti's Cave is the name I'll give to the Caffe Trieste in San Francisco, where Jack Sarfatti, Ph.D. in physics, writes his poetry, evokes his mystical, miracle-working ancestors, and has conducted a several-decade-long seminar on the nature of reality ... to a rapt succession of espresso scholars. ... It's Jack Sarfatti against the world, and he is indomitable. ...One of his soaring theories is that things, which have not happened, yet can cause events in the present. ... Cornell University B.A. , University of California Ph.D., his credentials are impeccable. Following is a quotation from a Lecture given to a San Francisco State physics seminar on 30 April 1991:

CAUSALITY VIOLATING QUANTUM ACTION AT A DISTANCE
By Dr. Jack Sarfatti

The universe is created by intelligent design but the Designer lives in our far future and has evolved from us ... Perhaps, all the works of cultural genius, from the music of Mozart to the physics of Einstein, have their real origin in the future. The genius may be a *real* psychic channeler whose mind is open to telepathic messages from the future. The genius must be well trained in his or her craft and intellectually disciplined with the integrity of the warrior in order to properly decode the quantum signals from the future. The *purpose* of our existence would then be to ensure, not only the creation of life on earth, but also the creation of the big bang itself! We obviously cannot fail since the universe cannot have come into existence without us in this extreme example of Borgesian quantum solipsism [bolstered by John Archibald Wheeler's "observer-participator" and "the universe as a self-excited circuit]. Existentialism is wrong because it is an incorrect extrapolation of the old physics. Breton's surrealism, with its Jungian idea of meaningful coincidence, is closer to the truth. This would then be the final secret of the Illuminati – that charismatic chain of adepts in quixotic quest of their 'Impossible Dream' of the Grail. Enough of my subjective vision. Now on to the objective physics. Gold, Herbert. Bohemia: Where Art, Angst, Love & Strong Coffee Meet. [ii]

"Einstein's equations of relativity do not rule out "closed time-like curves", bizarre trajectories in space-time that might allow us to travel backwards in time. ... There is currently no evidence that closed time-like curves exist. For instance, we do not see future tourists coming back to visit the

present. However, it is not in the tradition of physics to turn the argument around and use this lack of evidence to argue that they cannot exist …" Jonathan Simon [iii]

Simon echoes Stephen Hawking's remark on the lack of time traveling tourists. I challenge that alleged fact. There is UFO evidence of time travellers from our future in my opinion.

"There is now a significant body of results on quantum interactions with closed timelike curves (CTCs) in the quantum information literature, … As a consequence, there is a prima facie argument exploiting entanglement that CTC interactions would enable superluminal and, indeed, effectively instantaneous signaling. …. Using the consistency condition, we show that there is a procedure that allows Alice to signal to Bob in the past via relayed superluminal communications between spacelike-separated Alice and Clio, and spacelike-separated Clio and Bob. This opens the door to time travel paradoxes in the classical domain … offering a possible window on what we might expect in a future theory of quantum gravity. … Thus, P-CTCs model CTCs as cases of teleportation in which nature, as it were, picks out the projection onto the appropriate entangled state. This induces a different nonlinear evolution in the state of the CR system and can be interpreted as creating a quantum channel to the past."

'In this case, Bob possesses the unknown state even before Alice implements the teleportation. Causality is not violated because Bob cannot foresee Alice's measurement result, which is completely random. But, if we could pick out only the proper result, the resulting "projective" teleportation would allow us to travel along spacelike intervals, to escape from black holes, or to travel in time." Seth Lloyd et-al[iv] Quantum interactions with closed timelike curves and superluminal signaling, Jeffrey Bub and Allen Stairs, PHYSICAL REVIEW A 89, 022311 (2014)

This is a series of blog essays about teleological destiny, quick time travel to colonize Earthlike exoplanets through stargates, and the possibility that we are three-dimensional hologram images in a virtual reality programmed by a cosmological conscious super-intelligence that is alive and well on our future two-dimensional dark energy edge of space that we can ever hope to see with light signals. My speculative hypothesis-conjecture of this book is that our idea of time and cause and effect is profoundly wrong. In particular the "unproven theorem paradox" of time travel is not a paradox at all.[v]

"The "unproved theorem" paradox points out that if there are CTCs, then it might be possible to take a published proof of a theorem into the past and present it to someone, who then uses it to produce the very manuscript that leads to the theorem's publication Bub & Stairs op-cit[vi]

Evidence on "brain presponse" (Libet, Radin, Bierman, Bem[vii]) suggests that our consciousness and creativity are such meme self-creating strange loops. The universe does only not emerge out of the past, but is also pulled toward the future for a purpose. This idea is not new in philosophy, but has reappeared in physics starting with the work of John Archibald Wheeler and Richard Feynman in the 1940s.[viii] This back-from-the-future effect is needed to understand the nature of both dark matter and dark energy that is most of the stuff in our accelerating universe and most importantly to understand our own consciousness and how to reach the stars and beyond.[ix]

This general idea is in the air, a physicist from Moscow quite independently of me wrote, for example:

The postulate of post-correction broadens quantum mechanics, including in the consideration the law of evolution of living matter. The resulting theory is in a way symmetrical in time direction. Non-living matter evolves in the causal way (the past determines the future), but in the sphere of life only those initial conditions are left which provide survival (the future determines the past). This "influence of the future on the past" is realized as the selection of favorable scenarios and mathematically described by post-correction.[x]

Some Of My Original Ideas

We are all agreed that your theory is crazy. The question, which divides us, is whether it is crazy enough to have a chance of being correct. My own feeling is that it is not crazy enough. Niels Bohr

I make Popper falsifiable[xi] original predictions in this book: Dark matter[xii] detectors will fail to register true signals because dark matter is caused by virtual particles inside the quantum vacuum not real particles outside the vacuum whizzing through space. Trying to find real dark matter particles is like Michelson and Morley in 1887 trying to detect the motion of Earth through the aether with their interferometer.[xiii] A preponderance of virtual spin ½ fermion-antifermion pairs over virtual spin 1 boson pairs creates the net gravity attraction of dark matter that mimics cold dark matter real particles. Dark energy is the opposite.

I also claim to have essentially solved the mind-matter "hard problem."

"It is undeniable that some organisms are subjects of experience. But the question of how it is that these systems are subjects of experience is perplexing. Why is it that when our cognitive systems engage in visual and auditory information processing, we have visual or auditory experience: the quality of deep blue, the sensation of middle C? How can we explain why there is something it is like to entertain a mental image, or to experience an emotion? It is widely agreed that experience arises from a physical basis, but we have no good explanation of why and how it so arises. Why should physical processing give rise to a rich inner life at all? It seems objectively unreasonable that it should, and yet it does." David Chalmers[xiv]

I used David Bohm's picture of quantum theory.[xv] The non-relativistic limit is valid for biological physics. I postulate that Bohm's quantum information field called the quantum potential Q that pilots particles and electromagnetic fields is essentially "mental" or "thoughtlike" (Henry P. Stapp[xvi]) with the particles and electromagnetic fields as "matter" in the common sense way of thinking. Orthodox quantum theory, that I will call "special quantum theory" in analogy with Einstein's "special theory of relativity," obeys the no entanglement signal theorem ("no communication theorem) in its several guises.[xvii] This means that nonlocal quantum entanglement,

now a powerful resource in applied physics of imaging, cryptography, teleportation, cannot be used as a stand-alone command-control-communication-channel C4. Yes, one can encode a complex message nonlocally in a spatially extended entangled quantum system, like the electron switches inside the protein dimers in the microtubules of our brains in the Stuart Hameroff model,[xviii] for example, but we cannot decrypt the spread-out coded message without light-speed limited classical signal keys. I say that our consciousness violates this restriction and the theory that explains it is, in analogy with Einstein's general theory of relativity of the gravitational field - "general quantum theory." Antony Valentini has published papers on "general" quantum theory where he introduces the idea of "signal nonlocality" in a more formal way than I did and Brian Josephson did independently before him. I claim that evidence for signal nonlocality is found in the independent "brain presponse" data of several experimental scientists, Ben Libet, Dean Radin, Dick Bierman, and most recently Cornell's Daryl Bem in his paper "Feeling the Future."

Technically, the special quantum theory taught in school is linear and unitary provided that "strong" measurements are not made in between the time evolution of the quantum system. General quantum theory is nonlinear and non-unitary. Both of these properties can arise in different ways. Spontaneous symmetry breaking of the ground state of complex systems is one way. General quantum systems, it seems, must be open systems pumped far from thermodynamic equilibrium like Ilya Prigogine's "dissipative structures." David Bohm with Basil Hiley showed that the no-communication theorem of special quantum theory comes from the violation of Einstein's philosophical "action-reaction principle" that forms the essence of his general theory of relativity of the gravitational field.[1] In special relativity, the four-dimensional spacetime continuum pilots the real force-free "geodesic" motion of particles and field configurations without any direct back-reaction of those piloted particles and fields on the spacetime-continuum. That is, the space-time continuum acts without being reacted upon directly! The quantum potential Q in orthodox special quantum theory is absolute exactly like the spacetime continuum in Einstein's 1905 special theory of relativity. In the case of the spacetime continuum Einstein found this to be repugnant to his intuition of how God should have created the universe. Indeed, Wolfgang Pauli quipped that Einstein should stop telling God what to do. Einstein did not know about the Bohm quantum potential Q until about 1952 when David Bohm became his student at Princeton. Bohm was a young professor at the time, but sat at Einstein's feet so to speak. Einstein by 1916 transformed the spacetime continuum from an absolute object into a relative object the geometrodynamical field in which the particles and non-gravity fields back-react

[1] Newton's third law is a special case of Einstein's more general action-reaction principle. It follows from conservation of linear momentum in a closed system that has spatial translational invariance from Emmy Noether's theorem. One must be careful when there are retardation effects and when special relativity is important. I have shown, in an important special case, how to avoid the retardation problem using local gauge invariance and the canonical momentum of an electric charge in the electromagnetic field. My argument appears to be original not noticed before as far as I am aware.

directly producing curvature of the spacetime continuum.[2] Indeed, such curvature permits time travel to the past as well as global faster than light messaging through traversable "stargate" wormholes that is the other side of the quantum entanglement coin where "ER = EPR." Note, that locally, the message-signal travels slower than light inside the wormhole. It is faster than light only to observers outside the wormhole. So we have to borrow from John Archibald Wheeler "faster-than-light without faster-than-light." The no-communication theorem of special quantum theory corresponds to wormholes with event horizons that pinch off before a message or traveller can get through the warped space tunnel. Anti-gravitating amplified dark energy holds the wormhole open. General quantum theory violating the no-signal theorem of special quantum theory depends on the dark energy that is about 68% of all the stuff in the universe. Now there are the naysayers who discount all this. However, because of the UFO evidence, I take the position in this book of "Damn the photon torpedoes, full warp ahead." One other point, Einstein's equivalence principle allows artificial "non-tidal" gravity even in special relativity. We experience artificial gravity without curvature when we are at rest in accelerating reference frames called "non-inertial frames." Real gravity fields, in the sense of Newton's theory, correspond to hovering in a "stretch-squeeze" Weyl "tidal" curvature field. This is called the "static LNIF" observer in general relativity and it does not exist behind the event horizon of a black hole – at least prior to Stephen Hawking's recent change of heart on what lies behind the event horizon because of the so-called "firewall" paradox. However, even in such a real gravity field with curvature, we can eliminate its "non-tidal" artificial gravity component by freely falling weightless on a timelike geodesic that is inside our local light cone. The light cone is the essential object in both special and general relativity. Ordinary material objects are always inside their local light cones. The simple light cone is the spherical electromagnetic far field radiation wave from a point source. Retarded history light waves travel from now along the future light cone. Advanced destiny light waves travel from now backwards in time along the past light cone. We must specify the sign of the energies of these waves. This is called a boundary condition. Feynman uses the natural one where retarded waves carry positive energy and advanced waves carry negative energy. This choice generates the ordinary universally attractive gravity field. However, if we invert this boundary condition we get a universally repulsive anti-gravity field like the actually observed dark energy accelerating the expansion of 3D space in our observable universe.

Now, let's return to the hard problem of our immediate experience of the "Now" in our consciousness called "qualia" by the mind-matter philosophers. I say that "qualia" are generated in our minds as immediate experiences from the direct back-reactions of the charged particles and electromagnetic fields in our brain on a macroscopically coherent quantum potential Q mental pilot field. Our conscious

---

[2] Oddly Bohm did not seriously apply this action-reaction insight to his quantum theory until near his death in the early 1990s. That's when the torch was passed to me as I read his short remark in 1994 about this in his last book "The Undivided Universe" with Basil Hiley. Most mainstream quantum mechanics did not understand Bohm's idea at all.

experiences, qualia, are simply excited states out of the ground state of our Q-field. The Q-field emerges from spontaneous symmetry breaking of a dissipative structure in our brains. Topological computing also probably plays an essential role because it is robust against thermal environmental decoherence. This would be a off-equilibrium biological version of the fractional quantum Hall effect in 2D nano-quantum wells with the braid group of anyonic fractional quantum statistics replacing the spin-statistics connection of 3D quantum systems. Indeed, the wrapping of the protein dimers around the microtubules inside our nerve cells is, it seems to my intuition, such a 2D nano-quantum well structure. Summarizing, the analogy of real tidal gravity curvature to conscious qualia is profound.

There are two kinds of Stephen Hawking black body radiation[xix] from black holes and our two past and future cosmological horizons that define the edges of our observable universe. Hawking's original prediction was from low energy horizon surface area modes of vibration. The new higher energy radiation is from the quantum uncertainty thickness of these horizons. In particular, the black hole horizons are heat engines doing work whose outer regions pump out beams of particles.

- Dark energy accelerating the expansion rate of the three-dimensional space of our universe, itself maybe a back-from-the-future hologram image, is redshifted advanced Wheeler-Feynman Hawking black body radiation with negative energy density. Retarded radiation from past obeys the Feynman propagator boundary condition that positive energy propagates forward in time, while negative energy propagates backward in time. I postulate here, the mirror image anti-Feynman boundary condition for back-from the future advanced radiation: that negative energy propagates forward in time, while positive energy propagates backwards in time. Therefore, even though $w = +1/3$ for real black body thermalized photons they generate universally repulsive anti-gravity. The cosmological expansion of space makes a blue shift for back-from-the-future advanced radiation, but it's a very small correction to the enormously larger gravity redshift from our future dark energy de Sitter cosmological event horizon that may well be the holographic Hawking Brain/Brane of God, whose software is his "Mind of God." Indeed, the Hawking radiation energy density is the actually observed hc/ALp^2 where A is the area-entropy of the observer-dependent future cosmic horizon. $A \sim 10^{124}$ quantum bits of information. In general quantum theory we have entanglement signal nonlocality, which makes the Brane of God conscious in my opinion – take it, or leave it.[xx]
- One of the most important principles in modern theoretical physics is that of local gauge invariance used in conjunction with the idea of spontaneous symmetry breaking of the lowest energy state called the quantum vacuum for virtual particles and the quantum ground state for real particles. The "God Particle" of Peter Higgs found in the CERN LHC in Geneva, Switzerland, that

gives rest masses to spin ½ fermion leptons and quarks as well as weak force spin 1 vector bosons is an example of the former. The persistent electric currents in quantized magnetized superconducting rings are an example of the latter. The equations of local gauge invariance that explain all the real forces of electromagnetism, weak and strong interactions are presented in text books as formal mathematical tricks without any immediate physical meaning. I have recently discovered their physical meaning. I have connected the pure mathematics of local gauge transformations to Einstein's "objects of experience." The simplest case is that of electromagnetism from the internal symmetry U1 unitary Lie group of continuous phase transformations. The electromagnetic field potential A transforms to A + (hc/e)df. Of course, h is the Planck's quantum of action and c is the speed of light in vacuum. Everyone knows that f is the quantum phase of, for example, the electron test charge e's wave function y, whose rest mass m is induced by the Higgs vacuum superconductor field that presumably forms in the moment of inflation Alpha Point creation of our universe in the quantum phase transition from a false to the "true" vacuum. The total linear momentum of the charge coincident with the electromagnetic field A is the canonical momentum P

$$P = mV + (e/c)A$$

The gauge transformation keeps the canonical momentum P invariant. It does not change because from the Schrodinger quantum equation of motion

$$mV \rightarrow mV - hd\phi$$

$$(e/c)A \rightarrow (e/c)A + hd\phi$$

It suddenly dawned on me that $hd\phi$ is simply the linear momentum transfer Δp between the test charge and the electromagnetic field it is in local contact with. This is a near field electrical contact force caused by the exchange of a virtual photon whose momentum is simply $hd\phi$. Indeed, from Fourier analysis it is easily shown that the virtual photon has longitudinal polarization pointing in the same direction as its linear momentum. Let me remind the physicist reader that virtual particles do not obey Einstein's "mass shell" constraint between energy and momentum. That is, unlike the case for real particles excited out of the vacuum, the equation

$$E^2 = c^2P^2 + (mc^2)^2$$

Is violated for virtual particles. Since $\Delta p = hd\phi$ cancels out in an elementary exchange, $DP/ds = 0$ and $DE/ds = 0$ separately in such an exchange that takes time Δt. The local contact force per elementary exchange is

$$hd\phi/\Delta t \sim -(e/c)DA/ds \sim e(\text{electric field})$$

Where

$$\Delta E\, \Delta t < h.$$

The action-reaction principle in this case in the form of linear momentum conservation and Noether's theorem connecting conservation laws with continuous symmetries of dynamical fields is trivially obeyed locally without any need for the astrological belief called Mach's Principle that inertial resistance to off-geodesic pushes by real forces in Newton's second law of particle mechanics comes from the far away stars as suggested by Dennis Sciama and promoted by James Woodward and others. Einstein may be forgiven for flirting with Mach's Principle in his struggle to create general relativity. He eventually rejected it as no more than a useful psychological crutch in his creative process. This same idea will work for the SU2 weak real force as well as the SU3 strong real force. Real forces push slower than light massive test particles off the timelike geodesics of the gravitational field in contrast to fictitious forces that are actually the non-tidal curvature-free part of the gravitational field itself! This is what the equivalence principle demands.

Amazingly enough, local gauge invariance also works for the proper off-geodesic accelerations of test particles in the gravitational field rather than the linear momenta of test particles being measured by those detectors. The key idea of gravity is that of the geodesic, which is longest proper time path connecting two events in Einstein's unified four-dimensional spacetime continuum. That is, all neighboring paths that have the same starting and ending events have smaller proper times. This is an example of the "Action Principle" that is a key organizing idea of all theoretical physics. Clocks moving on these paths, called "world lines" measure proper time. Proper time is the amount you age if you are on that world line journey. Indeed, this explains why your twin who is abducted by an evil extra-terrestrial is much younger than you when they return him as in Francis Ford Coppola's "4400" sci fi TV series for example. The proper acceleration of a test particle is DV/ds where V is the "four-velocity" of the test particle relative to some detector at the origin of a local frame of reference. In general, using my symbolic short hand without tensor indices to keep it as simple as possible, without being simpler than is possible (Einstein paraphrase):

$$DV/ds = dV/ds - \{LNIF\}(VV)$$

Where the symbol {LNIF} describes the detector at the origin of the local frame, in this case a "Local Non-Inertial-Frame." It's also called the "Christoffel symbol", the "Levi-Civita connection" and the "affine metric

connection with zero torsion." Mathematically it describes, "parallel transport" of geometric objects in a tangent fiber bundle whose base space is Einstein's world spacetime continuum. Physically it encodes all the fictitious forces on the observed test object Eve caused by real forces on the detector at the origin of the local frame of reference, either Alice or Bob's. For example, {LNIF} could describe a rotating frame or a frame with translational proper off-geodesic acceleration, or both at once. Any object, is on an off-geodesic world line only if an external real (EM-weak-strong) force acts on it. This is Newton's second law of motion. Newton's first law of motion is simply the "geodesic equation" that if no real forces act, the massive object moves along a timelike geodesic that is independent of the mass of the object. In this case, we assume that the mass of the object is not changing as it would in a rocket or jet ejecting mass in the exhaust.

We now consider a physical local frame transformation. Suppose Alice is measuring Eve's motion. Also imagine that Bob is momentarily coincident with Alice and they both measure Eve's motion with radars. Remember now, that Eve, Alice and Bob all with rest masses are each independently on arbitrary timelike world lines. Eve's world line need not be close to Alice's and Bob's since they measure Eve's motion with light signals. However, Alice and Bob must be physically near each other and must make their measurements of Eve almost simultaneously in order to test Einstein's general relativity field equations. The local frame transformation between coincident Alice and Bob is X. The Christoffel symbol then transforms as

$$\{LNIF\}_A \rightarrow \{LNIF\}_B = XX^{-1}X^{-1}\{LNIF\}_A + X^{-1}X^{-1}dX$$

$$V_A \rightarrow V_B = XV_A$$

$$\{LNIF\}(VV)_A \rightarrow XX^{-1}X^{-1}\{LNIF\}XX(VV)_A + X^{-1}X^{-1}XX(VV)_A dX$$

$$= X\{LNIF\}(VV)_A + (VV)_A\, dX$$

$$dV_A/ds \rightarrow dV_B/ds = XdV_A/ds - (VV)_A\, dX$$

Just as the exchanged virtual photon momentum transfer $hd\phi\Delta t$ cancels out in the local electrical U1 contact gauge force for coincident fermion charge and spin 1 boson field, so does the gravity gauge transformation term $(VV)_A dX$ cancel out leaving the first rank tensor transformation

$$DV_A/ds \rightarrow DV_B/ds = XdV_A/ds$$

What is the physical meaning of the gravity gauge term $dX(VV)_A$? Obviously, it is the proper acceleration difference between coincident Alice and Bob. Einstein's equivalence principle tells us that a frame with proper acceleration is the same as a frame at rest in a non-tidal Newtonian gravity

field. Because of the Unruh effect, it corresponds to the momentum of a macro-quantum coherent Glauber state of near field virtual spin 2 gravitons with momentum $(h/c^2)dX(VV)_A$

I was much enthralled with John Archibald Wheeler's geometrodynamics back in the late 1960s when I was a very young assistant professor of physics at San Diego State with Fred Alan Wolf who was an associate professor. Wheeler modeled the electron as a tiny wormhole with closed lines of quantized electric flux lines threading it. The quantization of electric charge was then trivially explained from the single-valuedness on the wormhole's quantum wave function around a closed loop exactly like the quantization of magnetic flux vortices in Type II superconductors and the magnetic flux through superconducting rings carrying persistent currents. The electric flux entering one of the two wormhole mouths of the Einstein-Rosen bridge would be a tiny Kerr-Newman black hole pure vacuum black hole with negative electric charge from Gauss's theorem. The flux leaving the other mouth in possibly a different parallel universe would have positive electric charge and would be a white hole. What we didn't know back then, but what we know now some forty plus years later is that the white hole mouth is unstable while the black hole mouth is stable. Therefore, we have a trivial explanation for the C-charge violation, why we do not see anti-matter in the universe. One major problem, if we want to explain the rest of the lepton and the quarks this way, is that Newton's gravity G is too small. I should add, that quarks were not totally accepted back then. Geoffrey Chew's analytic S-Matrix was also a competitor. Gerard t' Hooft had not yet showed the renormalizability of Yang-Mills gauge theories and the role of spontaneous symmetry breaking of the vacuum giving a "superconducting" order parameter for the SU2 weak force. This order parameter was described by Glauber macro-quantum coherent states of virtual massive Higgs and virtual massless Goldstone quanta forming a spin 0 cosmic field that gives rest masses to the weak spin 1 boson of the radioactive weak force as well as rest mass to the spin ½ leptons and quarks. Abdus Salam had introduced the idea of f-gravity with a strong force massive graviton. This gave a strong short-range gravity on the scale of a Fermi that was forty powers of ten stronger than Newton's gravity at short scales. I immediately realized that Salam's idea naturally explained why the slopes of all the Regge trajectories for hadronic resonances were parallel to each other in the plot of their spins against the square of their masses seen in the peaks in the resonance scattering cross sections. The hadrons were little black holes. Their Hawking radiation would explain their decay times. Salam was excited by my discovery and he invited me to his Institute for Theoretical Physics in Trieste, Italy 1973-4. My old idea has recently been rediscovered in 2013. I also got the idea that EPR quantum entanglement was the other face of the same coin describing the wormhole ER. That is, the two mouths of the wormhole connected by a stringy tunnel described, for example, an entangled electron-positron pair. Lenny Susskind and I knew each other at Cornell in 1963-5 and

he rediscovered this idea not long ago. We now know that all the no-go theorems of quantum information theory, which prohibit faster-then-light messaging, correspond to the pinch off of the wormholes with event horizon mouths when signals try to get through them. However, we also now know that the anti-gravitating dark energy permits traversable "stargate" wormholes whose mouths are not event horizons. Therefore, signals can get through them not only faster-than-light, but also even back-from-the-future in time.

What Einstein Actually Wrote About His Theories of Relativity

Like quantum theory, every sane competent physicist agrees on the mathematics of classical special and general relativity. However, there is a surprisingly wide spectrum of disagreement on what the theory means physically even though, as shown by Cliff Will, Roger Penrose and others, general relativity passes every classical test with extraordinary accuracy and precision. The puzzle of dark matter has stimulated work in MOND alternatives. Dark energy, on the other hand, is easily accommodated mathematically with the cosmological term, though its physical nature is not explained classically. There are disagreements about the equivalence principle and the use of the words "gravitational field" that has at least three meanings as metric tensor, Levi-Civita-Christoffel connection, which is not a tensor and the curvature tensor. There is a current attempt by James Woodward to bring back Mach's Principle in an engineering program to develop a new kind of spacecraft engine. There are deep issues of principle associated with this program. Are all forms of motion really relative, as Mach would have us believe? Einstein seems to have believed so, yet there are solid arguments that proper tensor acceleration in off-timelike geodesic world lines is an absolute local observable relative to the local geometrodynamical field. Would then be a conceptual inconsistency in Einstein's intuitive informal thinking? Albeit a minor one since it does not affect the comparison of the theory with observation. Actually no, what Einstein meant by "absolute" was a violation of the general action-reaction principle.

1. *"Mathematics deals exclusively with the relations of concepts to each other without consideration of their relation to experience."*
2. *"Physics too deals with mathematical concepts; however, these concepts attain physical content only by a clear determination of their relation to the objects of experience."*
3. *"This in particular is the case for the concepts of motion, space, time."*
4. *"The theory of relativity is that physical theory which is based on a consistent physical interpretation of these three concepts."*
5. *"Motion from the point of view of possible experience always appears as the relative motion of one object with respect to another."*[xxi]
6. *"Motion is never observable as 'motion with respect to space' or, … as absolute motion."*
7. *"The 'principle of relativity' … is … there is no absolute motion."*
8. *"An analogy between … relativity and thermodynamics … there is no perpetuum mobile."*
9. *"Geometry, from a physical standpoint, is the totality of laws according to which bodies mutually at rest can be placed with respect to each other."*

10. *"The Euclidean laws are … 'Space' is … an infinite rigid body (skeleton) to which the position of all other bodies is related (body of reference)."*
11. *"Analytic geometry (Descartes) uses as the body of reference, which represents space, three mutually perpendicular rigid rods on which the 'coordinates' (x, y, z) of space points are measured in the known manner as perpendicular projections (with the aid of a rigid unit measure)."*
12. *"Physics deals with 'events' in space and time."*
13. *"To each event belongs, besides its space coordinates x, y, z a time value t … measured by a clock (ideal periodic process) of negligible spatial extent. This clock C is … at rest at … $x = y = z = 0$."*
14. *"The concept 'simultaneous' was assumed as physically meaningful without special definition. This is a lack of exactness …"*
15. *"The special theory of relativity removes this lack of precision by defining simultaneity physically using light signals."*
16. *"The time t of an event in P is the reading of the clock C at the time of arrival of a light signal emitted from the event, corrected with respect to the time needed for the light signal to travel the distance. This correction postulates that the velocity of light is constant."*
17. *"This definition reduces the concept of simultaneity of spatially distant events to that of the simultaneity of events happening at the same place (coincidence), namely the arrival of the light signal at C and the reading at C."*
18. *"Classical mechanics is based on Galileo's principle: A body is in rectilinear and uniform motion as long as other bodies do not act on it. This statement cannot be valid for arbitrarily moving systems of coordinates. It can claim validity only for so-called 'inertial systems.'"*
19. *"Inertial systems are in rectilinear and uniform motion with respect to each other."*
20. *"In classical physics laws claim validity only with respect to all inertial systems (special principle of relativity)."*
21. *"Experience and theory have led to the conviction that light in empty space always travels with the same velocity c independent of its color and state of motion of the source. … 'L-principle'…"*
22. *"The L-principle holds for all inertial systems."*
23. *"The transformations thus defined, which are linear in x, y, z, t are called Lorentz transformations … formally characterized by the demand that the expression $dx^2 + dy^2 + dz^2 - c^2dt^2$, which is formed by the coordinate differences dx, dy, dz, cdt of two infinitely close events, be invariant (i.e., that through the transformation it goes over into the same expression formed from the coordinate differences in the new system)."*
24. *"The special principle of relativity can be expressed thus: The laws of nature are invariant with respect to Lorentz transformations (i.e. a law of nature does not change its form if one introduces into it a new inertial system with the help of a Lorentz transformation on x, y, z, ct."*
25. *"The special theory of relativity has led to a clear understanding of the physical concepts of space and time … of moving measuring rods and clocks … removed the concept of absolute simultaneity … also that of instantaneous action at a distance in the sense of Newton. It has shown how the laws of motion must be modified in dealing with motions that are not negligible compared to the velocity of light. It has led to a formal clarification of Maxwell's equations of the electromagnetic field … the essential oneness of the electric and the magnetic field. It has unified the conservation of momentum and of energy into one single law and has demonstrated the equivalence of mass and energy. From the formal point of view … the special theory of relativity has shown the role of … the universal constant c … plays in the laws of nature … the close connection between … time … and space … into the laws of nature."*
26. *"The special theory retained the basis of classical mechanics … namely … the permissible transformations for the coordinates (i.e., those that leave the form of the laws unchanged) are exclusively the (linear) Lorentz transformations. Is this restriction really founded in physical facts? The following argument convincingly denies it."*

27. *"Principle of equivalence. A body has an inertial mass (resistance to acceleration) and a heavy mass (which determines the weight of the body in a given gravitational field, e.g., that at the surface of the earth. These two quantities, so different according to their definition, are according to experience measured by one and the same number. … The fact can also be described thus: In a gravitational field different masses receive the same acceleration. Finally, it can also be expressed thus: Bodies in a gravitational field behave as in the absence of a gravitational field if, in the latter case, the system of reference used is a uniformly accelerated coordinate system (instead of an inertial system)."*
28. *"One considers the system as being 'at rest' and considers the 'apparent' gravitational field which exists with respect to it as a 'real' one. This gravitational field 'generated' by the acceleration of the coordinate system would of course be of unlimited extent in such a way that it could not be caused by gravitational masses in a finite region; however, if we are looking for a field-like theory, this fact need not deter us. With this interpretation, the inertial system loses its meaning and one has an 'explanation' for the equality of heavy and inertial mass (the same property of matter appears as weight or as inertia depending on the mode of description)."*
29. *"Considered formally, the admission of a coordinate system that is accelerated with respect to the original 'inertial' coordinates means the admission of nonlinear coordinate transformations, hence a mighty enlargement of the idea of invariance."*
30. *"With such a generalization the coordinates can no longer be interpreted directly as the results of measurements. Only the coordinate differences together with the field quantities which describe the gravitational field determine measurable distances between events."*
31. *"Empty space without electromagnetic field and without matter … is completely described by (1) $ds^2 = dx_0^2 + dy_0^2 + dz_0^2 - c^2dt_0^2$ is a measurable quantity which is independent of the special choice of the inertial system. If one introduces in this space the new coordinates x_1, x_2, x_3, x_4 through a general transformation of coordinates, then the quantity ds^2 for the same pair of points has … $ds^2 = \Sigma g_{ik}dx^i dx^k$ (summed for i and k from 1 to 4) where the $g_{ik} = g_{ki}$ … a symmetric tensor … are continuous functions of x_1, x_2, x_3, x_4 then describe according to the 'principle of equivalence' a gravitational field of a special kind (namely one that can be retransformed to … (1))."*
32. *"We are looking for equations satisfied by 'general' gravitational fields* [xxii] *… These equations yield Newton's equations of gravitational mechanics as an approximate law and in addition certain small effects which have been confirmed by observation (deflection of light by the gravitational field of a star, influence of the gravitational potential on the frequency of emitted light, slow rotation of the elliptical circuits of planets – perihelion motion of the planet Mercury). They further yield an explanation for the expanding motion of galactic systems, which are manifested by the redshift of light emitted from these systems."*
33. *"The principle of inertia … seems to compel us to ascribe physically objective properties to the spacetime continuum."*
34. *"'Absolutum' means not only 'physically real,' but also 'independent in its physical properties, having a physical effect, but not in itself being influenced by physical conditions. … It is contrary to the mode of thinking in science to conceive of a thing which acts itself, but which cannot be acted upon.'"* [xxiii]
35. *"This is the reason why E. Mach was led to make the attempt to eliminate space as an active cause in the system of mechanics. According to him, a material particle does not move in unaccelerated motion relatively to space, but relatively to the centre of all the other masses in the universe … in order to develop this idea within the limits of the modern theory of action through a medium, the properties of the spacetime continuum which determine inertia must be regarded as field properties of space, analogous to the electromagnetic field."*

The problem of the rotating disk even in 1905 special relativity, as well as 1916 general relativity, remains unresolved and controversial even to this day. There are issues of how to synchronize clocks around the rim of the rotating disk. However,

that may be, the controversy is beyond the purpose of this book. Suffice it to say that Einstein in his book "The Meaning of Relativity" wrote:

"The principle of equivalence demands that in dealing with Galilean regions[xxiv] *we may equally make use of non-inertial systems, that is, such coordinate systems as relatively to inertial systems, are not free from acceleration or rotation. … Let K' be a coordinate system whose z'-axis coincides with the z-axis of K, and which rotates about the latter axis with constant angular velocity. Are the configurations of rigid bodies at rest relatively to K' in accordance with the laws of Euclidean geometry? … Imagine … a large number of rigid rods, all equal to each other, laid in series along the periphery and the diameter of this circle at rest relatively to K'. If U is the number of these rods along the periphery, D the number along the diameter, then, if K' does not rotate relatively to K, we shall have*

$$U/D = \pi$$

But if K' rotates we get a different result. Suppose that at a definite time t of K we determine the ends of all the rods. With respect to K all the rods along the periphery experience the Lorentz contraction, but the rods along the diameter do not experience this contraction … therefore …

$$U/D < \pi$$

These considerations assume that the behavior of rods and clocks depends only upon velocities and not upon accelerations, or, at least that the influence of acceleration does not counteract that of velocity."

There appears to be a misprint in the 1979 edition of the book where "$U/D > \pi$" is written. This is inconsistent because it would mean that the rods along the periphery (edge) of the rotating disk shrink whilst that of the material of the disk's edge does not. Also this perception of the non-Euclidean geometry is that of the inertial observer at rest in K not in K'. The simultaneous measurements of the ends of the rods at K time t corresponds to different moments of rotating K' time t'. What do observers at rest in K' see? From the equivalence principle, they see a radially outward pointing non-tidal Newtonian gravity centrifugal acceleration field of magnitude $g(r) = \omega^2 r$. There is a radially inward equal and opposite electrical force keeping the observer at radial distance r clamped to the rotating disk as well as a tangential constraint electrical force. The observers at rest in K' are pushed off geodesics by real electrical forces in the actual physical flat Minkowski spacetime that is free of curvature. Therefore, the effective metric component for these "hovering" or "static LNIF" K' observers clamped to the 2D rotating disk is

$$g_{rr}(r)_{disk} = (1 - \omega^2 r^2/c^2)^{-1}$$

Causing an inside gravitational dilation of the radial rods relative to the rods on the periphery in direct qualitative agreement with what the inertial K observer infers from his "simultaneous" outside measurements, i.e., $U/D < \pi$. Indeed, this rotational metric intuitively agrees with the radial part of the 3D Schwarzschild metric

$$g_{\rho\rho}(r)_{blackhole} = (1 - 2GM/\rho c^2)^{-1}$$

Where the interior radial space is gravitationally stretched compared to the circumference that remains spatially "flat". That is, in both the rotating disk and the non-rotating wormhole with event horizon the spatial geometry is non-Euclidean elliptical with positive curvature not hyperbolic negative curvature like a saddle. Of course "r" for the disk is in 2D + 1 cylindrical coordinates (r, ϕ, z) with $z = 0$, whilst "ρ" for the black hole is in 3D spherical coordinates (ρ, θ, ϕ).

"... It therefore follows that the laws of configuration of rigid bodies with respect to K' do not agree with the laws of configuration of rigid bodies that are in accordance with Euclidean geometry. If, further, we place two similar clocks (rotating with K') one upon the periphery, and the other at the centre of the circle, then, judged from K, the clock on the periphery will go slower than the clock at the center. The same thing must take place judged from K' ..."

The gravity redshift z of frequency f for a static metric field is

$$1 + z = f_{emit}/f_{observe}$$

$$1 + z = [g_{tt}(observe)/g_{tt}(emit)]^{1/2}$$

If a light signal is sent from the periphery of the rotating disk to the center axis of rotation along a radial optical fiber clamped to the rotating disk then, in that special case,

$$1 + z = [1/ (1 - \omega^2 r^2/c^2)]^{-1/2}$$

$$\sim 1 + \omega^2 r^2/2c^2$$

$$\omega^2 r^2/2c^2 \ll 1$$

This is a gravity redshift seen at axis of rotation $r = 0$ of K' which is same as the metric seen by the observer in the inertial frame K in external Minkowski spacetime.

"Space and time, therefore, cannot be defined with respect to K' as they were in the special theory of relativity with respect to inertial systems. But, according to the principle of equivalence, K' may also be considered as a system at rest, which respect to which, there is a gravitational field (field of centrifugal force, and force of Coriolis.)"

Back From The Future Destiny Signals

"I'm very well acquainted, too, with matters mathematical,
I understand equations, both the simple and quadratical,
About binomial theorem I'm teeming with a lot o' news,
(Bothered for a rhyme)
With many cheerful facts about the square of the hypotenuse.
I'm very good at integral and differential calculus;
I know the scientific names of beings animalculous:
In short, in matters vegetable, animal, and mineral,
I am the very model of a modern Major General."
Pirates of Penzance, Gilbert and Sullivan

"Sing Heav'nly Muse, that on the secret topOf Oreb, or of Sinai, didst inspireThat Shepherd, who first taught the chosen Seed,In the Beginning how the Heav'ns and EarthRose out of Chaos: Or if Sion Hill [10]Delight thee more, and Siloa's Brook that flow'dFast by the Oracle of God; I thenceInvoke thy aid to my adventrous Song,That with no middle flight intends to soarAbove th' Aonian Mount, while it pursues [15]Things unattempted yet in Prose or Rhime.And chiefly Thou O Spirit, that dost preferBefore all Temples th' upright heart and pure,Instruct me, for Thou know'st; Thou from the firstWast present, and with mighty wings outspread [20]Dove-like satst brooding on the vast AbyssAnd mad'st it pregnant: What in me is darkIllumin, what is low raise and support;That to the highth of this great ArgumentI may assert Eternal Providence, [25]And justifie the wayes of God to men."
John Milton, Paradise Lost

"In another moment Alice was through the glass, and had jumped lightly down into the Looking-glass room." Lewis Carroll

"That with no middle flight intends to soar …"

"A wormhole is a hypothetical shortcut for travel between distant points in the universe. The wormhole has two entrances called 'mouths,' one (for example) near Earth, and the other (for example) in orbit around Vega, 26 light years away. The mouths are connected to each other by a tunnel through hyperspace (the wormhole) that might be only a kilometer long. If we enter the near-Earth mouth, we find ourselves in the tunnel. By traveling just one kilometer down the tunnel we reach the other mouth and emerge near Vega, 26 light-years away as measured in the external universe." Kip Thorne[xxv]

"Prior to the development of digital computers in the 20th century, the only systems on Earth, which incorporated bulk, reliable digital storage, were living organisms. DNA, neural networks and brains, and the adaptive immune system all have the ability to robustly store large quantities of information and retrieve it when needed. But storage is tough—each of these biological systems is enormously more complicated than any existing computer, and it took biology billions of years to evolve its second and third kinds of digital storage. The intertwined complexity of DNA and protein synthesis in even the simplest living cells is such that how it came to be remains one of the central mysteries of biological science, a conundrum so profound that one of the two discoverers of the structure of DNA, Nobel Prize winner Francis Crick, believes the first living cells were placed on Earth by intelligent aliens from elsewhere in the Galaxy. (But then how did the aliens get started?)"
John Walker, Computation, Memory, Nature, and Life
Is digital storage the secret of life? [xxvi]

"At last we have a book which squarely takes on the central puzzle of the supposedly blind, purposeless universe to which so many scientists presently ascribe the origin of life on Earth. There's hardly any point debating evolution: it can be demonstrated in the laboratory. (Some may argue that Spiegelman's monster is an example of devolution, but recall that evolutionists must obligately eschew teleology, so selection in the direction of simplicity and rapid replication is perfectly valid, and evidenced by any number of examples in bacteria.) …

No, the puzzle—indeed, the enigma— is the origin of the first replicator. Once you have a self-replicating organism and a means of variation (of which many are known to exist), natural selection can kick in and, driven by the environment and eventually competition with other organisms, select for more complexity when it confers an adaptive advantage. But how did the first replicator come to be? …

Or consider my own favorite hypothesis of origin that we're living in a simulation. I like to think of our Creator as a 13 year old superbeing who designed our universe as a science fair project. I have written before about the clear signs accessible to experiment, which might falsify this, hypothesis but which, so far, are entirely consistent with it. In addition, I've written about how the multiverse model is less parsimonious than the design hypothesis. …

In addition to the arguments in that paper, I would suggest that evidence we're living in a simulation is that we find, living within it, complex structured information, which we cannot explain as having originated by the physical processes we discover within the simulation. In other words, we find there has been input of information by the intelligent designer of the simulation, either explicitly as genetic information, or implicitly in terms of fine-tuning of free parameters of the simulated universe so as to favour the evolution of complexity. If you were creating such a simulation (or designing a video game), wouldn't you fine tune such parameters and pre-specify such information in order to make it "interesting"? …

Opponents of intelligent design's hearts go all pitty-pat because they consider it (gasp) religion. Nothing could be more absurd. Francis Crick (co-discoverer of the structure of DNA) concluded that the origin of life on Earth was sufficiently improbable that the best hypothesis was that it had been seeded here deliberately by intelligent alien life forms. These creatures, whatever their own origins, would have engineered their life spores to best take root in promising environments, and hence we shouldn't be surprised to discover our ancestors to have been optimised for our own environment. One possibility (of which I am fond) is that our form of life is the present one in a "chain of life" which began much closer to the Big Bang. One can imagine life, originating at the quark-gluon plasma phase or in the radiation dominated universe, and seeing the end of their dominion approaching, planting the seeds of the next form of life among their embers. Dyson, Tipler, and others have envisioned the distant descendants of humanity passing on the baton of life to other lifeforms adapted to the universe of the far future." – John Walker, review of Meyer, Stephen C. Signature in the Cell. New York: HarperCollins, 2009 xxvii

While I am not against sentient quark-gluon plasma, similar conscious entities are found in the science faction of Olaf Stapledon, Fred Hoyle and Freeman Dyson. My conjecture that is the foundation stone, the core of my thesis in this book is that the "bootstrap paradox" of time travel is not a paradox at all, but is, in fact the basic teleological mechanism of physical reality.

"The bootstrap paradox, or ontological paradox, is a paradox of time travel in which information or objects can exist without having been created. After information or an object is sent back in time, it is recovered in the present and becomes the very object or information that was initially brought back in time in the first place. Numerous science fiction stories are based on this paradox, which has also been the subject of serious physics articles."[xxviii]

We have direct evidence in the phenomenon of "brain presponse" in the workings of our own minds. Roger Penrose first noticed this back-from-the-future retrocausal property of our everyday consciousness.

"Suppose that there is something even vaguely teleological about the effects of consciousness, so that so that a future impression might affect a past action." Roger Penrose, Where lies the physics of the mind? Ch. 10, "The Emperor's New Mind" Penguin Edition (1991)

"Experiments repeated in a half-dozen laboratories around the world, and published in peer-reviewed scientific journals, have confirmed that humans can sense unpredictable future events. These effects are detected through unconscious bodily responses such as changes in sweat, heart rate, pupil dilation (in the eye), blood pressure, and electro cortical activity (i.e. brainwaves). The body shows signs of stress before exposure to randomly selected emotional stimuli and no stress before exposure to calm stimuli." Dean Radin[xxix]

"Theoretical model of a purported empirical violation of the predictions of quantum theory ABSTRACT: A generalization of Weinberg's nonlinear quantum theory is used to model a reported violation of the predictions of orthodox quantum theory.

This work concerns the possibility of causal anomalies. By a causal anomaly I mean a theoretical or empirical situation in which the occurrence or nonoccurrence of an observable event at one time must apparently depend upon a subsequently generated (pseudo) random number, or willful human act. Henry P. Stapp (Originally published in Physical Review A, Vol.50, No.1, July 1994)[xxx]

"'Perverse' consequences of nonlinearity. After Weinberg proposed nonlinear variants of the Schr¨odinger equation, Gisin and Polchinski independently observed that almost all such variants would allow superluminal signaling. Later Abrams and Lloyd argued that a "nonlinear quantum computer" could solve NP -complete and even #P -complete problems in polynomial time." Scott Aaronson[xxxi]

"There are several objections to the firewall proposal. First, if the firewall were located at the event horizon, the position of the event horizon is not locally determined but is a function of the future of the spacetime." Stephen Hawking[xxxii]

Hawking jumps through hoops to try to avoid back-from-the-future CTC computation type destiny effects and non-unitarity. His cure is worse than the disease in my opinion. Violate unitarity,[xxxiii] violate CPT, violate no-signaling. It's time for a real revolution in physics and it's time to come out of Plato's dark cave of "orthodox" quantum theory. Sure, it works well for dead matter in particle beams scattering off other dead lumps of matter, but it does not work for emergent collective modes of high complexity, i.e. us. Forcing life into the coffin of orthodox quantum theory is like collecting butterflies in glass cases. Orthodox quantum theory is simply a limiting case of a non-linear non-unitary post-quantum theory with entanglement signal nonlocality without which conscious life is impossible in my opinion.

My new paradigm, my "great Argument" in this book, "things unattempted yet in" theoretical physics "And justifie the wayes of God to men," is that Hawking's

chronology protection conjecture[xxxiv] is wrong and that Crick's "aliens" are actually future humans[xxxv] who have mastered time travel to the past through stargates and have found at least one that was created in the very early universe, which allows them to get to Earth and create us and obviously themselves in a physical globally self-consistent[xxxvi] Godelian strange loop[xxxvii] in time. In other words the time travel bootstrap paradox[xxxviii] is not a paradox at all, but is the way reality works including our own consciousness. The back from the future Destiny Matrix emerges out of the ashes of discredited teleology[xxxix] as the scientific revolution[xl], the really new paradigm for the 21st Century.[xli]

A negatively charged particle has electric flux entering the wormhole mouth. The other mouth is then positively charged. If the first mouth is a little black hole, then the second mouth is a little white hole. However the white hole is unstable and the black hole is stable. This might explain why there are more electrons than positrons. Unfortunately, the idea does not work for protons and it's not obvious how to make it work for the other leptons and quarks that have weak and strong field fluxes in addition to the electric fluxes. This 1950s period of Wheeler's geometrodynamics introduced the ideas of "mass without mass," "charge without charge," "spin without spin," and finally "law without law" that captured the imaginations of us "Hippies who saved physics" (David Kaiser, MIT). Wheeler's "mass without mass," "charge without charge," "spin without spin," plus my 1974 precognition that the quantum entanglement of the Einstein-Podolsky-Rosen correlations correspond to "mass without mass" Einstein-Rosen bridge wormholes at the tiny quantum level, does explain the origin of inertia partially in terms of gravity. However, it does not explain the actual numerical values of say the rest mass of the electron ~ 10^{-27} grams. The idea of the cosmic landscape of the multiverse at Max Tegmark's Levels 1 and 2 is that the several dozen parameters of the standard model are contingent. In other words there are other universes in which all numerical values of the basic parameters can be found. The leptons and quarks as well as the W bosons get their inertias (rest masses) from the Higgs-Goldstone vacuum superconductor field. The much heavier hadrons get their rest masses from the confined quark-gluon zero point energies according to quantum chromodynamics local SU3 gauge theory. Our universe obeys the Weak Anthropic Principle (WAP). The parameters are just right "fine tuned" to permit us to exist. This is simply generalized Darwinian evolution and natural selection without the need for a God as an Intelligent Designer (ID). However, there are also arguments to the contrary involving the teleological Final Anthropic Principle (FAP). Actually, a conscious ID in the FAP combined with the dS/CFT world hologram conjecture and quantum computing around CTCs is not at all inconsistent with the WAP of string theory.

Back from the future communication between parallel universes

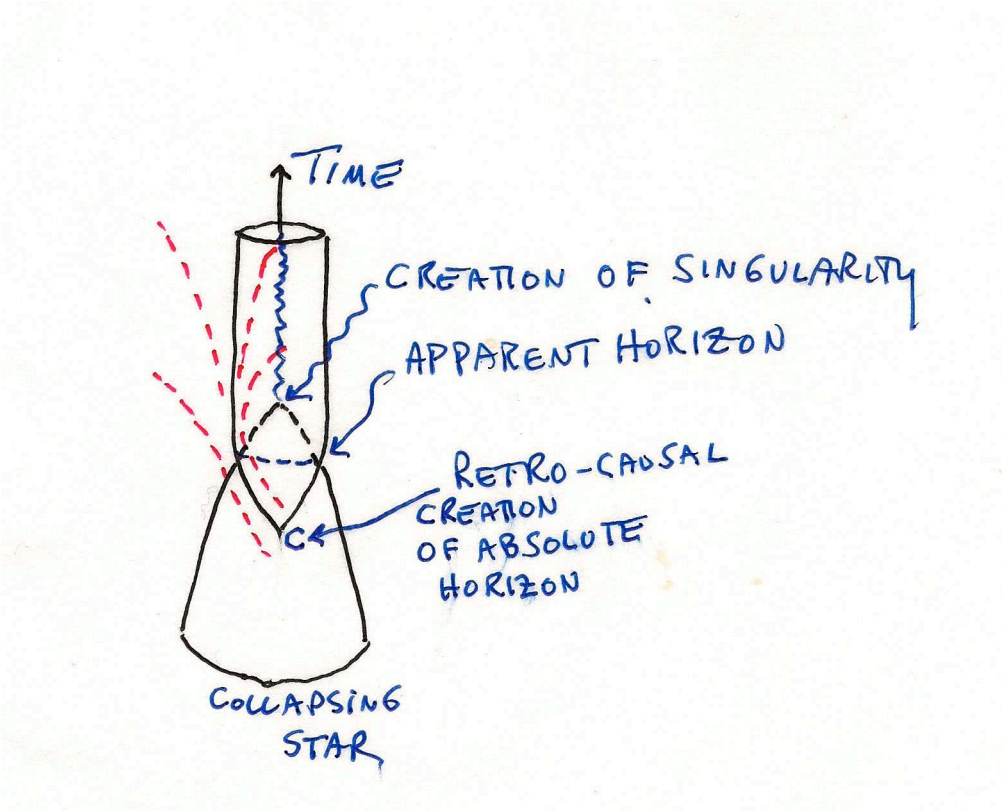
"A series of quantum experiments shows that measurements performed in the future can influence the present. Does that mean the universe has a destiny—and the laws of physics pull us inexorably toward our prewritten fate? … Cosmologists have long been puzzled about why the conditions of our universe—for example, its rate of expansion—provide the ideal breeding ground for galaxies, stars, and planets. If you rolled the dice to create a universe, odds are that you would not get one as handily conducive to life as ours is. Even if you could take life for granted, it's not clear that 14 billion years is enough time for it to evolve by chance. But if the final state of the universe is set and is reaching back in time to influence the early universe, it could amplify the chances of life's emergence."[xlii] Discover Magazine

The existence of future nonchronal regions of spacetime will influence probabilities in the present. A theory of the future geometry of spacetime, as well as of the initial condition of the closed system and the geometry up to the present, is thus required for present prediction. Jim Hartle[xliii]

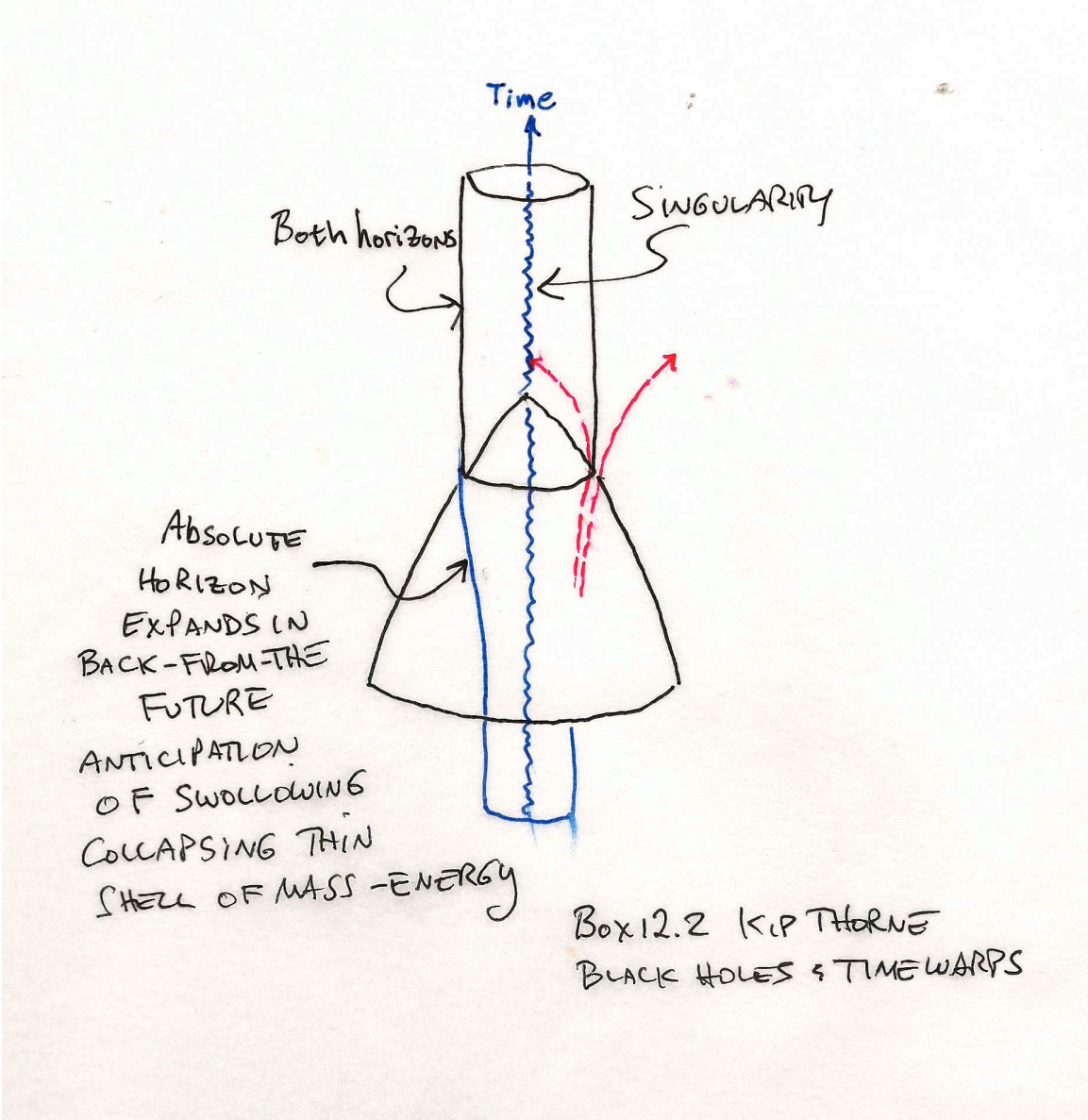
A wormhole is a nonchronal region of spacetime.

Black hole formation has anticipatory presponse just like our brains have.

"Penrose and Israel … could not conceive of jettisoning the [local frame-dependent] apparent horizon as the definition of a black hole's surface. They especially could not conceive of jettisoning it in favor of [Hawking's local-frame independent] absolute horizon. Why? Because the absolute horizon – paradoxically, it might seem – violates our cherished notion that an effect should not precede its cause. When matter falls into a black hole, the absolute horizon starts to grow ("effect") before the matter reaches it ('cause'). The horizon grows in anticipation that the matter will soon be swallowed and will increase the hole's gravitational pull … The very definition of the absolute horizon depends on what will happen in the future: on whether or not signals will ultimately escape to the distant universe. … It is a teleological definition … that relies on 'final causes'"… Kip Thorne P. 417 Chapter 12, *Black Holes and Time Warps*.



"The apparent horizon is the outermost location where outgoing light rays, trying to escape the hole, get pulled inward toward the singularity … The apparent horizon is created suddenly, full sized … where the star's surface shrinks through the critical circumference [horizon g00 = 0]. The absolute horizon is the boundary between events that can send signals to the distant Universe [observable causal diamond] … and events that cannot send signals to the distant Universe. The absolute horizon is created at the star's center … well before the star's surface shrinks through the critical circumference. The absolute horizon is just a point when created, but it then expands smoothly, like a balloon being blown up, and emerges through the star's surface precisely when the surface shrinks through the critical circumference … It then stops expanding, and thereafter coincides with the suddenly created apparent horizon." Kip Thorne, Box 12.1 P. 414, *Black Holes and Time Warps*



"The spacetime diagram … illustrates the jerky evolution of the apparent horizon and the teleological evolution of the absolute horizon. At some initial moment of time … an old nonspinning black hole is surrounded by a thin, spherical shell of matter … The apparent horizon (the outermost location at which outgoing light rays … are being pulled inward) jumps outward suddenly, and discontinuously, at the moment when the shrinking shell reaches the location of the final hole's critical circumference. The absolute horizon (the boundary between events that can and cannot escape to the distant Universe) starts to expand before the hole swallows the shell. It expands in anticipation of swallowing, and then, just as the hole swallows the shell, it comes to rest at the same location of the jumping apparent horizon." Kip Thorne, Black Holes and Time Warps

I suspect that Roger Penrose became more open to the teleological final cause paradigm explanation of Ben Libet's brain presponse experiments because he realized his blunder in his initial reluctance to grok[xliv] Hawking's discovery, which itself, in a spooky Godelian strange loop precognitive way came to Hawking suddenly in November of

1970 as a kind of Biblical Revelations from The Voice that crieth in the wilderness of our universal precognitive remote viewing subconscious collective cosmic mind that comes to some rather more than others. Indeed, Hawking's physical disability may make him more open to contact with advanced higher intelligences like a Tibetan Tulku in deep meditation? Thus, Kip writes earlier in his Chapter 12:

"The Idea hit Stephen Hawking one evening in November 1970, as he was preparing for bed. It hit with such force that he was left almost gasping for air. Never before or since has an idea come to him so quickly. … The Idea excited him. He was ecstatic … He couldn't sleep. His mind kept roaming over the Idea's ramifications, its connections to other things." Pp.412-13

"The Novikov self-consistency principle, also known as the Novikov self-consistency conjecture, is a principle developed by Russian physicist Igor Novikov in the mid-1980s to solve the problem of paradoxes in time travel, which is theoretically permitted in certain solutions of general relativity (solutions containing what are known as closed timelike curves). Stated simply, the Novikov consistency principle asserts that if an event exists that would give rise to a paradox, or to any "change" to the past whatsoever, then the probability of that event is zero. In short, it says that it's impossible to create time paradoxes."[xlv]

"The spectre of the grandparent paradox does rear its head for interacting fields. … the scattering amplitude becomes non-unitary. … James Hartle of the University of California at Santa Barbara has developed a framework in which genuine nonunitary evolution is possible with the probability still always proportional to the square of the quantum amplitude. … Because the probabilities depend on the future value of the norm of the initial state, probabilities of events that take place before the formation of closed time-like curves depend on what happens once the closed time-like curves form. This gives an extra form of causality violation before the closed timelike curves form, independent of any causality violations occurring after they form … There is at least one more version of quantum mechanics with yet another set of odd behaviours in the presence of closed time-like curves. An information theoretic formulation of quantum mechanics due to David Deutsch of Oxford University, like the Wick-rotated path-integral formulation, routinely destroys quantum coherence, but in a novel way. The elements of the density matrix get mixed up in such a way that, in the language of the Everett-Wheeler "many worlds" interpretation of quantum mechanics, macroscopic observers can move and communicate from one "branch" to another by interacting with the closed time-like curve region" [xlvi]

Nietzsche anticipated Igor Novikov's destiny global self-consistency principle.

"Das aus sich rollende
Art thou a new strength and a new authority?
A first motion?
A self-rolling wheel?
Canst thou also compel stars to revolve around thee?"
Friedrich Nietzsche Thus Spake Zarathustra [xlvii]

DARPA-NASA STARSHIP CRASH

Is a Pentagon plan for a spaceship travel outside our solar system a crackpot idea, or a visionary blueprint for reaching the stars?

Astronaut to lead starship effort
The Pentagon's premiere research agency has chosen a former astronaut to lead a foundation that is designed to take humanity to the stars.

When Jack Sarfatti was 13 years old, he began receiving phone calls from a strange metallic voice that told him he would someday become part of an elite group of scientists exploring uncharted territory. Those calls, which he believes may have come from a computer on a spacecraft, proved a seminal influence on his life and led him to pursue a career that combined mainstream physics with an enduring interest in UFOs and the far-out reaches of science.

For those who might dismiss Sarfatti as a crank, he is quick to point out that he is not interested in debating the reality of little green men, but rather whether the existence of UFOs might prove that the technology required for interstellar travel is possible. "It's the physics that interests me," says Sarfatti, who received his PhD in the subject from the University of California.

That experience, and interest, also helped make Sarfatti one of the key figures invited last year to help formulate an unusual government programme: the 100-Year Starship (100YSS).
Sharon Weinberger

The discussion, which ranged from the impractical (giant, expensive nuclear powered rockets) to the improbable (antimatter powered engines), to the possibly impossible (worm holes, warp drives, and other ideas from science fiction), hit a roadblock when the topic of extraterrestrial visitors was raised by 72 year old rogue San Francisco physicist Dr. Jack Sarfatti. Sarfatti is no stranger when it comes to over-the-top speculative physics based on reverse engineering alleged machines from somewhere "out there" — but his virtual saucer crashed and burned when he posed the question to the panel.

'[Physicist] John Cramer calls on me to ask the Pundits — Ken Olum, Marc Millis, Eric Davis, Harold White & some Sci Fi writer I never heard of — a question. I ask: What about the 800 pound gorilla in the room, flying saucers?'

At this point the UFO topic crashed and burned. Gary Bekkum [xlviii]

Doug Trumbull, academy award for special effects in Stanley Kubrick's Space Odyssey 2001, is an avid UFO investigator using special equipment of his own design on a truck, was also there as an invited speaker and took my side in the closing event the next day.

DARPA and NASA combined efforts in 2011 to try to achieve interstellar flight in the next 100 years using private money because the US government is bankrupt and dysfunctional. I was invited to the first two meetings where I gave a paper on low power warp drive reproduced in this book and also created a stir for attempting to include UFOs in the agenda. As to be expected nothing much has come of the DARPA-NASA project

except, perhaps, for a book by the Benford twins who were fellow graduate students with me at UCSD in La Jolla in the late 1960s.

"A chapter explores "exotic propulsion", beyond our present understanding of physics, which might change the game. (And before you dismiss such speculations, recall that according to the consensus model of cosmology, around 95% of the universe is made up of "dark matter" and "dark energy" whose nature is entirely unknown. Might it be possible that a vacuum propeller could be discovered which works against these pervasive media just as a submarine's propeller acts upon the ocean?)" John Walker [xlix]

The University of California Berkeley announced in November, 2013 that statistical analysis of the NASA Kepler Space Craft data[l] shows that about one fifth of the exoplanets[li] of Sun type stars are in the habitable zone on which carbon-based life like our own might evolve. The nearest star system with such an exoplanet is twelve light years away from us. Therefore, the probability of contact with an advanced civilization with warp drive [lii]stargate technology is much higher than previously thought. This puts the UFO evidence into a new more immediate international security perspective.

"The Question is: What is The Question?" John Archibald Wheeler[liii]

The Culture of Theoretical Physics

"The mental processes by which a theoretical physicist works are beautifully described by Thomas Kuhn's concept of a paradigm … is a complete set of tools that a community of scientists uses in its research on some topic, and in communicating the results of its research to others. The curved spacetime viewpoint on general relativity is one paradigm; the flat spacetime viewpoint is another.[liv] *Each of these paradigms includes three basic elements: a set of mathematically formulated laws of physics; a set of pictures (mental pictures, verbal pictures, drawings on paper) which gives us insight into the laws and helps us to communicate with each other; and a set of exemplars – past calculations and solved problems, either in textbooks or in published scientific articles, which the community of relativity experts agrees were correctly done and were interesting, and which we use as patterns for our future calculations." P. 401 Kip Thorne, Black Holes and Time Warps (1994)*

Professor Max Heirich of the University of Michigan gave even deeper insight on Kip Thorne's important remark:

"Kuhn distinguishes between … 'normal science' and 'scientific revolutions' … The first term refers to everyday science, which proceeds within commonly accepted paradigms or models that suggest what the universe is like, what questions are relevant to ask, and how one should gather evidence relating to these questions. In a revolution, Kuhn (1970) argues, the paradigm itself is changed so that quite different questions emerge, along with new procedures for answering them. … Within prestigious universities, rewards are distributed on the basis of a star system, with 'cultural innovators' eligible for star status based on a 'publish or perish' tradition and review of performance by peers. … it … encourages the creation of products that are forward looking, but not too far out of step with what others are producing … Peer review … encourages conceptualizations that are innovative but not too extreme … What kinds of experiences allow for a new sense of ultimate framework to emerge? … First, if a large number of people begin to have experiences on a fairly regular basis that contradict what should be possible, it is only a matter of time until someone is likely to suggest a different set of organizing parameters for understanding these events. Second, fundamental reexamination of organizing perspectives also can be expected during time periods when quite undesirable outcomes seem to be imminent and unavoidable."

Certainly the case again today in 2013 starting with 9-11-2001, the wars in Iraq, Afghanistan, world financial melt-down of Sept 15, 2008[lv], Arab Spring turned Arab Winter, Syria, Iran nuclear weapons non-aggression pact,[lvi] Putin's move in Crimea, Obama's lack of clarity on foreign policy, anxiety over causes of climate change super storms, methane release in arctic, asteroids hitting earth, etc. etc. – Apocalyptic Times for many.[lvii]

General Relativity Lite

One of Einstein's key insights in addition to his "happiest thought":

"All our space-time verifications invariably amount to a determination of space-time coincidences. If, for example, events consisted merely in the motion of material points, then ultimately nothing would be observable but the meeting of two or more of these points. Moreover, the results of our measuring are nothing but verifications of such meetings of the material points of our measuring instruments with other material points, coincidences between the hands of a clock and points on the clock dial, and observed point-events happening at the same place at the same time. The introduction of a system of reference serves no other purpose than to facilitate the description of the totality of such coincidences." Albert Einstein, "Grundlage der allgemeinen Relativitätstheorie", Annalen der Physik, 49 (1916)

"These basic tools [for space-time relativity physics] are 1) the clock, 2) the accelerometer, 3) the gravity gradiometer and 4) the gyrocompass (either in its mechanical or more modern optical incarnation.) With these four tools one is able to define a local inertial frame (LIF) and to quantify deviations from a LIF." (Local Inertial Frame)[lviii] Nick Herbert[lix]

Einstein further stipulates that the Local Inertial Frame (LIF) must always be given in diagonal Cartesian coordinates T, X, Y, Z, i.e.,

$$ds^2 = (cdT)^2 - dX^2 - dY^2 - dZ^2$$

Where the gradients (first order partial derivatives) of the four nonzero metric tensor components (+1,-1,-1,-1) are obviously zero. In this special case, and only in this special case the Cartesian LIF coordinates X, Y, Z have what Einstein calls *"immediate metrical significance"* showing the readings of simultaneous measurements of the ends of moving objects.

Space geometry in rotating reference frames: A historical appraisal

The problem of giving a relativistic description of the geometry of a rotating disk has a history nearly as old as that of the theory of relativity itself. Already in 1909 Ehrenfest formulated his famous paradox in the context of the special theory of relativity. A few years later Einstein made heuristic use of this problem in order to motivate the introduction of non-Euclidean geometry in a relativistic theory of gravity. We shall here follow the conceptual evolution of this topic from Ehrenfest and Einstein to the present time. In particular we emphasize the importance of taking the relativity of simultaneity properly into account in order to obtain a full understanding of the issues connected with Ehrenfest's paradox. [lx]

Making a spatial coordinate transformation to, for example, cylindrical coordinates relevant to the rotating disk problem, gives for the same globally flat Minkowski spacetime (no curvature)

$$ds^2 = (cdt)^2 - dr^2 - r^2 d\phi^2 - dz^2$$

$$(ds/dt)^2 = c^2 - (dr/dt)^2 - r^2(d\phi/dt)^2 - (dz/dt)^2$$

$$= c^2 [1 - (v_r/c)^2 - (v_\phi/c)^2 - (v_Z/c)^2]$$

$$= c^2/\gamma^2$$

$$\gamma = [1 - (v/c)^2]^{-1/2} > 1$$

Therefore, because $\gamma > 1$ $d\tau = ds/c < dt$ which is special relativity time dilation since $d\tau$ is the proper time shown by a good clock in the rest frame of the test particle whose motion is being measured by the tracking Doppler radar getting its kinematic relative position, velocity and acceleration. The clock at the origin of the rotating radar tracking frame measures dt directly. Suppose, for example that the test particle is moving uniformly at ω radians per second in a circle in the x-y plane at z = 0. In that special case,

$$(ds/dt)^2 = c^2 - r^2(d\phi/dt)^2$$

$$d\phi/dt = \omega$$

Or in spherical polar coordinates

$$ds^2 = (cdt)^2 - dr^2 - r^2 (d\theta^2 + \sin^2\theta d\phi^2)$$

Note that

$$\gamma = [1 - (v/c)^2]^{-1/2} > 1$$

is true in both cylindrical and spherical coordinates for these properly accelerating LNIF radar tracking frames. In both of the above curvilinear coordinate representations, the gradients of the spatial metric components no longer vanish because these metrics in curvilinear coordinates really describe a special class of properly accelerating Local Non-Inertial-Frames (LNIFs) that I will call Doppler Radar Tracking Frames. The origins of the LIF and the two above LNIFs coincide. Let's take the spherical polar form. We imagine a radial unit vector (arrow) $\mathbf{e}_r$ that is pointing at the test object that the radar is tracking via electromagnetic waves with large finite speed c ~ 186,000 miles per second ~ 300 million meters per second etc.. There are two other all mutually orthogonal unit vectors $\mathbf{e}_\theta$ and $\mathbf{e}_\phi$ forming a triad spatial frame. We assume that the relative speed v of the test object is small compared to that of light obeying the inequality $v \ll c$. We do not yet have to worry about special relativity time dilation and length contraction and whether

they are optical illusions or material distortions depending on the total experimental arrangement as specified by Niels Bohr. Obviously, if one is looking at a non-rotating spherical shell at high relative speed, there is no real local anisotropic distortion of the sphere. In fact, if one looks at a freely moving rod on a geodesic, the rod will look rotated not contracted because of the different time delays of light signals to the observer from the ends of the rods. This is a purely optical illusion. The observer on the rod, with zero proper tensor acceleration, does not feel any anisotropic material compression along its direction of motion. That would mean an absolute rest frame violating Einstein's basic idea in his 1905 special relativity. The case of the rotating disk, however, is completely different because different points on the disk have different proper tensor accelerations due to internal quantum electromagnetic stresses causing strains in it.

Thus, the cylindrical coordinate frame is not the LNIF clamped to a rotating disk. That is a different "total experimental arrangement" (Niels Bohr) given in the non-relativistic limit by the approximate metric:[lxi]

Here the x,y,z space coordinates are fixed to the disk in the z = 0 plane rotating with angular speed ω radians per second. Let X,Y,Z,T be the coordinates of the Local Inertial Frame (LIF) whose origin is coincident with that of the rotating disk frame.

Simply substitute LIF → rotating LNIF:

$$T = t \quad \text{(neglect time dilation)}$$

$$X = x\cos\omega t - y\sin\omega t$$

$$Y = x\sin\omega t + y\cos\omega t$$

$$Z = z$$

Into the LIF metric (which must be in Cartesian coordinates in Einstein's definition)

$$ds^2 = c^2dT^2 - dX^2 - dY^2 - dZ^2$$

to get

$$ds^2 = [c^2 - \omega^2(x^2 + y^2)]dt^2 + 2\omega ydxdt - 2\omega xdydt - dx^2 - dy^2 - dz^2$$

The component geodesic equations from DV(test particle)/ds = 0 for the rotating disk observer clamped to the disk at (x = 0, y = 0, z = 0, t) tracking the test particle at (x,y, z, t) moving on the real force-free timelike geodesic of globally flat Minkowski spacetime (without any real curvature) are:

$$d^2t/d\tau^2 = 0$$

$$d^2x/d\tau^2 - \omega^2 x\,(dt/d\tau)^2 - 2\omega(dy/d\tau)(dt/d\tau) = 0$$

$$d^2y/d\tau^2 - \omega^2 y\,(dt/d\tau)^2 - 2\omega(dx/d\tau)(dt/d\tau) = 0$$

$$d^2z/d\tau^2 = 0$$

In general

$$(d\tau/dt)^2 = 1/\gamma^2$$

$$\gamma = [1 - (v/c)^2]^{-1/2} > 1$$

$$\gamma = [1 - (\omega^2(x^2 + y^2)/c)^2]^{-1/2}$$

Therefore, the approximate geodesic equations for the real force-free motion of the test particle are re-expressed as:

$$d^2x/dt^2 - \omega^2 x - 2\omega(dy/dt) = 0$$

$$d^2y/dt^2 - \omega^2 y - 2\omega(dx/dt) = 0$$

$$d^2z/dt^2 = 0$$

taking $\gamma = 1$ in this approximation where we neglected time dilation at the very beginning. The special relativity equations are more complicated and obscure the basic point I wish to make here. The rotational fictitious inertial pseudo forces per unit test mass, e.g., centrifugal $\omega^2 x$ and Coriolis $2\omega(dy/dt)$ are universal just like gravity. An observer on the test particle does not feel them. They are contingent artifacts of the proper acceleration of the spinning detector at the origin of the LNIF.

In **3-vector** notation, Newton's first law of real force-free geodesic motion in flat spacetime as seen from the rotating non-inertial (LNIF) frame observer at the LNIF origin is $DV/ds = 0$ that simplifies to

$$d^2\mathbf{r}/dt^2 + \boldsymbol{\omega} \times \boldsymbol{\omega} \times \mathbf{r} + 2\boldsymbol{\omega} \times d\mathbf{r}/dt = 0$$

Next, consider a different total experimental arrangement where the test object of mass/inertia m is clamped to a point x, y, z = 0 on the rotating disk. The world line of this test object is now off-geodesic in the ambient globally flat Minkowski spacetime with zero curvature tensor throughout. We no longer can use the above geodesic equation $DV/ds = 0$, which is Newton's first law of motion in any local frame, inertial free of proper tensor acceleration, or non-inertial with proper tensor acceleration. We must now use, Newton's second law for a real electromagnetic-

weak-strong local gauge force F that pushes the test particle off the timelike geodesic world line of the physical space-time geometrodynamic field.

$$F = DP/ds$$

In general this is

$$F = Vdm/ds + mDV/ds$$

Assume again

$$dm/ds = 0$$

To keep it simple, imagine we have a single electron of charge e as our clamped test object.

$$e\mathbf{E} = mD\mathbf{V}/ds$$

Because the electron is clamped to a point on the rotating disk, the constraints are

$$d^2x/dt^2 = 0$$

$$dy/dt = 0$$

$$d^2y/dt^2 = 0$$

$$dx/dt = 0$$

Therefore,

$$d^2x/dt^2 - \omega^2x - 2\omega(dy/dt) = (e/m)E_x$$

$$d^2y/dt^2 - \omega^2y - 2\omega(dx/dt) = (e/m)E_y$$

simplify to

$$- m\omega^2x - = eE_x$$

$$- m\omega^2y = eE_y$$

Thus, in this constraint case, the centrifugal inertial fictitious pseudo-force balances the real electrical force. In 3-vector notation this is for electric field vector $\mathbf{E}$

$$d^2\mathbf{r}/dt^2 + \boldsymbol{\omega} \times \boldsymbol{\omega} \times \mathbf{r} + 2\boldsymbol{\omega} \times d\mathbf{r}/dt = (e/m)\mathbf{E} \rightarrow \boldsymbol{\omega} \times \boldsymbol{\omega} \times \mathbf{r} = (e/m)\mathbf{E}$$

Finally, the null geodesic equation for a light ray as seen in the rotating disk frame is

$$ds^2 = 0 = [c^2 - \omega^2(x^2 + y^2)]dt^2 + 2\omega y dx dt - 2\omega x dy dt - dx^2 - dy^2 - dz^2$$

Divide by cdt to get

$$[1- \omega^2 r^2/c^2] + 2(\omega \mathbf{r}/c^2)\times d\mathbf{r}/dt - ((d\mathbf{r}/dt)/c)^2 = 0$$

This is a quadratic equation in the speed of light dr/dt as seen by the rotating observer. It has two distinct roots corresponding to the Sagnac effect for the phase shift of fringes of rotating interferometers for two light beams in opposite directions when ω is not zero. This shift is from the "gravimagnetic" cross terms mixing space and time in the rotating effective metric.

What happens when special relativity time dilation and length contraction is important for the rotating disk? Einstein's 1905 special relativity transformations did not include this situation of rotation, which always involves proper accelerations. The trick is to consider an instantaneous LIF momentarily coincident and at rest with respect to a point on the disk itself at (r, ϕ, z = 0, t) with ω = dϕ/dt. I now present an original set of equations as a conjecture. I have not seen them in any textbook or paper and I do not know if they are correct. The problem of rotating extended objects is still controversial in the literature on Einstein's relativity. For the observer (in the momentarily relatively at rest to the rotating disk) co-moving LIF whose measurements are

$$T(\omega,r) = [1 - (\omega r/c)^2]^{-1/2}[T(0) - r^2 \omega/c^2]$$

$$L(w,r) = [1 - (\omega r/c)^2]^{-1/2} [L(0) - r\omega T(0)]$$

Where T(0) and L(0) are the measurements for an observer in the Laboratory Inertial Frame. L is the length of a short rod always oriented in the tangential $\mathbf{e}_\phi$ direction perpendicular to the radial $\mathbf{e}_r$ unit base **3-vector**. Now, if we further conjecture, and this is controversial, that the proper acceleration of the LNIF observer does not affect the measurements, and then we can say that these are also the measurements made by the LNIF observer fixed to the rotating disk at r. However, I think that is wrong, in violation of Einstein's equivalence principle. There is actually a radially pointing outward centrifugal non-tidal artificial gravity field $g = \omega^2 r$. Therefore, different hovering static LNIF detectors clamped to the rotating disk at different radii r will see an additional gravity time dilation effect for light confined to a radial optical fiber not seen by the coincident LIF. Indeed, the transformation connecting them is a tetrad transformation. Note also that there is a radially inward electrical constraint force balancing the radially outward artificial gravity field for the hovering static LNIF detector/observer clamped to a point on the rotating disk.

Neglecting for now the gravimagnetic cross terms in the rotating disk metric,

$$1 + z = f_{send}/f_{receive} \sim [g_{tt}(receive)/g_{tt}(send)]^{1/2}$$

$$\rightarrow [(1 - (\omega r(receive)/c)^2)/(1 - (\omega r(send)/c)^2)]^{1/2}$$

Imagine an optical fiber along a radius from the axis of rotation r = 0. If a light signal is sent from that axis through the fiber to a receiver at r, then

$$1 + z = [1 - (\omega r(receive)/c)^2]^{1/2} \sim 1 - (1/2)(\omega r(receive)/c)^2$$

This is a gravitational blue shift for the light pulse moving radially outward in the centrifugal artificial gravity field. There will of course be a gravity redshift in the opposite radially inward direction.

The geodesic equation (aka Newton's first law of test particle mechanics in any physically possible local frame of reference) is in its full glory with tensor indices summed (0, 1, 2, 3) over repeated pairs of upper and lower indices.

$$D^2x^\mu/d\tau^2 = d^2x^\mu/d\tau^2 + \Gamma^\mu_{\nu\lambda}(dx^\nu/d\tau)(dx^\lambda/d\tau) = 0$$

All of the contingent fictitious inertial pseudo-forces subject to the free will of the observer if he has suitable technology at his disposal are in the Levi-Civita-Christoffel terms $\Gamma^\mu_{\nu\lambda}(dx^\nu/d\tau)(dx^\lambda/d\tau)$ of the above geodesic equation. The absolute local tensor proper acceleration of the test particle as measured by an accelerometer rigidly clamped to the test particle (i.e. rest frame of the test particle) is $D^2x^\mu/d\tau^2$, which is a first rank tensor. Einstein realized that, unlike special relativity, only transformations between local frames whose origins are "coincident" are physically meaningful when there are real tidal gravity fields from the tensor curvature of spacetime. Physically this means that the separations between the origins of the local frames must be small compared to the set of radii of curvature. Here on Earth that scale is 10^{13} cm so it is not too restrictive practically speaking. The geodesic equation is a local differential equation, therefore same holds for the separation of the test object from the origin of the local frame where the detector is located by definition if the equation is to be a good approximation in real problems of experimental/observational physics generally ignored in many GR textbooks and papers that are strong on the math and weak on the physics. The relative non-tensor kinematic acceleration measured completely differently and independently by a Doppler radar or even telescope located at the origin of the local frame that is tracking the test particle is $d^2x^\mu/d\tau^2$. Finally, the non-tensor fictitious forces encoded in $\Gamma^\mu_{\nu\lambda}(dx^\nu/d\tau)(dx^\lambda/d\tau)$ are also measured locally by a second accelerometer rigidly clamped to the origin of the local frame. Eugene Wigner commented on the "unreasonable effectiveness of mathematics in the natural sciences"[lxii] Riemann's differential geometry is the mathematical language Einstein used in general relativity, however, what is physically relevant is only a coarse-grained compressed image of the full mathematical structure. There are a lot of redundant irrelevant formal details that are, to borrow a term from John Archibald Wheeler on Everett's (Tegmark Level 3, also David Deutsch) many-worlds quantum theory, "excess

baggage." In terms of differential geometry, the $\Gamma^{\mu}{}_{\nu\lambda}$ Levi-Civita Christoffel torsionless metric connection components are used in the parallel transport of tensor fields along worldlines. In particular, if the world line is a closed loop in spacetime, and this includes mixed space/time travel to past closed timelike curves (CTCs), and if those loops are shrunk to quantum gravity Planck scale pixel size 10^{-66} cm^2 areas, the angular topological disclination defect, in the simple case of four-vector first-rank tensors, is a measure of the fourth-rank curvature tensor. Another way of saying this is that the tensor curvature is the covariant partial derivative curl of the connection with respect to itself. I only mention this in passing for completeness. I will emphasize the operational experimental meanings of the mathematical symbols rather than the formal mathematics behind them.

Alice and Bob, each on an arbitrary timelike world line, are physically close to each other at some moment. The physical local orthogonal group frame transformation between them is represented by the symbol $X_{\mu A}{}^{\mu B}$, where at the same physical point-like event in spacetimw

$$X_{\mu Alice}{}^{\mu Bob} = \partial x^{\mu B} / \partial x^{\mu A}$$

The local tensor transformation of the test particle's proper acceleration is

$$D^2x^{\mu A}/d\tau^2 \rightarrow D^2x^{\mu B}/d\tau^2 = X_{\mu A}{}^{\mu B}\, D^2x^{\mu A}/d\tau^2$$

I showed the mathematical essence, sans the tensor indices, of the non-tensor transformations earlier in my index-free notation. For Alice and Bob momentarily very close to each other, both measuring the same events, the conventional formula connecting their respective non-tidal Newtonian gravitational fields (i.e., inertial fictitious pseudo-forces) is

$$\Gamma^{c'}{}_{a'b'(Alice)} = (\partial x^{c'}/\partial x^{d})(\partial x^{n}/\partial x^{b'})(\partial x^{m}/\partial x^{a'})\,\Gamma^{d}{}_{mn(Bob)} + (\partial x^{c'}/\partial x^{d})(\partial x^{n}/\partial x^{b'})\,(\partial^2 x^{d}/\partial x^{n}\,\partial x^{a'})$$

The term that spoils the tensor property of the non-tidal gravity field Γ is the nonlinearity of the second order partial derivative $(\partial^2 x^{d}/\partial x^{n}\,\partial x^{a'})$. This term vanishes for the strictly linear transformations between coincident inertial frames in Einstein's limiting case of 1905 special relativity without real gravity curvature fields. As soon as the coincident local frames have themselves off-geodesic proper accelerations, the X transformations between them are nonlinear, i.e.

$$(\partial^2 x^{d}/\partial x^{n}\,\partial x^{a'}) \neq 0$$

Einstein's equivalence principle (EEP) then corresponds to the locally coincident LNIF(Bob) $\leftrightarrow$ LIF(Alice) called the <u>tetrad transformation</u> whose equations are

$$\Gamma^{K}{}_{IJ(LIF)} = 0$$

$$= (\partial x^{K}/\partial x^{d})(\partial x^{n}/\partial x^{J})(\partial x^{m}/\partial x^{I})\,\Gamma^{d}{}_{mn(LNIF)} + (\partial x^{K}/\partial x^{d})(\partial x^{n}/\partial x^{J})\,(\partial^2 x^{d}/\partial x^{n}\,\partial x^{I})$$

because the LIF must always be expressed in Cartesian coordinates in Einstein's definition in order to correspond to special relativity as the limiting case for inertial frames in which the coordinate differences have "immediate metrical significance". In other words, special relativity works approximately in a small enough spacetime region even if the curvature tensor is not zero. The tidal geodesic deviations of the Weyl vacuum part and the compression of the Ricci matter part of the full curvature tensor can be made arbitrarily small classically (ignoring quantum gravity). Alternatively, simple lower the resolution of the measuring instruments to have special relativity as a good approximation locally.

Another mathematical meaning of the $\Gamma^{\mu}{}_{\nu\lambda}$ symbols more relevant to the fictitious inertial pseudo-forces is the set of 4-vector equations:

$$\partial e_a/\partial x^b = \Gamma^c{}_{ab}\, e_c$$

Where the e's are each different 4-vectors (not the four components of a single 4-vector) forming the basis of a local frame including the time "0" component that is a unit tangent vector along the world line of the particle in 4D space-time. The ∂ mean partial derivative. The usual convention is that "1" is the unit tangent 4-vector to the path of the test particle in 3D space, with "2" and "3" in the plane perpendicular to it.

We want to get deeper insight into the physical meanings of the metric tensor in curvilinear coordinates where the coordinate differences along a given dimension no longer have "immediate metrical significance." Indeed, Einstein struggled for years with this problem between 1905 and 1915 approximately. The Einstein "hole paradox" leading to modern ideas of local gauge symmetry is discussed well in Carlo Rovelli's on-line lectures Quantum Gravity.[lxiii] Therefore, let us return to the simplest case of the radar tracking LNIF in cylindrical coordinates in globally flat Minkowski spacetime far from gravitating source tensors $T_{\mu\nu}$. Do not confound this case with the different problem of hovering static LNIF observers clamped to different points on a rotating disk. We are now back to

$$c^2 d\tau^2 = (cdt)^2 - dr^2 - r^2 d\phi^2 - dz^2$$

$$(d\tau/dt)^2 = c^2 [1 - (v_r/c)^2 - (v_\phi/c)^2 - (v_z/c)^2]$$

$$= 1/\gamma^2$$

$$\gamma = [1 - (v/c)^2]^{-1/2} > 1$$

The only nonvanishing (symmetric in lower pair of indices) Christoffel symbols here are:

$$\Gamma^r{}_{\phi\phi} = - r$$

$$\Gamma^{\phi}{}_{r\phi} = 1/r$$

When the test particle is on a timelike geodesic in completely flat Minkowski space-time free of any real gravity curvature fields, Newton's first law of mechanics in the radar-tracking LNIF is the set of geodesic equations DV/dt = 0, which reduce here to

$$d^2r/d\tau^2 \; - \; \Gamma^r_{\phi\phi} \, (d\phi/d\tau)^2 = 0$$

$$d^2\phi/d\tau^2 + \Gamma^\phi_{r\phi}(dr/d\tau)(d\phi/d\tau) = 0$$

Define

$$\varpi = d\varphi/d\tau = (dt/d\tau)\omega = \gamma\omega$$

Therefore, it is obvious that in this case

$$\Gamma^r_{\phi\phi}(d\phi/d\tau)^2 = \; -\gamma^2 r\omega 2$$

is a time-dilated centrifugal fictitious force not felt by the test particle on a geodesic in flat space-time.

$$\Gamma^\phi_{r\phi}(dr/d\tau)(d\phi/d\tau) = \gamma^2(\omega/r)(dr/dt)$$

is a time-dilated Coriolis-type fictitious force.

Is Gravity a Force?

"Gravity is not a foreign and physical force transmitted through space and time. It is a manifestation of the curvature of spacetime."

This is John Archibald Wheeler's synopsis of Einstein's theory as we essentially understand it today 2013 in hindsight. Wheeler means real gravity as distinct from artificial gravity caused by the observer's off-geodesic proper acceleration from a real primarily electrodynamic force with quantum statistical zero point pressure and Pauli-exclusion principle corrections. When you weigh yourself on a scale there is an unbalanced electrical force pushing you radially outwards in order to hover on an off-geodesic world line in fixed position in the Earth's curvature field. How Einstein conceived it on his rocky road of discovery between 1905 and 1916 is not of fundamental importance for the task of building stargates and warp drives. We are here more interested in the future than the past, though of course we need to know enough about the past not to repeat mistakes already made.

What is time?[lxiv]
Time is what clocks measure.

What is a real force?[lxv]
A real force is what accelerometers measure when clamped to test particles.[lxvi]
What is real gravity?[lxvii]

Real gravity is what gravity gradiometers measure. The real gravity field is the geodesic pattern of force-free motions of neutral test particles that changes when the distribution of mass-energy flows change.

Geodesics are the straightest world line paths in curved four-dimensional spacetime. The proper time of clocks is longest on slower than light timelike geodesics compared to any other neighboring world line that starts and ends at the same two points on the time like geodesic from which the measurements of duration are made. This is an example of the action principle.[lxviii]

Is gravity a real force?
No, gravity is a fictitious (aka: inertial; pseudo, phantom) force.[lxix]

*"**Inertial force,** also called **Fictitious Force**, any force invoked by an observer to maintain the validity of Isaac Newton's second law of motion in a reference frame that is rotating or otherwise accelerating at a constant rate. For specific inertial forces, see centrifugal force; Coriolis force; d'Alembert's principle." Encyclopedia Britannica*

If gravity is not a real force, then does it make sense to try to unify it with the three real forces we know, electromagnetism, weak radioactivity, and strong nuclear?
If gravity is emergent[lxx] from a false vacuum[lxxi] of zero rest mass spin 1/2 [lxxii]leptons, quarks, and electromagnetic, weak and strong spin 1 vector bosons[lxxiii] then one must be careful. Gravity like rest mass[lxxiv] then comes from a multiplet[lxxv] of Higgs-Goldstone vacuum superconductor order parameters.[lxxvi] These order parameters[lxxvii] do have quantum noise.[lxxviii] In particular, if we have a classical curved spacetime, then it certainly makes sense to think of quantum fluctuations[lxxix] around the mean values of the curvature tensor field. The classical gravity fields are already unified with all the matter fields in the form of universal minimal coupling[lxxx] that is a consequence of the equivalence principle, i.e. covariant derivatives with the space-time connections similar to the covariant derivatives of leptons and quarks with the respect to the vector boson internal space connections in local gauge theories.[lxxxi] I will discuss this in more detail later in the book in Rovelli's equations (2.30) and (2.31). Of course, the firewall horizon paradox seems to show a conflict, or creative tension, between unitarity and the equivalence principle similar to the conflict between locality and objectivity (realism) in quantum entanglement.[lxxxii] Locality in linear quantum theory is closely related to unitarity.[lxxxiii]

If quantum theory is unitary[lxxxiv], you cannot use entanglement to send signals that do not need a classical decryption key.[lxxxv] If quantum theory is non-unitary, you can and the new larger-post quantum theory is nonlinear as in the models of Steven Weinberg and Henry Stapp.[lxxxvi]

What is a fictitious force?[lxxxvii]

Fictitious forces appear to act on freely falling test particles (zero proper acceleration) from the point of view of the properly accelerating observer even though the accelerometer pointers clamped to the test particles register zero. In fact, however, another accelerometer clamped to the observer will show a movement of its pointer away from zero. Therefore, it is the observer who is really accelerating from a real force on her not the test particle. In Einstein's mathematics of the general relativity of the gravitational field, all of the fictitious forces, which includes Newton's inverse square law force, as well as Coriolis, centrifugal, Euler and translational "inertial forces" are pieces of the Levi-Civita connection field[lxxxviii] for parallel transport [lxxxix]of objects in curved spacetime. The curvature tensor[xc] is the "curl"[xci] of the Levi-Civita connection field with respect to itself. Curvature is related to disclination defects[xcii] in crystal lattices[xciii] when the lattice spacing shrinks to zero. Hagen Kleinert has developed this in detail for the four-dimensional "world crystal lattice" paradigm. Imagine parallel transporting a vector around a closed loop in the space. If the space is curved, then the final orientation of the vector will be different from its initial orientation. Finally, shrink the loop to zero. This is the "disclination". Physically, different components of the curvature tensor (of 4th rank) are measured by observing the relative apparent acceleration between two neighboring force-free test particles each on a timelike geodesic. One can also use light signals on null geodesics in principle. This is called "geodesic deviation." [xciv]Space can also have "torsion"[xcv] related to dislocation defects in crystal lattices. Given two tiny vectors A and B with a common origin, first parallel transport A by B and then B by A. Next, go back to the origin, reverse the procedure, i.e., first parallel transport B by A and then A by B. If there is torsion, there will be a dislocation gap, the tiny parallelogram will not close to first order of smallness in the Taylor series expansions. Einstein's 1916 theory does not have torsion. However, the discovery of both attractive dark matter and repulsive dark energy may require torsion beyond Einstein's 1916 theory. Gravity as the local gauge theory of the Poincare group of Einstein's special relativity requires both curvature and torsion as independent dynamical fields. Torsion also arises naturally in super-symmetry string theory. Because, spacetime is curved[xcvi], the properly accelerating observer can be standing still relative to the mass-energy source of the gravity spacetime curvature field. The key organizing principle of Einstein's theory of gravity is the equivalence principle known also as "Einstein's happiest thought."

The Equivalence Principle

Einstein's happiest thought (1907): For an observer falling freely from the roof of a house, the gravitational field does not exist. Conversely (right), an observer in a closed box—such as an elevator or spaceship—cannot tell whether his weight is due to gravity or acceleration. … Gravitation is (locally) equivalent to acceleration. This is the principle of equivalence. [xcvii] *James Overduin*

This profound principle takes many forms both intuitive and mathematical, as we shall see below. Intuitively there are two ways to look at it, two sides of the same coin; the two faces of Janus:

1) Alice in free fall in a gravitational field has the same weightless experience as Bob in a rocket ship freely floating way out in space far from large masses.

2) Alice standing still on surface of Earth in its gravity field has the same experience of feeling heavy weight as does Bob now firing his rocket engine at 1g thrust.

The second organizing principle Einstein used was the invariance/covariance principle embodied in the tensor/spinor calculus that the local partial differential equations of classical field physics should all have the same mathematical form in all physically possible local frames of reference. Local frames of reference refer to actual small detectors and to arrays of such detectors synchronized with each other using modern technology like Doppler radars. The mathematics of differential geometry is a model for such frames of reference. However, the correspondence between the mathematics and actual physical procedures of experimental physics is only approximate. The mathematics is secondary to the physics. The mathematics has excess baggage compared to the physics. We have to know how to compress this excess mathematical information into useful procedures for the experimental physicists and engineers. Too many theorists lose contact with real physics by getting lost in the seductive opium of pure mathematics. Quoting a rigorous theorem of differential geometry or any other branch of mathematics is almost always completely irrelevant to significant problems for experimental physicists making real measurements. The mathematics provides an approximate model, a map for the territory of real work in the laboratory. There is always two-way feedback between theory and experiment and the great physicists have the artistic judgment, that mediocre hacks lack, as to what the important problems are. Indeed, intuition like Einstein and Feynman's is a genius talent a paranormal precognitive sixth sense similar to Mozart's musical creativity.

Wormholes, Time Machines, and the Weak Energy Condition

Michael S. Morris, Kip S. Thorne,[xcviii] *and Ulvi Yurtsever*
Theoretical Astrophysics, California Institute of Technology, Pasadena, California 91125
(Received 21 June 1988)
"It is argued that, if the laws of physics permit an advanced civilization to create and maintain a wormhole in space for interstellar travel, then that wormhole can be converted into a time machine with which causality might be violatable. Whether wormholes can be created and maintained entails deep, ill-understood issues about cosmic censorship, quantum gravity,[xcix] *and quantum field theory*[c]*, including the question of whether field theory enforces an averaged version of the weak energy condition."*

What is a stargate?
It is an alternate path[ci] through four-dimensional space-time that can get us to the stars and beyond quickly. We can travel to the past and to the future through the stargate. There is controversial evidence that advanced intelligence with stargate super-technology has been influencing us as a species on this planet for thousands of years.
I adopt as a working hypothesis that the flying saucers[cii] are real and that they get here through stargates[ciii] that are shortcut tunnels in Einstein's warped spacetime continuum.[civ] The task is then to see what modern physics has to say about such a scenario even if it's

not true. Whether or not it's true is beside the point and I will not discuss the actual UFO evidence, good, bad and bogus in this book. I will also write about quantum theory[cv] and its relation to computing, consciousness, cosmology, and the hologram universe

According to 't Hooft the combination of quantum mechanics and gravity requires the three-dimensional world to be an image of data that can be stored on a two dimensional projection much like a holographic image. Leonard Susskind[cvi]

And ending in a scenario for Stephen Hawking's "Mind of God." [cvii] That Hawking thinks God is not necessary[cviii] and that conscious mind is not the missing thread in the fabric of reality is again is beside the point.[cix] If you have the patience, Leonard Susskind's Stanford University lectures in physics online videos[cx] are also worth the effort as is Wikipedia for fast convenient online access to prerequisite concepts needed to understand this book.[cxi]

A good layman's background reference here is Enrico Rodrigo's "The Physics of Stargates: Parallel Universes, Time Travel and the Enigma of Wormhole Physics."[cxii]

Stargate Manifesto

"These concepts are not merely fanciful notions, but are instead likely representations of the actual nature of fundamental reality. ... Wormholes not only force the consideration of time travel, but also that of travel between parallel universes. They demand a re-evaluation of the fate of intelligent life in the universe of the distant future. ... It is, moreover, to confront startling implications of religion, ethics and the future of humanity." Enrico Rodrigo

The 1998 discovery of the cosmic antigravity field accelerating the expansion speed of three dimensional space dooms intelligent consciousness unless stargate time travel[cxiii] to the past has been achieved by an advanced civilization who in all likelihood are our future descendants to go back in time genetically engineering us in what Igor Novikov calls a globally self-consistent loop in time.[cxiv] Indeed, we all seem to descend from a single Eve consistent with the Old Testament "Garden of Eden." Almost every major religion if not all, certainly Hindu, Jewish, Christian and Muslim can be understood as a Sky God UFO Cult gone mainstream with the Messiah figures as human-ET hybrids with paranormal powers like Uri Geller on steroids.[cxv]

Next, I merge Enrico Rodrigo's useful brief history of modern stargate physics with Kip Thorne's much broader "Chronology" that should be consulted in his "Black Holes and Time Warps. This is a partial incomplete list. Note that this timeline is an elementary example of a lattice fiber bundle. The base space is the set of discrete chronological entries. The fibers are the bit strings attached to them.

> 1590: Galileo formulates the weak equivalence principle that all bodies fall with the same apparent kinematical acceleration independent of their mass and composition after corrections for air resistance.
>
> 1687: Newton's Principia[cxvi] included first, second and third laws of particle mechanics, gravity and the calculus; application to the motion of planets around

the Sun. Newton's first law becomes Einstein's geodesic equation. Newton's second law defines a real force as the deviation away from force-free geodesic motion. In Einstein's general relativity, a geodesic is the straightest path in a curved four-dimensional spacetime. Newton's third law that when Alice and Bob interact, the real force of Alice on Bob induces an equal and opposite real force of Bob on Alice follows from conservation of linear momentum provided that Alice and Bob are isolated from the rest of the universe. Conservation of linear momentum in a closed system then follows from translational symmetry, which is a special case of Emmy Noether's theorem.[cxvii]

1783 & 1795: Michell and Laplace use Newton's physics to conceive of a black hole.

1864: James Clerk Maxwell formulates his unified electromagnetic field equations[cxviii]: no magnetic monopoles, Gauss's law of electric flux from electric charges, Faraday's law of electromotive force, Ampere's law of magnetism from currents both real and virtual including the all important vacuum displacement electric current that gives far field transverse polarized microwave, infrared, radio, light, x-ray, gamma ray et-al far field radiations, and local conservation of current densities.

1871 Lewis Carroll writes Alice Through The Looking Glass coding many future physics ideas.[cxix]

1879: Mach's naïve relationalism[cxx] begins to form in his mind in regard to Newton's bucket experiment.[cxxi] Mach's thinking influenced Einstein in his creation of General Relativity, but it was essentially a psychological crutch for Einstein that he discarded. We now know that Newton was essentially correct. Newton's *local* absolute space separated from absolute time is replaced by Einstein's *local* geometrodynamic field $g_{uv}(x)$ that defines the geodesic world lines of real force-free motion in four-dimensional spacetime. Although, thinking of the bucket rotating with the stars not rotating is kinematically equivalent to thinking of the bucket as not rotating with the stars rotating around it, the two situations are dynamically inequivalent as shown by accelerometers clamped to different locations on the bucket and on the stars respectively. This is a gedankenexperiment[cxxii] of course. When it is the bucket that is really rotating, the concave shape of the water surface is essentially a set of accelerometers measuring the differences between the actual off-geodesic world lines of small volume elements of water and the (timelike) geodesics of the actual Einstein geometrodynamic field. The geometrodynamic field is determined by the distribution of mass-energy in the past history light cones[cxxiii] of the field points and, if Wheeler-Feynman are correct, also in the future destiny light cones. When quantum entanglement is included beyond Einstein's strictly classical 1916 field theory, we will also get effects outside the light cones as we see in the effective exotic matter of virtual particles stuck to geometrodynamic field horizons[cxxiv] $g_{00} = 0$ in the Hawking radiation. Indeed, there seems to be a close connection

between quantum entanglement of quanta in hologram dual field theories stuck on 2D gravity horizons with gravity wormholes in the interior 3D bulk. Current theories of this holographic duality are based on the extra non-commuting dimensions of superstring theory, but I am calling for a simpler theory in our actual four-dimensional spacetime with braid group fractional quantum anyon topological computer field theory on both our future dark energy and past particle cosmological horizons.[cxxv] As in the standard model, induced internal symmetry fiber connection fields explain the spin 1 electromagnetic-weak-strong virtual boson real forces. Non-traversable wormholes like Einstein-Rosen bridges "ER" then correspond to orthodox quantum theory's no-signaling via entanglement arguments. However, quite obviously, dark energy supported traversable wormholes correspond to a more general post-quantum theory with direct entanglement signaling that does not require a classical signal key to decrypt the message encoded in the nonlocal pattern of entanglement.

1887: Michelson and Morley at Case Institute in Cleveland using an optical interferometer show that the motion of Earth through Newton's conjectured absolute space decoupled from absolute time is undetectable. Newton's theory of light predicted a shift in the fringe interference pattern that was not observed.[cxxvi]

1905: Einstein's close telepathic "remote viewing" encounter with advanced time traveling intelligence from the future?[cxxvii] He publishes three breakthrough papers each in a different field of fundamental physics: the special theory of relativity showing that in a sense, space shrinks along a geodesic and time dilates relative to a given observer; the speed of light in vacuum is the same in all inertial frames, which by definition do not rotate and whose centers of mass move on real force-free geodesic world lines; energy is equivalent to mass $E = mc^2$ leading to nuclear physics, the laws of mechanics of particles at speeds close that of light made consistent with Maxwell's electromagnetic field equations that he realizes were already automatically special relativistic in their vacuum version. Second, Einstein explains the photoelectric effect, which with Planck's 1900 explanation of black body radiation's spectrum are two of the basic building blocks of quantum theory. Third, his theory of Brownian motion that established beyond much doubt that atoms are real. It was indeed Poincaré (1906) who made Lorentz's theory fully compatible with the relativity principle. [cxxviii]

1907: Einstein sleepwalks into the rudiments of his theory of general relativity, formulating the concept of the Local Inertial Frame (LIF), his stronger version of Galileo's equivalence principle, and the gravitational time dilation (redshift) analogous to the special relativistic time dilation of fast moving particles. For example, fast muons from cosmic rays high in the stratosphere have a longer lifetime than their identical twins at rest on surface of Earth.[cxxix] Indeed, this time dilation together with the stargate traversable wormhole consequence of general relativity immediately shows time travel to the past. The simple stargate has two portals (mouths). Move one of them very fast, or place it hovering in a very strong gravity field. Therefore, Bob enters the unmoved portal in 2014 and he exits the

moved portal that has time dilation relative to the external universe and which has aged, say ten years while Bob has only aged one minute. Bob exits the moved portal into 2024. Bob looks through the very short stargate and sees Alice at the unmoved portal in 2014 whose objectively real local proper time aging is phase-locked synchronized to his. There is a kind of absolute simultaneity through the wormhole. That is, Bob looking through the portal back at Alice sees her only one minute older the same as he is. But if he stays outside the portal and returns to Alice she will be ten years older than he is. The stargate is a two-way street through time. You can go back and forth between future and past, as the UFOs seem to be doing as a matter of controversial "fact."

1908: Hermann Minkowski, a former professor of Einstein's who he called a "lazy dog" shows that Einstein's still clumsy equations of special relativity of 1905 can be more elegantly formulated in covariant form in four-dimensional spacetime geometrical terms.

1912: Einstein struggling with differential geometry under Marcel Grossman's tutoring realizes that four-dimensional spacetime must be curved, and that Newton's inhomogeneous gravity field forming tidal effects is most simply explained as the curvature. Note, there are no real forces involved. Tidal effects are relative kinematical accelerations between pairs of particles each in real force-free geodesic motion. Of course, there are real off-geodesic forces in ocean tides because electrical forces play a key role in addition to gravity, which is never a real force. That is, accelerometers never move off zero under purely gravitational influences, which are always locally weightless "Einstein's happiest thought." Later on, Feynman in early 1960s at Cal Tech shows that Einstein's general relativity of the nonlinear self-interacting geometrodynamical field comes from summing an infinite set of tree Feynman diagrams[cxxx] of a spin 2 quantum field on a non-dynamical flat Minkowski spacetime background. In other words, Einstein's curved spacetime gravity tensor field is emergent with c-number tetrad order parameters[cxxxi] from an unstable flat false vacuum in a non-perturbative quantum phase transition to a more stable vacuum. This is analogous to the emergence of superconductivity in the BCS theory.[cxxxii] Quantum corrections come from diagrams with closed loops and one needs ghost fields[cxxxiii] that violate the spin-statistics connection[cxxxiv] so that we have spinor bosons and vector fermions.

1915 Einstein and Hilbert independently formulate the Einstein field equation showing how local mass-energy stress current densities here curve spacetime here and there. Hilbert uses the action principle[cxxxv] perhaps the most fundamental organizing idea in all of theoretical physics.[cxxxvi]

1916: Schwarzschild solution for a spherically symmetric source in the static LNIF representation for hovering observers with real forces on them keeping them at fixed radial distance from the source. The static LNIF is also called a

"shell frame" by Wheeler and Taylor in their excellent introductory text "Exploringblack holes."

1916 and 1918 Reissner and Nordstrom add an electric charge to Schwarzschild's vacuum solution. Flamm notices the future Einstein-Rosen bridge wormhole possibility by imposing multiply connected global topology.[cxxxvii]

1924: Hermann Weyl pictures electric charges as wormholes in space with electric fluxes through them using Gauss's law part of Maxwell's equations.
1935: Einstein and Rosen wormhole for the vacuum spherically symmetric static Schwarzschild solution of Einstein's 1916 gravity tensor field equations.

1953: Something causes Wheeler to switch from nuclear physics to gravity. Was it only Einstein? Or, did flying saucers as a military threat have something to do with Wheeler's switch? Wheeler had the highest classified security clearances with deep connections to the Pentagon.

1955: John Archibald Wheeler's "geons" as elementary particles. However, this requires gravity to get very strong on the scale of a 43ermi 10^{-15} meters by about forty powers of ten. All of these attempts need David Bohm's particle as hidden variable theory[cxxxviii] because Niels Bohr's Copenhagen interpretation only has the quantum wave without any particle to go with it. Bohr has a mystical miracle called "collapse of the state" reminiscent of Marxism that in some vague way replaces the need for actual particles as material objects. Bohm, though a Marxist as a young man in Berkeley in J. Robert Oppenheimer's group in the 1930s, did not need Bohr's wave function collapse. Bohm developed his quantum theory under Einstein's urging at Princeton right before Senator Joseph McCarthy hounded him out of America in 1951. A negatively charged particle has electric flux entering the wormhole mouth. The other mouth is then positively charged. If the first mouth is a little black hole, then the second mouth is a little white hole. However the white hole is unstable and the black hole is stable. This might explain why there are more electrons than positrons. Unfortunately, the idea does not work for protons and it's not obvious how to make it work for the other leptons and quarks that have weak and strong field fluxes in addition to the electric fluxes. This 1950s period of Wheeler's geometrodynamics introduced the ideas of "mass without mass," "charge without charge," "spin without spin," and finally "law without law" that captured the imaginations of us "Hippies who saved physics" (David Kaiser, MIT). Wheeler's "mass without mass," "charge without charge," "spin without spin," plus my 1974 precognition that the quantum entanglement of the Einstein-Podolsky-Rosen correlations correspond to "mass without mass" Einstein-Rosen bridge wormholes at the tiny quantum level, does explain the origin of inertia partially in terms of gravity. However, it does not explain the actual numerical values of say the rest mass of the electron ~ 10^{-27} grams. The idea of the cosmic landscape of the multiverse at Max Tegmark's Levels 1 and 2 is that the several dozen parameters of the standard model are contingent. In other words there are other universes in which all numerical values

of the basic parameters can be found. The leptons and quarks as well as the W bosons get their inertias (rest masses) from the Higgs-Goldstone vacuum superconductor field. The much heavier hadrons get their rest masses from the confined quark-gluon zero point energies according to quantum chromodynamics local SU3 gauge theory. Our universe obeys the Weak Anthropic Principle (WAP). The parameters are just right "fine tuned" to permit us to exist. This is simply generalized Darwinian evolution and natural selection without the need for a God as an Intelligent Designer (ID). However, there are also arguments to the contrary involving the teleological Final Anthropic Principle (FAP). Actually, a conscious ID in the FAP combined with the dS/CFT world hologram conjecture and quantum computing around CTCs is not at all inconsistent with the WAP of string theory.

1957: Wheeler's "quantum foam" probably the first attempt at a quantum gravity theory where virtual Planck scale wormholes of energy 10^{19} Gev (10^{-5} grams) pop into and out of existence every 10^{-43} seconds. If gravity gets stronger at shorter distances then these numbers change to the scale of nuclear physics 1 Gev, 10^{-24} grams and ~ 10^{-23} second.

1957: Wheeler and Regge study perturbations of wormholes.

1958: David Finkelstein[cxxxix] discovers a new mathematical representation beyond static LNIFs that lets him calculate inside the event horizon of the Schwarzschild vacuum solution where static LNIFs do not exist because coordinate time and coordinate radial distance (not proper distance) interchange roles. Therefore, collapse to the r = 0 curvature singularity is unavoidable for timelike and lightlike world lines. I met Finkelstein with Lenny Susskind[cxl] at Yeshiva University in the 1960s and I took him to Esalen in January 1976 and introduced him to Werner Erhard.[cxli]

1959: Wheeler introduces "quantum gravity" to supplement the classical collapse to spacetime singularities.

1960: Wheeler becomes an advocate forblack holes (though they are not generally called that until 1967 when Wheeler coins the term and it sticks) even though Einstein, now dead, Phil Morrison and others were skeptical. I was with Morrison at Cornell in the late 1950s. John Cramer and Dieter Brill show that an electrically charged Reissner-Nordstrom wormhole has a minimal throat passageway or tunnel that oscillates in time. Martin Kruskal[cxlii] showed that a vacuum Schwarzschild wormhole pinches off too fast to be used as a stargate. I met Kruskal with Wheeler and Heisenberg at the Max Planck Institute in Munich in 1966 at a NATO Summer School in Nonlinear Physics.

1962: John Wheeler and Robert Fuller show that the Einstein-Rosen bridge wormhole pinches off so that a traveler trying to get through it on a slower-than-light timelike world line will get crushed out of classical existence.

1962: Kip Thorne begins to study gravity with Wheeler at Princeton before coming to Cal Tech where I met him with Richard Feynman in 1967. Feynman took me to Kip's house that he was just moving into.

1963: Roy Kerr gets an exact vacuum solution for a rotating wormhole.
1964: Roger Penrose[cxliii] introduces global topology methods and shows that if the energy conditions are obeyed, then singularities inside black holes are inevitable. However, decades later we now know that the energy conditions are violated, so that the singularity theorems are probably not a true description of the physics. Salpeter and Zeldovich[cxliv] predict correctly that supermassive black holes power quasars and radio galaxies. I knew Salpeter at Cornell. Colgate, May and White in US, and Russians in Soviet Union independently use nuclear weapon computer codes to confirm Zwicky's 1934 prediction that implosion of a low mass star forms a supernova with a neutron star residue and that gravity collapse of larger stars form a black hole. Herbert Friedman using a high altitude rocket with a Geiger counter finds what later proves to be the black hole in Cygnus X-1.[cxlv]

1968: Roger Penrose then with David Bohm at Birkbeck College, University of London, proves that the charged wormhole is unstable. Therefore, it's not a good prospect for a stargate. Brandon Carter discovers swirl of space around spinning Kerrblack holes and its dragging of infalling LIFs. Misner and Soviet physicists, Belinsky, Khalatnikov, and Lifshitz (BKL) independently find the chaotic anisotropic "mixmaster" singularity as a possible model for the creation of the universe.[cxlvi] Khalatnikov visited Cal Tech and Feynman asked me and Fred Alan Wolf[cxlvii] to show him Hollywood. Fred took us to the famous private club Magic Castle where he was a member and where we were mistaken for Hollywood producers.

1969: BKL describe the oscillatory Big Crunch and black hole singularities in detail up to the quantum gravity limit. Penrose shows that Carter's space swirl tornados are a gravity engine producing energy in huge amounts. Penrose proposes that there are no naked singularities not hidden by a one-way membrane horizon where $g_{00} = 0$. Lyndon-Bell correctly predicts gigantic black holes in the nuclei of galaxies surrounded by accretion disks.[cxlviii] Christodoulou, who I knew at Abdus Salam's ICTP Trieste in 1973-4, discovers black hole horizon thermodynamics. Soviet physicist Braginsky investigates quantum noise limit of gravity wave detectors.

1970: Bardeen shows that the accretion of gas makes black holes spin rapidly. Hawking identifies black hole horizon area A with thermodynamic entropy and shows that classically A must increase in accord with the second law of thermodynamics.

1973: H. G. Ellis's "drainhole," the first plausible stargate candidate where the gravity wormhole is coupled to a massless negative energy spin zero field. That year is also a year of high strangeness, but that story is not for this book.

I would rather be right than rigorous.

Stephen Hawking, cited by Kip Thorne, p. 441, Black Holes and Time Warps

Bekenstein and later Hawking realize a limited information capacity for space because too much energy in too small a volume will make a black hole. The amount of information-entropy S in a volume V surrounded by an area A cannot exceed $A/4L_P^2$, $L_P \sim hG/c^3 \sim 10^{-33}$ cm. This assumes that G does not get bigger at smaller scales. There are extra space dimension string theories where this is no longer true. If they turn out to be right, then the information capacity of the universe would be much lower than currently estimated. The idea of Lenny Susskind's that the world is a hologram image started here. The basic idea that the world is a hologram is very simple. Imagine N 2D pixels (discrete quanta of area L_P^2) on the 2D cosmological horizons past and future that surround our three dimensional space that is not only expanding, but is also accelerating increasing its expansion speed. The interior bulk 3D voxels (discrete quanta of volume ΔL) are the same in number N in 1-1 correspondence. Therefore,

$$N = A/4L_P^2 = V/\Delta L^3$$

Now $V \sim A^{3/2}$, therefore:

$$N = A/4L_P^2 \sim A^{3/2}/\Delta L^3$$

$$\tfrac{1}{4}L_P^2 \sim A^{1/2}/\Delta L^3$$

$$\Delta L^3 \sim A^{1/2}\, L_P^2$$

If we take $A^{1/2}$ to be the Hubble scale of our universe 10^{28} cm ~ 14 billion light years, then, amazingly enough the 3D voxel scale $\Delta L \sim 10^{-13}$ cm ~ 1 Gev, which is the scale of hadronic low energy nuclear physics of protons and neutrons. Is this numbo jumbo a random coincidence, or is it a clue to new physics? Associated with this, Heisenberg's uncertainty principle has a quantum gravity correction term because of small black hole formation estimated to be:

$$\Delta x \sim h/\Delta p + L_P^2 \Delta p/h$$

where ~ means "less than" for virtual particles, and means "greater than" for real particles. Our bodies are made mostly from real particles, but are our minds non-random patterns of virtual particles?

1974: Hawking shows that all black holes radiate black body radiation[cxlix] whose peak wavelength λ_{max} is roughly the square root of the area-entropy of the black hole's horizon, i.e., $\lambda_{max} \sim A^{1/2}$ where the entropy $S \sim k_B A/4L_P^2$.

Kip Thorne's book "Black Holes and Time Warps" (1994) gives the best popular explanation of Hawking's horizon evaporation radiation and the history of its discovery including the role of Zeldovich in the Soviet Union some forty years ago. Zeldovich arguing by analogy to the electrodynamics of a rotating neutral conducting sphere said that the virtual photons of the zero point vacuum fluctuations would "tickle" the metal like spontaneous emission of light triggered by virtual photons interacting with real electrons in excited atoms, the rotational energy of the sphere then converting to real photons. Hawking was with Zeldovich at Les Houches in France. Some time later Hawking, using Bekenstein's thermodynamics of horizons where the temperature is proportional to the inverse square root of the horizon's area-entropy A. That is the Hawking temperature was proportional to the *surface gravity* $T_{cold} \sim A^{-1/2}$. I realized in 2013 that this is only half the story, and that there is a second higher temperature $T_{hot} \sim (LA^{1/2})^{-1/2}$, which is the reciprocal proper quantum thickness of the horizon proportional to the quantum thickness gravity. This is the first potentially Popper-falsifiable observational test of quantum gravity, more specifically Wheeler's mental picture of quantum foam, of tiny virtual Einstein-Rosen bridges of fluctuating topology in the transient numbers of wormhole handles. For example, when L = Planck length $\sim hG/c^3 \sim 10^{-35}$ meters, we have gravity wave Hawking horizon thickness radiation, when L = Compton wavelength we have electromagnetic radiation from properly accelerating real electrons and positrons. There will also be a sharp gamma ray signal from electron-positron annihilations outside the black hole horizon. Indeed, the horizon, in the stretched membrane description, is a heat engine of high maximal efficiency $\sim 1 - (L/A^{1/2})^{1/2}$. Returning to Kip Thorne's narrative, Zeldovich was convinced the mostly gravity wave rotation radiation would stop when the black hole stopped rotating from Kerr metric to Schwarzschild metric. However, Hawking did rough calculations suggesting that even stationary black holes would evaporate mostly by gravity wave emission, although all kinds of thermal emission of every type would also occur. Kip Thorne wrote:

There are several different ways to picture black hole evaporation … However, all the ways acknowledge vacuum fluctuations as the ultimate source of the outflowing radiation … The waves fluctuate randomly and unpredictably, with positive energy momentarily here, negative energy momentarily there, and zero energy on average. The particle aspect is embodied in the concept of virtual particles, that is particles that flash into existence in pairs (two particles at a time) …

And they are quantum entangled as in the EPR effect.[cl]

Living momentarily on fluctuational energy borrowed from neighboring regions of space, and that then annihilate and disappear, giving their energy back to the neighboring regions. For electromagnetic vacuum fluctuations, the virtual particles are virtual photons; for gravitational vacuum fluctuations, they are virtual gravitons. … a virtual electron and a virtual positron are

likely to flash into existence as an [entangled] pair … the photon is its own antiparticle, so virtual photons flash in and out of existence in [entangled] pairs, and similarly for gravitons. …

The way the phenomenon appears depends on the local frame of the observer. First for the LIF non-rotating timelike geodesic observer in weightless free float:

A black hole's tidal gravity pulls an [entangled] pair of virtual photons apart, thereby feeding energy into them … The virtual photons can separate from each other easily, so long as they both remain in a region where the electromagnetic field has momentarily acquired positive energy … the region's size will always be about the same as the wavelength of the fluctuating electromagnetic field … If the wavelength happens to be about the same as the hole's circumference [~ $A^{1/2}$], then the virtual photons can easily separate from each other by a quarter of the circumference … A black hole with mass twice as large as the Sun has a circumference of about 35 kilometers, and thus the particle/waves …. All types of radiation … that it emits have wavelengths of about 9 kilometers and larger.

OK, so we see the resonance effect when the wavelength matches the square root of the proper area of the horizon. What Hawking missed, and what I noticed some forty years later, is that the same argument should apply to the proper quantum thickness of any horizon and that is the geometric mean of the long wave IR radial coordinate cutoff L with the circumference, that's where the second shorter wave resonance is ~ $(LA^{1/2})^{1/2}$. OK, using Kip's two solar mass black hole example above, the new second higher energy Hawking radiation I predict has minimum wavelength from the quantum gravity uncertainty thickness of the horizon is about $(10^{-35}\text{x } 10^{4})^{1/2}$ meters ~ 3 x10^{-16} meters ~ 3 x10^{-14} cm. However, this for a Planck scale IR coordinate cutoff, which means high frequency gravity waves. If we use, instead, the Compton wavelength of the electron for L, then $(10^{-13} \text{ x } 10^{4})^{1/2}$ meters ~ 10^{-3} meters ~ 10^{-1} cm ~ 3x10^{9} Hz.[cli]

The virtual photons … materialize, permanently, into real photons, one of which escapes from the hole while the other falls toward the hole's center … Kip Thorne

What about the evaporation time? There may be a problem with Hawking's and everyone else's current estimate ~ M^3. It seems to me that a gravity redshift factor is missing. The usual argument for Hawking's horizon surface modes is simple, basically for the observer far from the black hole, using the black body laws for total power radiated from the horizon gives $dM/dt \sim M^{-2}$, so that integrating gives evaporation lifetime $t \sim M^3$. The same argument for my new horizon thickness modes gives $dM'/dt \sim L^{-2}$, with $t' \sim L^2M$ which is very short when $L = L_P \sim 10^{-35}$ meters as Susskind, for example assumes for gravity wave Hawking radiation. However, when we replace d/dt by the gravity redshifted $(A^{1/2}/L)^{1/2}d/dt$, where A ~ M^2, we get more reasonable numbers. Thus, for my thickness modes, when L ~ m_P

$$dM'/dt \sim L^{1/2}/L^{-2}M^{1/2}$$

$$t' \sim m_P^{3/2}M^{3/2} = (m_P/M)^{3/2}M^3$$

A black hole of a few solar masses according to Hawking's calculation takes about 10^{67} years to evaporate.

$$M_P/M \sim 10^{-38}$$

$$(m_P/M)^{3/2} \sim 10^{-3x(38/2)} \sim 10^{-57}$$

Therefore, according to my new model where the high-energy horizon thickness modes dominate over Hawking's low-energy horizon surface modes t' $\sim 10^{10}$ years for smaller black holes of a few solar masses with a HFGW $\sim (10^{-33}10^{5})^{1/2}$ cm $\sim 10^{-14}$ cm $\sim 10^{24}$ Hz

In fact, the virtual LIF → real LNIF particles are at their moments of creation stuck in the horizon as tiny *hovering* static LNIF Wheeler Observer-Participators. This is the mental picture in my mind guiding my creative process. Here is what Kip Thorne says about them.

A different viewpoint on the hole's vacuum fluctuations, the viewpoint of observers who reside just above the hole's horizon and are forever at rest relative to the horizon. To prevent themselves from being swallowed up by the hole, such observers must [proper] accelerate hard, relative to falling observers [LIF zero proper acceleration on timelike geodesics] – using a rocket engine or hanging by a rope. ... these observers' viewpoint is called the "accelerated viewpoint." It is also the viewpoint of the "membrane paradigm" ... Surprisingly, from the accelerated viewpoint, the vacuum fluctuations consist not of virtual particles flashing in and out of existence, but rather as real particles with positive energies and long lives ... the real particles form a hot atmosphere around the hole ... The atmosphere's particles, in the accelerated viewpoint, appear to be emitted by a hot, membrane-like horizon. Kip Thorne

Also during this same time 1973-4 I was at Abdus Salam's Institute for Theoretical Physics in Trieste, Italy commuting to Paris and London with Fred Alan Wolf and Bob Toben. I conjectured in the pop physics book "Space-Time and Beyond" we did together mostly Kerouac stoned and drunk surrealist-style at the Café Deux Magots sur la place Saint- Germain des Prés in Paris, that Einstein-Rosen bridges and Einstein-Rosen-Podolsky[clii] quantum entanglement[cliii] were two sides of the same coin in some yet not well understood sense. This was a precognitive intuition on my part. Remember I wrote the quote below in 1974 almost 40 years ago. See David Kaiser's "How the Hippies Saved Physics" about me and my associates back then. We were way ahead of the pack.

From the 1975 book Space-Time and Beyond E.P. Dutton co-authored with Fred Alan Wolf and artist Bob Toben – First edition. P. 134 "Each part of space is connected to every other part through basic units of interconnection, called wormholes. Signals move through the constantly appearing and disappearing (virtual) wormhole connections, providing instant communication between all parts of space. These signals can be likened to pulses of nerve cells of a great cosmic brain that permeates all parts of space. This is a point of view motivated by Einstein's general theory of relativity in the form of geometrodynamics. A parallel point of view is given in the quantum theory as interpreted by Bohm. In my opinion this is no accident because I suspect that general relativity and quantum theory are simply two complementary aspects of a deeper theory that

will involve a kind of cosmic consciousness as the key concept. Bohm writes of "quantum interconnectedness":

However there has been too little emphasis on what is, in our view, the most fundamentally different new feature of all, i.e., the intimate interconnection of different systems that are not in spatial contact ... the well known experiment of Einstein, Podolsky and Rosen ... Recently interest in this question has been stimulated by the work of Bell..." D. Bohm & B. Hiley

End of excerpt from my 1975 *Space-Time and Beyond* book coauthored with Fred Alan Wolf and Bob Toben.

The Wheeler-Fuller pinch-off would then correspond to signal locality (later called "passion at a distance") corresponding to unitary linear orthodox quantum theory. Stargate traversable wormholes would correspond to what Antony Valentini would years later call "signal nonlocality" in a more general post-quantum theory that was both non-unitary and nonlinear in the sense later clarified independently by Steven Weinberg[cliv] and Henry Stapp. [clv]

MS argued that entanglement in general should be associated with wormhole formation. Individual Hawking quanta are claimed to be connected to the black hole interior via Planck-scale wormholes encoding the entanglement. When collapsing the Hawking radiation into a second black hole, all these micro wormholes combine into a single macroscopic ER bridge. At first sight, such a claim sounds preposterous. Quantum entanglement is a property of any quantum mechanical system, even when gravity is absent. Why microscopic wormholes should play a role in nongravitational systems is far from obvious.[clvi]

Only recently, Lenny Susskind and his students working on hologram universe ideas rediscovered this "ER = EPR"[clvii] connection in a more mathematically rigorous manner than my, perhaps, precognitive remote viewing intuitions over forty years ago. Back then no one else was linking EPR with ER to my knowledge. I conjecture, semiseriously given the claims of Puthoff and Targ at SRI[clviii], that since Lenny and I worked together at Cornell in 1963-4 that I was glimpsing his work of 2012 back then in 1974. John Baez in January of 2014 has written that ER = EPR is a "fake" entanglement because the quantum states corresponding to the two mouths of the wormhole are not really independent as they can be in real entanglement. Baez does say that the creation of a small wormhole corresponds to the creation of a particle-antiparticle pair in quantum field theory. I also said this in Space-Time and Beyond in 1975 and it was implicit in John Wheeler's geometrodynamics. However, since that time Enrico Rodrigo emphasized that the antiparticle "white hole" mouth is unstable, whilst the particle black hole mouth is stable. This is a nice qualitative explanation for C-violation, why there are not equal amounts of matter and anti-matter real particles in the universe. Note also that real particles are only about 5% of all the gravitating stuff in the universe. The rest in the form of attractive dark matter and repulsive dark energy is virtual particles inside the quantum vacuum in my opinion. This is why dark matter detectors never will show true signals in my opinion, although the Italians seem to claim otherwise.

Recent work has shown that the spacetime geometry of a wormhole is equivalent to what you'd get if you entangled two black holes and pulled them apart—an equivalence that can be summarized by "ER = EPR." – Michael Schirber [clix]

Cool horizons for entangled black holes

Juan Maldacena, Leonard Susskind[clx]

New Concepts for Old Black holes

Leonard Susskind
(Submitted on 13 Nov 2013) [clxi]

If spacetime is built out of quantum bits, does the shape of space depend on how the bits are entangled? The ER = EPR conjecture relates the entanglement entropy of a collection of black holes to the cross sectional area of Einstein-Rosen (ER) bridges (or wormholes connecting them.[clxii]

In this note we point out that the recently proposed bulk dual of an entangled pair of a quark and an anti-quark corresponds to the Lorentzian continuation of the tunneling instanton[clxiii] *describing Schwinger pair creation in the dual field theory. This observation supports and further explains the claim by Jensen & Karch that the bulk dual of an EPR pair is a string with a wormhole on its world sheet. We suggest that this constitutes an AdS/CFT*[clxiv] *realization of the creation of a Wheeler wormhole.*[clxv]

On the other hand, in spite of the fact that I am very fond of ER = EPR since I first discovered it in 1974, Nikolic has raised a cogent objection,[clxvi] allegedly claiming that there is no Hawking radiation because of the quantum Zeno effect.[clxvii].

Relevant to this is the profound connection between my conjecture that our physical world is an advanced back-from-the-future hologram 3D image, with the hologram as our geometrodynamical field $g_{\mu\nu}$ 2D de Sitter future event horizon $g_{00} = 0$, whose area is equal to the horizon's quantum entanglement entropy is:

Physical interactions in quantum many-body systems are typically local: Individual constituents interact mainly with their few nearest neighbors. This locality of interactions is inherited by a decay of correlation functions, but also reflected by scaling laws of a quite profound quantity: The entanglement entropy of ground states. This entropy of the reduced state of a subregion often merely grows like the boundary area of the subregion, and not like its volume, in sharp contrast with an expected extensive behavior. Such "area laws" for the entanglement entropy and related quantities have received considerable attention in recent years. They emerge in several seemingly unrelated fields, in the context of black hole physics, quantum information science, and quantum many-body physics where they have important implications on the numerical simulation of lattice models.[clxviii]

Lenny Susskind hopes to save both unitarity and the equivalence principle. He writes:

"In this paper I've made no attempt to prove that firewalls are absent in all circumstances. Indeed ER=EPR raises the possibility that an angry Alice can hit Bob with a nasty shockwave as he crosses the horizon [10]. What I have assumed is that firewalls are not inevitable— particularly so if the black hole begins with a smooth horizon—and then asked what new concepts are required to resolve the various paradoxes. In a sense I am trying to turn the firewall inevitability arguments into arguments for new physical concepts needed to reconcile unitarity and complementarity."

Lenny, along with G. 't Hooft, makes a profound mistake here in my opinion when he wrote around November 2013:

"This is a twist on two commonly held incorrect sci-fi ideas; the first being that super-luminal signals can be sent through wormholes; and the second that superluminal signals can be sent using entanglement. ER=EPR does not allow superluminal signals, but it gets very close, in the sense that there is no limit on how soon after horizon crossing Bob can receive Alice's message."

Oddly, Lenny seems to forget what he wrote in 2005[clxix] on this same problem:

"In [1], an argument was leveled against the possibility of traversable worm holes, that would allow travel to distant regions, in superluminal times. The argument, which reveals the authors deeply held prejudices against this interesting subject, [2, 3, 4] is incorrect."

Yes, what he says in November 2013 is true for orthodox quantum theory, but not for its extension (e.g. Antony Valentini's) that corresponds to traversable wormholes held open with either exotic matter, or couplings to a scalar field as described in current literature cited by Enrico Rodrigo in his Stargate book. Therefore, I prefer to keep the equivalence principle and junk unitarity because then we have entanglement signal nonlocality – that's a game changer – Brave New World, Men like Gods and we then understand the physical mechanism for consciousness leading to naturally conscious artificial intelligent androids.

"For years it was thought that the Schwarzschild spacetime did in fact exhibit some sort of radial singularity at r = 2GM/c2. Eventually physicists came to realize that it was not Schwarzschild spacetime that was behaving badly. It was his choice of coordinate system. ... the true singularity at r = 0." P. 126, Enrico Rodrigo, "The Physics of Stargates" (Eridanus Press, New York, 2010).

This is true, yet it also does not address an important question. While it is true that a freely falling observer Alice can pass through the event horizon of a large non-rotating black hole without feeling lethal tidal stretch-squeeze Weyl curvature tensor forces, nevertheless the universe will start to look weird to her. More importantly, if Bob is in a spaceship hovering at a fixed distance outside the event horizon with rockets firing radially inward, he will quickly find that there is a minimum distance he can get to without being sucked into the black hole. Indeed, if Bob does not want to exceed a 1g weight that minimum distance is even larger. This is because, the real proper acceleration of hovering, also called the "static LNIF", that Kip Thorne in his "black hole membrane paradigm" calls "the accelerated viewpoint," shoots up to a classical infinity at the event horizon

because of the square root of the time-time component g_{00} that approaches zero at the event horizon in the denominator of the relevant equation in Einstein's General Relativity. One over zero is infinity. Of course quantum gravity will prevent an actual infinity, but practically speaking that does not change the basic situation. Not only that, but Bob will see a very hot thermal blackbody bath of real photons proportional to his actual tensor proper acceleration that will burn him to a cinder. This will be very peculiar and tragic to Alice who passes close by him in her radial free fall into the black hole. Alice will not feel the heat unless she catches fire etc. from Bob's burning ship that explodes and flings debris hitting her. This is related to recent speculations by Leonard Susskind et-al on black hole firewalls.

There is a creative tension conflict between Gerard 't Hooft's pontifical proclamation that the S-Matrix must be unitary even in cosmology and Einstein's equivalence principle that nothing happens to a freely falling observer passing through a horizon $g_{00} = 0$ whether that of a black hole whose horizon is observer independent, or whether through our future dark energy de Sitter cosmological horizon, which is observer-dependent. Roughly, unitarity of the S-Matrix of the universe says that there is nothing new under the Sun that quantum information cannot be created or destroyed. This seems to fly in the face of human creativity. Does it really?[clxx]

If information is the flip side of entropy, then 't Hooft and Susskind must claim that the total entropy of the multi-verse is a constant and, therefore, it can't increase as the Second Law of Thermodynamics says it must. Furthermore, our observable universe restricted to retarded past to present history information flows only is not a closed system, but is an open system and there is no reason to think that entropy is a conserved quantity. Finally, entropy is too crude a measure for the increase of complexity of our thoughts and material civilization. In the final analysis, the basic premise of 't Hooft and Susskind that the unitarity of the S-Matrix is adequate at higher levels of organization of matter fields is very implausible.

Curiously, Susskind and I worked together at Cornell in 1963 with Johnny Glogower on the problem of phase and time operators in quantum theory.[clxxi] On Dec 31, 2004, at 1:20 PM Pacific Time, Leonard Susskind wrote:

"The Glogower Susskind paper of 1963, which introduced phase operators for a quantum oscillator was in direct response to discussions between Glogower, Susskind and Jack Sarfatti. The correct attribution should be to the "Glogower, Sarfatti, Susskind" operators."

1975: *"Bardeen and Peterson showed that the swirl of space around a spinning black hole could act like a gyroscope to maintain the direction of jets. ... Unruh and Davies inferred that, as seen by (static LNIF properly) accelerating observers just above a black hole horizon, the hole is surrounded by a hot atmosphere of particles, whose gradual escape accounts for the hole's evaporation. ... Hawking and Page proved from cosmic gamma ray data that there couldn't be more that 300 tiny, evaporating black holes in each cubic light year of space.* "(KT p. 544)

1977: Hawking and Gibbons in "Cosmological event horizons, thermodynamics, and particle creation" (Phys Rev D, 15) show that observer-dependent cosmological horizons have essentially the same quantum thermodynamics as observer-independent area-entropy black hole horizons. Znajek and Damour formulate the membrane description of a black hole horizon. (ER)

The key concept in the original black hole formalism was a hole's event horizon, viewed as a globally defined null surface in four-dimensional spacetime. By contrast, the membrane paradigm regards the event horizon as a two-dimensional membrane that resides in three-dimensional space. … The horizon is regarded as made from a two-dimensional viscous fluid that is electrically charged, electrically conducting and has a finite entropy and temperature, but that cannot conduct heat; and the interaction of the horizon with the external universe is described in terms of familiar laws for the horizon's fluid, e.g., the Navier Stokes equation, Ohm's law, a tidal force equation, and the first and second laws of thermodynamics. … The membrane paradigm … is the result of collaboration, mainly at Cal Tech. Kip Thorne

We are outside black holes horizons, both the observer dependent apparent horizon, and the observer-independent, but back-from-the-future destiny absolute horizon. However, in contrast, we are inside our future de Sitter dark energy horizon, which should also have this membrane description for us.
1985: Carl Sagan asks Kip Thorne if stargates are possible. We inaccurately described "Hippies Who Saved Physics" (David Kaiser, MIT) played a key role in that story described in the following excerpt by Saul-Paul Sirag from my 2002 biographical book *Destiny Matrix*. It was our (me and Sirag) discussions with the Coppolas that got them interested in doing a stargate TV project. There was some kind of falling out between them and Sagan.

The Godfather made an offer Carl Sagan refused (Saul-Paul Sirag)

It is well known that the movie version of Contact was based on the novel Contact by Carl Sagan published in 1985. Not so well known is the fact that the original version of contact was supposed to be a mini TV series produced and directed by Francis Ford Coppola. The protagonist of the movie and the book is the astronomer Ellie Arroway in the book she is described as driving a red sports car with the bumper sticker "Black holes are out of sight." Now the first time that Jack Sarfatti and I saw that bumper sticker was on Ellie Coppola's red sports car so for us Ellie Arroway was a character who was a mixture of Ellie Coppola and Jill Tarter (an astronomer who had devoted a career to the SETI [search for extra terrestrial intelligence] project). Jack met Ellie Coppola in 1975 at the April C EST training by Werner Erhard. Ellie was carrying a copy of the book Space-Time and Beyond, by Bob Toben, Jack Sarfatti and Fred Alan Wolf, which had just been published by Dutton. So Jack got to know Ellie and Francis and began introducing them to his friends and contacts in San Francisco (and vice versa). In this way the Coppolas met Uri Geller (whose Spectra contact story intertwines this story) and Jacques Vallee, who became a consultant to Francis's friend Steven Spielberg on the movie Close Encounters of the Third Kind; and in this movie Vallee was the

prototype for the character played by François Truffaut. This meeting between Coppola and Vallee was in 1976 the year that I was hired by the Coppola's to tutor his son Gio in mathematics and physics. As basic reading material I use the book Intelligent Life in the Universe by Carl Sagan and I.S. Shlovskii. This was Carl's first book (published in 1966) and he was sympathetic to the idea of possible ET contact the period of the early civilizations in Mesopotamia (3500 BC). During that year (1976) I kept a notebook of ideas called Time Travelers Notebook, and later got a series of (ever more insistent) requests from a Russian in Novosibirsk for novel on time travel I was supposed to have written (I haven't written it yet but maybe I will!)

In 1985, when Sagan was writing Contact, he wanted to have the most accurate description of the idea of passage through black holes to other places and times in the universe. So he contacted his friend Kip Thorne, the Caltech physicist (a former graduate student of John Wheeler and coauthor with Wheeler and Charles Misner of the seminal textbook Gravitation. Kip told Carl[clxxii] *that black holes were not the way to go but that wormholes might be feasible, provided they could be kept open with exotic matter. He put a couple of graduate students (M. Morris and U. Yurtsever) on the project, with the result that new ideas about time machines were published creating a flurry of interest in the whole issue of time machines. … Less well-known than the Kip and Carl story is the fact that in 1977 when Michael Murphy the cofounder of Esalen Institute was writing his novel Jacob Atabet and I was tutoring Mike in physics and told about Einstein Rosen bridges (another name for non-traversable wormholes) with event horizons.*

I had learned about Einstein Rosen bridges from the book Gravitation 1973 by Charles Misner, Kip Thorne and John Archibald Wheeler. The picture of such a bridge is on page 837 and is taken from the 1962 paper by Wheeler and his graduate student Robert (Bob) Fuller "Causality and multiply-connected space-time," Physical Review 128, 919 – 929. By1975 Bob Fuller had become a close adviser to Werner Erhard. He organized physics conferences in San Francisco, was director of the est Foundation and was later put in charge of Erhard's Hunger Project. Fuller resigned from that project when Erhard spent a large amount of money supporting himself as a race-car driver. Jack, Fred and I met Bob Fuller at various meetings, parties and dinners, when we became, for a short time, science advisers to Erhard, teaching physics to his est trainers.

This Einstein Rosen bridge idea got into Michael Murphy's Jacob Atabet novel, which was set in an apartment in North Beach formerly occupied by Mike, who had handed it on to Jack Sarfatti. To some extent Jacob Atabet is an artist modeled on Jack, so in a strange way as Ellie Coppola is to Elli Arroway as Jack Sarfatti is to Jacob Atabet while I am to Mike Murphy as Kip Thorne was to Carl Sagan.

Excerpted from a longer Chapter by Saul-Paul Sirag in Destiny Matrix.

1987-8: Kip Thorne's paper with Michael Morris "Wormholes in spacetime and their use for interstellar travel …" this is the breakthrough paper – the turning point. Also at this time Stephen Hawking publishes "Wormholes in Spacetime" using imaginary time that analytically continues to our real physical time in an attempt to understand the joining and splitting off of "baby universes." Sydney Coleman et-al tried to use Hawking's idea to show that the cosmological constant must be zero. This a decade before dark energy accelerating the universe showed that the cosmological constant is probably positive though small. If it were too large, our life form could not exist. Indeed, Steven Weinberg showed that also in this time period.

1988: Kip Thorne realizes that stargates can be used to time travel into the past, but not before the traversable wormhole is created. Igor Novikov in Moscow soon suggests with great plausibility that no time travel paradoxes need occur because traveling to the past on closed timelike curves (CTC's) are consistent Feynman quantum histories. The quantum probability amplitudes for inconsistent paradoxical histories around CTCs vanish. David Deutsch in his work on quantum computers also shows how such time travel to the past can be used to solve impossibly hard problems for classical computers in a consistent way using the multiple timelines of parallel universes. Both Novikov's and Deutsch's work fit the brain presponse data that Roger Penrose begins to write about based on experiments by Ben Libet.[clxxiii] Soon experiments by Dean Radin, Dick Bierman[clxxiv] and recently Daryl Bem[clxxv] confirm that our natural consciousness has an advanced destiny back-from-the-future dimension to it.[clxxvi] The connection to the Puthoff-Targ remote viewing experiments at Stanford Research Institute funded by the Central Intelligence Agency from the mid 1970's well into the 1980's is obvious to us Hippies who saved and we hope are still saving physics in spite of much sabotage by the professional "skeptics." Yakir Aharonov[clxxvii] also around this time introduces the back-from-the-future advanced destiny quantum wave as well as the ordinary retarded history wave.[clxxviii] The idea was in the air coming from the original work of Wheeler and Feynman developed by Hoyle and Narlikar as well as by John Cramer in his "transactional interpretation." Fred Alan Wolf and I were into all of these ideas as early as the late 1960s when we had offices next door to each other as professors in the physics department of San Diego State. Indeed, Fred published a book "Starwave" (1983) about back from the future influences in ordinary consciousness.

1989: Matt Visser develops traversable wormhole mathematics with portals that need not be closed spherical shells so that travellers need not pass through negative energy exotic matter that would be likely to kill them. Visser also showed that tidal forces need not be a danger. Steven Weinberg[clxxix] used the Anthropic Cosmological Principle[clxxx] to correctly predict the actual value of the dark energy observed ten years in his future.[clxxxi]

1991: David Deutsch (Oxford University) Quantum mechanics near closed time-like lines Phys. Rev. D 44 10 3197-217 (1991)

1992: Thomas Roman showed that old large stargates can form from cosmologically inflated quantum wormholes at the beginning of our universe. Therefore, in principle we can travel back to the hot Big Bang and even before although that would be unsafe. We could use nano-probe drones perhaps. Hawking does toy model calculations suggesting chronology protection that time travel to the past cannot happen because of an infinite CTC blueshift burn up when the stargate converts to a time travel to the past machine. György Paál predicted dark energy with $\Omega_\Lambda \sim 2/3$ years before it was observed. So did Steven Weinberg even before Paál.[clxxxii]

1994: Miguel Alcubierre's breakthrough paper on zero g-force warp drive bubble metric without time dilation. Although it's not possible to control the drive because light signals cannot get through the front of the bubble, the prospect of post-quantum entanglement signal nonlocality suggested by me back in the 1970's. Similar ideas were independently developed by Brian Josephson and later by Antony Valentini who coined the term "signal nonlocality, " which is one possible solution to that seeming obstacle.

1995: Visser publishes his book "Lorentzian Wormholes – From Einstein to Hawking." Also Cramer, Visser, Forward and Morris suggest a way to look for cosmic stargates using gravity lensing. Poisson and Visser design "thin shell" stargate models.

1996: Lawrence Ford and Thomas Roman's negative energy quantum inequalities in addition to older energy conditions invoked by Penrose and Hawking in their earlier work on black hole curvature singularities, as well as Hawking's chronology protection *conjecture*, suggest serious obstacles to building practical stargates for interstellar time travel to our past and our future, our elsewhere and beyond to parallel universes next door. However:

1997 Dan Vollick showed that:
"Normal (non-exotic) matter interacting via a normal scalar field can have negative interaction energy … to hold open a wormhole. Because this interaction energy was classical, rather than of quantum origin, the Ford-Roman constraints did not apply."
P. 42 Rodrigo

1998: Hochberg and Visser showed that the Null Energy Condition (NEC) must be violated near the throat of the stargate wormhole. Type 1a supernova luminosities and redshifts show exotic matter dark energy. Although the energy density is positive, the pressure is negative and three times stronger, hence the dark energy is exotic because what counts in Einstein's general relativity is the trace of the stress energy tensor $\sim \rho (1 + 3w)$ $w \sim -1$, which is negative.

1999: Sergei Krasnikov "showed how the Ford-Roman constraints could be met in a wormhole with quantum-based exotic matter…. Carlos Barcelo and Matt Visser were pointing out that every known energy condition had classical violations. This meant that precious theorems of general relativity whose proofs relied on these conditions – including the (Penrose-Hawking) singularity, positive mass, and topological censorship theorems do not apply. It also meant that wormhole-supporting exotic matter immune to the constraints of Ford and Roman could in principle exist." (Rodrigo, p. 43).

1999: Peter Kuhfittig showed that the exotic matter shell of a stargate could be as thin as we can make it. Sean Hayward conjectures that black holes with horizons and stargate portals without horizons can be converted into each other at least mathematically if not in reality by an advanced future time traveling super-intelligence.

2000: Sergei Krasnikov allegedly shows how we can maintain a stargate portal using random vacuum zero point stress-energy fluctuations of massless spin 0, spin ½ and spin 1 boson fields.

2002: Bronnikov & Grinyok and independently Shinkai, Hayward and Aremdariz-Picon argue that stargate portals are too unstable to exist.

2003: Visser & Co. argue that stargates can be supported by an amazingly small amount of exotic matter suggesting a contradiction to the "Jupiter mass" barrier mentioned by James W. Woodward in his Starship book. However, precisely how much exotic matter is needed is still not settled. My proposal to make c small with superconducting thin shells (explained later in this book) in the star gate portals and along the tunnel through the throat would be a game changer. Quite apart from that, Woodward's Mach Effect Thruster (MET), an actual machine in his lab to his credit, is in my opinion based on a wrong obsolete Machian theory by Dennis Sciama from 1953. Therefore, I predict that Woodward's and Fern's marginal data, like that for the CERN OPERA faster-than-light neutrino, will remain marginal and be shown to be a systematic error. They are also measuring off-geodesic thrusts like a rocket, so that what they have, if anything, is not a zero g-force weightless warp drive without time dilation. Woodward claims to have another warp term in his equations that I basically find un-intelligible. Of course, I hope I am wrong about this. M. Kanionkowski and N. Weinberg (not the Nobel laureate Steven) introduce the "Big Rip" of phantom energy with $w < -1$ that would destroy our future universe.

2004: K. Nandi et-al formulates a local frame invariant measure of exotic matter needed to violate the ANEC to support stargate portals. H. Koyama & S. Hayward showed how to convert a black hole into a stargate using a pulse "exotic radiation." Is this like my back-from-the-future de Sitter horizon destiny Hawking dark energy blackbody radiation obeying the anti-Feynman propagator boundary condition of positive energy backward in time equivalent to negative energy forward in time? P. Gonzalez-Diaz's "Big Trip" in which our entire future universe is swallowed and travels through a huge stargate into what exactly? This requires a multiverse of parallel universes that we can travel between.

2005: S. Shuskov and F. Lobo independently show that phantom energy with w < - 1 can support static stargates. Remember random quantum vacuum zero point fluctuations of all matter fields universally have w = - 1 because of Einstein's equivalence principle that special relativity always works as a good approximation on a scale small compared to the local radii of spacetime curvature.

2007: E. Gravanis & S. Willison showed that stargates, in an alternative theory of gravity (Einstein-Gauss-Bonnet), do not need negative energy (actually $T^{\mu}_{\mu} < 0$, explained below).

2009: Several groups begin to explore stargate quantum gravity thermodynamics related to hologram models of our universe as a cosmic computer simulation on our future event and past particle horizons. This idea is still at the cutting edge of physics in 2014. Can we as part of the simulated Destiny Matrix virtual reality reach out in a Godelian strange loop to influence the simulation the way Q does in the sci-fi epic Star Trek?

2012: Black Hole Horizon Firewall Paradox

Paradoxes in physics have a way of clarifying key issues. At the heart of this particular puzzle lies a conflict between three fundamental postulates beloved by many physicists. The first, based on the equivalence principle of general relativity, leads to the No Drama scenario: Because Alice is in free fall as she crosses the horizon, and there is no difference between free fall and inertial motion, she shouldn't feel extreme effects of gravity. The second postulate is unitarity, the assumption, in keeping with a fundamental tenet of quantum mechanics, that information that falls into a black hole is not irretrievably lost. Lastly, there is what might be best described as "normality," namely, that physics works as expected far away from a black hole even if it breaks down at some point within the black hole — either at the singularity or at the event horizon.[clxxxiii]

My opinion is to sacrifice unitarity and to keep the equivalence principle. We get entanglement signal nonlocality in that case in violation of orthodox quantum theory conjectures to the contrary. We need entanglement signal nonlocality to explain our own consciousness as well as to control warp drive and many other applications some of which are in the 2002 Antony Valentini paper I have cited.
2013: I predict a second higher temperature Hawking radiation with peak wavelength ~ $(LA^{1/2})^{1/2}$ where L is the coordinate long wave cutoff. This is actually the proper quantum thickness of the 2D horizon. When L is the Planck length the Hawking radiation is gravity waves from virtual quantum gravity foam black holes of mass ~ 10^{-5} grams stuck on the horizon. When L ~ Compton wavelength of the electron the Hawking radiation is photons from virtual electron-positron pairs stuck on the horizon.
Also discovery of the Amplituhedron:

Scattering amplitudes in gauge theories are amongst the most fundamental observables in physics. The textbook approach to computing these amplitudes in perturbation theory, using Feynman diagrams, makes locality and unitarity as manifest as possible, at the expense of introducing large amounts of gauge redundancy into our description of the physics, leading to an explosion of

apparent complexity for the computation of amplitudes for all but the very simplest processes. Over the last quarter-century it has become clear that this complexity is a defect of the Feynman diagram approach to this physics, and is not present in the final amplitudesthemselves, which are astonishingly simpler than indicated from the diagrammatic expansion.[clxxxiv]

The connection between the amplituhedron and scattering amplitudes is a conjecture, which has passed a large number of non-trivial checks, including an understanding of how locality and unitarity arise as consequences of positivity.

Locality and unitarity are encoded in the positive geometry of the amplituhedron in a beautiful way. As is well known, locality and unitarity are directly reflected in the singularity structure of the integrand for scattering amplitudes.

The more general theory with Antony Valentini's entanglement signal nonlocality extends to non-positivity like Euclidean to Lorentzian signature using complex variable analytic continuation, e.g., the imaginary time trick used by Hawking. The result is a *teleological* nonlocal non-unitary S-Matrix theory of the world in which information is not conserved but is created in globally self-consistent closed timelike Novikov loops.

There is a powerful clue to the coming quantum mechanics hidden in the structure of classical mechanics itself. While Newton's laws are manifestly deterministic, there is a completely different formulation of classical mechanics {in terms of the principle of least action}, which is not manifestly deterministic. The existence of these very different starting points leading to the same physics was somewhat mysterious to classical physicists, but today we know why the least action formulation exists: the world is quantum-mechanical and not deterministic, and for this reason, the classical limit of quantum mechanics can't immediately land on Newton's laws, but must match to some formulation of classical physics where determinism is not a central but derived notion. The least action principle formulation is thus much closer to quantum mechanics than Newton's laws, and gives a better jumping off point for making the transition to quantum mechanics as a natural deformation, via the path integral. We may be in a similar situation today. If there is a more fundamental description of physics where space-time and perhaps even the usual formulation of quantum mechanics don't appear, then even in the limit where non-perturbative gravitational effects can be neglected and the physics reduces to perfectly local and unitary quantum field theory, this description is unlikely to directly reproduce the usual formulation of field theory, but must rather match on to some new formulation of the physics where locality and unitarity are derived notions. Finding such reformulations of standard physics might then better prepare us for the transition to the deeper underlying theory.
Nima Arkani-Hamed and Jaroslav Trnka

2014: BICEP2 Measurements of polarization of Cosmic Microwave Background (CMB) from surface of last scattering 380,000 years after the quantum vacuum inflaton field phase transition causing the hot Big Bang suggest primordial gravitational radiation that can test different models of inflation. The data still has to be replicated.

The Physical Meaning of Einstein's General Theory of Relativity of the Gravitational Field

"I was dissatisfied with the special theory of relativity, since the theory was restricted to frames of reference moving with constant velocity relative to each other and could not be applied to the general motion of a reference frame. I struggled to remove this restriction and wanted to formulate the problem in the general case." Albert Einstein[clxxxv]

"Nowhere has a precise definition of the term 'gravitational field' been given --- nor will one be given. Many different mathematical entities are associated with gravitation; the metric, the Riemann curvature tensor, the curvature scalar ... Each of these plays an important role in gravitation theory, and none is so much more central than the others that it deserves the name 'gravitational field.'"[clxxxvi] *Wheeler and Ciufollini*

"We shall not in any absolute way be able to say that one effect is gravitational and one is inertial so it will not be possible to define a true gravity since we cannot ever define precisely how much of an observed force is given by gravity and how much is due to an acceleration." Feynman[clxxxvii]

The related key term "inertia" is also, like "gravitational field" used in different meanings:

As in Newton's first law: inertia as preferred zero g-force timelike geodesics for the universal motion of test particles independent of their rest masses m =/= 0 provided that dm/dt = 0. Newton's first law of particle mechanics becomes the geodesic equation in the mathematical formulation of Einstein's theory of gravity.

As in Newton's second law: inertia as rest mass m

$$m = F/a =/= 0$$

In limits v/c << 1 and dm/dt = 0

As in Newton's third law: Total linear **3-vector** momenta for bipartite pairs systems 1 and 2, i.e., $\mathbf{P_1} + \mathbf{P_2}$ is conserved in a closed system with translational symmetry as described generally for all continuous symmetries in Noether's theorem.[clxxxviii]

$$d\mathbf{P_{12}}/dt + d\mathbf{P_{21}}/dt = 0$$

$\mathbf{dP_{12}}/dt$ force 1 exerts on 2

$\mathbf{dP_{21}}/dt$ force 2 exerts on 1

There are non-trivial issues when retardation is included, that is, it takes time for forces to be transmitted! Wheeler-Feynman back-from-the-future advanced effects may need to be included. There is very little known about this loophole except in the case of classical

electromagnetic radiation reaction, which is also connected to quantum spontaneous emission and random virtual photons in quantum vacuum fluctuations.
4) As in fictitious forces (aka inertial forces) as contingent artifacts of LNIF proper accelerations[clxxxix]: Real forces are what accelerometers measure (off-timelike geodesic motion). Fictitious forces will not make an accelerometer pointer move off zero on the test particle, but will do so on the Doppler radar[cxc] measuring the motion of the test particle. Technically in Einstein's 1916 GR terms in the Levi-Civita connection are fictitious forces that are proportional to m, i.e. universal motions independent of m provided it is constant not ejecting mass like in a jet or rocket. The physical meaning of Einstein's relativity, both special (1905) and general (1916) is quite simple in contrast to the mathematics, which quickly gets very difficult. Except for the books by John Archibald Wheeler and his students like Kip Thorne, most books on the general theory get too mathematical leaving the physical meaning obscure. In the following quote, it is clear that Einstein is using Newton's meaning of "gravitational field strength," which is eliminated at the center of mass origin of a local inertial frame (LIF). Of course, the curvature is not eliminated, though its effects are ignorable in a small enough classical spacetime region in which random quantum gravity zero point vacuum fluctuations in the curvature are too small to detect.

"Heuristically, the interpretation of the field existing relative to a system, parallelly accelerated [parallel beschleunigten] against an inertial system (equivalence principle) was naturally of decisive importance, since this field is equivalent to a Newtonian gravitational field with parallel lines of force. In this case, the Newtonian field strengths are equal to the spatial derivatives of the g_{00}. Correspondingly, if one wants to, one can designate the first derivatives of the g_{uv} or the displacement quantities Γ [affine connection] as gravitational field strengths..." - A. Einstein, letter to von Laue (1951)[cxci]

"The Question is: What is The Question?" John Archibald Wheeler
The question that Einstein's relativity is the answer to is this: Alice and Bob have measuring instruments and they decide as voyeurs to watch Eve's dance. How do they compare their data? Relativity is an algorithm, a set of rules, which takes the raw measurement data input and processes it to give a set of "invariant" output real numbers. If Alice and Bob get the same set of invariants, then they can be quite confident, in the sense of Bayesean probability estimates[cxcii], that they measured the same set of events and that their measurements were good within the accuracy and precision limits of the technology of their instruments. This is basically classical because Heisenberg's quantum uncertainty principle will provide a barrier when Alice and Bob attempt to measure the same individual quantum events.

Einstein's 1905 special theory of relativity at first only considered inertial frames of reference. What is a frame of reference? Basically it is a local set of detectors. What kind of detector? It's necessary that an accelerometer, like the scales we weigh ourselves with, be included along with other devices like telescopes, Doppler radars etc. The test for an inertial frame is simple, the pointer of the accelerometer reads zero. Every object in the inertial frame is weightless in free-float like the astronauts in the International Space Station shown in the movie "Gravity." In this case of free-float zero g-force, we say that the center of mass of the local inertial frame (LIF)[cxciii] moves on a timelike geodesic world line in Einstein's four-dimensional spacetime continuum. Therefore, we here on

Earth are not in inertial frames. We are in non-inertial frames. Unfortunately, Newton defined the word "inertial frame" differently from Einstein and this continues to lead to much confusion when physicists attempt to communicate with each other because Newton's theory is in closer accord with our common sense. Einstein's relativity is counter-intuitive. In Newton's theory, points on the surface of Earth are approximate inertial frames if we ignore its rotation about the poles. However, in Einstein's theory, any point on Earth, approximated as an ideal non-rotating spherical surface has a real local objective tensor proper acceleration pointing radially outward from the center of the sphere. Of course, we are not moving relative to the center of the idealized spherical Earth yet we are accelerating and this is counter-intuitive violating common sense. It only makes sense in the curved space non-Euclidean differential geometries of Karl Friedrich Gauss and Bernard Riemann. Proper dynamical acceleration is what accelerometers measure. There is also the apparent kinematical acceleration that Doppler radars measure. Therefore, these two quantities can be measured independently by different kinds of detectors. Ideally in principle there must be accelerometers on both the test particle and the detector. In addition, the detector is equipped with Doppler radar to measure both the kinematic velocity and kinematic acceleration of the test particle relative to the detector. The general rule is:

Proper dynamical local acceleration of a test particle = Kinematical nonlocal acceleration of a test particle – Proper local dynamical acceleration of the detector.

In mathematical language the above word equation is:

$$DU/d\tau = dU/dt - \Gamma_{LNIF}\, UU$$

U is the special relativity version of the test particle's velocity relative to the detector. With the additional rule:

$$\begin{gathered}\text{Proper dynamical acceleration of the detector} \\ = \text{Fictitious pseudo-acceleration on the test particle} \\ = \text{Levi-Civita connection terms} \\ = \text{Real force on detector per detector mass} \\ = \Gamma_{LNIF}\, UU\end{gathered}$$

The above equation only works when the physical separation between the observed test particle and the observer's detector is small compared to the distance over which the radii of curvature of spacetime is noticeable to our gravity gradiometers that directly measure. Roughly speaking:

$$\text{Curvatures} \sim (\text{Radii of Curvature})^{-1}$$

When we switch off the real non-gravity force on the detector, then

$$\Gamma_{LNIF} \rightarrow \Gamma_{LIF} = 0$$

This is called the Einstein Equivalence Principle. It means that Newton's fictitious force of gravity as well as other fictitious forces like the centrifugal and the Coriolis vanish in the Local Inertial Frame (LIF). This is not a mystery, although many people who should know better, are completely muddled on this point and that is why I keep harping on it in this book. All fictitious forces on the observed object are real forces on the LNIF observer.

Let us consider all four physically interesting possibilities.

1) Accelerometer on test particle shows zero, accelerometer on detector shows zero. This is then a geodesic test particle whose motion is measured by an on-geodesic LIF detector. Of course, these are two different geodesics in general.
2) Accelerometer on test particle shows zero, accelerometer on detector shows not zero. This is then a geodesic test particle whose motion is measured by an off-geodesic LNIF detector. The LNIF observer looking at his Doppler radar tracks mistakenly thinks that there is some kind of universal force on the test particle proportional to its mass causing it to move in a curve at different speeds along it. Indeed, Newton called this "gravitational force" when he looked at the parabolic orbits of apples falling off trees and cannon balls, especially the latter to see a good parabola. Similarly for the elliptical orbits of the planets about the Sun. The Coriolis and centrifugal motions are essentially the same as Newton's gravity force field because they too are universal proportional to the mass of the test particle. Newton could not have conceived that his apple was on a timelike geodesic straightest possible world line in Einstein's future idea of the curved four-dimensional spacetime continuum. Newton could not have conceived that it was him who was really accelerating to the apple, which was not really accelerating at all! Indeed, many engineers and ordinary people – and even some physicists still cannot properly and consistently conceive of it so stuck are they in the persistent illusions of common sense.[cxciv]

Both 1) and 2) correspond to Newton's first timelike geodesic law of test particle motion: Proper dynamical local acceleration of a test particle = Kinematical nonlocal acceleration of a test particle – Proper local dynamical acceleration of the detector = 0

We are only interested in the center of mass of the test particle and ignore rotations about some axis through its center of mass.

3) Accelerometer on test particle shows not zero, accelerometer on detector shows zero. This is then an off-geodesic test particle whose motion is measured by an on-geodesic LIF detector.
4) Accelerometer on test particle shows not zero, accelerometer on detector shows not zero. This is then an off-geodesic test particle whose motion is measured by an off-geodesic LNIF detector.

Both 3) and 4) correspond to Newton's second off-geodesic law of test particle motion whose equation in words is

> Proper dynamical local acceleration of a test particle = Kinematical nonlocal acceleration of a test particle – Proper local dynamical acceleration of the detector = Real local force on test particle per mass of test particle.

In mathematical language, the above word equation is[cxcv]:

$$D\mathbf{U}/d\tau = d\mathbf{U}/d\tau - \Gamma_{LNIF}\mathbf{U}\mathbf{U} = \mathbf{F}/m$$

The relative kinematical acceleration first term on the RHS $d\mathbf{U}/d\tau$ is given by Einstein's 1905 special relativity's complicated formula.[cxcvi]
The proper tensor acceleration of any object is described by the "covariant derivative of the velocity tensor of the object with respect to proper time along the world line of the object in four-dimensional spacetime. Therefore, we have three independent pieces of technology:

1) Accelerometers make local proper acceleration measurements of the Levi-Civita connection when they are clamped to the LNIF not to the test particle. Newton's gravity field is one of the possible accelerometer measurement outputs only in the special contingent case of the hovering static LNIF.
2) Gravity gradiometers measure the Einstein curvature quasilocally and directly.
3) Doppler radars measure the relative kinematic acceleration between test particle and detector.

Einstein's equation above intuitively means:
Alice's accelerometer reading on the test particle = Doppler radar reading on the Bob's LNIF detector - Bob's accelerometer reading on the LNIF detector.
As noted earlier, Einstein's equation below is an approximation that gets better as the eparation between test particle and detector/radius of curvature << 1. In math symbols we take the limit of this ratio to zero.

$$LA^{-1/2} \rightarrow 0$$

L is the separation between test particle and detector as measured by Doppler radar tracking technology. 1/A is the curvature order of magnitude as measured by gravity gradiometers, which are getting more accurate and smaller rapidly as technology advances.
Einstein's 1905 special relativity showed that if Alice and Bob were each on different zero g-force timelike geodesics, then they would measure the same invariant speed of light $c \sim 3 \times 10^8$ meters per second in vacuum. However, Alice looking at Bob's clock would see it running slow (time dilation) and vice versa. A moving meter stick shrinks along its direction of motion relative to the observer for simultaneous measurements of the edges of the meter stick by the observer. However, a more careful analysis of light rays coming from a fast moving object by Richard Terrell[cxcvii] in the 1950s, and later by Sir Roger Penrose, revealed that the object looks rotated rather than contracted. We all know about $E = mc^2$ and I will not dwell on the details of special relativity here. What is not well known however, even by physicists is that one can use special relativity to deal with properly accelerating frames of reference. However, to do so, one must use the full tensor language of Einstein's 1916 general relativity. The only difference is that the curvature tensor computed from the "covariant curl" of the Levi-Civita connection with itself vanishes everywhere-when. Special relativity still works for artificial Newtonian gravity fields without curvature that appear in a rotating space station for example where the normally fictitious centrifugal pseudo force balances a real quantum electrical force in a rigid constraint connecting the test object to its detector. Alice and Bob working

together do the actual measurement of the local spacetime curvature tensor field. It's important that they are both on timelike geodesics and what they measure is their relative kinetic acceleration from each other (aka "geodesic deviation") in different spatial orientations to get all ten components of the Weyl tensor [cxcviii] in space. The Weyl tensor causes stretch-squeeze elliptical distortions in a set of geodesic test particles initially configured in a circle. There are also ten other components of the Ricci tensor coincident with mass-energy sources, but that is harder for Alice and Bob to directly measure. The Ricci tensor causes the radius of the circle of geodesic test particles to contract for positive mass-energy sources and to expand for the negative mass-energy exotic sources needed for warp-wormhole advanced super-technology. The full Riemann curvature tensor in four-dimensional spacetime is the sum of the Weyl vacuum and the Ricci matter tensors. Curvature introduces a severe restriction on measurements not found in Minkowski spacetime empty of real gravity fields. When the curvature is not zero Alice and Bob, both watching Eve's activities, must be "physically coincident" in order to compare their data by calculating invariants. This means that the actual physical separations between Alice and Bob must be less than the smallest radius of curvature in the components of the Riemann curvature tensor. Eve, however, can be arbitrarily far away with Alice and and Bob getting light signals and/or cosmic rays from her. The mathematics of tensor general coordinate transformations only connects physically coincident local frames of reference. In fact there are three groups of these reversible coincident frame transformations.

1) LNIF $\Leftrightarrow$ LNIF' general coordinate transformations corresponding to the local translation subgroup $T_4(x)$ of the Poincare group.[cxcix]
2) LIF $\Leftrightarrow$ LIF' local Lorentz transformations corresponding to the local Lorentz subgroup $SO(1,3)$[cc] of the Poincare group.
3) LIF $\Leftrightarrow$ LNIF tetrad transformations corresponding to Einstein's equivalence principle (EEP) for cancellation of Newton's artificial gravity force field. Of course there is no cancellation of Einstein's real gravity curvature field. This cancellation physically means switching off the real non-gravity forces acting on the LNIF. There is no actual cancellation of two independently existing dynamical fields that can be measured individually prior to cancellation. The "cancellation" Wheeler speaks of is purely formal and metaphorical not literal.

Here I follow "Gravitation and Inertia" by Ignazio Ciufolini and John Archibald Wheeler, which is a more up to date sequel to the Misner, Thorne, Wheeler classic book "Gravitation."

"Gravity is not a foreign and physical force transmitted through space and time. It is a manifestation of the curvature of spacetime."

This is Wheeler's synopsis of Einstein's theory as we essentially understand it today 2013 in hindsight. Wheeler means real gravity as distinct from artificial gravity caused by the observer's off-geodesic proper acceleration from a real primarily electrodynamic force with quantum statistical zero point pressure and Pauli-exclusion principle corrections. When you weigh yourself on a scale there is an unbalanced electrical force pushing you radially outwards in order to hover on an off-geodesic world line in fixed position in the Earth's curvature field. How Einstein conceived it on his rocky road of

discovery between 1905 and 1916 is not of fundamental importance for the task of building stargates and warp drives. We are here more interested in the future than the past, though of course we need to know enough about the past not to repeat mistakes already made.

"First, there was the idea of Riemann that space, telling mass how to move, must itself – by the principle of action and reaction – be affected by mass. It cannot be an ideal Euclidean perfection, standing in high mightiness above the battles of matter and energy. Space geometry must be a participant in the world of physics." John Archibald Wheeler (aka JAW)[cci]

"Second, there was the contention of Ernst Mach[ccii] *that the 'acceleration relative to absolute space' of Newton is only properly understood when it is viewed as acceleration relative to the sole significant mass there really is." JAW*

The above statement is now obsolete[cciii] since ordinary matter in the form of baryons, electrons, photons etc. is now known to be not more that approximately 5% of all the gravitating stuff that we can see in the past light cones[cciv] of our telescopes. About 70% is large-scale anti-gravitating dark energy accelerating the expansion speed of 3D space. Random quantum vacuum [ccv]zero point virtual photons[ccvi] and other spin 1 and spin 2 quanta in quantum field theory have negative pressure three times greater than their positive energy density and may be dark energy. The remaining approximately 25% is clumped shorter-scale gravitating dark matter that holds galaxies together. Random quantum vacuum zero point virtual electron-positron and other spin ½ quanta have positive pressure three times greater than their negative energy density causing attractive gravity like dark matter. If dark matter is this quantum vacuum effect dictated by local Lorentz covariance[ccvii] and Einstein's Equivalence Principle (aka EEP), then none of the attempts to measure real on-mass-shell particles whizzing through space to explain dark matter will succeed. There are, however, "f(R)" MOND variations of Einstein's general relativity that attempt to explain both dark matter and dark energy. The latest evidence as of late October, 2013 is that the spatial curvature $k < 0$ i.e. an open hyperbolic universe on the large scale rather than a perfectly flat one at $k = 0$. Also the dark energy equation of state's w = pressure/energy density is a bit more negative than the w = -1 that comes from random zero point quantum vacuum fluctuations of virtual bosons giving the anti-gravity.
"According to this 'Mach Principle,' inertia here arises from mass there." JAW

"That a real thing has to be presupposed as the cause for the preference of inertial systems over non-inertial systems is a fact that physicists have only come to understand in recent years." Albert Einstein (1924)

The above idea is mathematically expressed in Einstein's 1915 local tensor field equation relating the source stress-energy current densities of matter fields to the curvature of spacetime locally coincident with matter currents. However, when we solve those local field equations we have to impose global boundary/initial conditions and use the method of Green's function[ccviii] propagators to see how matter currents here change spacetime curvature there. The "inertia" in Wheeler's statement above refers to the pattern of force-

free time like geodesic paths[ccix] of test particles whose mass is small enough to neglect their distortion of the local curvature gravity field. The word "inertia" in the context of Mach's principle above does not refer at all to the actual rest masses of the test particles.

"How was the Machian positive program related primarily to inertial motion (rather than to inertial mass) to be implemented?"[ccx]

Indeed, the test particle rest masses cancel out of the timelike geodesic equations of motion that correspond to Newton's first law of motion. Galileo first understood this though he did not have the modern mathematical concepts I am using here.

"Third was that great insight of Einstein that … 'free fall is free float': the equivalence principle, one of the best tested principles of physics, from the inclined tables of Galilei and the pendulum experiments of Galilei, Huygens, and Newton to the highly accurate torsion balance measurements of the twentieth century, and the Lunar Laser Ranging experiment … With these three clues vibrating in his head, the magic of mind opened to Einstein what remains one of mankind's most precious insights: gravity is manifestation of spacetime curvature." JAW

What should we mean by the word "inertia" and what is its relation to gravity? There are two distinct meanings of the same word "inertia" that even physicists muddle. First, "inertia" is understood as meaning the real force-free inertial geodesic motions of test particles. The centers of mass (COM) of non-rotating Local Inertial Frames (LIFs) move on timelike geodesics inside their local light cones. This is basically Newton's first law of particle mechanics in its modern formulation that includes the curved spacetime of real gravity fields. The second meaning is that of inertial rest mass, e.g. ~ 10^{-27} grams for the electron that comes up in Newton's second law of particle mechanics where real forces push massive test particles off their natural timelike geodesics.. Although Einstein in his early work flirted with the idea that the inertial masses emerge in a kind of bootstrap Mach never did! We now know that inertial masses come from several mechanisms on different scales of energy: Higgs mechanism for leptons and quarks, quantum chromodynamics for hadrons, nuclear, atomic, molecular et-al mechanisms for lower energy emergence of complex systems. Einstein wrote in his famous 1916 paper: "The laws of physics must be of such a nature that they apply to systems of reference in any kind of motion." This is a formal mathematical statement of the need for tensor/spinor formulation of the local laws of dynamics for observables. To say in this sense, that the laws of nature look the same in any local frame properly accelerating or not (aka "covariance" with shared "invariants" for locally coincident observers measuring the same phenomena) is not to say that a properly accelerating LNIF (Local Non-Inertial Frame) measuring the motion of a test particle is not operationally (experimentally) different from a coincident LIF (Local Inertial Frame) also measuring the motion of the same test particle at the same point on its world line path in four-dimensional spacetime that is curved by mass-energy.[ccxi] Accelerometers clamped to them will show different readings. The accelerometer clamped to an LIF always shows zero even if it is kinematically accelerating relative to a Doppler radar clamped on a LNIF.

"Einstein's decade-long love affair with Mach's philosophy of inertia was complicated and tortuous. The first complication is that Einstein entertained two quite distinct Mach-inspired doctrines, one of which actually had no basis in Mach's writings, as Barbour first emphasized in 1990. This was the doctrine that

the inertial mass of a body is to be explained as arising from the presence of other bodies, with the consequence that a body at spatial infinity should have zero mass. (Mach himself had no difficulty in viewing inertial mass as an intrinsic property of the body, and, as mentioned above, used Newton's third law to reveal its operational significance.) Indeed it was this idea of the "relativity of inertia" that Einstein had in mind in his first endorsement of Mach's reasoning in a paper published in 1912." Harvey Brown[ccxii]

Wheeler means by the term "inertia":

"The local equivalence of 'gravitation' and 'inertia,' or the local cancellation of the gravitational field by local inertial frames ... A gravitational field is affected by mass-energy distributions and currents, as are the local inertial frames. Gravitational field and local inertial frames are both characterized by the spacetime metric, which is determined by the mass-energy distributions and currents."[ccxiii]

As mentioned in one of the quotes above, the same term "gravitational field" is used in several different meanings depending on context. When Wheeler talks about the "cancellation of the gravitational field by local inertial frames" he means Newton's universally attracting radial $1/r^2$ field from a spherically symmetric source mass. In the tensor calculus language of Einstein's 1916 general theory of relativity of gravitation, Newton's gravity field is a piece of the Levi-Civita connection[ccxiv] terms in the directional covariant derivative[ccxv] of the linear four-momentum of a test particle with respect to the proper clock time along its path or world line in four-dimensional spacetime. The second meaning of "gravitational field" is the tensor curvature,[ccxvi] which is the rotational covariant partial derivative "curl"[ccxvii] of the Levi-Civita connection with respect to itself. Einstein's theory is a local classical field theory whose measurable properties or "observables" must be tensors[ccxviii] and spinors.[ccxix] The local geometrodynamic field[ccxx] moves massive test particles in force-free inertial motion on timelike geodesics, but do not back-react on the geometrodynamic field. We distinguish test particles from source masses, which generate the geometrodynamic field in a similar way to how electric charges generate the electromagnetic field. Contrary to popular misconceptions, although the local laws of classical physics have the same "tensor" and/or "spinor" form for all motions of detectors measuring all the observables possessed by the "test particles," nevertheless, there still are privileged geodesic force-free dynamical motions of the test particles in Einstein's two theories of relativity special 1905 and general 1916.[ccxxi] This was in Einstein's words "My happiest thought."

"The breakthrough came suddenly one day. I was sitting on a chair in my patent office in Bern. Suddenly the thought struck me: If a man falls freely, he would not feel his own weight. I was taken aback. This simple thought experiment made a deep impression on me. This led me to the theory of gravity. I continued my thought: A falling man is accelerated. Then what he feels and judges is happening in the accelerated frame of reference. I decided to extend the theory of relativity to the reference frame with acceleration. I felt that in doing so I could solve the problem of gravity at the same time. A falling man does not feel his weight because in his reference frame there is a new gravitational field, which cancels the gravitational field due to the Earth. In the accelerated frame of reference, we need a new gravitational field." [ccxxii]

First note the date 1907. Einstein is using Newton's 1686 theory of gravity not his then future 1916 general relativity way of thinking that he has not yet created. Einstein is struggling with the wrong notion of "acceleration."

"A falling man is accelerated."

Yes, in Newton, but not in Einstein nine years in the future! The falling man's frame is LIF with zero proper acceleration. In fact it's the surface of static LNIF Earth with proper radial acceleration upward rushing toward the falling man.

Proper acceleration of falling man
= Relative 1905 SR kinematic acceleration - Proper acceleration of Earth

Proper acceleration of falling man = D^2X/ds^2

Relative 1905 SR kinematic acceleration = d^2X/ds^2

Proper acceleration of Earth
= $\{\text{STATIC LNIF EARTH}\}^i{}_{00}(dX^0/ds)(dX^0/ds)$
= $c^2\Gamma^i{}_{00}$

Note that $dX^0/ds = 1$ in the STATIC LNIF. The affine connection Γ has physics dimension 1/length because the metric tensor g_{uv} is a pure dimensionless numbered geometrodynamical field.

Here I put in the indices to show the correspondence with Einstein's 1951 letter to Von Laue cited above.

X = relative separation test particle to detector on Earth.

{ } = Christoffel symbol used in the Levi-Civita connection

v = dX/ds

In fact when v/c << 1, the **3-vector** piece of the above 4-vector equation is:

$$\mathbf{\{STATIC\ LNIF\ EARTH\}^i{}_{00}(dX^0/ds)(dX^0/ds)} \sim -GM_{Earth}\mathbf{r}/r^3$$

Now do a Taylor series expansion of g_{00} to first order in small h, the height above surface of Earth where h << r(surface), the result is that the g_{00} term is of order $1 + 2gh/c^2$. Taking the negative gradient of Newton's potential energy per unit test mass $-GM_{Earth}\mathbf{r}/r^3 \sim \mathbf{g}$, which approximates the universal stationary uniform Newtonian gravity field that Einstein has in mind in the quote below. Einstein never means a uniform Newtonian gravity field filling the entire universe at some point in its expansion. Proper acceleration of falling man = 0 because an accelerometer pinned to the man shows zero on its pointer. Therefore,

Relative kinematic acceleration = Proper acceleration of Earth (LNIF)

Where a Doppler radar measures the relative kinematic acceleration between the falling man and Earth. In contrast, a second accelerometer clamped to the detector at rest on

surface of the Earth measures $-GM_{Earth}\mathbf{r}/r^3$ as the weight divided by the mass of the detector.

"A falling man does not feel his weight because in his reference frame there is a new gravitational field, which cancels the gravitational field due to the Earth. In the accelerated frame of reference, we need a new gravitational field."

That statement by Einstein in 1907 is how Newton would explain it. Einstein put himself in Newton's shoes for a moment. It's not the way his later 1916 matured GR explains it.

0 = Relative 1905 SR kinematic acceleration - Proper acceleration of Earth

This "cancellation", the "0" on the above word equation is not a cancellation of two real dynamical fields. Einstein's unfortunate informal language in 1907 has no relevance to his, then, future theory.

"In the accelerated frame of reference, we need a new gravitational field."

That's the LIF, which is not accelerated in the sense of 1916 Einstein GR, but is accelerated in the different sense of 1686 Newton. These subtle oft unnoticed paradigm shifts in the meanings of "acceleration," "inertia," "inertial frame" cause many people a great deal of confusion even today. In fact, we have already seen the precise Einstein formula for the "cancellation"

$$\Gamma^{K}_{IJ(LIF)} = 0$$

$$= (\partial x^K/\partial x^d)(\partial x^n/\partial x^J)(\partial x^m/\partial x^I)\,\Gamma^{d}_{mn(LNIF)} + (\partial x^K/\partial x^d)(\partial x^n/\partial x^J)\,(\partial^2 x^d/\partial x^n\,\partial x^I)$$

So again, since even many physicists today are muddled on the different meanings of "acceleration": The freely falling LIF has non-zero kinematical acceleration

$$dV_{LIF}/d\tau \neq 0$$

relative to a coincident LNIF. However, this same freely falling LIF has zero proper acceleration.

$$DV_{LIF}/d\tau = 0$$

The coincident LNIF has non-zero proper tensor acceleration.

$$DV_{LNIF}/d\tau \neq 0$$

Einstein was still muddled in 1907 as he struggled to make the great breakthrough.
In summary: Einstein in 1907 was talking about Newton's 17th century fictitious gravity pseudo force, which in GR is included in the Γ^{i}_{00} part of the Levi-Civita connection for LNIFs. This fictitious force is zero in the coincident LIF simply because the real external non-gravity force acting on the LNIF is switched off transforming it to a LIF. Fictitious

forces on observed test particles are real forces on the observing LNIFs. There is no need to posit cancelling fields in the LIF. Einstein in 1907 used that unfortunate phrasing in his oft-cited "happiest thought" quote. All of Einstein's discussions of the equivalence principle deal with Newton's fictitious gravity field, i.e. Levi-Civita connection, not with his later final curvature field. There is no such thing as a gravity force. All forces we feel are non-gravity. Our weight is an unbalanced electrical force keeping us fixed in the curved spacetime of the Earth's 4th rank Riemann tensor field R_{uvwl}. We are static LNIFs. As I remarked above, Einstein's GR still has privileged motions are called "geodesic" motions or "world lines." Test particles are distinguished from "source particles." It is an approximation that test particles do not significantly modify the fields acting on them. They are, strictly speaking, a useful contradiction of the metaphysical principle of no action of Alice on Bob without a direct "back-reaction" of Bob on Alice. Massless point test particles in what physicists call the "classical limit" move on "null" or "lightlike" geodesics. Test particles with mass m move on timelike geodesics that are inside the "light cone" formed by all the light rays that might be emitted from that test particle if it were electrically charged and if it were really accelerating. The latter is a "counter-factual" statement. The key point is that Alice is weightless when traveling on a timelike geodesic inside her two local light cones past and future. There is no real force F acting on Alice. On the contrary, Bob who is measuring Alice with a detector (aka "measuring apparatus") need not be on another timelike geodesic. He can be off geodesic because real forces can be acting on him causing him to feel weight. The real forces acting on Bob appear as "fictitious" "inertial pseudo-forces"[ccxxiii] acting on Alice from Bob's frame of reference. The only real forces in nature that we know about in 2013 are the electro-magnetic, the weak and the strong. Gravity is not a real force in Einstein's theory. Gravity is one of the fictitious forces described above. Real forces on test particles, unlike all fictitious forces on them, are not universal. Fictitious inertial pseudo-forces that appear to, but are not really acting on the observed test particles all depend on the mass m of the test particle. The operational litmus test to distinguish a real force from a fictitious inertial pseudo-force is what an accelerometer[ccxxiv] rigidly clamped to the observed test particle measures. I repeat, because many engineers and even some physicists get muddled on what should be an elementary physics idea: Einstein's "happiest thought" that led to his general theory of relativity in the first place, was his epiphany that an accelerometer clamped to a freely falling object on a timelike geodesic path (i.e., world line) would not register any g-force (i.e., any weight). The apparent kinematical acceleration of a freely falling test particle seen in the gravitational field of the surface of Earth is because the surface of rigid Earth at every point on it has radially outward proper tensor acceleration whilst the test particle itself has zero proper tensor acceleration. The accelerometer on the test particle registers zero. The accelerometer at a point on the surface of Earth registers the "weight" an object of rest mass m clamped to it. That every point on a rigid sphere is accelerating radially outward is hard for common sense engineers and laymen to comprehend. It seems crazy to common sense, but that is precisely the counter-intuitive Alice in Wonderland reality of Einstein's curved spacetime that is battle-tested by very accurate experiments.[ccxxv] Consequently, if Alice and Eve are each on separate timelike geodesics very close to each other and if Bob who is not on a timelike geodesic of his own due to real forces acting on him, then Alice and Eve will have the same kinematical acceleration relative to Bob and they will both feel weightless

though Bob feels weight – also called "g-force." This causes a lot of confusion, especially to aerospace missile engineers and high-energy particle physicists, because Newton did consider gravity to be a real force, but Einstein did not. Gravity is not a force. Gravity is the curvature tensor of four-dimensional space-time. What Newton thought of as a real gravity force, is demoted to a fictitious inertial pseudo-force in Einstein's theory. In the language of the late John Archibald Wheeler, gravity is a "force without Force". The best local frame invariant way to think about gravity in an objective local frame-independent way is the pattern of both light like and timelike geodesics whose source is the "stress-energy density tensor field" T_{uv} of matter. By matter we mean spin 1/2 leptons, quarks, and the spin 1 electromagnetic-weak-strong gauge bosons as well as the spin 0 Higgs vacuum superconductor field that formed only when our observable piece of the multiverse called the "causal diamond" popped out of the false vacuum about 13.7 billion years ago.

To repeat as there is much confusion in the literature on this: Wheeler never intends the word "inertia" in its connection to gravity, as a theory that can compute the actual numerical rest masses of elementary particles, e.g., ~ 10^{-27}grams for the electron in low energy scattering. Wheeler means the global pattern of lightlike and timelike geodesics that are on and inside the field of light cones. Indeed, Roger Penrose, shows how to picture curvature's geodesic deviation as the relative tilting of neighboring light cones. The classical concept of causality is that effects can only propagate in the forward light cone of the cause. Advanced back-from-the-future signals (i.e. retrocausality[ccxxvi]) are forbidden.[ccxxvii]

Back From the Future

"A series of quantum experiments shows that measurements performed in the future can influence the present. Does that mean the universe has a destiny—and the laws of physics pull us inexorably toward our prewritten fate? … Cosmologists have long been puzzled about why the conditions of our universe—for example, its rate of expansion—provide the ideal breeding ground for galaxies, stars, and planets. If you rolled the dice to create a universe, odds are that you would not get one as handily conducive to life as ours is. Even if you could take life for granted, it's not clear that 14 billion years is enough time for it to evolve by chance. But if the final state of the universe is set and is reaching back in time to influence the early universe, it could amplify the chances of life's emergence."[ccxxviii]

In fact, I argue that the observed very small dark energy density accelerating the expansion of space has the same value as Hawking black body radiation coming back from our future de Sitter cosmological event horizon. Faster-than-light spacelike signals outside the light cones are also forbidden. However, the Wheeler-Feynman classical electrodynamics from the 1940's is retrocausal as is its generalization to cosmology by Hoyle & Narlikar, and to quantum theory's entanglement Costa de Beauregard ("Feynman zigzag"), and John Cramer (transactional interpretation). Indeed, in this book, I will propose my original idea that the dark energy accelerating the expansion speed of three-dimensional space is back-from-the-future Hawking radiation from the future event horizon boundary of the causal diamond that is our observable piece of the multiverse in modern precision cosmology. The latter assumes that we can only get information from

light signals and particles moving through space slower than the speed of light in vacuum. Orthodox quantum theory's entanglement requires faster-than-light and retro-causal "delayed choice" influences with a Catch 22 that such effects are locally random. Bob must wait for a light speed limited classical signal key to decrypt the message encoded by Alice into the pattern of entanglement. The Holy Grail here is to go beyond, to "smash" this "wall of light" (Carlo Suares, Paris 1973) in a post-quantum theory that is to orthodox theory as general relativity is to special relativity. Brian Josephson, Roger Penrose, Antony Valentini, Nick Herbert and myself have all been independently working on different approaches to this goal.
The origin of inertia as the real force-free pattern of geodesic, not as the generation of rest masses of particles, is according to John Archibald Wheeler

"The precise way by which the spacetime metric is determined by mass-energy and mass-energy currents is clarified by the initial-value problem of general relativity. Central to the understanding of the origin of inertia in Einstein theory are: (a) the geometrodynamical formulation of the initial value problem on a spacelike three-manifold and the Cauchy problem"

However, this assumes no time-travel to the past that, in my opinion, flying saucer evidence refutes. Be that as it may, Igor Novikov, Kip Thorne, David Deutsch, Seth Lloyd and others are actively researching closed timelike curves (CTCs) including retro-causal back-from-the-future quantum computing using them. Such work takes us beyond what Wheeler contemplated.

"(b) cosmological considerations on the compactness of space …"

This remark written in 1995 has since proved wrong since the discovery of dark energy accelerating the universe in 1998 by two competing independent experimental teams. Compact space corresponds to the Big Crunch $k > 1$ in the really large-scale coarse-grained cosmological metric field of mainstream cosmology. Current evidence points to an open non-compact hyperbolic universe $k < 0$ although it's very close to $k = 0$ of inflation cosmology that, however, is not accepted by Roger Penrose.

"… and on hypothetical rotations of the cosmological fluid with respect to the local inertial observers, that is with respect to the local gyroscopes"

Not, in fact, observed as far as I know.

" and (c) the theory of the measurement of the gravimagnetic field and 'dragging of inertial frames' by mass-energy currents."

Of direct importance to the advanced super-technology of warp drive and wormhole star gates from our alleged visitors from our own future is the problem of classical curvature singularities in Einstein's 1916 battle-tested standard geometrodynamics of the gravitational field.

"Together with the great theoretical and experimental successes of Einstein standard geometrodynamics, come two main conceptual problems.[ccxxix] *First, the theory predicts the occurrence of spacetime singularities, events that are not part of a smooth spacetime manifold,*[ccxxx] *where usually the curvature*

diverges and where the Einstein field equation and the known physical theories cease to be valid. Second, Einstein's theory of gravitation, unlike the other fundamental interactions, has not yet been successfully quantized."

Einstein's 1916 classical GR geometrodynamics in the weak field first order perturbation approximation against the non-dynamical globally flat Minkowski spacetime of his 1905 special relativity has "achieved an experimental triumph" with "direct confirmations" of gravitational time dilation, gravitational bending of light (lensing), lunar laser ranging, de Sitter geodetic effect, GPS. Transverse polarized far field gravity waves have been indirectly detected from the orbital energy loss of binary pulsar PSR 1913 + 16. Gravimagnetism, a very weak effect, has recently been measured in NASA's Gravity B space experiment.

"The concept of gravimagnetic field generated by mass currents, in partial analogy with electrodynamics, … its measurement of the dragging of inertial frames" constitutes "direct experimental evidence against an absolute inertial frame of reference and … experimentally displays the basic role in nature of the local inertial frames." [ccxxxi]

Einstein had a great intuitive mind was not a particularly good formal symbol twirling mathematician. The better the mathematician, the worse is the theoretical physicist in the eyes of the experimental physicist. One must achieve a proper balance. In fact, Einstein's teacher Hermann Minkowski called him "a lazy dog" as a student with, I might add, a roving eye for the ladies. Einstein's friend in his Bohemian Café "Olympia Academy" Marcel Grossman, who knew about the new non-Euclidean geometries as well as Gauss and Riemann's curved space differential geometry, tutored Einstein in his rocky road to discovery between 1905 and 1916. Wheeler continues:

"Bernhard Riemann went on to generalize the ideas of Gauss so that they could describe curved spaces in three or more dimensions.[ccxxxii] *Gauss had found that the curvature in the neighborhood of a given point of a specified two-dimensional space geometry is given by a single number: The Gaussian curvature. Riemann found that six numbers are needed to describe the curvature of a three-dimensional space at a given point, and that 20 numbers at each point are required for a four-dimensional geometry: the 20 independent components of the so-called Riemann curvature tensor." P.3*

Wheeler is very clear on what should be meant by the word "inertia" in the context of Mach's Principle. It should not be confounded with the "inertial rest mass" of Newton's second law of test particle mechanics. Rather "inertia" is meant in the sense of Newton's first law (the geodesic equation postulate of Einstein's geometrodynamics). Note also Wheeler's use of the generalized action-reaction principle, which I also use to extend quantum theory to explain consciousness as presponse[ccxxxiii] entanglement signal nonlocality.

"Let us bring out the main idea in what we may call the poor man's language. Inertia here, in the sense of local inertial frames that is the grip of spacetime here on mass here is fully defined by the geometry, the curvature, the structure of spacetime here. The geometry here, however, has to fit smoothly to the geometry of the immediate surroundings; those domains, onto their surroundings; and so on, all the way around the great curve of space. Moreover, the geometry in each local region responds to the mass in that region. Therefore every bit of momentum-energy, wherever located, makes its influence felt on the geometry of space throughout the whole universe – and felt, thus on inertia right here." P. 4

We also have to restrict classical influences from matter sources there to the past light cone of geometry here in the traditional retarded causality belief of mainstream physics. The first crack in that marble slab was Wheeler and Feynman's use of retrocausal advanced back-from-the-future electromagnetic waves from a future absorber on the radiation reaction "jerk" force on the past emitter of retarded electromagnetic waves in a closed self-consistent loop in time. Quantum entanglement enlarges that crack to a gaping rip allowing spacelike faster-than-light influences outside both future and past light cones. However, the retrocausal-advanced effects can mimic spacelike influences as in John Cramer's transactional interpretation of quantum theory. Wheeler, continues:

"If the spacetime has a Cauchy surface, that three-geometry once known – mathematical solution as it is of the so-called initial value problem of geometrodynamics – the future evolution follows straightforwardly and deterministically. In other words, inertia (local inertial frames) everywhere and at all times is totally fixed, specified, determined, by the initial distribution of momentum-energy, of mass and mass in motion. The mathematics cries out with all the force at its command that mass there does determine inertia here." P.5

In fact, Cauchy surfaces do not exist at the level of quantum gravity where the initial value problem cannot be posed because of Heisenberg's uncertainty principle. Furthermore, the concept of Cauchy surfaces breaks down when there are closed-time-like-curves (CTCs) permitting time travel to the past in violation of Stephen Hawking's "chronology protection conjecture." Key word in last sentence is "conjecture." Wheeler's rough simplistic formula using instant action at a distance violating light cone causality is

"Fractional contribution by a given mass, there to the determination of the direction of axes of the local gyroscopes, the compass of inertia, here is of the order of (mass, there)/(distance, there to here). In this rough measure of the voting power, the 'inertia-contributing power' of any object or any concentration of energy, its mass is understood to be expressed in the same geometric units as the distance." P.5

If all the mass of the universe were located at the Hubble distance, which it is not, but if it were, this corresponds to the dimensionless number 1 when the correct constant G/c^2 is put in. It corresponds to Jim Woodward's phi/c2 = 1 in his Mach-Sciama-based theory of vector gravity. However, it is obviously way too simplistic to be taken seriously. Wheeler continues on Mach's principle:

"Does this whole idea of voting rights and inertia-contributing power make sense? It surely does so if the total voting power of all the mass there is in the whole universe adds up to 100%. But does it? Let's run a check on the closed Friedmann model universe. There the total amount of mass is of the order of 6×10^{56} grams. This amount translated into geometric units by way of the conversion factor 0.742×10^{-28} centimeters/gram is 4.5×10^{28} cm of mass. It is much harder to assign an effective distance at which that mass lies from us, and for two reasons. First distances are changing with time. So at what time is it that we think of the distance as being measured?"

Wheeler continues in this vein, but basically winds up with a circular argument. That Mach's principle of 100% voting power is a conjecture calling it "the poor man's version of the origin of inertia." Gyroscopes measuring Mach's "inertia":

"Now for inertia determination in action. Mount a gyroscope on frictionless gimbals" in the static LNIF on Earth's surface. "Or better, float it weightless in space to eliminate the" [Newtonian] "gravity force that here on Earth grinds surface to surface."

Remember, this metaphorical "grinding" that Wheeler poetically speaks of are equal and opposite quantum electrical contact forces having nothing whatsoever to do with distant matter, or frame dragging as James Woodward seems to believe in his book "Making Starships and Stargates" as far as I can understand his obscure writing on this particular topic. When you stand still on a scale on the surface of the Earth there is a real net unbalanced quantum electrical force pushing you off the local timelike geodesic in the local real gravity curvature field. In accord with Newton's third law of total linear momentum conservation, you exert an equal and opposite quantum electrical inertial reaction force back on the scale causing a compression in the spring mechanism of the scale. This is entirely a local matter without any direct astrological influences from the cosmos as a whole in the domain of validity of Einstein's classical geometrodynamics of real gravity as tensor curvature. Local 4-momentum conservation follows from local translation symmetry according to Noether's theorem. Using the Levi-Civita connection covariant proper time derivatives of the linear 4-momenta of the interacting test objects includes the influence of gravity in the static LNIF. More generally, one thinks of the total classical particle and classical field stress-energy current density tensor T_{uv} (particles + fields). All the local space-time translational conservation laws for the mass-energy current densities with minimal coupling to the local real gravity curvature field come from the vanishing of the covariant divergence

$$DT_{uv}/\partial x^{v} = T_{uv}{}^{;v} = 0$$

that follows from Einstein's gravity field equations

$$G_{uv} + \Lambda g_{uv} + (8\text{pi}G/c^{4})T_{uv} = 0.$$

Note that there are covariant partial derivatives of the Levi-Civita connection components in the covariant divergence that are real gravity field curvature contributions to the local mass-energy current conservation laws. Wheeler continues on P.6 explaining the tiny dragging of LIFs by local rotating mass-energy:

"Picture our ideal gyro as sitting on a platform at the North Pole with the weather so cloudy that it has not one peek at the distant stars. Pointing initially to the flag and flagpole at a corner of the support platform, will the gyro continue to point that way? … No … The clouds do not deceive it. It does not see the star to which its spin axis points, but to that star it continues to point as the day wears on. Earth turns beneath the heedless gyro … That is the inertia-determining power of the mass spread throughout space, as that voting power is seen in its action on the gyro. … The voting power of the Earth at the location of the gyro is small … of the order of magnitude [mass of Earth/radius of Earth] ~ 0.44 cm/6.4 x 10^{8} cm ~ 0.69 x 10^{-9} (1.12)

… roughly only one billionth as much influence as all the rest of the universe together. … The free-float frame of reference that Earth wanted the gyro axis to adhere to was so little different from the frame demanded by the gyro by the far away stars … Earth wants the gyroscope to axis to creep slowly around the in a twenty four hour day rather than keep pointing at one star … Do you know how many milliseconds of arc the axis of the gyro would turn through in the course of a whole year, relative to the distant stars, if it followed totally and exclusively the urging of Earth? …[voting power of Earth] x [rate of turn desired by Earth] = [0.698 billionth of total voting power of universe] x [473 billion milliarcsec per year] = [330 milliarcsec per year] However, nobody has figured out how to operate on Earth's surface a gyroscope sufficiently close to friction-free that it can detect the predicted effect."

This is the Lense-Thirring frame dragging effect now detected in space with the Gravity B probe.[ccxxxiv] The effective torque on the spin axis of the LIF gyro is called the gravimagnetic field in *analogy* with the Maxwell magnetic field. The importance of gyroscopes for the construction of real LIFs[ccxxxv]

"Local inertial frames have a fundamental role in Einstein geometrodynamics. The spatial axes of a local inertial frame along the world line of a freely falling observer are mathematically defined using Fermi-Walker transport (eq. 3.4.25); that is, along … her geodesic they are defined using parallel transport. These axes are physically realized with gyroscopes. … The most advanced gyroscopes … measure the very tiny effect due to the gravimagnetic field of the Earth: the 'dragging of inertial frames,' that is, the precession of the gyroscopes by the Earth's angular momentum, which in orbit, is of the order of a few tens of milliarcseconds/year. There are two main types of gyroscopes … mechanical and optical. The optical gyroscopes … are usually built with optical fibers or with ring lasers." (6.12)

Fermi-Walker Transport, De Sitter (Geodetic)&Lense-Thirring Effects
For weak gravity fields in the first Einstein 20th Century correction to Newton's 17th century gravity theory: S^{α} is a spacelike 4-vector outside its local light cone that describes the spin of the test gyroscope about its rotation axis. The test gyroscope travels along a timelike world line x^{α} (s) with tangent vector u^{α}. $S^{\alpha}u_{\alpha} = 0$ and the equation for Fermi-Walker transport is:

$$S^{\alpha}{}_{;\beta}u^{\beta} = u^{\alpha}\,(a^{\beta}S_{\beta}) = u^{\alpha}(u^{\beta}{}_{;\gamma}u^{\gamma}S_{\beta}) \quad (3.4.25)$$

Where a semi-colon ";" always stands for the covariant partial derivative with respect to the Levi-Civita connection that describes fictitious forces on the test gyroscope that are, in reality, real forces on the detector measuring the motion of the gyro. Repeated upper and lower indices are summed through 0,1,2,3. The local observable objectively real proper acceleration first-rank tensor directly measured by accelerometers clamped to the center of mass of the test gyro is

$$a^{\beta} = u^{\beta}{}_{;\gamma}u^{\gamma}$$

If the arbitrary timelike world line of the center of mass of the test gyro (remember LIFs have three of them forming a spacelike triad base frame) is a geodesic, then, by definition, the proper acceleration tensor $a^{\beta} = 0$. Therefore,

$$S^{\alpha}{}_{;\beta}u^{\beta} = 0$$

This is the equation for Fermi-Walker transport.

"A mechanical gyroscope is … made of a wheel-like rotor, torque-free to a substantial level, whose spin determines the axis of a local, nonrotating frame. Due to very tiny general relativistic effects … that is, the 'dragging of inertial frames' and the geodetic precession, this spin direction may differ from a direction fixed in 'inertial space' that may be defined by a telescope always pointing toward the same distant galaxy assumed to be fixed with respect to some asymptotic quasi-inertial frame (see 4.8)."

Inertial Navigation From ICBMs to Starships

"Mechanical gyroscopes are based on the principle of conservation of angular momentum of an isolated system … with no external forces and torques. … the spinning rotor maintains its direction fixed in 'space' (apart from dragging effects as Earth rotates but, however, a vector with general orientation, fixed with respect to the laboratory walls, describes a circle on the celestial sphere in 24 hours, a spinning rotor … describes a circle with respect to the laboratory walls in 24 hours … In a moving laboratory, using three 'inertial sensors', that is, three gyroscopes to determine three fixed directions (apart from relativistic effects…) plus three accelerometers to measure linear accelerations and a clock (and possibly three gravity gradiometers to correct for torques due to gravity gradients, one can determine the position of the moving laboratory with respect to its initial position. This can be done by a simple integration of the accelerations measured by the three accelerometers along the three fixed directions determined by the gyroscopes [held by gimbals]. Position can thus be determined solely by measurements internal to the [starship] laboratory … a priori independently of external information is called 'inertial navigation' … an onboard computer integrates the accelerations … one is able to find velocity, attitude, and position of the object."

The word "acceleration" here means off-geodesic proper tensor acceleration not the old Newtonian kinematic acceleration measured by Doppler radar in Einstein's somewhat misleading popular "happiest thought quote" I discussed earlier whose Siren's song has shipwrecked many a wannabe physicist-philosopher Flying Dutchman searching for Ithaca. However, for a starship in free float on a timelike geodesic we can dispense with the gyroscopes to preserve "direction." Instead one may use gradiometers.

"The needs of air navigation have generated a powerful drive for a compact, light weight gyroscopic compass[ccxxxvi] *of high accuracy … Today, optical gyros have displaced the mechanical gyro … A wave-guide is bent into a circle. A beam splitter takes light from a laser and sends it round the circle in two opposite directions. Where the beams reunite, interference between them gives rise to wave crests and troughs. If the wave-guide sits on a turning platform, the wave crests reveal the rotation of the platform or the airplane that carries it.*

While mechanical gyroscopes are based on the principle of conservation of angular momentum, optical gyroscopes (really optical rotation sensors) are essentially based on the principle of the constancy of the speed of light c in every inertial frame. Therefore, in a rotating circuit and relative to the [LNIF] observers moving with it, the round trip travel time of light depends on the sense of propagation of light with respect to the circuit angular velocity relative to a local inertial frame." [LIF]

From the general connection of continuous Lie groups[ccxxxvii] of symmetries of closed dynamical systems to conserved local currents and global "charges" that form the group's non-commuting Lie algebra[ccxxxviii], we conclude that the operation of the gyroscope corresponds to the three rotational symmetries of Einstein's 1905 special relativity's Poincare group. Therefore, the Sagnac effect[ccxxxix] basis of the optical gyros correspond to

the three Lorentz boosts of that same Poincare group that formally express the constancy of the speed of light in inertial frames. Newton's action-reaction third law comes from the three-space translation symmetry's conservation of linear momentum and the conservation of energy comes from the time translation symmetry – if these symmetries are not broken. Does the accelerometer's operation depend on the Rindler boosts of constant proper accelerating hyperbolic world lines of test particles? These are outside of the Poincare group requiring Roger Penrose's twistor conformal group.[ccxl] The Poincare group is a subgroup of the conformal group that also includes dilations. Here is Wheeler on the relation of gravity to the electro-weak-strong interactions – local gauge and string theories:

"What of the other forces of nature? Every other force – the electric force that rules the motion of the atomic electrons, the weak nuclear force that governs the emission of electrons and neutrinos from radioactive nuclei, and the strong nuclear force that holds together the constituents of particles heavier than the electron – demands ... a geometry of more than four dimensions, perhaps as many as ten. The extra six dimensions are envisaged as curled up into an ultra-small cavity, with one such cavity at each point in spacetime. ... The theories of the unification of forces with greatest promise today all have this striking feature that they, like the battle-tested, but simpler and older Einstein gravitation theory, build themselves on the [vanishing] boundary of a boundary principle, though in a higher dimensional version ... Elie Cartan's penetrating insight ... from the grip of spacetime on mass to the grip of mass on spacetime, and from the automatic conservation of momentum-energy ... the unfolding of all this from 'the one-dimensional boundary of the two-dimensional boundary of a three-dimensional region is zero' and the 'two-dimensional boundary of the three-dimensional boundary of a four-dimensional region is zero.'" Pp. 9,10 Wheeler & Ciufolini "Gravitation and Inertia"

"Thus gravity is that field which corresponds to a gauge invariance with respect to displacement transformations." P.115 Feynman's Cal Tech "Lectures on Gravitation"

All four interactions are boson local gauge theories of different groups of local frame transformations also called "gauge transformations" needing the mathematics of fiber bundles. Maxwell's electromagnetism mediated by spin 1 massless vector photons corresponds to the internal U(1) group that can be pictured as a circle "fiber" at each point on the "base" spacetime. Think of the circle as a one handed Salvador Dali clock. The clock hand can be moved locally at each spacetime point independently of all the other clocks at other spacetime points only because there is an induced connection field, analogous to the Levi-Civita connection (more precisely its more fundamental spin connection from which it derives) connecting the different fibers. Moving each local clock hand arbitrarily induces a gauge transformation in the connection field. The connection field supplies a covariant derivative and parallel transport of objects through the fiber space corresponding to world lines in the projected base space-time beneath it. The disclination curvature in closed loops in the fiber space corresponds to the electromagnetic field tensor. Similarly for the SU(2) group of the weak interaction which has three "flavor" quanta called the spin 1 vector W-bosons with electric charges +1, 0, -1 of the electron's charge. Now we have a three-dimensional hyper-sphere bounding a four-dimensional internal fiber space not to be confused with spacetime. These W-bosons have rest masses from the Higgs spin 0 boson because of a kind of superconductivity that forms in the moment of inflation from a false vacuum at the Alpha Point creation of our observable universe (aka "causal diamond") bounded in the past by an observer-dependent particle horizon and in the future by an observer-dependent de

Sitter dark energy event horizon. Both of these cosmological horizons have quantum thermodynamic hologram computational capacity and they emit Hawking radiation. Our past history pre-selected particle horizon emits retarded Hawking radiation to us here-now along our past light cone. Our future destiny post-selected de Sitter event horizon sends us back-from-the-future advanced Wheeler-Feynman Hawking radiation that happens to have the same energy density as the anti-gravity dark energy accelerating the rate of expansion of three-dimensional inter-galactic space. This is not a meaningless random Darwinian coincidence. There is the w-problem that dark energy needs $w < -1/3$ whilst retarded Hawking radiation has $w = +1/3$. However, we also have the Unruh effect here that the $w = +1/3$ Hawking blackbody radiation seen in LNIFs whose temperature is proportional to its local proper accelerometer reading, looks like $w = -1$ zero point radiation in coincident LIFs both connected to each other by tetrad transformations[ccxli] via the Einstein Equivalence Principle (EEP). However, this is a weak argument that I have since rejected. I now think that we must stick with $w = + 1/3$ for real advanced photons coming from our future cosmological event horizon, but with the anti-Feynman boundary condition that they propagate negative energy to the future, therefore, generating universally repelling anti-gravity. The question then is to see if there is an inconsistency with retarded real photons from our past particle horizon that must obey the Feynman boundary condition that they propagate positive energy to the future.

Returning to the strong interaction, the internal group is SU(3) with eight massless spin 1 vector gluon quanta corresponding to an eight-dimensional hyper-sphere fiber bounding a nine-dimensional internal fiber space at each point in spacetime. The spin 0 Higgs boson does not directly interact with the eight "color" gluons that bind the spin ½ quarks into hadrons. The photon does not directly interact with itself, unlike the three weak massive W-bosons and the eight strong massless gluons, which do interact with themselves respectively, as well as with each other. Each boson charge of the internal groups is a hermitian generator of the Lie algebra of the unitary Lie group. SU2 and SU3 Lie algebras have non-vanishing commutators of these internal charges. This implies Heisenberg uncertainty relations for simultaneous quantum measurements of the internal weak flavor and strong color charges. It is this incompatibility of the charges that causes the self-interactions.

We have a similar situation with gravity as a local gauge fiber bundle. We now have four mutually commuting tetrad charges that form the momentum-energy Hermitian observables in the LIF tangent space-fiber over spacetime base space. However, in addition we have the six spin-connection charges consisting of three space-rotation angular momenta and three Lorentz boosts. All ten of these charges form the non-commuting Lie algebra of the Poincare group, which unlike the electro-weak-strong unitary groups is not compact. However, the failure of the ten charges of the Poincare group to mutually commute completely causes the non-linear self-interaction of the massless spin 2 tensor gravitons of classical GR. Dennis Sciama mentioned the distinction between real particle on-mass-shell processes occurring inside and virtual particle processes outside the light cone back in 1973:

"In general relativity it is essential to distinguish between wave and static contributions ... The former propagate on or inside the light cone, while the latter are instantaneous ... One extra particle outside the

particle horizon would have to contribute to the potential at the field point. Gravitational waves emitted by this particle would not be able to reach this field point, but the existence of the particle would be manifest. This was first stressed by Penrose. Elsewhere we have summarized the situation by saying that although we cannot see an extra particle outside our horizon we can certainly feel it." D.W. Sciama preprint IC/73/94 ICTP Trieste Gravitational Waves and Mach's Principle

The classical near fields of all of these four basic interactions consist of "super conducting" macro-quantum coherent Glauber states of off-shell virtual bosons with all possible polarizations. This is in contrast to the far-field radiations consisting of Glauber coherent states of massless photons or massless gravitons with only two transverse polarization states. One point of interest is that the gravity quanta are spin 1 vector bosons at Dirac square root LIF tetrad/spin connection level of the formalism. Einstein's 1916 GR is a constrained limiting case of the local gauge theory just described in which zero dynamical dislocation torsion is imposed ad hoc giving only dynamical geodesic deviation disclination curvature. In this limiting case, the six spin-connection components are no longer an independent dynamical field, but are determined from the LIF tetrads also called "frame fields" (consisting of a spacelike triad and a timelike tangent vector). From Wikipedia:

In general relativity, a frame field (also called a tetrad or vierbein) is a set of four orthonormal vector fields, one timelike and three spacelike, defined on a Lorentzian manifold that is physically interpreted as a model of spacetime. The timelike unit vector field is often denoted by $\hat{e}_0$ *and the three spacelike unit vector fields by* $\hat{e}_1, \hat{e}_2, \hat{e}_3$. *All tensorial quantities defined on the manifold can be expressed using the frame field and its dual coframe field (Cartan's differential forms). Frames were introduced into general relativity by Hermann Weyl in 1929. [1] ... Frame fields always correspond to a family of ideal observers immersed in the given spacetime; the integral curves of the timelike unit vector field are the world lines of these observers, and at each event along a given world line, the three spacelike unit vector fields specify the spatial triad carried by the observer. The triad may be thought of as defining the spatial coordinate axes of a local laboratory frame, which is valid very near the observer's world line. ... In general, the world lines of these observers need not be timelike geodesics. If any of the world lines bends away from a geodesic path in some region, we can think of the observers as test particles that accelerate by using ideal rocket engines with a thrust equal to the magnitude of their acceleration vector. Alternatively, if our observer is attached to a bit of matter in a ball of fluid in hydrostatic equilibrium, this bit of matter will in general be accelerated outward by the net effect of pressure holding up the fluid ball against the attraction of its own gravity. Other possibilities include an observer attached to a free charged test particle in an electrovacuum solution, which will of course be accelerated by the Lorentz force, or an observer attached to a spinning test particle, which may be accelerated by a spin-spin force… It is important to recognize that frames are geometric objects. That is, vector fields make sense (in a smooth manifold) independently of choice of a coordinate chart, and (in a Lorentzian manifold), so do the notions of orthogonality and length. Thus, just like vector fields and other geometric quantities, frame fields can be represented in various coordinate charts. But computations of the components of tensorial quantities, with respect to a given frame, will always yield the same result, whichever coordinate chart is used to represent the frame. ... These fields are required to write the Dirac equation in curved spacetime. ... Specifying a frame: To write down a frame, a coordinate chart on the Lorentzian manifold needs to be chosen. Then, every vector field on the manifold can be written down as a linear combination of the four coordinate basis vector fields:*

$$X = X^{\mu}\partial/\partial x^{\mu}$$

The lower case Greek indices denote arbitrary local detector frame fields on arbitrary subluminal (i.e., timelike inside the local light cone at each point) world lines. They transform in what Einstein called "general coordinate transformations." What does that

mean physically? It means Bob and Ted are each on arbitrary timelike world lines that either cross or momentarily get close to each other and in that brief time of coincidence they quickly measure the same actions of Alice using light limited signals. Alice can be arbitrarily far from both Bob and Ted. They then compute invariants from their raw measurements and radio each other what they computed. If they made good measurements, and made no computational errors, then they will get the same set of invariant numbers. That's what a good theory in physics must be, and that's what local objective reality at least in classical physics means. So, that's the physical meaning. What is the mathematical meaning? There are all sorts of excess formal mathematics in many GR textbooks and one must spend too much time trying to learn it all. It is not worth the effort for practical experimental physicists and engineers who have better things to do and are not pure mathematicians. However, the local gauge theories[ccxlii] are very successful and are beautiful and not that hard to intuitively grasp in pictures. The local frame transformation (general coordinate transformations) on the Greek indices are the locally gauged four parameter translation orthogonal Lie group[ccxliii] T4 → T4 (x) whose Lie algebra[ccxliv] of observables is the energy-momentum four-vector (first-rank tensor) P = (iE, **P**) in either particle mechanics or classical and quantum field theory. In the case of particle physics $P^2 = - E^2 + \mathbf{P}^2 = - m_0^2$ where E is the total energy, P is the linear momentum 3-vector, m0 is the particle's rest mass (c = 1) and $P^2 = - m_0^2$ defines the mass-shell pole of the Feynman propagator in the complex energy plane in quantum field theory. The inequality $P^2 \neq - m_0^2$ describes virtual particles. The virtual particles can be random zero point vacuum fluctuation noise inside the vacuum, or they can be Glauber macro-quantum coherent near field states[ccxlv] that are the order parameters[ccxlvi] from a spontaneous broken symmetry of the ground state of a complex system. The non-radiative electrical power fields that surround us from the electricity of wires in our walls, cars, planes, house hold appliances, and computers are good every day examples. The Greek indices μ,ν generally denote LNIFs that are either rotating about their centers of mass or are on off geodesic timelike world lines or both. However, in special cases they can also be LIFs. Physically, this is easy because all one need do is switch off the rocket engines if out in space, or fall off a ladder if you are a tipsy painter in Berne. I will keep repeating this very important organizing idea of Einstein's that many mathematicians trying to explain Einstein's theory of gravity seem not to understand:

"All our space-time verifications invariably amount to a determination of space-time coincidences. If, for example, events consisted merely in the motion of material points, then ultimately nothing would be observable but the meeting of two or more of these points. Moreover, the results of our measuring are nothing but verifications of such meetings of the material points of our measuring instruments with other material points, coincidences between the hands of a clock and points on the clock dial, and observed point-events happening at the same place at the same time. The introduction of a system of reference serves no other purpose than to facilitate the description of the totality of such coincidences." Albert Einstein, "Grundlage der allgemeinen Relativitätstheorie", Annalen der Physik, 49 (1916)

Therefore, the local translational group gauge transformations (generally between coincident LNIFs in near collision, or a single LNIF that changes its proper off-geodesic center of mass acceleration, or changes its rotational angular momentum with a torque, or both) obeys the equations

LNIF' ⇔ LNIF

$$X^{\mu'} = T4(x)^{\mu'}{}_{\mu} X^{\mu} = (\partial x^{\mu'}/\partial x^{\mu}) X^{\mu}$$

$$\partial/\partial x^{\mu'} = T4(x)^{\mu'}{}_{\mu} \partial/\partial x^{\mu} = (\partial x^{\mu}/\partial x^{\mu}) \partial/\partial x^{\mu}$$

Orthogonality of the locally gauged Lie group T4(x) means

$$(\partial x^{\mu'}/\partial x^{\mu}) (\partial x^{\mu}/\partial x^{\lambda'}) = \delta^{\mu'}{}_{\lambda'} \text{ (4 x 4 identity matrix Kronecker delta)}$$

Therefore, X is an INVARIANT geometric object under the T4(x) group.

$$X' = X$$

Physically X is a LNIF' $\Leftrightarrow$ LNIF invariant. Now for the particular application to LIF tetrads, we have four LNIF INVARIANTS X_I, where now CAPITAL Latin indices, I, J, K always mean LIF indices that transform under the six parameter Lorentz group[ccxlvii] SO(1,3) of Einstein's 1905 special relativity. That is, for coincident

$$LIF' \Leftrightarrow LIF$$

$$X^{I'} = SO(1,3)^{I'}{}_{I} X^{I}$$

In our special case of physical interest, the set of four mutually orthogonal tetrads tangent vectors $\hat{e}_{I(LIF)}$, each individually a T4(x) LNIF invariant, form a spin 1four – vector Lorentz group first rank tensor. The spin 1 is very important for quantum gravity.

$$\hat{e}_{I(LIF)} = e_{I(LIF)}{}^{\mu(LNIF)} \partial/\partial x^{\mu}$$

Where $\hat{e}_{0(LIF)}$ = points along a timelike geodesic. The three tetrad tangent vectors I = 1,2,3 form a spacelike triad. Note that the curvature tensor being zero or non-zero does not matter. Of course, changing the curvature tensor field by changing its matter source stress-energy tensor current densities will change the pattern of null, timelike and spacelike geodesics objectively in a local frame invariant way. However, everything I say in this section works trivially for globally flat Minkowski spacetime that is an unstable false vacuum for curved spacetime.

The dual co-frame is the Cartan 1-form basis set with sixteen tetrad coefficients whose products are orthogonal in repeated upper and lower indices in summation convention.

$$\hat{e}^{I(LIF)} = e^{I(LIF)}{}_{\mu(LNIF)} dx^{\mu}$$

Again, because it's so important to the physical understand of Einstein's theory of gravity:

"All our space-time verifications invariably amount to a determination of space-time coincidences. If, for example, events consisted merely in the motion of material points, then ultimately nothing would be observable but the meeting of two or more of these points. Moreover, the results of our measuring are

nothing but verifications of such meetings of the material points of our measuring instruments with other material points, coincidences between the hands of a clock and points on the clock dial, and observed point-events happening at the same place at the same time. The introduction of a system of reference serves no other purpose than to facilitate the description of the totality of such coincidences." Albert Einstein, "Grundlage der allgemeinen Relativitätstheorie", Annalen der Physik, 49 (1916)

In accord with Einstein's key remark above, the tetrad map connecting physically momentarily coincident zero g-force geodesic LIFs with non-zero g-force off-geodesic LNIFs is:

$$g^{\mu\nu(LNIF)} = e_{I(LIF)}{}^{\mu(LNIF)}\, e_{J(LIF)}{}^{\nu(LNIF)} \eta^{IJ(LIF)}$$

$$g_{\mu\nu(LNIF)} = e^{I(LIF)}{}_{\mu(LNIF)}\, e^{J(LIF)}{}_{\nu(LNIF)}\, \eta_{IJ(LIF)}$$

This is still another mathematical way to express Einstein's equivalence principle that Newton's gravity fictitious force field on the test particle, (which is a real force on the detector), expressed as a piece of the Levi-Civita connection Christoffel symbol, along with rotational centrifugal and Coriolis fictitious forces if present, is eliminated at the center of mass origin of the LIF with diagonal Cartesian metric $\eta_{IJ(LIF)}$. In general, fictitious forces on the observed object are real forces on the observer who sees the metric $g_{\mu\nu(LNIF)}$. We also see that Einstein's spin 2 metric tensor field is quadratic in the spin 1 tetrad Lorentz group tetrad tangent vector frame fields and their dual co-frame Cartan 1 form fields. Quantum mechanically we know that entangling two spin 1 fields gives spin 0, spin 1 and spin 2 fields. However, we only see the spin 2 component at large distances in the classical limit. This is where the Higgs-Goldstone spontaneously broken pre-inflation false vacuum symmetry may come into play giving large rest mass to the spin 0 and spin 1 quanta of the gravitational field. Indeed, one may think that some of the low energy gravity forces are of this nature. However, the successful theory of the strong interaction at higher energies than nuclear physics has internal SU3 symmetry. In contrast, Einstein's gravity has T4(x) symmetry, more precisely local Poincare group symmetry with the added constraint of zero torsion. Indeed, gravity may have Penrose twistor conformal group symmetry also broken. There are also models connecting Einstein gravity in the interior 3D bulk with a product of SU(3) x SU(3) on a hologram 2D horizon. I first suggested something like that back in 1973 - 4.[ccxlviii]

The force of gravity looks like two copies of the strong subnuclear interactions working in unison.[ccxlix]

Coordinate basis vectors have the special property that their Lie brackets pairwise vanish. Except in locally flat regions, at least some Lie brackets of vector fields from a frame will not vanish. The resulting baggage needed to compute with them is acceptable, as components of tensorial objects with respect to a frame (but not with respect to a coordinate basis) have a direct interpretation in terms of measurements made by the family of ideal observers corresponding the frame. Coordinate basis vectors can very well be null, which, by definition, cannot happen for frame vectors.

Nonspinning Local Inertial Frames (LIF)

Some frames are nicer than others. Particularly in vacuum or electrovacuum solutions, the physical experience of inertial observers (who feel no forces) may be of particular interest. The mathematical characterization of an inertial frame is very simple: the integral curves of the timelike unit vector field must define a geodesic congruence, or in other words, its acceleration vector must vanish:

$$\nabla_{\hat{e}_0} \hat{e}_0 = 0$$

It is also often desirable to ensure that the spatial triad carried by each observer does not rotate. In this case, the triad can be viewed as being gyrostabilized. The criterion for a nonspinning inertial (NSI) frame is again very simple:

$$\nabla_{\hat{e}_0} \hat{e}_j = 0, j = 1,2,3$$

This says that as we move along the worldline of each observer, his or her spatial triad is parallel-transported. Nonspinning inertial frames hold a special place in general relativity, because they are as close as we can get in a curved Lorentzian manifold to the Lorentz frames used in special relativity (these are special nonspinning inertial frames in the Minkowski vacuum).

More generally, if the acceleration of our observers is nonzero,

$$\nabla_{\hat{e}_0} \hat{e}_0 \neq 0$$

We can replace the covariant derivatives

$$\nabla_{\hat{e}_0} \hat{e}_j$$

with the (spatially projected) Fermi-Walker derivatives to define a nonspinning frame.

Fermi–Walker transport is a process in general relativity used to define a coordinate system or reference frame such that all curvature in the frame is due to the presence of mass/energy density and not to arbitrary spin or rotation of the frame.[ccl]

In the theory of Lorentzian manifolds, Fermi-Walker differentiation is a generalization of covariant differentiation. In general relativity, Fermi-Walker derivatives of the spacelike unit vector fields in a frame field, taken with respect to the timelike unit vector field in the frame field, are used to define non-inertial but nonspinning frames, by stipulating that the Fermi-Walker derivatives should vanish. In the special case of inertial frames, the Fermi-Walker derivatives reduce to covariant derivatives DX/ds. This is defined for a vector field X (first rank tensor) along a curve $\gamma(s)$, with • denoting inner product with respect to the curvilinear metric $g_{\mu\nu}$.

$$D_F X/ds = DX/ds + (X \bullet DV/ds) + (X \bullet V)DV/ds$$

$$V = dX/ds = \text{generalized four velocity}$$

$$DV/ds = \text{generalized proper four acceleration – a tensor}$$

X is a vector field not the position of a particular point test particle.

However, if we think of a field of tiny detectors in motion, then DV/ds is their proper off-geodesic acceleration measured locally and directly by accelerometers clamped to them. For example:

A co-moving rest frame system co-moving with the particle can be defined. If we take the unit vector $\hat{u}^\mu$ as defining an axis in the co-moving coordinate system, then any system transforming with proper time is said to be undergoing Fermi Walker transport. [2] If

$$D_F X/ds = 0$$

the vector field X is Fermi–Walker transported along the curve (see Hawking and Ellis, p. 80). Vectors tangent to the space of four-velocities in Minkowski spacetime, e.g., polarization vectors, under Fermi–Walker transport experience Thomas precession.

Static LNIF observers outside the event horizon of a non-rotating Schwarzschild black hole horizon hologram quantum computer[ccli] of area-Bekenstein entropy $A = 4\pi r_s^2$ with memory $N \sim A/4L_P^2$ QUANTUM BITS

It may be possible to use a black hole as a data storage and/or computing device, if a practical mechanism for extraction of contained information can be found. Such extraction may in principle be possible (Stephen Hawking's proposed resolution to the black hole). This would achieve storage density exactly equal to the Bekenstein Bound. Professor Seth Lloyd calculated the computational abilities of an "ultimate laptop" formed by compressing a kilogram of matter into a black hole of radius 1.485×10^{-27} meters, concluding that it would only last about 10^{-19} seconds before evaporating due to Hawking radiation, but that during this brief time it could compute at a rate of about 5×10^{50} operations per second, ultimately performing about 10^{32} operations on 10^{16} bits (~1 PB). Lloyd notes "Interestingly, although this hypothetical computation is performed at ultra-high densities and speeds, the total number of bits available to be processed is not far from the number available to current computers operating in more familiar surroundings."[3] [cclii]

Specifying the metric using a coframe: The metric tensor can be specified by writing down a coframe in terms of a coordinate basis and stipulating that the metric tensor is given by

The diagonal coframe representation should not to be confused with the local frame invariant ds^2.

$$g = -\hat{e}^0 \times \hat{e}^0 + \hat{e}^1 \times \hat{e}^1 + \hat{e}^2 \times \hat{e}^2 + \hat{e}^3 \times \hat{e}^3$$

This is just a fancy way of saying that the coframe is orthonormal. Whether this is used to obtain the metric tensor after writing down the frame (and passing to the dual coframe), or starting with the metric tensor and using it to verify that a frame has been obtained by other means, it must always hold true.

Obviously, there are no mixed spacetime Ray Chiao[ccliii] "gravimagnetic" $A_i = g_{0i}$ cross terms $\hat{e}^0 \times \hat{e}^i$ in this representation. Such terms do appear in rotating[ccliv] and accelerating LNIFs[cclv] in globally flat Minkowski spacetime, as well as in rotating source vacuum solutions like the black hole Kerr metric[cclvi] in curved spacetime, or the Gödel cosmological metric[cclvii] for a really rotating universe. This is appears to be another major conceptual error in James W. Woodward's Mach Principle theory because he seems to think that because we see the stars rotate in the sky, that a rotating universe with Earth not rotating is physically equivalent to Earth rotating with the stars not rotating. The latter is the actual fact to a good approximation with the distant stars described by the non-rotating FRLW metric not the Gödel metric. The formal requirement of tensor covariance of the local laws of classical physics should not be confounded with physical equivalence. Rotation, for example, is a proper off-geodesic motion of points on the extended rotating object. Thus, in the case of the Earth, points on say the surface of Earth are off geodesic in the actual local curvature field. In contrast, the distant stars that

Woodward invokes in his Mach theory are generally on geodesics in their actual local curvature field. The non-rotating spherically symmetric static LNIF metric representation of the local frame invariant is

$$ds^2 = - (1 - A^{1/2}/r)\, dt^2 + (1 - A^{1/2}/r)^{-1}\, dr^2 + r^2\, d\Omega^2$$

$$d\Omega^2 = d\theta^2 + \sin^2\theta d\varphi^2$$

$$A^{1/2}/r < 1$$

The differential proper time ds^2 is invariant under all three distinct 1-1 mappings of coincident local frame transformations:

$$\text{LIF'} \Leftrightarrow \text{LIF 6-parameter Lorentz group}$$

$$\text{LNIF'} \Leftrightarrow \text{LNIF 4-parameter translation group}$$

$$\text{LIF} \Leftrightarrow \text{LNIF}$$

This tetrad map is not a group. It has no identity element. Note the algebraic closed cycle commutative diagram[cclviii]

$$\text{LIF} \Leftrightarrow \text{LNIF} \Leftrightarrow \text{LNIF'} \Leftrightarrow \text{LIF'} \Leftrightarrow \text{LIF}$$

Identify the first and last "LIF" symbols.

In mathematics, and especially in category theory, a ***commutative diagram*** *is a diagram of objects (also known as vertices) and morphisms (also known as arrows or edges) such that all directed paths in the diagram with the same start and endpoints lead to the same result by composition. Commutative diagrams play the role in category theory that equations play in algebra (see Barr-Wells, Section 1.7). Note that a diagram may not be commutative, i.e., the composition of different paths in the diagram may not give the same result.*[cclix]

The black hole horizon equation is $g_{00} = 0$ at $r = A^{1/2}$ for positive source mass creating a normal attractive universal gravity field. If the source mass is negative then there is no horizon because $g_{00} = 1 + A^{1/2}/r$ and we have an anomalous universal repulsive anti-gravity field. As Hermann Bondi first, it seems, pointed in the 1950s while consulting for MOD[cclx], out a negative mass chases a positive mass in self-acceleration, which may be the basis of a warp drive for starships.
From[cclxi]

$$g = - \hat{e}^0 \times \hat{e}^0 + \hat{e}^1 \times \hat{e}^1 + \hat{e}^2 \times \hat{e}^2 + \hat{e}^3 \times \hat{e}^3$$

Example 1: Hovering static LNIF observer-detectors at fixed r:

$$\hat{e}^{0(\text{static LNIF})} = -\,\hat{e}^{t}\,(1 - A^{1/2}/r)^{1/2}dt$$

$$\hat{e}^{1(\text{static LNIF})} = \hat{e}^{r}\,(1 - A^{1/2}/r)^{-1/2}dr$$

$$\hat{e}^{2(\text{static LNIF})} = \hat{e}^{\theta}\,r\,d\theta$$

$$\hat{e}^{3(\text{static LNIF})} = \hat{e}^{\varphi}\,r\sin\theta\,d\varphi$$

Of crucial importance for the understanding of the objectively locally real first rank tensor proper acceleration measure of off timelike geodesic motion caused by real, as distinguished by fictitious, forces in Newton's 2nd law of particle mechanics, is the dual form in terms of tangent vectors.

$$\hat{e}_{0(\text{static LNIF})} = \hat{e}_{t}\,(1 - A^{1/2}/r)^{-1/2}\,\partial/\partial t$$

$$\hat{e}_{1(\text{static LNIF})} = (1 - A^{1/2}/r)^{1/2}\,\partial/\partial r$$

$$\hat{e}_{2(\text{static LNIF})} = \hat{e}_{\theta}\,r^{-1}\,\partial/\partial\theta$$

$$\hat{e}_{2(\text{static LNIF})} = \hat{e}_{\varphi}\,(r\sin\theta)^{-1}\,\partial/\partial\varphi$$

The all-important proper off-geodesic acceleration of the test particle and also of LNIF detectors (they are different of course when the test particle and the detector are not rigidly clamped together) is, in the special case of the hovering static LNIF observer at fixed r:

$$g(r)_{(\text{static LNIF})} = \nabla\,\hat{e}_{0}\,\hat{e}_{0(\text{static LNIF})} = (1 - A^{1/2}/r)^{-1/2}\hat{e}_{r}\,A^{1/2}/2r^{2}$$

This radially outward pointing real proper acceleration on the static LNIF observer is the product of the gravity redshift time dilation factor $(1 - A^{1/2}/r)^{-1/2}$ with the gradient of the Newtonian gravity potential energy per unit test mass, multiplied by the unit radial vector $\hat{e}_r$. Remember, and this is counter-intuitive to the common sense of many mechanical aerospace engineers brainwashed in Euclidean geometry and Newtonian gravity force ideas, the static LNIF hovering observer is properly accelerating in curved spacetime, while standing still relative to the apparent source of the curvature at the horizonblack hole surface of area A. The apparent kinematical acceleration as measured by Doppler radars and the like is zero, even though the proper acceleration as measured by accelerometers is not zero. The quantum mechanical Unruh effect[cclxii] says that a detector with proper acceleration g will see a bath of blackbody real photons with temperature ~ hg/ck_B. This temperature is classically infinite at the black hole horizon. Of course, the Heisenberg uncertainty principle gives the horizon some quantum thickness, whose implications are profound – there must be a second higher energy Hawking radiation in addition to the one Hawking found. Therefore, the horizon is a Carnot heat engine.
Example 2 Radial Geodesic Non-Spinning LIF Lemaître Observers

To find an inertial frame, we can boost our static frame in the $\hat{e}_r$ direction by an undetermined boost parameter (depending on the radial coordinate), compute the acceleration vector of the new undetermined frame, set this equal to zero, and solve for the unknown boost parameter. The result will be a frame, which we can use to study the physical experience of observers who fall freely and radially toward the massive object. By appropriately choosing an integration constant, we obtain the frame of Lemaître observers, (LmIF) who fall in from rest at spatial infinity. In the static polar spherical chart, this frame can be written:

$$\hat{e}_{0(\mathrm{LmIF})} = \hat{e}_t \, (1 - A^{1/2}/r)^{-1/2} \, \partial/\partial t - \hat{e}_r \, (A^{1/2}/r)^{1/2} \, \partial/\partial r$$

$$\hat{e}_{1(\mathrm{LmIF})} = \hat{e}_r \, \partial/\partial r - \hat{e}_t \, (1 - A^{1/2}/r)^{-1} \, (A^{1/2}/r)^{1/2} \, \partial/\partial t]$$

$$\hat{e}_{2(\mathrm{LmIF})} = \hat{e}_\theta \, r^{-1} \, \partial/\partial \theta$$

$$\hat{e}_{2(\mathrm{LmIF})} = \hat{e}_\varphi \, (r \sin\theta)^{-1} \, \partial/\partial \varphi$$

Note that $\hat{e}_{0(\text{static LNIF})} \neq \hat{e}_{0(\mathrm{LmIF})}$ & $\hat{e}_{1(\text{static LNIF})} \neq \hat{e}_{1(\mathrm{LmIF})}$, and that $\hat{e}_{0(\mathrm{LmIF})}$ "leans inwards", as it should, since its integral curves are timelike geodesics representing the world lines of infalling observers. Indeed, since the covariant derivatives of all four basis vectors (taken with respect to $\hat{e}_{0(\mathrm{LmIF})}$) vanish identically, our new frame is a nonspinning inertial frame.

Static LNIFs do not exist inside the SSS black hole event horizon.

Example 3: In the same way that we found the Lemaître observers, we can boost our static frame in the azimuthal $\hat{e}_\varphi$ direction by an undetermined parameter (depending on the radial coordinate), compute the acceleration vector, and require that this vanish in the equatorial plane $\theta = \pi/2$. The new Hagihara frame describes the physical experience of observers in stable circular orbits around our massive object. ...

See http://en.wikipedia.org/wiki/Frame_fields_in_general_relativity for the formulae.

Thus, compared to a static observer hovering at a given coordinate radius, a Hagihara observer in a stable circular orbit with the same coordinate radius will measure radial tidal forces which are slightly larger in magnitude, and transverse tidal forces which are no longer isotropic (but slightly larger orthogonal to the direction of motion). Note that the Hagihara frame is only defined on the region $r > 3m = (3/2) A^{1/2}$. Indeed, stable circular orbits only exist on $r > 3A^{1/2}$, so the frame should not be used inside this locus. Computing Fermi derivatives shows that the frame field just given is in fact spinning with respect to a gyrostabilized frame. The principal reason why is easy to spot: in this frame, each Hagihara observer keeps his spatial vectors radially aligned, so $\hat{e}_{1(H)}$ & $\hat{e}_{3(H)}$ rotate about $\hat{e}_{2(H)}$ as the observer orbits around the central massive object. However, after correcting for this observation, a small precession of the spin axis of a gyroscope carried by a Hagihara observer still remains; this is the de Sitter precession effect (also called the geodetic precession effect).

One can also use the complex (Wheeler-Feynman Aharonov History-Destiny) Newman-Penrose light cone null tetrads.[cclxiii]

Calculations in the Newman–Penrose (NP) formalism of general relativity[cclxiv] normally begin with the construction of a complex null tetrad $\{l^a, n^a, m^a m^a{}^*\}$, where $\{l^a n^a\}$ is a pair of real null vectors and $\{m^a, m^a{}^*\}$ is a pair of complex conjugate null vectors.[cclxv] ...

l^a (n^a) are aligned with the outgoing retarded (Wheeler-Feynman[cclxvi]) history (Y. Aharonov[cclxvii]) offer (J. Cramer[cclxviii])(or ingoing advanced Wheeler-Feynman destiny (Aharonov) confirmation (Cramer)) tangent vector field of null radial geodesics
These spin 1 vector boson tetrad fields then entangle in pairs to get spin 0, spin 1 and spin 2 "gravitons" in the lowest S orbital angular momentum L = 0 state. However, the spin 0 and spin 1 must get rest masses via the Higgs bosons because we do not directly detect them at macroscopic distances.

Wheeler's Version of Einstein's Geometrodynamics[cclxix]

Rocklike (IT) spacetime, in addition to David Bohm's[cclxx] thoughtlike (BIT) quantum potential Q that operates from beyond spacetime, tells mass how to move on free-float weightless timelike geodesics where accelerometers measure zero local proper tensor acceleration. That is the action. The reaction is mass telling spacetime how to curve. If Einstein's 1916 geometrodynamics is merely a limiting case of Cartan's extension to it, then quantum spin and possibly orbital angular momentum of mass tell spacetime how to torsion causing dislocation cracks in the quantum gravity world crystal lattice of Hagen Kleinert, which must have a Fermi lattice spacing of 10^{-15} meters not Planck spacing of 10^{-35} meters[cclxxi] if the 't Hooft-Susskind[cclxxii] causal diamond[cclxxiii] observable universe is a hologram simulation is correct. This suggests a Yukawa strong finite-range micro gravity picture of nuclear forces with spin 0, spin1 and spin 2 components at the 1 Gev scale. Abdus Salam[cclxxiv] had such a spin 2 f-gravity idea[cclxxv] in the early 1970's, which, as I pointed out to him corresponded to the universal slope of Regge trajectories[cclxxvi] of hadronic string theory resonances that could be pictured as Kerr-type quantum black holes. Their Hawking radiation evaporation time[cclxxvii] would correspond to their instability. Including the quantum thickness evaporation of the horizon in addition to their original Hawking surface evaporation gives a much shorter black hole lifetime from gravity waves than previously computed using only electromagnetic waves. As of 2013 there is a newer model connecting two internal symmetry SU(3) theories to quantum gravity which comes from spacetime symmetries.

For completeness:
Minimal coupling of spin ½ fields ψ to Newton's gravity fictitious force (LNIFs), to Einstein's real gravity curvature field in the LIF, and to the real electromagnetic-weak-strong forces. This must be done in two steps, first, for the LNIFs only

$$D_{\mu(LNIF)}\psi = \partial_\mu\psi + \omega_\mu{}^I{}_J\, L_I{}^J\, \psi + A_\mu{}^\alpha L_\alpha \psi \quad (2.30)$$

The real gravity field spin connection is $\omega_\mu{}^I{}_J$. It contains information about the space-time curvature tensor, which does not vanish in the LIF. The Cartan 1-form[cclxxviii] spin connection is

$$\omega^I{}_{J(LIF)} = \omega_\mu{}^I{}_J\, e^{\mu(LNIF)}$$

Einstein's real gravity curvature field, is then given by the LIF Cartan 2-form exterior covariant derivative of the spin connection with itself:

$$R^{I}{}_{J(LIF)} = D\omega^{I}{}_{J(LIF)} + \omega^{I}{}_{K(LIF)} \wedge \omega^{K}{}_{J(LIF)}$$

The six $L_I{}^J$ are the matrix representations of the Lie algebra[cclxxix] generator "charges" of the Lorentz group[cclxxx] consisting of three space rotations and three spacetime rotations (boosts) in the representation of the ψ multiplet (column & row vectors). The internal symmetry connections four-potentials are $A_\mu{}^\alpha$ where L_α are the Lie algebra generator charges, again in the matrix representation dictated by ψ, of U1, SU2, SU3 unitary Lie groups[cclxxxi] for the electromagnetic, weak and strong real forces respectively. There is only one electric charge for U1, three weak force charges for SU2 and eight strong force gluon charges for SU3. SU2 and SU3 are Yang-Mills fields.[cclxxxii]
The second and final step is to include Newton's fictitious gravity force, which by the equivalence principle, is always equivalent to a local accelerating frame (LNIF) coincident with the LIF. We do this using the universal minimal coupling with the sixteen tetrad coefficients $e^\mu{}_I$ and the four Dirac gamma matrices γ^I [cclxxxiii] to end up with an absolute objective local covariant spinor derivative $D\psi$ invariant in both coincident LIF and LNIFs just like ds^2 is. This is actually quite beautiful. If you do not find this beautiful, then you have not understood the book the way I intended it. Perhaps that is my fault, perhaps yours or both? In any case, if you get this, then you understand the basic flaw in Jim Woodward's Sciama Mach model. Proceeding:

$$D\psi = \gamma^I e^\mu{}_I D_\mu \psi \quad (2.31)$$

Equations (2.30) and (2.31) are numbered as in Rovelli's Quantum Gravity notes.[cclxxxiv]
Returning to Wheeler:

1) Equivalence principle
2) Geometry
3) Geodesic equation of motion of point test particles (aka Newton's 1st Law first-order partial derivatives of the metric tensor field describe fictitious inertial pseudo-forces on the test particle corresponding to real forces on the detector)
4) Intrinsic tensor curvature geodesic deviation (disclinations of vectors parallel transported around closed loops in spacetime) from second order partial derivatives of the metric tensor field describing relative covariant tensor accelerations between two neighboring geodesic test particle each with zero g-force proper acceleration.

One must use the LIF to distill the intrinsic geometry of the real Einstein gravity field. The LNIF is fool's gold, MAYA, illusion, the shadow on the wall of Plato's Cave that has ship wrecked many a careless mariner including Isaac Newton listening to the wiles of Circe. The LNIF is contingent random noise, all sound and fury a tale told by an idiot, and believed by sorry bastards, a fairy tale, and a mask. Only Einstein escaped the Cave that Newton was trapped in. Of course, Newton had a good excuse. Newton's "gravity

force" is simply the real quantum electrodynamic force sustaining the static LNIFs. It is a fictitious pseudo-force as far as the observed test particle is concerned without any intrinsic objective reality, same ontic status as Coriolis and centrifugal pseudo-forces all parts of the LNIF Levi-Civita Christoffel symbols that depend only on first order partial derivatives of the metric tensor field. Einstein's equivalence principle (EEP) relegates them to Prospero's phantoms, the illusions of the Wizard of Oz behind the theater curtain of the world stage. There are three levels of the equivalence principle:

1) Weak – uniqueness/universality of free fall known to Galileo – the motion of any freely falling point test particle (or center of mass of an extended object) in vacuum is independent of its composition and structure.
2) *"A test particle is … electrically neutral … negligible gravitational binding energy compared to its rest mass … negligible angular momentum … [negligible] inhomogeneities of the gravitational field within its volume … the ratio of inertial mass to the gravitational passive mass is the same for all bodies."*
3) In every LIF the path of a force-free geodesic test particle is a straight line with constant speed in accord with Einstein's 1905 special theory of relativity that works increasingly well as the scale shrinks compared to the scale of curvature radii until quantum gravity is reached where the curvature field itself has large random zero point quantum fluctuations. Although this scale is thought to be 10^{-35} meters, the hologram conjecture combined with cosmology give a quantum gravity scale that is twenty powers of ten larger at 10^{-15} meters ~ (Planck length x area-entropy of our future dark energy de Sitter event horizon) $^{1/3}$.
4) Medium strong – metric theories of gravity. Einstein went beyond the weak form to the hypothesis that all the non-gravity laws of physics obey special relativity in a LIF in the same shrinking limit as above.
5) Very strong – replace non-gravity laws of physics with all the laws of physics.

In this book we assume 3) the very strong form as there is no experimental evidence yet that it is false. See the online Living Reviews of Relativity article by Cliff Will that is periodically updated for the confrontation of Einstein's general relativity with experiments.

Fermi Normal Coordinates for the LIF's Image of Intrinsic Geometry

"The metric tensor can indeed be written using the Riemann (curvature) tensor, in a neighborhood of a spacetime event, in a freely falling non-rotating local inertial frame to second order in the separation δx^i from the origin"

Where i,j,k,l are spacelike (outside local light cones with origins at the spacetime event of interest) 1,2,3 indices. The Taylor series expansion to lowest non-vanishing order for the LIF is

$$g_{00(LIF)} \sim - 1 - R_{0i0j}\delta x^i \delta x^j \quad \text{for the } 2^{nd} \text{ order LIF gravity redshift}$$

$$g_{0k(LIF)} \sim -(2/3)R_{0ikj}\delta x^i \delta x^j \quad \text{for the } 2^{nd} \text{ LIF drag gravimagnetic field}$$

$$g_{kl(LIF)} \sim \delta_{kl} - (1/3)R_{kilj}\delta x^i \delta x^j$$

for the curved spacelike 3-geometry. Next, consider what the physically coincident LNIF metric looks like including the first order terms that are zero in the LIF. Here u,v,w,z = 1',2',3' for LNIF like i,j,k,l = 1,2,3 for the coincident LIF. To repeat, the key idea is that the first order terms that depend on Γ describe the proper acceleration of the detector that is reinterpreted by the observer as a fictitious force on the test particle.

$$g'_{0'0'(LNIF)} \sim -1 - \Gamma_{u0'0'}\delta x^u - R'_{0'u0'v}\delta x^u \delta x^v \quad \text{gravity redshift (includes first order)}$$

$$g'_{0'v(LNIF)} \sim -\Gamma_{u0'v}\delta x^u - (2/3)R'_{0'uvw}\delta x^u \delta x^w \quad \text{gravimagnetic field}$$

$$g'_{uv(LNIF)} \sim \delta_{uv} - \Gamma_{wuv}\delta x^w - (1/3)R'_{uwvz}\delta x^w \delta x^z$$

The gravity redshift z is determined from

$$1 + z = [g_{00}(\text{absorber})/g_{00}(\text{emitter})]^{1/2}$$

$$1 + z = f_{emitter}/f_{absorber}$$

Where $z > 0$ is a redshift and $z < 0$ is a blueshift.
Newton's gravity force is purely 100% fictitious and corresponds to the first order terms in separation δx^u from the origin of the special static LNIF in the above Taylor series expansion of the metric tensor field. These are the Levi-Civita connection Γ terms, which by the equivalence principle, vanish in the physically coincident LIF.
Kornel Lanzcos in "On the Problem of Rotation in the General Theory of Relativity" proved that in any LNIF for test particle rest mass m:

1) $mg_{0'0'}{}^{-1}\Gamma^u{}_{0'0'}$ independent of the test particle's velocity corresponds both to Newton's gravity fictitious force $-GMmr/r^3$ in the particular contingent choice of the static LNIF and to the centrifugal force mwxwxr in the particular contingent choice of a uniformly rotating LNIF with angular momentum pseudo-vector w along the rotation axis. That we are in the slow speed weak curvature limit is understood.
2) $2mg_{0'0'}{}^{-1}\Gamma^u{}_{0'v'}dx^v/d\tau$ linear in the velocity of the test particle is the Coriolis fictitious force $2m\mathbf{w}x\mathbf{v}$ analogous to the magnetic Lorentz force in Maxwell's electrodynamics and to the vortex force in irrotational hydrodynamics. The Greek symbol τ refers to proper clock time along the world line of the test particle.
3) Finally, $mg_{0'0'}{}^{-1}\Gamma^u{}_{vw}(dx^v/d\tau)\ (dx^w/d\tau)$ quadratic in the velocity of the test particle is also a fictitious force. Lanzcos wrote that has no name and is usually too small to measure. However, I think Lanzcos was mistaken. When the rotating frame

radial unit vector er tracks the particle then this component describes centrifugal fictitious force. That is, the physical meaning of the connection components must be studied on a case-by-case basis. It is contextual depending precisely on the arbitrary choice of coordinates.

All of these fictitious forces blow up at horizons where the LNIF $g_{0'0'}$ vanishes. To summarize: an instrument defines each observable. Newton's fictitious force gravity field is defined by accelerometer technology. In contrast, Einstein's objectively real curvature gravity field is defined by gradiometer technology.[cclxxxv]

The relative covariant tensor acceleration between two freely-falling geodesic test particles each with zero local proper tensor acceleration, is

$$d^2\delta x^\alpha/dt^2 \sim R^\alpha{}_{0\mu 0}\delta x^\mu \quad \text{(i.e, equation of geodesic deviation)}$$

"The Riemann curvature tensor ... cannot be eliminated with a coordinate transformation. Therefore, the relative, covariant acceleration cannot be eliminated with a change of frame of reference."

Wheeler (with Ciufolini understood) wrote:

"In general relativity, the content and meaning of the strong equivalence principle is that in a sufficiently small neighborhood of any spacetime event, in a locally freely falling frame, no gravitational effects are observable. ... for every spacetime event (then excluding singularities) for any experimental apparatus, with some limiting accuracy, there exists a neighborhood, in space and time, of the event, and infinitely many local freely falling frames, such that for every nongravitational phenomenon the difference between the measurements performed (assuming that the smallness of the spacetime neighborhood does not affect the experimental accuracy) and the theoretical results predicted by special relativity (including the Minkowskian character of the geometry) is less than the limiting accuracy and therefore undetectable in the neighborhood. ... For a test particle in orbit around a mass M, the geodesic deviation equation gives

$$d^2\delta x^a/dt^2 \sim R^a{}_{0b0}\delta x^b \sim \omega_o{}^2\delta x^a \qquad (2.1.2)$$

Where ω_o is the orbital frequency. Thus, one would sample large regions of the spacetime if one waited for even one period of this oscillator. We must limit the dimensions in space and time of the domain of observation to values small compared to one period if we are to uphold the equivalence principle."

That is, the scale of temporal curvature is the orbital period itself; therefore, each LIF can only extend in time for duration much less than the orbital period. Mathematically this constraint is formulated as

$$\delta x^a /c << 1/\omega_o$$

The gravity field that is eliminated in the LIF is Newton's static LNIF fictitious gravity pseudo-force field encoded in the Levi-Civita connection along with all the other fictitious pseudo-inertial forces as shown by Lanzcos above. The Levi-Civita connection is zero at the center of mass origin of the LIF. All the fictitious forces that the LNIF observer mistakenly attributes to the test particle under observation are real forces on the LNIF itself. The test particle is on an arbitrary timelike world line, geodesic or not. In contrast, the LNIF is on an arbitrary off-geodesic timelike world line. Therefore, having eliminated Newton's mirage to the precision we can obtain with our technology, how do we measure Einstein's real gravity field, i.e., the curvature tensor field induced by mass-energy source currents?[cclxxxvi] The answer is basically simple; increase the resolution precision setting of your detector so that you "see" regions larger than the locally variable

scales of curvature outside of the domain of validity of the LIF approximation. More precisely, we are measuring at least the second quadratic order terms in the Taylor series expansion of the metric tensor, i.e., to repeat because it is important:

$$g_{00(LIF)} \sim -1 - R_{0i0j}\delta x^i \delta x^j \quad \text{for the LIF second order gravity redshift}$$

$$g_{0k(LIF)} \sim -(2/3)R_{0ikj}\,\delta x^i \delta x^j \quad \text{for the LIF drag second order gravimagnetic field}$$

$$g_{kl(LIF)} \sim \delta_{kl} - (1/3)R_{kilj}\,\delta x^i \delta x^j \quad \text{for the curved spacelike 3-geometry}$$

"A liquid drop which has surface tension, and which resists distortion from sphericity, supplies an additional example of how to interpret the equivalence principle. In order to detect a gravitational field, the measurable quantity – the observable – is the tidal deformation δx of the drop. … if we choose a small enough drop, we will not detect any deformation because the tidal deformations are proportional to the size D of the small drop … this can be easily seen from the geodesic deviation equation with a springlike force term (3.6.1), in equilibrium: (k/m) δx ~ $R^i_{0j0}D \sim MD/R^3$, where M is the mass of an external body and $R^i_{0j0} \sim M/R^3$ are the leading components of the Riemann tensor generated by the external mass M at distance R. Thus, in a spacetime neighborhood, with a given experimental accuracy, the deformation δx, is unmeasurable for sufficiently small drops." P. 17

In other words:

$$\delta x \sim (m/k)R^i_{0j0}D \sim mMD/kR^3$$

Therefore the observable tidal distortion of the drop δx can always be made smaller than the resolution L of the detector until the quantum gravity limit is reached.

"We overthrow yet a third attempt to challenge the equivalence principle – this time by the use of a modern gravity gradiometer – by suitably limiting the scale or time of action of the gradiometer. Thus either one needs large distances over which to measure the gradient of the gravitational field, or one needs to wait a period of time long enough to increase, up to a detectable value, the amplitude of the oscillations measured by the gradiometer. Similarly, with gravitational wave detectors (resonant detectors, laser interferometers etc. …) … In the final attempt to challenge the equivalence principle one may try to measure the local deviations from geodesic motion of a spinning particle, given by the Papapetrou equation … these deviations are … $d^2\delta x^i/dt^2 \sim R^i_{0uv}J^{uv}$ where J^{uv} is the spin tensor of the particle and $u^0 \sim 1$. However, general relativity is a classical – nonquantized – theory. Therefore … one has to consider only classical angular momentum of finite-sized particles. However, the classical angular momentum goes to zero as the size goes to zero …"

Remember, Einstein's 1916 theory is disclination curvature only. The larger Einstein-Cartan theory has an independent dislocation torsion field. Just like supersymmetry[cclxxxvii], it should be there. The Einstein-Cartan theory is the local gauge theory of the Poincare group and supersymmetry is the Dirac square root of the Lie algebra of the Poincare group. The Poincare group is a subgroup of Roger Penrose's conformal twistor group. Indeed, this twistor group must be locally gauged to get the extended gravity theory. The twister group contains the Rindler horizons with Hawking radiation that is closely connected with Einstein's equivalence principle and is the basis of Ted Jacobson's attempt to derive gravity from quantum thermodynamics. The

quantum spin is a source of torsion in some models. However, the classical orbital angular momentum of the mass-energy currents both real outside the quantum vacuum and virtual inside the quantum vacuum should also be a source one would think.
The geodesic equation is simply Newton's first law of motion in a non-inertial frame. The Levi-Civita connection is essentially the physical description of non-inertial frames plus some extra space coordinate gauge redundancy. Newton's gravity theory is simply the choice of static LNIFs in the Schwarzschild metric in the weak-field slow-speed limit from the POV of GR. Newton's non-tensor Levi-Civita connection first order gravity field is a fictitious force on the test particle measured by accelerometers clamped to the off-geodesic non-inertial frames measuring real forces on those frames. Einstein's real gravity curvature tensor field is measured by gravity gradiometers. The ideal way to measure Weyl tensor vacuum spacetime curvature is to exchange electromagnetic signals between two closely separated freely falling LIF transceivers in several different spatial orientations to measure their relative tidal stretch-squeeze kinematical accelerations. The local proper accelerations on each LIF are zero, so accelerometers are of no use there. However, most practical curvature measurements are made in non-inertial frames LNIFs, which is where the accelerometers and other sensor technologies come into play.[cclxxxviii]

The symmetric torsion-free Levi-Civita metric-determined connection field for parallel transporting geometric objects along world lines connecting different quasi-flat LIF tangent space fibers of the curved LNIF base space in the world fiber bundle is in a special coordinate basis (holonomic basis):

$$\Gamma^{\alpha}{}_{\chi\beta} = \Gamma^{\alpha}{}_{\beta\chi} = (1/2)g^{\alpha\sigma}(g_{\sigma\beta,\chi} + g_{\sigma\chi,\beta} - g_{\beta\chi,\sigma}) = \{^{\alpha}{}_{\beta\chi}\} \qquad (2.2.3)$$

Where the connection takes the form of Christoffel symbols on the extreme right of (2.2.3). The comma denotes ordinary partial derivative and the equation numbers are those of Wheeler and Ciufolini. Repeated lower and upper indices are summed over 0,1,2,3 where 0 is always the timelike direction inside the local light cones. These Christoffel symbols in the holonomic basis are not homogeneous multilinear tensors under the continuous group of general coordinate transformations of the locally gauged translation subgroup T4(x) of the Poincare group, but transform with an inhomogeneous term for nonlinear transformations LNIF $\Leftrightarrow$ LNIF' as:

$$\Gamma^{\alpha'}{}_{\beta'\gamma'(LNIF')}$$

$$= (\partial x^{\alpha'}/\partial x^{\sigma})\,(\partial x^{\mu}/\partial x^{\beta'})\,(\partial x^{\nu}/\partial x^{\gamma'})\Gamma^{\sigma}{}_{\mu\nu(LNIF)} + (\partial^{\alpha'}x/\partial x^{\sigma})\,(\partial^{2}x^{\sigma}/\partial x^{\beta'}\partial x^{\gamma'}) \neq 0$$

What is the physical meaning of these transformations? First of all, The Levi-Civita connection is not a third rank tensor under nonlinear transformations connecting physically coincident different local non-inertial frames each with non-vanishing proper acceleration. There is no GCT non-zero third rank tensor hidden inside the Levi-Civita

connection. That is a totally crank idea in my opinion.[3] This is related to the fact that the spin-connection Cartan one form $\omega^{I}{}_{J}(x)$ is, similarly, not a tensor under nonlinear transformation $\lambda^{I}{}_{K}(x)$ zero forms of the locally gauged Lorentz subgroup of the Poincare group connecting physically coincident local inertial frames: LIF $\Leftrightarrow$ LIF' as shown explicitly in Rovelli's eq. 2.56 in his on-line quantum gravity notes. There is a typo in Rovelli's equation (2.56) , which should be in Cartan 1-form notation:

$$\omega^{I'}{}_{J'}(x)_{(LIF')} = \lambda^{I'}{}_{K}(x)\, \omega^{K}{}_{L}(x)_{(LIF)}\ \lambda_{J'}{}^{L}(x) + \lambda^{I'}{}_{K}(x) d\lambda_{J'}{}^{K}(x)$$

$$d^2 = 0$$

Indeed, the spin connection Cartan one form $\omega^{K}{}_{L}(x)_{(LIF)}$ is the induced multiplet of six Lorentz group spin 1 vector gauge boson disclination defect gravitons whose entangled pairs contribute to the spin 2 Lorentz group gravitons of Einstein's theory at the quantum level. The four tetrad Cartan one forms e^{I} are also induced spin 1 vector gauge boson dislocation defect graviton fields. However, in Einstein's 1916 theory, the four ad-hoc constraint of zero torsion

$$De^{I} = de^{I} + \omega^{I}{}_{J}(x) \wedge e^{J} = 0$$

Results in Rovelli's very complicated eq. (2.89):

$$\omega^{IJ}{}_{\mu}(x) = 2e^{\nu[I}\, \partial_{[\mu} e_{\nu]}{}^{J]} + e_{\mu K}\, e^{\nu I}\, e^{\sigma J} \partial_{[\sigma} e_{\nu]}{}^{K}$$

$$\omega^{IJ}(x) = -\,\omega^{JI}(x) = \omega^{IJ}{}_{\mu}(x)\, dx^{\mu} = 2e^{\nu[I}\, \partial_{[\mu} e_{\nu]}{}^{J]}\, dx^{\mu} + e_{\mu K}\, e^{\nu I}\, e^{\sigma J} \partial_{[\sigma} e_{\nu]}{}^{K}\, dx^{\mu}$$

The square brackets mean, as usual, anti-symmetrization of the indices.
LIF Lorentz group indices, I,J,K are raised or lowered with the appropriate locally flat Minkowski metric η^{IJ} or η_{IJ} respectively. Similarly use the LNIF curvilinear metric $g^{\mu\nu}$ and $g_{\mu\nu}$ to raise or lower the LNIF indices.
Obviously, the real gravity field is in the six spin connection Cartan one-forms that, in Einstein's 1916 GR limit of zero independent dynamical torsion, is determined by the four tetrad one-forms and their antisymmetrized first order partial derivatives. All of the

[3] I have had an on-line email debate on this point for maybe ten years with Paul Zielinski who invokes Einstein's unfortunate informal remark that the freely falling frame is "accelerating" (i.e. kinematic $dV_{LIF}/ds \neq 0$ whilst $DV_{LIF}/ds = 0$) so that there is "cancellation" between two gravity fields in the LIF. Zielinski insists there is a non-zero third rank tensor for the non-tidal gravity field within Einstein's 1916 theory. I insist that this tensor is zero. It is not zero, however, in the Einstein-Cartan extended theory with both curvature and torsion as independent geometrodynamical fields. The torsion third rank tensor addition to the affine connection is assumed to be zero in 1916 GR. There is also the teleparallelism theory preferred by Waldyr Rodrigues, Jr of UNICAMP, Brazil, in which Einstein's 1916 as well as several non-metrical alternative theories of gravity in the literature. So far, with the possible exception of dark energy and dark matter as the elephant and the gorilla in the room, there seems to be no evidence for torsion and non-metricity additions to Einstein's 1916 GR.

Cartan one-forms are T4(x) local frame invariants, but they are not local Lorentz group invariants. Remember that accelerometers locally measure off-geodesic g-force proper first-rank tensor (4-vector) accelerations. Second of all, remember that two local frame/detector/observers Alice and Bob must be physically very close together in the same sense that the LIFs are small compared to the locally varying radii of curvature. Alice and Bob are each free to move on any physically possible timelike world line always inside their local light cones. There are subgroups of physical importance as mentioned already in Chapter 1 in an intuitive way. When Alice and Bob are both on nearly intersecting free-float timelike LIF geodesics, the transformations are that of the 6-parameter Lorentz Lie group SO(1,3) with generators of the Lie algebra consisting of three space rotations and three velocity boosts. When Alice is on a LIF geodesic and Bob in a LNIF is not, or vice versa, then we have the tetrad map that formalizes Einstein's equivalence principle.[cclxxxix]

$$\Gamma^{I}_{JK(LIF)} = (\partial x^{I}/\partial x^{\sigma})\,(\partial x^{\mu}/\partial x^{J})\,(\partial x^{\nu}/\partial x^{K})\Gamma^{\sigma}_{\mu\nu(LNIF)} + (\partial^{I}x/\partial x^{\sigma})\,(\partial^{2}x^{\sigma}/\partial x^{J}\partial x^{K}) = 0$$

Again, I repeat because it is so important. This is the tetrad map equation connecting LIF indices I,J,K for the locally flat Minkowski metric in Cartesian coordinates η_{IJ} with coincident LNIF indices, σ,μ,ν with the coincident curvilinear metric $g_{\mu\nu}$. In Cartan form notation, we have a set of nonlinear partial differential equations for the sixteen tetrad coefficients in terms of the LNIF Levi-Civita connection coefficients. Einstein's equivalence principle in the form that Newton's fictitious force vanishes at the origin center of mass in any local inertial frame (LIF) is in terms of the sixteen tetrad coefficients connecting the pair of physically momentarily coincident non-inertial and inertial frames like two ships almost colliding in the night:

$$\Gamma^{I}_{JK(LIF)} = e^{I}_{\sigma}\, e^{\mu}_{J}\, e^{\nu}_{K}\, \Gamma^{\sigma}_{\mu\nu(LNIF)} + e^{I}_{\sigma} e^{\sigma}_{J,K} = 0$$

Therefore, the above tetrad equations are another aspect of the purely mathematical "cancellation" of Newton's first order gravity inertial force field of the geodesic equation that Einstein and Wheeler talk about.[ccxc] "First order" in the sense of Chapter 1's metric tensor expansion in displacement δx away from the center of mass origin of the LNIF:

$$g'_{0'0'(LNIF)} \sim -1 - \Gamma_{u0'0'}\delta x^{u} - R'_{0'u0'v}\delta x^{u}\delta x^{v}$$

$$g'_{0'v(LNIF)} \sim -\Gamma_{u0'v}\delta x^{u} - (2/3)R'_{0'uvw}\,\delta x^{u}\delta x^{w}$$

$$g'_{uv(LNIF)} \sim \delta_{uv} - \Gamma_{wuv}\delta x^{w} - (1/3)R'_{uwvz}\,\delta x^{w}\delta x^{z}$$

Einstein's equivalence principle is simply that the Γ linear terms are zero in the LIF. The Γ linear terms apply only to the point like center of mass of the LNIF. The equivalence principle is trivial if one looks at its physical meaning clearly and directly. Because the linear Γ terms the above Taylor series expansion of the LNIF metric field represent

fictitious forces on the observed object that are simply real forces on the LNIF measuring apparatus, it's obvious that if you remove the real forces on the LNIF, then Γ is zero at the center of mass of the LNIF and LNIF $\rightarrow$ LIF. It makes no physical sense whatsoever to claim the above tetrad map's formal cancellation represents the cancellation of two real forces and/or "kinematical acceleration fields." That is muddled thinking in my opinion without any reason, as there is no way to independently measure the two alleged real forces that cancel each other. Finally, we have the case when both Alice and Bob are off-geodesic LNIF's. The latter corresponds to localizing the four-parameter translation subgroup of the ten-parameter Poincare group that is the ground of Einstein's 1905 special theory of relativity – with the subsidiary condition constraint that the dynamically independent dislocation torsion field is suppressed to be zero even though esthetically it wants to burst out of its prison like Merlin under the spell of The Lady of the Lake. In any case the fourth rank Riemann curvature tensor components are the structure constants of the covariant curl of first rank tensor vector field. The semi-colon represents the covariant partial derivative.

$$\text{Curl A} = \text{D x A} = A^{\alpha}{}_{;\beta\chi} - A^{\alpha}{}_{;\chi\beta} = R^{\alpha}{}_{\sigma\chi\beta}A^{\sigma} \qquad (2.2.4)$$

What we here on Earth experience as Newton's gravity force is, in reality, an unbalanced quantum electrodynamic real force keeping us at fixed distance from the Earth's center of mass in the curved spacetime generated by Earth's mass. This is called the static LNIF. I mention again since so many have difficulty grasping this that we have real non-zero proper tensor acceleration whilst, so to speak, standing still in curved spacetime. The fourth rank Riemann curvature tensor of Wheeler's (2.2.4) above in Einstein's 1916 tensor language that he learned from Marcel Grossmann is the covariant curl of the connection for parallel transport through the LIF tangent fiber space with itself, i.e.,

$$R^{\alpha}{}_{\beta\chi\delta} = \Gamma^{\alpha}{}_{\beta\delta,\chi} - \Gamma^{\alpha}{}_{\beta\chi,\delta} + \Gamma^{\alpha}{}_{\sigma\chi}\Gamma^{\sigma}{}_{\beta\delta} - \Gamma^{\alpha}{}_{\sigma\delta}\Gamma^{\sigma}{}_{\beta\chi} \qquad (2.2.5)$$

OK, imagine that you are with Alan Turing at Bletchley Park in the summer of 1940 trying to break the Nazi coded messages to submarines in the Atlantic attacking convoys from America and to the Luftwaffe bombing London, you see (2.2.5). You have to know that the commas mean ordinary partial derivative, that you sum over repeated upper and lower dummy indices through 0 for timelike inside the light cones at the event (a small three dimensional sphere in 4D spacetime, where the tensor is measured in principle to some approximation. All waves shorter than the size of the sphere are integrated out. The other three spacelike indices 1,2,3 are outside that local light cone. Most important of all is to remember that the essential physical meaning of the Levi-Civita connection symbols Γ is to describe the fictitious forces that appear to act on the pairs of freely falling geodesic test particles measured by the gravity-gradiometer that is clamped to the LNIF in which the curvature tensor is being measured. Newton's first law (aka the geodesic equation) is simply the vanishing of the first rank tensor proper acceleration of the test particle provided it has constant rest mass along its world line $X^{u}(t)$, i.e., for the accelerating LNIF Doppler radar detector

$$D^2X^u/d\tau^2 = d^2X^u/d\tau^2 + \Gamma^u{}_{vw}(dX^v/d\tau)(dX^w/d\tau) = 0$$

$$d\tau = g_{00}{}^{1/2}dt$$

However, in the coincident LIF the fictitious force term ~ Γ is zero and we only have the 1905 special relativity 4-acceleration term $d^2X^u/d\tau^2$, which is also equal to zero. Returning to the LNIF, suppose its Doppler radar shows a test particle with speed u moving close to the speed of light, in that case we must use for the special relativity 4-vector test particle acceleration, the time dilated components:

$$d^2X^u/d\tau^2 = dU/d\tau = (c\gamma d\gamma/dt, \gamma(d\gamma/dt)\mathbf{u} + \gamma^2\mathbf{a})$$

$$= (\gamma^4\mathbf{a}.\mathbf{u}/c, \gamma^2 a + \gamma^4(\mathbf{a}.\mathbf{u}/c2)\mathbf{u})$$

$$\gamma = (1 - u^2/c^2)^{-1/2}$$

$$\mathbf{u} = d\mathbf{r}/dt \text{ 3-vector}$$

$$\mathbf{a} = d\mathbf{u}/dt \text{ 3-vector}$$

If the test particle is on a timelike geodesic then, of course, **a** = 0.
The LNIF metric tensor field here is again, including both LNIF first order gravity redshifts and gravimagnetic frame drags as well as LIF second order gravity redshifts and gravimagnetic frame drags.

$$g'_{0'0'(LNIF)} \sim - 1 - \Gamma_{u0'0'}\delta x^u - R'_{0'u0'v}\delta x^u\delta x^v$$

$$g'_{0'v(LNIF)} \sim - \Gamma_{u0'v}\delta x^u - (2/3)R'_{0'uvw}\delta x^u\delta x^w$$

$$g'_{uv(LNIF)} \sim \delta_{uv} - \Gamma_{wuv}\delta x^w - (1/3)R'_{uwvz}\delta x^w\delta x^z$$

The first order terms ~ Γ are contingent Newtonian artificial gravity effects like in the rotating space station of Stanley Kubrick's film Space Odyssey. The real intrinsic objective gravity effects are in the second order and that subset of higher order terms that do not have Γ factors. Remember that the test particle fictitious force connection symbols Γ describe the real forces pushing the LNIF gravity-gradiometer off a local timelike geodesic of the curvature field being measured. These equations only work well when the measuring instruments are close to the test particles being measured, i.e. separations between observed and observer small compared to the local radii of curvature. Finally, invoking Einstein's Equivalence Principle (EEP) if we switch off the real forces on the gravity-gradiometer, it's now LIF and the connection symbols Γ vanish at the center of

mass (COM) origin of the LIF but their partial derivatives (first two terms on the RHS of 2.2.5) do not vanish and we are back to the now oft-repeated very important:

$$g_{00(LIF)} \sim - 1 - R_{0u0v}\delta x^u \delta x^v$$

$$g_{0v(LIF)} \sim - (2/3)R_{0uvw}\,\delta x^u \delta x^w$$

$$g_{uv(LIF)} \sim \delta_{uv} - (1/3)R_{uwvz}\,\delta x^w \delta x^z$$

Mach's Principle Origin of Inertia

The role of the gravitational field is to determine the real force-free geodesic patterns, both null for light rays and timelike inside the local light cones for real test particles with non-zero rest masses m. The key point here is that, the test particle rest masses m cancel out of the geodesic equation completely exactly like any other fictitious force that appears to act on a test particle but really does not. The fictitious force is entirely an optical illusion due to the off-geodesic world line that the observer is not. Provided that there is no constraint between the test particle and the observer-detector, the fictitious forces do not cause accelerometer pointers to move off their zero mark. This is the empirical operational definition of a real force. The only real forces we know of for sure in 2014 are the electromagnetic, weak and strong forces. Newton's non-tidal gravity force expressed as the affine Levi-Civita-Christoffel connection is a fictitious force exactly like the rotational centrifugal and Coriolis fictitious pseudo-forces. Indeed, this is a consequence of Einstein's equivalence principle. Indeed, Einstein did not consider curvature as necessary for gravity fields. Curvature in Einstein's opinion was sufficient but not necessary for there to be an empirical gravity field. In other words, Einstein did not give as much weight to the distinction between artificial and real gravity fields. Artificial gravity fields with zero curvature can be eliminated by global frame transformations over a large region of spacetime, real gravity fields with non-zero curvature cannot be so eliminated. They can only be made of negligible effect locally in a small region of spacetime – small compared to the radii of curvature far from a real black hole singularity.[ccxci]

The geodesic equation means zero proper tensor acceleration DV/ds = 0 where D/ds is the covariant directional derivative along the timelike tangent vector of the real test particle corresponds to Newton's first law of particle mechanics. The affine connection terms describe the fictitious forces on the test particle that, in turn, is the effect of real forces on the observer-detectors. Newton's second law of particle mechanics is F = mDV/ds where F is a real force (only electromagnetic, weak or strong) pushing the test particle off a timelike geodesic of the actual gravitational field. Therefore, m is the inertial resistance to such a push.

THE PROBLEM OF INERTIA IN FRIEDMANN UNIVERSES

JOSEPH SULTANA
Department of Mathematics, Faculty of Science, University of Malta Msida MSD2080, Malta
joseph.sultana@um.edu.mt

DEMOSTHENES KAZANAS
Astrophysics Science Division, NASA/Goddard Space Flight Center Greenbelt, Maryland 20771, USA
demos.kazanas@nasa.gov

"In this paper we study the origin of inertia in a curved spacetime, particularly the spatially flat, open and closed Friedmann universes. This is done using Sciama's law of inertial induction, which is based on Mach's principle, and expresses the analogy between the retarded far fields of electrodynamics and those of gravitation. After obtaining covariant expressions for electromagnetic fields due to an accelerating point charge in Friedmann models, we adopt Sciama's law to obtain the inertial force on an accelerating mass m by integrating over the contributions from all the matter in the universe. The resulting inertial force has the form $F = -kma$, where $k < 1$ depends on the choice of the cosmological parameters such as Ω_M , Ω_Λ , and Ω_R and is also red-shift dependent." (Cited as KS below)

The above gravity "retarded far fields" are gravity wave radiation that falls off in a spherical wave from a point source as 1/r. I do not think one can explain inertia here from these retarded gravity waves of positive energy collapsing on the test particle along its past light cone. The idea strikes me as obviously nuts because we have not yet succeeded in detecting any gravity waves directly locally the coupling is too weak.[ccxcii]

Far field gravity waves are real on mass shell f = ck spin 2 gravitons in two transverse polarization states in macro-quantum coherent Glauber states.
Near field[ccxciii] gravity fields right at the particles are obviously more important. They consist of all five spin 2 polarization states of off-mass-shell f =/= ck virtual gravitons also in macro-quantum coherent Glauber states.[ccxciv]

"The concept of inertia has been one of the most debated topics of classical physics, starting with Newton's ideas of absolute space and that of inertia as an intrinsic property of matter devoid of any external influence. Leibniz and later Bishop Berkeley who claimed that it is metaphysical criticized the notion of absolute space. They were followed by Ernst Mach 1 who in 1872 rejected the existence of absolute space in favour of relative motion with respect to a "fixed" frame provided by the matter distribution in the universe, and claimed that it is the acceleration relative to this frame that determines the inertial properties of matter."

The above seems to be only a quaint Victorian notion of a global fixed frame, after all such a thing is not permitted in Einstein's 1916 GR. Only local frames are permitted. Local means the spacetime region of validity of the frame is small compared to the radii of curvature of 4D spacetime. Furthermore, all the physical transformations idealized by differential geometry's "diffeomorphisms" (too much excess math baggage for us mechanics in the Starship engine room) must be between locally coincident local frames Alice and Bob, who can both observe Eve who can be far away on their almost common past light cone. However, most of what I said above is not really true because of Higgs-

Goldstone spontaneous symmetry breaking of the Lorentz spacetime symmetry group of the quantum vacuum at large cosmological scales. The Friedman-Walker-Lemaitre-Robinson metric used in modern cosmology has a scale factor a(t) where t is an absolute cosmic time with three-dimensional spacelike slices that are almost flat k = 0. The Cosmic Microwave Background (CMB) black body radiation from the Big Bang 13.7 billion years ago provides a Hubble flow frame of reference of absolute rest in which the radiation is maximally isotropic, the same in all directions of the sky to one part in a hundred thousand, which is pretty damn good. Not only that, but the peculiar local velocities of distant stars and galaxies etc. are all quite small compared to the speed of light. The 2005 Ph.D. dissertation of Tamara Davis from the University of New South Wales is free on line and has the details that I do not have time and space to discuss in this book. Of course the laws of physics are still Lorentz group symmetric even though the quantum vacuum state solution to them is not. The same thing happens in many condensed matter systems, for example, in the ferromagnet the absolute zero temperature quantum ground states have most of the spins pointing in the same direction of space even though the equations of the ferromagnetic are rotationally symmetric. There are other examples like the superconductor in which the internal U1 symmetry of electromagnetism is spontaneously broken given the photon a rest mass inside the superconductor and expelling magnetic flux from its interior in the Meissner effect that form quantized magnetic flux vortices in Type II superconductors. However, the several spacetime symmetries of Einstein's general relativity are obeyed in the local field equations, but are violated in the ground state quantum vacuum solutions. Another example is that total energy is not conserved in our universe because time translation symmetry is broken. The energy density is proportional to $a(t)^{-3(1 + w)}$,where w is the ratio of pressure to energy density in the equation of state for the gravitating source. There is a constant dark energy density w = - 1 and as the universe speeds up in its rate of expansion the total amount of dark energy increases as the total amount of light energy w = +1/3 decreases, while the total amount of real particle ordinary cold matter w = 0 is conserved. Furthermore, virtual spin 1 bosons like light have positive quantum vacuum zero point fluctuation energy with negative quantum pressure because one can prove that w = -1 from Lorentz invariance of the field equations combined with Einstein's equivalence principle. The negative pressure is three times stronger than the positive energy density and, this gives a universally repulsive anti-gravity field exactly like we see in the dark energy. Similarly, the virtual spin ½ fermion-antifermion pairs inside the quantum vacuum have negative energy density with positive quantum pressure. Again the pressure is three times stronger than the energy density and this generates an attractive quantum gravity field like we see in dark matter. That dark matter comes from virtual particles immediately explains why we do not detect them here on Earth with WIMP detectors. Hermann Herman Bondi showed us at Cornell in the late 1950s how a plate of dark energy with an equal amount of dark matter in a second plate parallel to the first would be a warp drive engine for something like a flying saucer time travel machine. The positive pressure plate attracts the negative pressure plate, while the negative pressure plate repels the positive pressure plate. This generates a weightless timelike self-propelled timelike geodesic. Remember, according to the equivalence principle there is zero non-tidal gravity field on a timelike geodesic inside the local light cones. In other words, you are weightless in free-fall. The other side of this same coin is that when a real

electric force pushes you off a geodesic, you then feel heavy as if you are at rest in a gravity field. Indeed, when you are in a real gravity field in curved spacetime you need an electric force to push you off a weightless timelike geodesic in order to "hover" or stand still at the same place in the curvature field. This is also called the "static LNIF." It is counter intuitive because in flat Euclidean space, if you accelerate you are moving not staying in the same place relative to other objects that are not accelerating. This is the subtle distinction between tensor proper acceleration DV/ds and kinematical acceleration dV/ds, which are measured in different ways independently of each other. Thus we arrive at the naive idea of acceleration relative to the stars used by Dennis Sciama, Jim Woodward and other Machians! That is almost astrology. Sure, we can measure apparent kinematical accelerations of distant objects on our past light cones, but the only accelerations that matter for "inertia" are obviously the locally measurable tensor proper accelerations. Only the local deviations away from timelike geodesics are important for the origin of the rest masses of test particles. These rest masses cancel out of the timelike geodesic motions.

"This is the essence of Mach's Principle, a term coined by Albert Einstein in 1918, which says that "the inertial force which acts on an accelerating object is due to its interaction with all matter present in the rest of the universe". There are indeed several interpretations of Mach's principle and arguments on whether the general relativity theory is Machian or not. ... if we choose the currently favored cosmological parameters $\Omega_M = 0.3$, $\Omega_\Lambda = 0.7$ *we get* $F = -0.23ma$."

The coefficient 0.23 would have to be 1 for Sciama's theory to work. The above calculation is for k = 0 flat 3D space, however there is new evidence that k = -1 in a hyperbolic 3D space of negative curvature. The Sciama theory then gives an even smaller Mach screening coefficient ~ 0.19. The integral, however, is only along our past history light cone out to our past particle horizon. The Wheeler-Feynman-Aharonov destiny future light cone advanced potential effect is not in the Sultana-Kazanas paper. It could conceivably give the total 1^{ccxcv}, which would be startling since the Sciama theory must be wrong on other grounds – it violates Einstein's general relativity for a number of deep reasons. What are these reasons? It is always dangerous to argue from analogy. Indeed, this was Dennis Sciama's really greatest blunder at Cambridge University way back in 1953 in the dark ages of cosmology. In Einstein's gravity theory, Newton's gravity potential energy gets absorbed into the metric field g_{uv}, whose Levi-Civita connection, from its first order partial derivatives, becomes Newton's gravity "force." However, we have seen that Newton's gravity force is a fictitious force on the observed test particle's center of mass because an accelerometer rigidly clamped to it shows zero. In contrast, an accelerometer placed at the origin of the static LNIF detector on Earth's surface does show what we regard as Newton's gravity force. It is not a gravity force at all. It is an unbalanced electrical force keeping the LNIF detector at rest relative to the source of the Earth's gravity curvature tensor field. Newton's theory was only designed for that special set of static LNIFs fixed to the surface rock of Earth. In contrast, the goal is to explain Newton's second law of motion, which is, in the simplest case in a LIF, $\mathbf{F} = m\mathbf{a}$. The real **3-vector force** is **F**, the rest mass of the test particle is m, and the **3-vector acceleration a** must be the spacelike part of the proper acceleration that pushes the test object off the local timelike geodesic of the total ambient curvature field. Here, we have a contradiction because in the Sciama theory the acceleration dependent gravity force must be fictitious

not real! The Sciama model is based on a false analogy, which at first sight looks deceptively simple and pretty. Maxwell's electrodynamics says that the electric 3-vector field is

$$\mathbf{E} = -\nabla\phi + \partial\mathbf{A}/\partial t$$

Sciama then assumes that by analogy:

$$-\nabla\phi = -\, GM\mathbf{r}/r^3$$

$$\partial\mathbf{A}/\partial t = GM\mathbf{a}/c^2 r = (r_s/r)\ \mathbf{a}$$

Using a corollary of Gauss's theorem in Newtonian gravity potential theory

"For example, a hollow sphere does not produce any net gravity inside. The gravitational field inside is the same as if the hollow sphere were not there (i.e. the resultant field is that of any masses inside and outside the sphere only)."[ccxcvi]

Therefore, since the universe on a large scale is supposed to be isotropic and homogeneous, the integral of $\nabla\phi$ term using the standard cosmological FLRW metric for all the masses of the universe is supposed to vanish. OK, this is plausible as a rough back-of-the-envelope argument that is not rigorous the way the KS paper is. Arguing still in this intuitive analogical way, one can guess on dimensional grounds that for the entire universe $r_s/r = 1$. That was basically Sciama's idea back in 1953. It is superficially neat and appealing. However, we know from our detailed analysis of the physical meaning of the Levi-Civita connection as the representation of fictitious forces that alleged Newtonian second law expression

$$\partial\mathbf{A}/\partial t = GM\mathbf{a}/c^2 r = (r_s/r)\ \mathbf{a}$$

Must correspond to terms $\sim \partial g_{0i}/\partial t$, which vanish in the LIF because of the equivalence principle, and therefore, cannot explain the origin of inertial resistance to the real electromagnetic-weak-strong forces that push test charges off the local timelike geodesics of the physical curvature tensor field. Furthermore, the FLRW cosmological metric[ccxcvii] has zero **A** as defined properly in terms of GR by Kip Thorne, Cliff Will et-al. Bottom line, the Sciama model violates Einstein's "happiest thought" - the equivalence principle that requires Newton's gravity force to be a fictional force, not a real force that accelerometers measure locally and directly.

James F. Woodward, in his book "Making Starships and Stargates" uses Sciama's vector model of gravity to propose a method of starship propulsion. However, for the reasons I have given I don't think it can work. Woodward is actually doing real experiments in the lab to test his theory, which is admirable, but the results are marginal and inconclusive and I believe will remain so.[ccxcviii] Of course, I hope to be proved wrong here.

My Amazon Review of James F. Woodward's book

"Making Starships and Stargates" Springer 2013 V2

Jack Sarfatti

John G. Cramer, proponent of the transactional interpretation of orthodox quantum theory based on the Wheeler-Feynman back-from-the-future advanced potential of classical electromagnetism, endorses Woodward's theory in the "Foreword"[i] I will play Devil's Advocate usually assigned to Wolfgang Pauli. I pretty much agree with most of Woodward's "Preface" except for his short shrift for the reality of flying saucers operated by an advanced intelligence. I mean, "advanced" in two senses including the back-from-the-future meaning. So I will home in on what I think are Woodward's mistakes in his theory. I have nothing intelligent to say about his experiments except that scientists at Oak Ridge National Laboratory seemingly refuted them about fourteen years ago and that Woodward has not succeeded in getting a small model to fly under its own power in those fourteen years. Neither have any of his competitors in the fringe physics propellantless propulsion world. Of course, we Pirates of Penzance are all on the same side against the establishment pundits of physics who, in Cramer's words:

"Erect a 'picket fence' around those solutions of Einstein's equations … to place stable traversable wormholes, faster-than-light warp drives, and time machines in the forbidden area outside the fence … it is presumed that nature does not allow such disreputable objects to exist.

Woodward professes that "both inertial reaction forces and mass itself" have a "gravitational origin." (p.xviii) He hedges on whether his approach will allow us to manufacture practical stargates (i.e., traversable wormholes without event horizons that do not pinch off killing the traveler and destroying any message in a signal) but is more optimistic that "at least a means of propellant-free propulsion can be created using Mach effects."(p.xix) Using orthodox theory assuming Newton's G requires an impossible Jupiter mass of exotic negative mass matter to make a stargate of few tens of meters across. Woodward invokes the classical 1960 ADM model. Curiously, I was a graduate student in physics at Brandeis in 1960 when Deser was there creating that model. Woodward does not seem to realize that he needs David Bohm's hidden variable picture of classical particles piloted by a quantum information field in order for the ADM model to make sense. Niels Bohr's "Copenhagen interpretation" with its magical collapse of the state does not even allow such a picture as ADM suggest. Since I am partial to Bohm's picture, this is not a bad thing. Woodward alleges that the ADM model "when fixed" shows that there is a lot of negative energy matter locked inside ordinary matter like the electron. Of course, we now know since 1998 that about 68% of our observable universe's stuff is exotic "dark energy" exactly what we need. However, its energy density 6.7×10^{-10} Joules/meter^3 is way too small for our purpose unless we can amplify it by many powers of ten. Perhaps, the advanced intelligences in the flying saucers are doing just that? Woodward claims that the negative exotic matter creating universally repelling antigravity is screened at a distance by distant matter by. This is definitely not

mainstream textbook physics taught in the top universities. He proposes a kind of catalytic avalanche effect, like the straw that broke the camel's back, or the butterfly wing flapping creating a super storm across the world, a pistol shot causing an avalanche. [ii] What is disturbing, however, is Woodward's Frankenstein Monster supposing he were on the right track, fortunately my bet is that he is not, but I could be wrong. Woodward intends to expose a Jupiter mass of exotic matter as his end product, and to concentrate it in a region a few meters across. If this isn't madness I don't what is. ;-)

[i] *"Woodward extended the work of Sciama in investigating the origins of inertia in the framework of general relativity by consideration of time-dependent effects that occur when energy is in flow while an object is being accelerated. … It predicts large time-dependent variations in inertia, the tendency of matter to resist acceleration. … The inertial transient effects … have G in the denominator, and dividing by a small number produces a large effect. … he has been able to demonstrate tens of micronewton-level thrusts … they represent convincing evidence that Woodward-Sciama inertial transients are a real physical phenomenon and that the underlying calculations behind them should be taken seriously … Personal flying cars and reactionless heavy-lift Earth-to-orbit space vehicles cannot be ruled out … The … inertial transient … second term, which is always negative and can in principle drive the inertial mass to zero or negative values … could … be used to provide the 'exotic mass' needed to stabilize wormholes and produce superluminal warp drives. " P.ix*

[ii] *"Exotic matter is available in everyday matter, normally screened by the gravitational interaction with chiefly distant matter in the universe. … exposure can be achieved by cancelling the gravitational effect of the chiefly distant matter with nearby exotic, negative rest mass matter. The amount … needed to trigger this is miniscule in comparison with the Jupiter mass that results from exposure. Mach effects … produce the exotic matter required … for exposure." P.xix*

Page 8 chapter 3rd paragraph down of "Making Starships …"

"The notion has gotten abroad since the advent of general relativity that inertia - the property of the massive objects that makes them resist acceleration by external forces - does not involve force."

Professor Woodward gives no reference in the literature back up this statement, which to me seems totally bizarre red herring no one actually says anything like that. He then goes on to make some obscure unintelligible remark about inertial forces. In fact, Einstein's general relativity says nothing at all about the origin of inertia where by the word "inertia" we mean resistance to external force. That Einstein may have initially thought there was a connection is irrelevant because his final equations showed that there was no such connection after all. Indeed, the role of the gravitational field is to provide force-free motions - the geodesics.

$$F^u = DP^u/ds = D(mV^u)/ds \rightarrow ma^u$$

is Newton's 2nd law of test particle motion in an arbitrary local frame of reference. "Inertia" = m as resistance to proper tensor acceleration $a^u = DV^u/ds$ measured locally with an accelerometer clamped to the test particle. In contrast, dV^u/ds = kinematical acceleration measured not locally with light signals using a Doppler radar located at the origin of the frame of reference. If the test particle has constant "inertia" m then

Newton's 2nd law becomes Newton's first law when the real force $F^u = 0$. There is no Newton's third law here as yet. That requires additional physical assumptions. In Newton's 2nd law F is the unbalanced net force on the test particle - no assumption about back-reaction on the source of F need be made yet. What PURE general relativity does is to provide the global Γ^u_{vw} fields for a given class of observers for the GEODESIC real force-free F = 0 test particle orbits. The inertia m of the test particles is nowhere to be seen at this classical level of pure gravity. If we only had gravity all motions would be geodesics. However, we could not have stable sources Tuv with pure gravity. The inertia of test particles canceled out of the geodesic equation of motion. Therefore by elementary logic gravity cannot explain the origin of the inertia of test particles. The only exception would be Wheeler's wormhole geons mass without mass etc., but that also needs non-gravity quantum physics.

On Mar 12, 2014, at 2:26 AM, James F. Woodward wrote:

I wouldn't have spent my time writing the book if I didn't think that there is a reasonable chance we will eventually be able to build starships and stargates. And, truth be told, leaving the details of the enabling physics aside, it seems to me obvious that the only way to create a Jupiter mass of exotic matter in a structure with the dimensions of meters is to find a way to transform normal matter into the exotic matter needed in situ. As I say in the book, I do not claim that the ADM electron model is a substitute for the standard model of RQFT. But it sure has a lot of desirable features to recommend it -- like includng gravity without having to assume that gravity at short range miraculously becomes decades of orders of magnitude stronger than it is at all other scales. And I really like Asim Barut's lepton quantization scheme.

Dark Energy as Destiny Hawking Radiation

The basic local frame invariant is the space-time separation between two neighboring events, which incorporates Einstein's equivalence principle

$$ds^2 = g_{\mu\nu}(\text{LNIF})dx^{\mu}dx^{n} = \eta_{IJ}(\text{LIF})dx^{I}dx^{J}$$

The LIF metric $\eta_{IJ}(\text{LIF})$ is always written in Cartesian coordinates where the 4x4 matrix has diagonal elements -1, 1, 1,1 with all off-diagonal elements 0.
There are three connected mappings of locally coincident frame transformations. The actual small detectors that are the local frames must be separated by distances that are small compared to the locally variable radii of spacetime curvature for this to be an accurate theory.

"In the middle of the journey of our life I found myself within a dark woods where the straight way was lost."
— *Dante Alighieri, Inferno*

This physical interpretation is the master with the formalism of differential geometry as the slave not the other way around. So long as the physical interpretation is logically and formally consistent and leads to predictions that agree with experiment we can jettison much of the excess formal baggage of the associated pure mathematics that compulsive semi-autistic theoretical physicists get bogged down in as an occupational disease and which requires a wasted lifetime divorced from contact with physical reality to master if one is not a pure mathematician. One example that comes to mind of course is string theory, although the situation there seems to be improving in terms of contact with experiment.

1) Locally gauged 6-parameter Lorentz group $SO_{1,3}(x)$ space-time rotations of geodesic non-rotating LIF↔LIF'
2) Local 4-parameter general coordinate gauge transformations of off-geodesic LNIF↔LNIF' whose group is the locally gauged translation group $T_4(x)$.
3) Tetrad mapping of coincident LIF↔LNIF'

Weak gravity wave fields[ccxcix]

This is Einstein's linearized GR in first order perturbation theory, which misses important horizon effects where $g_{00} = 0$.

$$g_{\mu\nu(\text{LNIF})} \sim \eta_{\mu\nu(\text{LIF})} + h_{\mu\nu(\text{LNIF})}$$

$$\eta_{\mu\nu(\text{LIF})} >> h_{\mu\nu(\text{LNIF})}$$

$$\Gamma^{\alpha}{}_{\beta\chi(\text{LNIF})} \sim (1/2)\eta^{\alpha\sigma}(h_{\sigma\beta,\chi} + h_{\sigma\chi,\beta} - h_{\beta\chi,\sigma}) + ...$$

$$R_{\alpha\beta\chi\delta} \sim -(1/2)(h_{\alpha\gamma,\beta\delta} + h_{\beta\delta,\alpha\gamma} - h_{\alpha\delta,\beta\gamma} - h_{\beta\gamma,\alpha\delta}) + ...$$

A comma means partial derivative, and we sum repeated upper and lower indices over, 0,1,2,3. The LIF Minkowski metric signature is (-,+,+,+). The symbol ~ means "approximately equal to." The linearized special relativity wave operator is

$$\Box = \eta^{\mu\nu}\partial_\mu\partial_\nu = - \partial_0^2 + \nabla^2$$

$$\partial_0 = c^{-1}\partial_t$$

The linearized Ricci tensor has this wave propagation in it. Thus,

$$R_{\mu\nu} = R_{\alpha\mu\beta\nu}g^{\alpha\beta} \sim - (1/2)[h_{,\mu\nu} + \Box h_{\mu\nu} - \eta_{\sigma\rho}(h_{\mu\sigma,\rho\nu} + h_{\nu\sigma,\rho\mu})$$

$$h = \eta^{\mu\nu} h_{\mu\nu} = -h_{00} + h_{11} + h_{22} + h_{33}$$

Impose the gravity analog to the electromagnetic covariant Lorentz gauge constraint for spin 1 vector (first rank tensor) photons

$$\partial_\mu A^\mu = 0$$

In Fourier transform frequency-wave vector space this constraint equation is

$$- (\omega/c)A_0 + \mathbf{k}\cdot\mathbf{A}_k = 0$$

The physical meaning of the constraint is that there are only three independent polarization states. Real rest massless photons only have the two transverse polarizations to k in the far field where they fall off as 1/r for a spherical wave from a point source. Coherent Glauber quantum states of virtual photons with all three polarizations form the non-radiating near fields of electric motors, solenoids, power transmission lines without which modern civilization would collapse into Thomas Hobbes's nasty post-Apocalyptic "State of Nature."

The more complicated gravity gauge constraint consists of the four tensor equations

$$\partial_\mu(h^{\mu\nu} - (1/2)h\eta^{\mu\nu}) = 0$$

$$\partial_\mu h^{\mu\nu} = (1/2)\,\partial^\nu h$$

This is also called the linearized harmonic gauge constraint. In this gauge, the linearized Ricci tensor is

$$R_{\mu\nu} \sim - (1/2)\Box h_{\mu\nu}$$

Einstein's 1916 GR field equations in this weak field linearized approximation against the non-dynamical globally flat Minkowski metric of his 1905 special theory of relativity are the constrained spin 2 gravity tensor wave equations to first order only in perturbation expansion in powers of h and/or

$$T = \eta^{\mu\nu} T_{\mu\nu} = - T_{00} + T_{11} + T_{22} + T_{33}$$

$$\Box (h_{\mu\nu} - (1/2)h\eta_{\mu\nu}) \sim - (16\pi G/c^4)T_{\mu\nu}$$

which is equivalent to

$$\Box h_{\mu\nu} \sim - (16\pi G/c^4)(T_{\mu\nu} - (1/2)T\eta_{\mu\nu}) \text{ spin 2 gravity } \textit{weak field}$$

In particular

$$\Box h_{00} \sim - (16\pi G/c^4)(T_{00} - (1/2)(T)\ \eta_{00})$$

$$\Box h_{00} \sim - (16\pi G/c^4)(T_{00} - (1/2)(- T_{00} + T_{11} + T_{22} + T_{33})\ \eta_{00})$$

$$\Box h_{00} \sim - (16\pi G/c^4)[T_{00} + (1/2)(- T_{00} + T_{11} + T_{22} + T_{33})]$$

$$\Box h_{00} \sim - (8\pi G/c^4)(T_{00} + T_{11} + T_{22} + T_{33})$$

In the isotropic special case

$$T_{11} = T_{22} = T_{33} = p = \text{pressure}$$

$$T_{00} = \rho = \text{energy density}$$

$$\Box h_{00} \sim - (8\pi G/c^4)\ \rho(1 + 3w)$$

In the static weak near field limit made from Glauber macro-quantum phase coherent states of uncertain numbers of virtual spin 2 gravitons:

$$\Box h_{00} \rightarrow \nabla^2 h_{00}$$

$$h_{00} = 2V_{Newton}/c^2$$

$$\nabla^2 V_{Newton} \sim -(4\pi G/c^2)\rho\,(1 + 3w)$$

Therefore, Einstein's GR has a new pressure source term not found in Newton's theory of gravity. In fact, w = 0 for real cold dark matter particles whizzing through space with v/c << 1. It can be proved that w = + 1/3 for far field massless photons, and w = -1 for all zero point vacuum fluctuations both bosons and fermions. That w = -1 follows from local Lorentz invariance plus the equivalence principle.

Stargates and warp drive require exotic stress-energy currents. There are several ways to get them. We see that the virtual zero point bosons have negative quantum pressure causing a repulsive anti-gravity field that may be dark energy. The virtual fermion-antifermion pairs obey the Pauli exclusion principle this gives positive quantum pressure causing an attractive gravity field that may be dark matter. The relative densities of these two classes of virtual particles will determine whether the quantum vacuum appears as dark energy or as dark matter. So far all attempts to locally detect real dark matter particles whizzing through space have failed. Looking for them may be like looking for the motion of Earth through the Victorian mechanical aether of James Clerk Maxwell with a Michelson-Morley interferometer. There are two other ways to get the exotic mass-energy stress currents we need for stargate time travel to distant places and times including our past on closed timelike world lines (CTCs). Destiny waves back from our future will antigravitate if they obey the anti-Feynman boundary condition on his propagators. We see elsewhere there is good evidence for this as Hawking radiation from our future de Sitter cosmological event horizon. Finally, we have superconducting meta-materials. The superconductor makes the speed of light in the meta-material small close to zero. It is the fourth power of the speed of light in the denominator of G/c4 that is the warping power coupling strength of applied electromagnetic fields to the metric engineering of the local curvature geometrodynamic fields. The negative electric permittivity and negative magnetic permeability make the non-radiative virtual photon near field electromagnetic stress-energy currents negative instead of positive giving us, *I conjecture*, amplified controllable repulsive anti-gravity. [ccc]
Compare to the analogous Maxwell electromagnetic field equation in the covariant Lorentz gauge constraint

$$\Box A_\mu \sim J_\mu \text{ spin 1 EM field}$$

The metric field $h_{\mu\nu}$ is a symmetric second rank tensor in four-dimensional spacetime with four diagonal and six off-diagonal independent components.
However, there are four Lorentz gauge constraints leaving six undetermined variables. There are four more general coordinate gauge transformations so that leaves only two on-mass-shell (light cone) independent components corresponding to the two independent massless gravity far field transverse polarized stretch-squeeze Weyl tensor gravity waves that Kip Thorne's LISA and LIGO are trying to detect directly on Earth and in near Earth space. We already have indirect measurements from binary pulsars.
How a source particle generates a real gravity wave far field in the weak field approximation.

The source of the torsion-free Einstein 1916 gravity local Poincare group gauge field is the symmetric 2nd rank stress-energy current density tensor $T_{\mu\nu}$ whose general form is a square 4x4 matrix-like array of components. Where $\rho = T_{00}$ is the purely timelike energy density, $S_i = T_{0i}$ is the mixed spacetime generalized Poynting vector energy flux (power flow per unit cross sectional area), and π_{ij} is the 3x3 spacelike stress tensor that generalizes the notion of pressure (force per unit area) to include anisotropic media. The source particle has rest mass m_0, four velocity $V_\mu(\tau)$ on world line $y^\mu(\tau)$ with proper clock time τ along its world line. The source particle stress-energy current density tensor is the classical world line (not quantum) path integral with the Dirac delta function constraint

$$T_{\mu\nu}(x) = m_0 \int d\tau\, V_\mu(\tau)V_\nu(\tau)\delta(x - y(\tau))$$

The weak gravity field linearized (first order perturbation theory away from the non-dynamical Minkowski globally flat spacetime of Einstein's 1905 special theory of relativity of the rigid Poincare symmetry group) far field gravity wave equations are:

$$\Box h_{\mu\nu} \sim -(8\pi G/c^4)\, m_0 \int d\tau\, (2V_\mu(\tau)V_\nu(\tau) + \eta_{\mu\nu})\, \delta(x - y(\tau))$$

Whose far field radiative solutions are the light cone-limited retarded (-) and advanced (+) Wheeler-Feynman Lienard-Weichert potentials:

$$h_{\mu\nu}(x) \sim (-2Gm_0/c^2)\, V_\mu(\tau)V_\nu(\tau)\, /V\cdot\delta(x -(+)\, y(\tau))|_{[x - y(\tau)]^2 = 0}$$

The RHS for the retarded (-) potential "is evaluated at the point where the particle path $y(\tau)$ intersects the past light cone with apex at x." (Matt Visser)
In the special case that the source particle is on a timelike geodesic of the Minkowski non-dynamical background with zero proper acceleration:

$$h_{\mu\nu}(x) \sim (-2Gm_0/rc^2)V_\mu(\tau)V_\nu(\tau)$$

Which in the rest frame $\mathbf{V} = 0$ of the source particle becomes we get a non-radiative near field solution corresponding to virtual photons of zero frequency and all wave vectors weighted by k^{-2} in macro-quantum coherent Glauber states

$$h_{00}(x) \sim (-2Gm_0/rc^2) = 2V_{Newton}/c^2$$

The Arnowitt-Deser-Misner (ADM) strong field metric field 3+1 split is

$$g_{00}(t, \mathbf{x}) = -(N^2 - g^{ij}\beta_i\beta_j)$$

$$g_{0i}(t, \mathbf{x}) = \beta_i$$

And the three-dimensional purely spacelike 3-geometry metric $g_{ij}(t, \mathbf{x})$
The spacelike indices outside the local frame invariant light cone are i,j = 1,2,3. N is the timelike lapse function and the three β_j are the spacelike shift functions, with g_{ij} as the spacelike hypersurface three-dimensional metric field. This representation is useful for the description of stargates.
One reason that Jim Woodward's use of Dennis Sciama's spin 1 vector field Mach Principle model of gravity that I briefly discussed in Chapter 3 violates Einstein's "happiest thought," the equivalence principle is that Maxwell's electromagnetic field theory is the local gauge theory of the non-universal compact internal U(1) symmetry group. In contrast, Einstein's geometrodynamic field theory is the local gauge theory of the universal Poincare spacetime symmetry group P(10) plus the zero torsion field constraint. The equivalence principle of weightless timelike geodesics locally determined by the local curvature tensor field is closely linked to the universality of the spacetime symmetries that apply to all matter fields in exactly the same way. Therefore, Newton's gravity field encoded in the Christoffel symbols of the torsion-free Levi-Civita metric connection field is a fictitious force, just like the Coriolis and centrifugal forces in the absence of rigid mechanical constraints of course. Mathematically, the electromagnetic vector potential A_μ is the connection field for parallel transport of geometric objects in the extra-dimensional circle fiber space where each circle fiber hair has its root at a space-time event. Note that a space-time event is not a point on a bare manifold, but is an equivalence class consisting of an infinite set of such bare manifold points[cccci] that are all connected by general coordinate gauge transformations between physically coincident local frames of reference both LNIF and LIF. Not realizing this has confused many people I know. The analogous electromagnetic gauge transformations $A_\mu \rightarrow A'_\mu = A_\mu + \partial_\mu f$ moves points around the circle fiber independently at each spacetime event.
Now, one of several problems with James Woodward's MET theory for starship propulsion is that the gravity wave equation is for the metric field not for the Levi-Civita connection that is a combination of first order partial derivatives of the metric field.

$$\Gamma^{\alpha}{}_{\beta\chi(\mathrm{LNIF})} \sim (1/2)\eta^{\alpha\sigma}(h_{\sigma\beta,\chi} + h_{\sigma\chi,\beta} - h_{\beta\chi,\sigma}) + ...$$

It is the fictitious Newton gravity force connection for parallel transport $\Gamma^{\alpha}{}_{\beta\chi}$ that is analogous to the electromagnetic A_μ connection again for parallel transport in terms of the local gauge theory using the mathematics of fiber bundles.[ccccii] In electromagnetic field theory, it is the curvature 4-curl of the connection A_μ that makes the real electromagnetic Lorentz force that pushes test charges off their gravity curvature field timelike geodesics. Similarly, in gravity, it is only the curvature 4-curl of the Levi-Civita connection that is second order in partial derivatives of the metric field that is the objectively real Einstein gravity field as distinct from Newton's fictitious gravity force that is only first order in the partial derivatives of the metric field and which vanishes in the LIF in accord with "Einstein's happiest thought." Note however, that gravity curvature is geodesic deviation between neighboring pairs of real force-free test particles each on timelike geodesics. Therefore, accelerometers clamped on each of them in vacuum will show zero. In that case, Doppler radars on each test particle can measure their relative kinematic acceleration. On the other hand, if a mechanical spring connects the two test masses, then accelerometers will register off zero from the electrical reaction forces induced in the

spring by the curvature tensor field. This is indeed how most gravity gradiometers work using sets of accelerometers connected in various ways not only with mechanical springs. This set of linearized non-self interacting gravity wave equations has both far field and near field solutions. The 1/r far field spherical waves only have two Weyl stretch-squeeze transverse polarization states. These are Glauber macro-quantum coherent states of spin 2 real gravitons on the classical light cone mass shell poles of the Feynman propagator in the complex energy plane of quantum field theory. The usual boundary condition is a contour in this complex energy plane that goes around the poles

$$(\omega/c) - k = 0$$

Such that retarded spherical waves of positive energy real quanta $h\omega > 0$ propagate on the forward light cone from present to future, whilst advanced Wheeler-Feynman spherical wave quanta of negative energy $hw < 0$ propagate on the past light cone from present to past. These waves will cause attractive gravity. In contrast, the mirror image anti-Feynman contour does just the opposite propagating positive energy real quanta along the past light cone and negative energy quanta along the future light cone. This is indeed, what happens in back from the future advanced Hawking-Unruh black body radiation from our observer-dependent future de Sitter cosmological horizon whose redshifted energy density that we see in our present day detectors as the Einstein cosmological constant with the actually observed dark energy density $\sim hc/L_P^2A$ and peak wavelength $(L_PA^{1/2})^{1/2}$, where A is the area-entropy of our future horizon where it intersects our future light cone. Since this corresponds to negative energy propagating forward in time with w = pressure/energy density = +1/3 this advanced Hawking radiation with the anti-Feynman boundary condition generates the repulsive antigravity accelerating the expansion rate of 3D space in our universe.

Einstein's Curved Spacetime vs. Quantum Field Theory's Flat Spacetime[ccciii]

The curved spacetime paradigm is based on three sets of mathematically formulated laws: Einstein's field equation, which describes how matter generates the curvature of spacetime; the laws which tell us that perfect rulers and perfect clocks measure the lengths and times of Einstein's curved spacetime; and the laws which tell us how matter and fields move through curved spacetime, for example, that freely moving bodies travel along straight lines (geodesics). The flat spacetime paradigm is also based on three sets of laws: a law describing how matter in flat spacetime, generates the gravitational field; laws describing how that field controls the shrinkage of perfect rulers and the dilation of the ticking rates of perfect clocks; and the laws describing how the gravitational field also controls the motions of particles and fields through flat spacetime. Kip Thorne, P. 401

In the weak field first order perturbation theory case relative to the globally flat Minkowski spacetime of Einstein's 1905 Special Relativity, Fourier transformed Feynman propagators in four-momentum k-space using plane wave basis[ccciv] can be defined with the results:

$$\Delta_0 \sim k^{-2} \text{ spin 0 scalar boson like the Higgs vacuum superconductor}$$

$$\Delta_{1\mu\nu} \sim \eta_{\mu\nu} k^{-2} \text{ spin 1 vector boson like photon \& W bosons}$$

$$\Delta_{1\mu\nu\sigma\rho} \sim \eta_{\mu\nu}\eta_{\sigma\rho} k^{-2} \text{ spin 2 tensor boson like graviton}$$

$$k^2 = - k_0^{\,2} + \mathbf{k}^2$$

"In order to produce a static force and not just scattering, the emission or absorption of a single graviton by either particle must leave both particles in the same internal state. This rules out the possibility that the graviton carries half-integer spin … when the exchanged particle carries odd integer spin, like charges repel and opposite charges attract, just as in the example of electrodynamics. On the other hand, when the exchanged particle carries even integer spin, the potential is universally attractive… If we assume that the exchanged particle is spin 0, then we lose the coupling of gravity to the spin 1 photon. Since we know that light is deflected by massive objects, e.g. the Sun, then the graviton cannot be spin 0."[cccv]

However, the modern way of doing general relativity uses the tetrads, which are a kind of spin 1 vector field square root of the spin 2 metric tensor fields. This would then give spin 0, spin 1 and spin 2 "gravitons" for quantum entangled tetrad quanta in the lowest orbital S-wave. A Higgs-Goldstone type vacuum spontaneous symmetry breaking could give masses to the spin 0 and spin 1 gravitons, but not to the spin 2 graviton. Indeed, these massive spin 0 and spin 1 gravitons might correspond to parts of the complicated low energy nuclear force.

Spin 0 gravity has the lowest order Feynman diagram quantum amplitude

$$T^{\mu}{}_{\mu}(1)\, k^{-2}\, T^{\nu}{}_{\nu}$$

However, $T^{\mu}{}_{\mu}(1) = 0$ for the electromagnetic field, which is why spin 0 scalar gravity has no bending of light.

Spin ½ gravity does not give Newton's static near field force in lowest order perturbation theory because it emerges from the coherent interference of two Feynman diagrams, one where nothing happens,

$$\uparrow\uparrow$$

The other is the Feynman diagram where a single massless virtual particle is exchanged.

$$\uparrow\leftarrow\text{virtual graviton}\rightarrow\uparrow$$

These pieces are complex numbers.

Coherent interference where the Born probability P is

$$P = |\uparrow\uparrow+\uparrow\leftarrow\text{virtual graviton}\rightarrow\uparrow|^2$$

Is not possible for spin ½ because such an emission cannot leave the source in the same internal state it started in. Coherent interference of Feynman quantum amplitudes can only happen if there is no way, even in principle, to distinguish the two alternative histories. Feynman shows that exchanging a single virtual spin zero massless graviton does give a 1/r static potential to lowest order. He then computes the exchange of two un-entangled spin ½ massless gravitons to get a $1/r^3$ static potential, which is no good.

Boson source fields have symmetric quantum wave functions for all permutations among N identical particles representing a base state in second-quantized Fock occupation number space.

Spin 0 has ϕ scalar potential.

Spin 1 has A_{μ} vector potential.

Spin 2 has $h_{\mu\nu}$ symmetric tensor potential

"Another theory would result from assuming that the tensor was antisymmetric; it would not lead to something resembling gravity, but rather something resembling electromagnetism; the six independent components of the antisymmetric tensor would appear as two space vectors." Feynman pp. 31-32

For electromagnetism in four-momentum Fourier transform space, for source current j_μ to lowest order perturbation theory

$$A_\mu = - k^{-2} j_\mu$$

The lowest order Feynman diagram connecting two current sources has minimal coupling amplitude is the frame invariant scalar

$$j'_\mu A^\mu = - j'_\mu k^{-2} j^\mu$$

Choose c = 1 and

$$k^\mu = (\omega, \kappa, 0, 0)$$

$$x^\mu = (t, z, y, x)$$

$$A_\mu = (A_0, A_3, A_2, A_1)$$

Substituting and remembering summation on repeated upper and lower indices with the flat spacetime Minkowski metric tensor before imposing retarded past to future history and advanced back from the future destiny boundary conditions on the Green's propagation functions

$$- j'_\mu k^{-2} j^\mu = - (\omega^2 - \kappa^2)^{-1} (j'_0 j_0 - j'_3 j_3 - j'_2 j_2 - j'_1 j_1)$$

Local conservation of electrical current densities is described by the equation

$$k_\mu j^\mu = 0$$

This constraint implies

$$j_3 = (\omega / \kappa) j_0$$

Real spin 1 photons correspond to the pole factor $(\omega^2 - \kappa^2)^{-1}$ blowing up to infinity, i.e., mass shell (light cone) is $\omega = \kappa$ for 1/r spherical far field radiation from point sources with only two transverse 1 & 2 polarization states. However, even more important for starship warp drive/stargate metric engineering are the virtual spin 1 photon and virtual spin 2 graviton non-radiative near fields where $\omega \neq \kappa$, and there are extra polarization states 3. Now we see an amazing result from simple algebra.

$$- j'_\mu k^{-2} j^\mu = - (\omega^2 - \kappa^2)^{-1} (j'_0 j_0 - j'_3 j_3 - j'_2 j_2 - j'_1 j_1)$$

$$= - (\omega^2 - \kappa^2)^{-1} (j'_0 j_0 - (\omega/\kappa)^2 j'_0 j_0 - j'_2 j_2 - j'_1 j_1)$$

$$= - (\omega^2 - \kappa^2)^{-1} j'_0 j_0 (1 - (\omega/\kappa)^2) - (\omega^2 - \kappa^2)^{-1} (- j'_2 j_2 - j'_1 j_1)$$

$$= - (\omega^2 - \kappa^2)^{-1} [(\kappa^2 - \omega^2)/\kappa)^2] j'_0 j_0 + (\omega^2 - \kappa^2)^{-1} (j'_2 j_2 + j'_1 j_1)$$

$$= (1/\kappa)^2 j'_0 j_0 + (\omega^2 - \kappa^2)^{-1} (j'_2 j_2 + j'_1 j_1)$$

The term $(1/\kappa)^2 j'_0 j_0$ is the Fourier transform of the electrostatic 1/r Coulomb potential energy between two point charges. This potential term independent of frequency ω seems to act instantaneously, but we see that this is an illusion coming from cancellation of the $(\omega^2 - \kappa^2)$ propagation factors in numerator and denominator from local current density conservation. Feynman's equation (3.2.9) is that the inverse Fourier transform

$$(FT)^{-1} \{(1/\kappa)^2 j'_0 j_0\} = (e^2/4\pi r)\delta(t - t') \quad (3.2.9)$$

The Dirac delta function $\delta (t - t')$ means zero time delay in this static potential. Feynman wrote:

"This is always the leading term in the limit of small velocities. The term appears instantaneous, but this is only because the separation we have made into two terms is not manifestly covariant. The total interaction is indeed a covariant quantity; the second term represents corrections to the instantaneous Coulomb interaction." P.33

Essentially the same thing occurs for the spin 2 gravity case, but the algebra is more complicated. However, it's so important that we will go through Feynman's first order perturbation theory calculation in four momentum Fourier transformed spacetime in detail. The source stress tensor induces the metric field in a linear way in this approximation with the non-dynamical globally flat Minkowski special relativity metric field.

$$h_{\mu\nu} = k^{-2} T_{\mu\nu}$$

Where the basic Feynman diagram for the exchange of a single spin 2 graviton

Is the local frame invariant scalar minimal coupling is Feynman's (3.3.4).

$$T'_{\mu\nu}h^{\mu\nu} = T'_{\mu\nu}\, k^{-2}\, T^{\mu\nu}$$

$$= (\omega^2 - \kappa^2)^{-1} [T'_{00}T_{00} - 2T'_{03}T_{03} - 2T'_{02}T_{02} - 2T'_{01}T_{01}$$

$$+ 2T'_{23}T_{23} + 2T'_{31}T_{31} + 2T'_{21}T_{21}$$

$$+ T'_{33}T_{33} + T'_{22}T_{22} + T'_{11}T_{11}]$$

In the special case that the source mass-energy current density tensor is homogenous and isotropic, the off-diagonal tensor $T_{\mu\nu}$ components are zero and the three pressure space diagonal components are equal. The result is

$$T'_{\mu\nu}h^{\mu\nu} =$$

$$= (\omega^2 - \kappa^2)^{-1} [T'_{00}T_{00} + T'_{33}T_{33} + T'_{22}T_{22} + T'_{11}T_{11}]$$

$$= (\omega^2 - \kappa^2)^{-1}\, T'_{00}T_{00}\, [1 + 3T'_{33}T_{33}/\, T'_{00}T_{00}]$$

$$= (\omega^2 - \kappa^2)^{-1}\, \rho^2\, [1 + 3w^2]$$

Where ρ is the energy density and w is the ratio of pressure to energy density of the mass-energy source of the curved spacetime metric field.
The geometrodynamic zero torsion field Bianchi identity plus Einstein's gravity field equations implies local conservation of the matter field stress-energy current densities. That is,

$$k^{\mu}T_{\mu\nu} = 0$$

$$\omega T_{0\nu} = -\, \kappa\, T_{3\nu}$$

Eliminate index 3 in Feynman's equation (3.3.4) above, gives two contributions. The first is the static quasi-instantaneous near field

$$T'_{\mu\nu}h^{\mu\nu}{}_{\text{quasi static}}$$

$$= -\kappa^{-2} [T'_{00}T_{00}\, (1 - \omega^2/\kappa^2) \; - 2T'_{02}T_{02} - 2T'_{01}T_{01}]$$

The static limit is $\omega \rightarrow 0$ and $\kappa \neq 0$. This is purely a spacelike virtual graviton effect outside the classical light cone, which is why it is quasi-instantaneous.
The retarded history and advanced Wheeler–Feynman destiny far-field gravity wave first order minimal coupling contribution is

$$T'_{\mu\nu}h^{\mu\nu}{}_{\text{far field}} = (\omega^2 - \kappa^2)^{-1}\,[T'_{11}T_{11} + T'_{22}T_{22} + + 2T'_{21}T_{21}]$$

However, looking at the original (3.3.4), the total amplitude clearly corresponds to the lowest order Feynman diagram amplitude for a massive graviton including the spin 0 longitudinal index 3 polarization. Therefore, Feynman subtracts the spin 0 Dicke-Brans lowest order amplitude

$$\alpha\, T'^{\nu}{}_{\nu}\, k^{-2}\, T^{\mu}{}_{\mu}$$

From (3.3.4) with a weighting factor $\alpha = ½$ to get the Weyl tensor purely spin 2 massless graviton far field gravity wave amplitude, which is

$$T'_{\mu\nu}h^{\mu\nu}{}_{\text{far field}} \rightarrow (\omega^2 - \kappa^2)^{-1}\,[(1/2)\,(T'_{11} - T'_{22})(T_{11} - T_{22}) + 2T'_{21}T_{21}]$$

There are now only two transverse polarized far field massless graviton gravity waves in the limit of the Feynman propagator pole in the complex variable energy $E = h\omega$ plane.

$$(\omega^2 - \kappa^2)^{-1} \rightarrow \infty$$

See Sir Roger Penrose's book "The Road to Reality" for the prerequisite brilliantly clear introduction to complex variables and quantum field theory.
Feynman uses plane waves as a basis rather than spherical history-destiny waves. He did not know about zoom-in/out scale dependent wavelets, which have not yet been used in quantum field theory in mainstream textbooks, although they are a natural fit for renormalization group flow running of force interaction coupling "constants."
Furthermore, the single graviton exchange needs to be replaced by the exchange of an indefinite number of virtual spacelike gravitons in a conjugate phase Glauber macro-quantum coherent state similar to the Gorkov Green's function model of the BCS superconductor with a complex local order parameter from spontaneous broken Higgs-Goldstone type of continuous vacuum symmetry. Therefore, only now for the far field piece not for the near field piece (which is actually more important for warp drive/stargate metric engineering with superconducting meta-materials and dark energy amplifiers) we have for the leakage from the warp drive generators:

$$h_{\mu\nu} = e_{\mu\nu}\exp(ik_{\sigma}x^{\sigma})$$

$$e_{11} = (1/2)^{1/2}$$

$$e_{22} = - e_{11}$$

$$e_{12} = e_{21} = e_{11}$$

The purely spin 2 lowest order Feynman diagram amplitude algebraic formula again is

$$T'^{\mu\nu}\, k^{-2}\, T_{\mu\nu} - (1/2)\, T'^{\mu}{}_{\mu}\, k^{-2}\, T^{\nu}{}_{\nu} = T^{\sigma\tau}\, P_{\sigma\tau,\mu\nu}\, T^{\mu\nu}$$

Where the spin 2 Feynman propagator prior to imposing a boundary condition contour constraint $\pm \varepsilon$ is in the Minkowski background

$$P_{\sigma\tau,\mu\nu} = (1/2)(\eta_{\mu\sigma}\eta_{\nu\tau} + \eta_{\mu\tau}\eta_{\nu\sigma} - \eta_{\mu\nu}\eta_{\sigma\tau})k^{-2}$$

And

$$h_{\mu\nu} = k^{-2}\,(T_{\mu\nu} - (1/2)\eta_{\mu\nu}T^{\sigma}{}_{\sigma})$$

Local gauge invariance demands minimal coupling $h_{\mu\nu}T'^{\mu\nu}$ to absorb a real graviton.

"The amplitude to emit a real graviton of polarization $e_{\sigma\tau}$ if $e_{\sigma\sigma} = 0$ as in (3.3.13) is ... $e_{\sigma\tau}T^{\sigma\tau}$"
Feynman p. 38

Feynman re-expresses the far field amplitude in terms of the spin 2 Weyl vacuum tensor analog version of the well-known circular polarization basis for the spin 1 electromagnetic field. For spin 1 the transformation from linear to circular polarization in the far field electromagnetic radiation Feynman amplitude to lowest order is (3.2.10)

$$e'_1e_1 + e'_2e_2 =$$

$$(1/2)^{1/2}(e'_1 + ie'_2)\,(1/2)^{1/2}(e_1 + ie_2) + (1/2)^{1/2}(e'_1 - ie'_2)\,(1/2)^{1/2}(e_1 - ie_2)$$

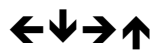
Similarly in the spin 2 far field gravity wave radiation case,

$$[(1/2)\,(T'_{11} - T'_{22})(T_{11} - T_{22}) + 2T'_{21}T_{21} =$$

$$(1/4)(T'_{11} - T'_{22} + 2iT'_{12})\,(T_{11} - T_{22} - 2iT_{12})$$

$$(1/4)(T'_{11} - T'_{22} - 2iT'_{12})\,(T_{11} - T_{22} + 2iT_{12})$$

The rotation operator in the transverse plane perpendicular to the far field propagation 3-vector κ is $e^{iJ\theta}$ where J = 2 is the spin in this case. These two transverse gravity wave polarization states are quadrupole stretch-squeeze Weyl curvature tensor modes. One quadrupole tensor polarization state looks like in time



Above we have the first half cycle. This is a stretch along the horizontal x-axis, and it is also a squeeze along the vertical y axis.

We have the opposite obviously in the next half cycle. This is a squeeze along the horizontal x-axis and it is also a stretch along the vertical y-axis. The first arrow is the stress pointing along the negative x-axis. The second arrow is stress pointing along the positive y-axis. The third arrow is stress pointing along the positive x-axis. The fourth arrow is stress pointing along the negative y-axis. The other polarization mode is at 45 degrees from the axes of the first because 2 x 45 degrees = orthogonal 90 degrees. Therefore, the second orthogonal quadrupole tensor polarization in the diagonal basis looks like

↘↗↖↙ in first half cycle

↖↙↘↗ in the next half cycle

We can replace the Minkowski metric $\eta_{\mu\nu}$ with the curvilinear metric *near field* $g_{\mu\nu}$ as a curved background provided that the periods of oscillation and the wavelengths of the far field gravity waves are small compared to the radii of spacetime curvature. This is precisely, where the scale-dependent wavelets are needed. Now when the curvature is zero we can still have a curvilinear $g_{\mu\nu}$ in a LNIF as in Rindler[cccvi] constant proper acceleration (in proper world line time though not uniform in space[cccvii]) hyperbolic motion of the origin of the LNIF, or as in a rotating disk LNIF. The horizon area-entropies A provide a curvature scale IR cutoff $\sim A^{1/2}$. The proper acceleration is $g \sim c^2/A^{1/2}$.

Feynman shows that in order to get Einstein's classical nonlinear field equations, he must sum an infinite set of special tree diagrams without closed loops. This is a non-perturbative procedure of spontaneous broken symmetry analogous to the BCS theory of superconductivity of phonon bound entangled electron Cooper pairs that form a macro-quantum coherent lower energy ground state with zero electrical resistance and the Meissner effect expulsion of magnetic flux from the bulk (e.g., quantized vortices forming the Type II Abrikosov lattice). Indeed, Einstein's nonlinear gravity is emergent in the Alpha Point moment of inflation – a quantum phase transition out of the unstable false vacuum in which we only have zero rest mass leptons, quarks and the electromagnetic, weak and strong gauge bosons.

There are two possible boundary conditions here for

$$(\omega^2 - \kappa^2)^{-1} \rightarrow \infty$$

that are expressed as contours for integration around the two poles at $\omega = \pm\kappa$ (c = 1). The one taught everywhere is a positive energy retarded spherical wave from a point source propagating in that point source's forward light cone together with a negative energy advanced spherical wave propagating in the past light cone of that same point source. The stress-energy tensor $T_{\mu\nu}$ from this *Feynman* boundary condition gives the usual universally attracting gravity. However, the mirror image contour that everyone ignores is the opposite a negative energy retarded spherical wave from a point source propagating

in that point source's forward light cone together with a positive energy advanced spherical wave propagating in the past light cone of that same point source. The stress-energy tensor $T_{\mu\nu}$ from this *anti-Feynman* boundary condition gives the universally attracting gravity is the universally repelling antigravity that we actually detected starting in 1998 in the anomalous redshifts of the Type 1a supernovae as the dark energy accelerating the expansion speed of 3D space since the moment of chaotic inflation leading to the hot big bang and us. Advanced Wheeler-Feynman Hawking-Unruh gravity Aharonov destiny waves from our observer-dependent future de Sitter cosmological *evaporating* horizon must have back-from-the-future positive energy propagating along the past light cone of a virtual particle point source on the horizon, that is our future light cone, or, more to the point, the future light cone of a Type 1a supernova in our past light cone. This high-energy advanced Hawking gravity radiation comes from the Planck length L_P quantum gravity Heisenberg uncertainty thickness of the metric field zero point vacuum fluctuations of transient virtual microscopic quantumblack holes of Wheeler's "quantum foam". Their very large energy hc/L_P is gravity redshifted down to the actually observed very low energy $hc/(L_P A^{1/2})^{1/2}$ where A is the Bekenstein area entropy of the future horizon where the future light cone of the past receiver intersects it. There is also the cosmological expansion blue shift counter-term to this advanced gravity redshift. They are completely independent physical effects, and the advanced wave cosmological blue shift is many powers of ten smaller than the advanced gravity redshift. Therefore, it is completely ignorable.

The Stargate Geometrodynamical Field

"Our analysis implies that either the wormhole must be only a little larger than Planck size or that there is a large discrepancy in the length scales which characterize the wormhole. In the latter case, the negative energy must typically be concentrated in a thin band many orders of magnitude smaller than the throat size. These results would seem to make the existence of macroscopic traversable wormholes very improbable … there are a number of possible ways to circumvent our conclusions … our results can be construed as placing upper bounds on the actual allowed thicknesses of such layers of negative energy density. We conclude that, unless one is willing to accept fantastically large discrepancies in the length scales, which characterize wormhole geometries, it seems unlikely that quantum field theory allows macroscopic static traversable wormholes … One possible constraint upon such violations is given by averaged energy conditions … A second type of constraint upon violations of the weak energy condition are "quantum inequalities" (QI's), which limit the magnitude and spatial or temporal extent of negative energy [4]. … We will also assume that the spacetime contains no closed timelike curves. This latter assumption may not be necessary, but we make it in order to insure that quantum field theory on the wormhole spacetime is well-defined." Ford and Roman. 1995

Evidently there are strong arguments based on our limited present knowledge of physics against the possibility of stable stargates and controllable warp drives.[cccviii] See Chapter 8 " Wormhole Stability" of Enrico Rodrigo's book on this delicate issue.

Survivability inside the bubble
A paper by José Natário published in 2002 argues that crew members could not control, steer or stop the ship because the ship could not send signals to the front of the bubble.[22]
A more recent paper by Carlos Barceló, Stefano Finazzi, and Stefano Liberati uses quantum theory to argue that the Alcubierre drive at faster-than-light velocities is impossible mostly because extremely high

temperatures caused by Hawking radiation would destroy anything inside the bubble at superluminal velocities and destabilize the bubble itself; the paper also argues that these problems are absent if the bubble velocity is subluminal, although the drive still requires exotic matter.[8]
http://en.wikipedia.org/wiki/Alcubierre_drive

However, we take the point of view that there is strong UFO evidence for both and that we need to be skeptical at this stage about no-go theoretical arguments not only for stable stargates and controllable warp drive, but also for the use of quantum entanglement as a stand-alone back-from-the-future retro-causal command-control-communication channel not requiring a classical light cone limited signal decryption key, i.e. "signal nonlocality." While I do not contest, that orthodox quantum theory with its postulates of linear operators and unitary time evolution is the maximal theory that derives from denial of signal nonlocality and the demand for Abner Shimony's "passion at a distance," I think the pundits are looking at that important result in a topsy-turvy way. What they have done is to show what is needed for a more general quantum theory that contains the orthodox theory as a limiting case, in the same way, that Einstein's 1905 special relativity is the limiting case of his 1916 general relativity as the spacetime curvature tensor field vanishes globally.
Remembrance of things past and future, we find the Allegory of the Cave in Plato's Republic, which precognitively anticipates the archetype idea of all of modern day theoretical physics: reality and appearance as light and shadow. In the modern mathematical language of group representation theory reality and appearance correspond to invariant and representation. The metric field's representation depends on the contingent (arbitrary) choice of a fleet of small detector drones communicating with each other by far field electromagnetic radiation with only two transverse modes of polarization because the photon quantum of the electromagnetic field has zero rest mass. Each detector can be on an arbitrary timelike world line. Einstein's "general coordinate transformation"[cccix] is simply the mapping between two sets of paired coincident detectors each in arbitrary relative timelike motion. For example, There are N Alice detectors and N Bob detectors, such that A(i) and B(i), are physically close together. Each set is observing Eve doing something. Einstein's general relativity allows the individual paired Alice and Bob detectors to compute invariant numbers describing Eve's activities. Even though the raw data on tensor and spinor observables of Eve that each collects via electromagnetic far field radiation signals looks very different for Alice and Bob, their computed invariant numbers are the same. That is what is meant by "local objective reality" in the context of Einstein's theory of geometrodynamics. The convenient choice is that of static LNIFs for fixed Schwarzschild radial coordinate r outside of horizons containing spacetime singularities. Given a static spherically symmetric star gate portal to a distant Earthlike exoplanet, the stargate geometrodynamic field looks like

$$ds^2 = - N^2(r)dt^2 + g_{rr}dr^2 + r^2d\Omega^2$$

$$g_{00} = N^2(r) = e^{2\phi(r)}$$

There is no horizon, i.e., no zero for g_{00}.

$$g_{rr} = \{1 - b(r)/r\}^{-1}$$

We will see below that the coordinate singularity in g_{rr} is not physical.
Newton's fictitious gravity force is part of the Levi-Civita connection field that is for gravity what the four potential A is for electromagnetism. Newton's potential and the off-diagonal g0i when they are not zero should not be compared with A from the point of view of local gauge theory. Einstein's 1916 gravity is essentially that of the local gauging of the four-parameter translation group whose gauge transformations are the general coordinate transformations as remarked by Feynman: "Thus gravity is that field which corresponds to a gauge invariance with respect to displacement transformations." P.115 Feynman's Cal Tech "Lectures on Gravitation"
The nine non-vanishing Levi-Civita connection components for the above simplest stargate metric field in the static LNIF representation are:

$$\Gamma^0_{01} = (2e^{2\phi(r)})^{-1}\partial(e^{2\phi(r)})/\partial r = \partial\phi/\partial r$$

$$\Gamma^1_{00} = (1/2)\{1 - b(r)/r\}\ \partial(e^{2\phi(r)})/\partial r$$

$$= \{1 - b(r)/r\}\ e^{2\phi(r)}\ \partial\phi/\partial r$$

$$\Gamma^1_{11} = (1/2)\{1 - b(r)/r\}^{-}\partial(\{1 - b(r)/r\}^{-1})/\partial r$$

$$\Gamma^1_{22} = -\ r\ \{1 - b(r)/r\}$$

$$\Gamma^1_{33} = -\ (r\sin^2\theta)\{1 - b(r)/r\}$$

$$\Gamma^2_{12} = 1/r\ \ \&\ \Gamma^3_{13} = 1/r$$

$$\Gamma^2_{33} = -\sin\theta\cos\theta\ \&\ \Gamma^3_{23} = \cot\theta$$

The real non-gravity radially outward force at the center of mass origin of the static LNIF required to keep it on a timelike non-geodesic world line corresponding to fixed r is:

$$F^1 = M_{LNIF}\ c^2\Gamma^1_{00}$$

$$= M_{LNIF}\ c^2\ \{1 - b(r)/r\}\ e^{2\phi(r)}\ d\phi/dr$$

The two functional parameters in this historically original Morris-Thorne stargate (aka "traversable wormhole" without a horizon and no collapse of the portal as we walk

through it) are b(r) the "shape function" and the "redshift function" $\phi(r)$. No horizon barrier pinch off killing us requires that $g_{00} \neq 0$. The physically relevant proper circumference is $2\pi r$. The Schwarzschild-type radial coordinate r decreases from $+\infty$ to a minimum r_0 where $b(r_0) = r_0$ is the size of the throat of the spacetime tunnel through which we must walk or fly in a conventional craft depending on the advanced extra-terrestrial time-traveler civilization's design. Remember Stephen Hawking's "chronology protection conjecture" is only a conjecture condemning us to what Matt Visser calls the "boring universe." It's too early to give up the good fight, so I say, "damn the torpedoes, full warp ahead."

Following Ford and Roman (1995): the radial proper distance from the edge of the stargate throat outward $\iota(r)$ is finite even though the integrand has an infinite non-physical formal singular infinity at the throat edge, given by the definite integral r_0 to r

$$\iota(r) = \int_{ro}^{r} (1 - b(r)/r)^{-1/2} \, dr$$

The actual physical proper radial distance $\iota(r)$ is always longer than the formal radial coordinate distance r.

$$|\iota(r)| \geq r - r_0 \geq 0$$

Note that $\iota(r_0) = 0$ at the throat $r = r_0$. The actual physical circumference of the throat passage way is $2\pi r_0$ so we have an actual Euclidean geometry physical tunnel passageway of $2r_0$. The four velocity of the static LNIF detector/observer is

$$V^{\mu} = dX^{\mu}/d\tau = (V^t, 0, 0, 0) = (e^{-\phi(r)}, 0, 0, 0)$$

The static LNIF's proper first rank tensor four-acceleration, that requires an external non-gravity electromagnetic (weak, strong) force to sustain it in an off-geodesic timelike world line at fixed r, is:

$$g^{\mu} = DV^{\mu}/d\tau$$

$$= V^{\mu}{}_{;\nu} V^{\nu}$$

$$= (V^{\mu}{}_{,\nu} + \Gamma^{\mu}{}_{\beta\nu} V^{\beta}) V^{\nu}$$

$$g^t = 0$$

Obviously the index notation can be switched 0 = t, 1 = r etc. in spherical polar coordinates.

$$g^r = \Gamma^r{}_{tt} (dt/d\tau)^2 = (d\phi/dr)(1 - b(r)/r)$$

This is the radial component of proper acceleration that the static LNIF observer must maintain to stay at fixed r. The proper acceleration is zero at the throat itself where the static LNIF limits to a free-float weightless LIF. If $d\phi/dr = 0$, then the static LNIF also switches to a free-float weightless LIF.
If $g^r > 0$, the static LNIF observer Bob needs to fire his rocket thrust radially outward if he does not want to get sucked into the attractive gravitational field of the stargate. On the other hand if $g^r < 0$ the stargate will have an anti-gravitational repulsive field and Bob needs to fire his rocket thrust radially inward in order to stay at fixed distance from it. Indeed, this feature can be adapted for a defensive force shield deflecting space junk from a starship, or defending a city from ICBM attack.

The off-geodesic non-zero real g-force static LNIF basis can be expressed as the tetrad transformation from the geodesic zero g-force free-float weightless non-rotating LIF basis for this Morris-Thorne toy model stargate metric.

$$e_{t'LNIF} = e^{-\phi}\, e_{tLIF}$$

$$e_{r'LNIF} = (1 - b(r)/r)^{1/2}\, e_{rLIF}$$

$$e_{\theta'LNIF} = r^{-1}\, e_{\theta LIF}$$

$$e_{\varphi'LNIF} = (r \sin\theta)^{-1}\, e_{\varphi LIF}$$

The exotic negative mass-energy stress source current densities needed to manufacture this stargate in the static LNIF representation are:

$$T_{t't'LNIF} = \rho = (c^4/G)(8\pi r^2)^{-1}\, db/dr$$

$$= \text{Static LNIF energy density}$$

$$T_{r'r'LNIF} = p_r = -(c^4/G)(8\pi)^{-1}[b/r^3 - 2\,(db/dr)\,(1 - b/r)\,r^{-1}]$$

$$= \text{Static LNIF radial pressure}$$

$$T_{\theta'\theta'LNIF} = T_{\varphi'\varphi'LNIF} = P$$

$$= (c^4/G)(8\pi)^{-1}[(1/2)(b\, r^{-3} - r^{-2}\, db/dr) + r^{-1}(d\phi/dr)(1 - b/2r - (1/2)db/dr)$$

$$+ (1 - b/r)((d^2\phi/dr^2) + (d\phi/dr)^2)$$

$$= \text{Static LNIF transverse pressure}$$

Note that in a Bose-Einstein condensate $c \rightarrow 0$. Therefore, inside that material a much smaller energy density has a much larger warping power of the geometrodynamic field. These complicated formulae simplify at the throat of the stargate $r = r_0$ where

$$\rho_0 = (c^4/G)(8\pi r_0^2)^{-1} db(r_0)/dr$$

$$p_0 = (c^4/G)(8\pi r_0^2)^{-1}$$

$$P_0 = (c^4/G)(16\pi r_0)^{-1}(1 - db(r_0)/dr)(d\phi(r_0)/dr + 1/r_0)$$

"Sec. 3, we briefly review some of the essential features of traversable (Morris-Thorne) wormholes. We next consider a number of particular wormhole models in Sec. 4, and argue that the quantum inequality places strong restrictions upon the dimensions of these wormholes. ... we used a bound on negative energy density derived in four-dimensional Minkowski spacetime to constrain static, spherically symmetric traversable wormhole geometries. In Sec. 2, we argued that the bound should also be applicable in curved spacetime on scales, which are much smaller than the minimum local radius of curvature and/or the distance to any boundaries in the spacetime. The upshot of our analysis is that either a wormhole must have a throat size, which is only slightly larger than the Planck length L_P, or there must be large discrepancies in the length scales, which characterize the geometry of the wormhole. These discrepancies are typically of order $(L_P/r_0)^n$, where r0 is the throat radius and $n <\sim 1$. They imply that generically the exotic matter is confined to an extremely thin band, and/or that the wormhole geometry involves large redshifts (or blueshifts). The first feature would seem to be rather physically unnatural. Furthermore, wormholes in which the characteristics of the geometry change over short length scales and/or entail large redshifts would seem to present severe difficulties for traversability, such as large tidal forces."

Ford and Roman consider several toy model stargate (traversable wormhole) geometrodynamical field configurations. Their 4.1 has $\phi = 0$ and $b(r) = r_0^2/r$. Their 4.2 has $\phi = 0$ and $b(r) = r_0 =$ constant. Their 4.3 is the physically more interesting "absurdly benign wormhole," which has the negative effective energy mass current densities in a small layer around the throat like a rubber band. They consider two more toy models. Going through the details would be boring without too much of a conceptual payoff in insight. The fly in their soup, the loophole that was under their radar is that all of their negative energy bounds are fixed by the extreme smallness of the Planck scale $L_P \sim (hG/c^3)^{1/2} \sim 10^{-35}$ meters $\sim 10^{19}$ Gev. The practical metric engineering by the advanced civilization that seems to have been manipulating our evolution for a very long time is, in my opinion, able to use Bose-Einstein condensates to make the effective speed of light very small and perhaps, independently, if there is anything to the extra space dimension speculations to make G very large. In any case, manipulating only c for now, again in the non-radiative near EM field $T_{\mu\nu}$ source tensor for the exotic matter field with negative energy, gives us a gain of order $(c/c_{exotic})^{3/2}$ in the quantum gravity scale. There are at least two speculative ways to get negative energy in addition to squeezing light, Casimir effect etc. One is my meta-material negative permittivity and negative permeability idea again for non-radiating near fields not far fields. This idea has nothing whatsoever to do with analog computer simulations of warp drives using far field light propagation in meta-materials as the analog computer. My other idea is to amplify dark energy assuming that it is back from the future advanced Hawking radiation from our de Sitter cosmological horizon obeying the anti-Feynman boundary condition, which is the mirror

image of Feynman's contour around the mass-shell poles in the complex energy plane of his propagator formalism. That is, Yakir Aharonov's "destiny waves," in this context at least, propagate positive energy backwards in time, therefore, negative energy forwards in time opposite to the retarded "history wave" matter-gravity fields we are made of and familiar with. Furthermore, Enrico Rodrigo in Chapter 7 of his book writes:
"In 2000 Serguei Krasnikov showed how the effective ban due to the Ford-Roman constraints on the existence of traversable wormholes could be circumvented. By relaxing the assumed conditions on the wormhole's spacetime – replacing the requirement of asymptotic flatness – he was able to find a traversable wormhole solution whose negative energy was sourced by the quantum vacuum [fluctuations] of three matter fields. Three years later, by abandoning the assumption of spherical symmetry, he was able to drastically reduce (by 34 orders of magnitude!) the negative energy required to sustain a traversable wormhole." P. 203

The dark energy de Sitter field means that our actual universe is never exactly asymptotically flat. The de Sitter group[cccx] replaces the Poincare group.[cccxi] Rodrigo is optimistic and concludes:

The restrictions imposed by the Quantum Inequalities can be circumvented. They do not prevent existence of traversable wormholes sustained by the negative energy from the vacuum of quantum matter fields. P. 204

Turning now to Kip Thorne:

"The only way to hold the wormhole open is to thread the wormhole with some sort of material that pushes the wormhole's walls apart, gravitationally." Kip Thorne (KT), P.488

Kip's use of "pushes" is unfortunate and misleading because it unconsciously suggests that gravity is a real force that an accelerometer would measure as a morphing of a geodesic world line into an off-geodesic world line. It's hard even for Kip to break Newton's mold. In fact, the anti-gravity field is defocusing the null and timelike zero g-force geodesics themselves, which normally would converge in the presence of normal matter. Individual accelerometers will show zero. Gravity gradiometers, on the other hand, will detect the defocusing caused by the exotic matter.

The exotic material will behave like a defocusing lens; it will gravitationally defocus the light beam (through the wormhole). …. The exotic material threading the wormhole must have a negative average energy density, as seen by a light beam travelling through it. KT

More precisely, the average of $T_{00} + T_{11} + T_{22} + T_{33} = T_{00}\,(1 + 3w) < 0$.

If the energy density T_{00} is positive, then the three pressure terms must be more negative. That is, $w \leq -1/3$ for Feynman's propagator boundary condition (retarded history offer waves have positive energy). On the other, hand, if exotic matter obeys the anti-Feynman propagator boundary condition (advanced destiny offer waves have positive energy), then $T00 < 0$ for them, and $w \geq 1/3$ will be exotic causing anti-gravity defocusing. Is there any evidence that advanced destiny offer waves are exotic. Indeed, there is. It's the dark energy accelerating our causal diamond observable patch of the multiverse of parallel worlds both Levels 1 and 2 in Max Tegmark's classifications.[cccxii]

Then, in 1974, came a great surprise: Hawking inferred as a by-product of his discovery of black hole evaporation … that vacuum fluctuations near a hole's horizon are exotic. They have negative average energy density as seen by outgoing light beams near the hole's horizon. In fact, it is this exotic property of the vacuum fluctuations that permits the hole's horizon to shrink as it evaporates. KT P.491

What is the connection to dark energy I have alluded to? We are outside observer-independent black holes and the retarded Hawking radiation we see from their horizons must come from exotic quantum vacuum fluctuations. Now it turns out, as nicely explained in Tamara Davis's 2004 Ph.D. dissertation[cccxiii] from down under University of New South Wales that we are inside two observer-dependent cosmological horizons. One is called our past particle horizon infinite gravity redshift[cccxiv] surface for retarded history offer waves. It is the future light cone[cccxv] of the Alpha Point of Creation – the moment of inflation[cccxvi] when the false unstable vacuum has a quantum phase transition of spontaneous broken symmetry[cccxvii] that release the heat of the Big Bang. The second more important "home of explanation" (Henry Dwight Sedgwick quote) is our future destiny teleological[cccxviii] de Sitter dark energy event horizon. It is the past light cone of our future Omega Point or End Time if you want to go Christian Fundamentalist like Frank Tipler did in his book "The Physics of Immortality."[cccxix] This is not Frank's "Omega Point" that required a Big Crunch closed elliptical universe from too much matter density. We now know that this guess, also favored by John Wheeler in the early days, is wrong. Cosmological inflation requires that the spatial part of the metric field of the universe is exactly flat and open at the critical density boundary between ellipse and hyperbola in the Greek geometry of conic sections. See Roger Penrose's "The Road to Reality" for this history. However, the most recent data suggests that the density of stuff in the universe (mostly dark energy and dark matter only a snippet of the star stuff we are made of) universe is a little bit less than critical, so that we are in a slightly hyperbolic open universe. Our Omega Point is in the infinite future as measured by ordinary clocks like atomic clocks, pendulums, springs etc. However, that infinite metric proper time, integrating ds, is a finite Penrose conformal time [cccxx] as measured by the flight times of light bouncing back and forth between two mirrors each of which are "comoving" on timelike local geodesics of the Hubble flow[cccxxi] in our accelerating expanding three dimensional space. Being on a force-free geodesic in the Hubble flow is easy, in principle, to measure. It is that motion in which the cosmic microwave background black body radiation is maximally isotropic. The absolute temperature of that radiation remnant of the hot Big Bang[cccxxii] is an objective measure of the time since matter and radiation decoupled about 340,000 years after the moment of inflation.

What Hawking did in 1974 can be intuitively understood quick and dirty back of the envelope style in terms of the old quantized Bohr orbit theory together with the Heisenberg uncertainty principle and the idea of random virtual particles of the zero point vacuum fluctuations of quantum fields in their lowest energy state. The fields are collections of quantum springs that couple to each other with other quantum springs like the innards of a mattress. The virtual particles that are the sources of the Hawking radiation are stuck to the horizon where $g_{00} = 0$ classically. Hawking's radiation comes from random surface vibrations of the 2D horizon. Just like fitting waves in an organ pipe or on a guitar string, the basic longest fundamental surface wave length that fits is of the order of $A^{1/2}$ where A is the area of the horizon's classical 2D surface. It turns out that the virtual particles have a very large proper acceleration blue shift at the horizon because

they are stuck there, but the gravity redshift of retarded history waves reaching us from the black hole along our past light cone cancels the redshift, and we see a peak frequency or temperature ~ $A^{-1/2}$ that is Hawking's surface gravity when you stick in all the coefficients. However, Hawking forgot about the quantum thickness of the horizon since infinitely thin classical surfaces violate quantum theory. Suppose, there is a long wave IR cutoff of L in terms of the radial coordinate r. We have two toy model metrics both in the static LNIF case, which represents the virtual particles hovering, stuck at the horizon.

$$g_{00} = 1 - A^{1/2}/r$$

for the black hole we are outside of at $r \to \infty$. Likewise, for our observer-dependent future dark energy de Sitter horizon

$$g'_{0'0'} = 1 - r'^2/A$$

Where we are always exactly at r' = 0 in this static LNIF representation. This simple metric no way applies to our past particle horizon universe which is very complicated. Indeed, this fundamental asymmetry between past and future horizon boundaries is the fundamental explanation for the Arrow of Time, the fact that we age in the same direction that the universe expands. What matters here is the area-entropies of our past and future horizon boundaries at their intersections with out past and future light cones respectively. The area of our past horizon is always smaller than the area of our future horizon and it is this inequality of past and future entropies that explains the irreversibility of the Second Law of Thermodynamics in my opinion. Remember, we are getting back-from-the-future advanced Wheeler-Feynman influences both in John Cramer's transactional interpretation of quantum theory and in Yakir Aharonov's "weak measurement" pre-selected history wave and post-selected destiny wave interpretation of quantum theory.[cccxxiii] Already Dirac in the 1930's realized that we need a back-from-the-future effect to explain even classical electromagnetic radiation reaction that is tied in with Einstein's spontaneous emission and therefore, zero point electromagnetic and virtual electron-positron zero point vacuum fluctuations. These are all clues to the mystery. Next we need a wee bit of mathematics, the Taylor series expansion[cccxxiv] to first order will do.

Case 1, we are virtual particles hovering outside the black hole's $g_{00} = 0$ horizon at radial coordinate $r \sim A^{1/2} + L$ with the metric

$$g_{00} = 1 - A^{1/2}/r$$

The Taylor series expansion to first order in $L/A^{1/2} << 1$ gives the proper thickness gravity as the geometric mean of circumference to thickness ~ $(LA^{1/2})^{1/2}$ as the mean wavelength of this second component of the Hawking radiation. This is a black body temperature of order $(LA^{1/2})^{-1/2,}$ which is higher than Hawking's original temperature by the factor $(A^{1/2}/L)^{1/2} >> 1$ because

$$(A^{1/2}/L)^{-1/2}(LA^{1/2})^{-1/2} = 1/A^{1/2}.$$

Therefore, the Carnot heat engine efficiency ε of the black hole horizon's hot thickness temperature doing work and dumping heat into its cold surface temperature is

$$\varepsilon = 1 - (L/A^{1/2})^{1/2}$$

$$\rightarrow 100\% \text{ as } L \rightarrow 0 \text{ classical limit}$$

This assumes both horizon temperatures are positive. However, since the horizon is exotic, we must also explore other possible cases, both temperatures are negative, and one of the two is positive and the other negative – three cases in all. I leave this as a homework problem.

Finally, if we do the same thing with the de Sitter horizon that we are inside of, so that now $r \sim A^{1/2} - L$ we get exactly the same final results as for the black hole. This is easy to understand even in Newton's gravity because the gravity potential outside a uniform sphere is ~ 1/r whereas if you make a tunnel through its center, the interior potential is that of a harmonic oscillator ~ r^2 exactly like the de Sitter metric for our future dark energy universe.

But we are not quite there yet. What about the evaporation lifetime of the black hole? The black body power is ~ T4, my thickness prediction says that this is $((A^{1/2}/L)^{1/2})^4 = A/L^2$ faster than Hawking's prediction. Furthermore, the energy density of my new higher energy Hawking radiation is ~ hc/L^2A which happens to be in the same ball park as the observed dark energy density if we use L ~ quantum gravity Planck length for gravity wave black body radiation from virtual Planck black hole quantum foam from our future de Sitter horizon. This only works if this advanced destiny black body gravity wave radiation obeys the anti-Feynman propagator boundary condition so that w = +1/3 gives anti-gravity. Since the cosmological horizon must be exotic for the source virtual particles stuck on it, this is not implausible and it is a coherent logically consistent narrative rooted firmly in the observations of precision cosmology.

Time Travel to the Past? Fiction or Fact?

"How does time decide how to hook itself up through a wormhole? … The laws of general relativity predict, unequivocally, the flow of time at the two mouths, and they predict, unequivocally, that the two time flows will be the same when compared through the wormhole, but will be different when compared outside the wormhole. … Travel through the wormhole in one direction takes me … backward in time; travel in the other direction takes me forward in time." Kip Thorne, p. 504 "Black Holes and Time Warps"

I actually may have encountered back from the future time travel around 1952 in a weird close encounter of high strangeness[cccxxv], but my experience is not scientific, although it provides the fire in the belly for me writing this book, nevertheless, its details will not be discussed here. I mention it in passing for historians of physics like MIT's David Kaiser to give an inkling of my motive in case these speculations of mine come to pass as part of consensus reality. My remarks here are like Obama's Secretary of State John Kerry in middle of Iran nuke meetings on "Meet the Press," November 10, 2013 when he admitted that he thought the assassination of JFK was a conspiracy. When pressed he said that it was not the time and place to discuss it. Similarly, it is that way with me now.

Causality violation and semiclassical instability
Calculations by physicist Allen Everett show that warp bubbles could be used to create closed timelike curves in general relativity, meaning that the theory predicts that they could be used for backwards time travel.[25] While it is possible the fundamental laws of physics might allow closed timelike curves, the chronology protection conjecture hypothesizes that in all cases where the classical theory of general relativity allows them, quantum effects would intervene to eliminate the possibility, making these spacetimes impossible to realize. Some results in semiclassical gravity appear to support the conjecture, including a calculation dealing specifically with quantum effects in warp drive spacetimes which suggested that warp bubbles would be semiclassically unstable,[8][26] but ultimately the conjecture can only be decided by a full theory of quantum gravity.[27] http://en.wikipedia.org/wiki/Alcubierre_drive

Kip Thorne and his students in their breakthrough 1988 paper wrote:

"*Wormhole creation, with such mild spacetime curvature that classical general relativity is everywhere valid, must be accompanied by closed timelike curves … Wormhole maintenance. —For any traversable wormhole a two-sphere surrounding one mouth (but well outside it where spacetime is nearly flat), as seen through the wormhole from the other mouth, is an outer trapped surface. This implies' (since there is no event horizon) that the wormhole's stress-energy tensor $T_{\mu\nu}$ must violate the averaged weak energy condition" (AWEC); i.e., passing through the wormhole there must be null geodesics, with tangent vectors $k^{\mu}=dx^{\mu}/ds$ along which*

$$\int_0^{\infty} T_{\mu\nu}\, k^{\mu}\, k^{n}\, ds < 0$$

…

$$ds^2 = - e^{2\phi}\, dt^2 + d\iota(r)^2 + r^2\, (d\theta^2 + \sin^2\theta d\varphi^2)$$

$$\iota(r) = \int_{ro}^{r} (1 - b(r)/r)^{-1/2}\, dr$$

Where ϕ and r are functions of proper radial distance ι (set ι=0 at the throat, $\iota < 0$ on the "left" side of the throat and $\iota > 0$ on the "right" side). … The following model explores the use of the "Casimir vacuum" ' (a

quantum state of the electromagnetic field that violates the unaveraged weak energy condition") to support a wormhole: ... This violation of AWEC is compatible with a total nonnegative energy of plates plus Casimir field ... Conversion of wormhole into time machine Figure 2 is a spacetime diagram for the conversion of a spherical, traversable wormhole into a time machine. ... parametrized by a time coordinate t introduced below. ... At T =0, the wormhole's mouths are at rest near each other. Subsequently, the left mouth remains at rest while the right mouth accelerates to near-light speed, then reverses its motion and returns to its original location. The advanced beings can produce this motion by pulling on the right mouth gravitationally or electrically. This motion causes the right mouth to "age" less than the left as seen from the exterior. Consequently, at late times by traversing the wormhole from right mouth to left, one can travel backward in time (i.e., one can traverse a closed timelike curve) and thereby, perhaps, violate causality."

Alice's clock clamped to the left mouth of the wormhole and Bob's clock clamped to the right mouth of the wormhole remain synchronized showing the same times after correcting for the short ignorable flight time through the wormhole throat tunnel passage way. That is, Alice's and Bob's respective local proper times of aging from the initial moment Bob steps into the left mouth when they are together to the moment Bob steps back from the right mouth to the left mouth and they are together again to are always the same. There is no relative time dilation between Alice and Bob *as long as Bob stays clamped to the right mouth and does not explore Alice's future disconnected from the right mouth for too long in his proper time!* From special relativity we know that external to the stargate Bob has gone into the far future of Alice in the same amount of proper time that Alice locally experiences with Bob through the interior of the stargate. Alice's clocks are running faster than Bob's although they see the same clock times looking through the stargate, which is why it is a time machine. The only way to grasp this high strangeness is to look at Kip Thorne's Fig 2.

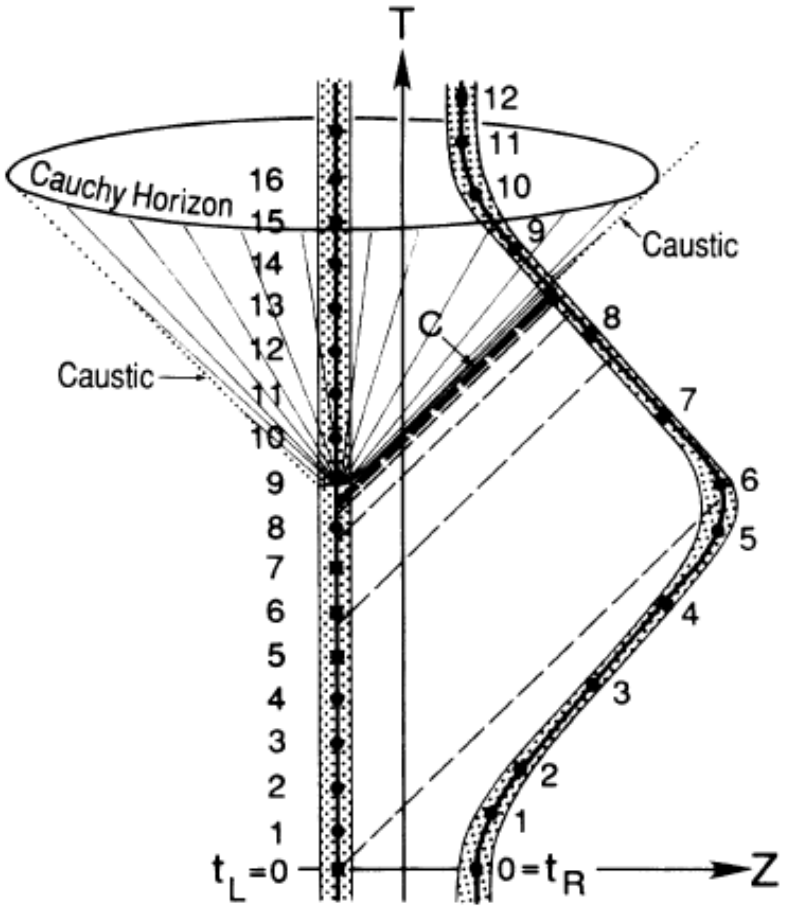


FIG. 2. Spacetime diagram for conversion of a wormhole into a time machine.

For example, suppose Bob and Alice are physically coincident at $t_L = 0$ at the left portal. Bob walks through the short throat passage (dashed - - - diagonal line where the clocks placed along the tunnel remain synchronized) and almost instantly is in Alice's far future at $t_R = 6$ when he walks out of the right portal. Bob can explore the universe in Alice's future where the CMB temperature from the Big Bang is lower than it was when he entered the left portal. However, Bob must only explore outside the right portal for a short time and return back to near the time he left according to his watch. If Bob waits too long say until $t_R = 7.75$, he will return to $t_L \sim 6$, which could be thousands of years of Alice's proper time while it is only a few hours of Bob's proper time depending on the details and his lover Alice will be long dead. Therefore, even with stargate time machines the time dilation problem is still there, but not as serious as without a time machine. If one plans properly, Bob can travel to the nearest perhaps habitable exo-planet 12 light years from Earth at breakfast, take some quick measurements and samples and return back to Alice at supper that same Alice day. There is at least one exo-planet much closer to us in the Alpha Centauri system (4.37 light years away), but it is uninhabitable not

rotating like Mercury. There may be other Earth like planets there, but we don't know yet as of November 12, 2013.

Appendix A: My DARPA-NASA Low Power Warp Drive Paper[cccxxvi]

I gave an invited paper on Oct 1, 2011 at the DARPA-NASA 100 Year Starship meeting in Orlando, Florida. My travel expenses were paid for by DARPA. **Some naïve people confounded my proposal below with metamaterial analog computer simulations of warp drive based on the propagation of radiation in such materials. The mathematical model of those proposals is based on Maxwell's equations and has nothing to do with my proposal based on Einstein's gravity equations with an electromagnetic stress tensor**. Note that I envision that we need a high temperature superconducting metamaterial to get low power warp drive.[cccxxvii]

Is Low Power Warp Drive Possible?

Breaking the Space-Time Stiffness Barrier

Jack Sarfatti

adastra1@me.com

ISEP

San Francisco, CA 94133

Abstract

All conventional forms of spacecraft propulsion are unlikely to motivate large-scale private capital because the time scales for interstellar travel even to the nearest exo-planet are simply too long for practical commerce, the habitat problems are likely to be too difficult, and the cost in our declining world economy on the brink of financial

if not environmental collapse in 2011 appear to be too great. Recent discoveries in the slowing of the speed of light in Bose-Einstein condensates and the negative electric permittivity and magnetic permeability in metamaterials suggests a low power speculative possibility for warp drive based on Einstein's orthodox field equation for gravity coupled to the electromagnetic field. Suppose we can slow down the speed of light to 3 cm/sec keeping the magnetic response χ_B close to 1 with an *anti-gravitating* non-propagating negative near field low frequency negative dielectric response susceptibility χ_E. Therefore, since c scales as the inverse square root of χ_E yielding a dimensionless amplification of the repulsive anti-gravity field of perhaps as much as order of the cube of $\chi_E \sim 10^{60}$. This would break the space-time stiffness barrier to low power warp-wormhole technology. This conjecture is entirely new and needs further investigation.

Keywords: warp drive, wormholes, metamaterials, dark energy, slow light

1. The basic idea

Einstein's symmetric second rank classical tensor field equations for the curving of spacetime $G_{\sigma\nu}$ by stress-energy current densities $T_{\sigma\nu}$ of matter fields is

$$G_{\sigma\nu} + \frac{8\pi G}{c^4} T_{\sigma\nu} = 0 \tag{1.1}$$

Maxwell discovered the relation of light to electricity and magnetism

$$c^2 = \frac{1}{\varepsilon\mu} \tag{1.2}$$

where ε is the electrical permittivity and μ is the magnetic permeability. The speed of light appears to the fourth power in the denominator of the coupling constant between $G_{\mu\nu}$ and $T_{\mu\nu}$. The speed of light is taken to be the vacuum speed of light. What if the speed of light here were the speed in whatever medium is present while keeping the field equation generally covariant? This is the new empirically falsifiable conjecture of this paper.

"Virtual electron-positron pairs and virtual photons off-mass-shell inside the vacuum primarily determine the speed of light in the absence of electric 4-current densities from real on-mass-shell particles in the sense of quantum field theory. The “mass shell” is the pole of the single-particle Feynman propagator in the complex energy plane whose position depends on the momentum according to Einstein’s special relativity for the frame-invariant rest mass m_0.

$$E^2-(cp)^2=\left(m_0c^2\right)^2 \tag{1.3}$$

Virtual particles inside the vacuum are internal lines in the Feynman diagrams of the S-Matrix perturbation series. Real particles outside the vacuum are the external lines.

Maxwell’s field equations in the interior of matter are formally covariant tensor equations under the Poincare group where the vacuum permittivity and permeability are simply renormalized to include the frame invariant “scalar” responses χ of the real interior electric 4-current densities j_σ as shown in (1.4) in the simplest case of an isotropic material to avoid unnecessary formal complications that would obscure the key physical idea.

$$\begin{aligned}\varepsilon&=\varepsilon_{vac}\left(1+\chi_E\right)\\ \mu&=\mu_{vac}\left(1+\chi_B\right)\end{aligned} \tag{1.4}$$

Assuming that the material responses are scalar invariants under the additional group of general coordinate transformations of general relativity [1], we can write Einstein’s gravity field equations in the interior of materials as

$$G_{\sigma\nu}+8\pi G\left(\varepsilon_{vac}\mu_{vac}\left(1+\chi_E\right)\left(1+\chi_B\right)\right)^2T_{\sigma\nu}^{EM}=0 \tag{1.5}$$

Where I have specialized the source tensor to the electromagnetic field.

$$T_{\sigma\nu}^{EM}=\begin{matrix}\frac{1}{2}\left(\varepsilon_{vac}\left(1+\chi_E\right)E^2+\frac{B^2}{\mu_{vac}\left(1+\chi_B\right)}\right) & \vec{S}\sqrt{\varepsilon_{vac}\left(1+\chi_E\right)\mu_{vac}\left(1+\chi_B\right)}\\ \vec{S}\sqrt{\varepsilon_{vac}\left(1+\chi_E\right)\mu_{vac}\left(1+\chi_B\right)} & \Xi_{ij}^{EM}\end{matrix} \tag{1.6}$$

$$\vec{S} = \frac{\vec{E} \times \vec{B}}{\mu_{vac}\left(1+\chi_B\right)} \tag{1.7}$$

$$\Xi_{ij}^{EM} = \varepsilon_{vac}\left(1+\chi_E\right)E_i E_j + \frac{B_i B_j}{\mu_{vac}\left(1+\chi_B\right)} - \frac{1}{2}\left(\varepsilon_{vac}\left(1+\chi_E\right)E^2 + \frac{B^2}{\mu_{vac}\left(1+\chi_B\right)}\right)\delta_{ij} \tag{1.8}$$

The material response functions are an infinite series in the electromagnetic field source tensor, which in the strong field case add new nonlinearities to Einstein's gravity field equations.

$$\chi_{E(B)} = \chi_{E(B)}^{0} + \chi_{E(B)}^{\lambda\rho} T_{\lambda\rho}^{EM} + \chi_{E(B)}^{\lambda\rho\lambda'\rho'} T_{\lambda\rho}^{EM} T_{\lambda'\rho'}^{EM} + \chi_{E(B)}^{\lambda\rho\lambda'\rho'\lambda''\rho''} T_{\lambda\rho}^{EM} T_{\lambda'\rho'}^{EM} T_{\lambda'\rho'}^{EM} + \ldots \tag{1.9}$$

These new source nonlinearities will be ignored as no research has been done on them and are presented here perhaps for the first time in the history of physics. Indeed, the new way of looking at Einstein's equations inside of materials is usually ignored because for most materials, up until the last decade or so

$$\chi_{E(B)} << 1 \tag{1.10}$$

The experimental physics of Bose-Einstein condensates [2], metamaterials and other devices [3] that slow the speed of light down to a crawl has advanced so much that now

$$\chi_{E(B)} >> 1 \tag{1.11}$$

can be realistically considered.

Metamaterials are now being fabricated for on-mass-shell propagating far field micro-waves and light waves with only two transverse polarizations in which

$$\chi_{E(B)} < 0 \tag{1.12}$$

However, what is required for practical low power warp drive is not propagating radiation, but a new kind of metamaterial, filled with very low frequency off-mass-shell non-propagating near field virtual photons that are Bose-Einstein condensed into macro-quantum coherent Glauber states of sharp phase and uncertain number. It may be possible to generate them from the aforementioned strong EM field

nonlinearities. Ideally, for example, the Fourier transforms of the material responses for the electric permittivity alone that is strongly negative for low frequencies as close to static as possible. Imagine such a longitudinally polarized non-propagating quasi-static near electric field in the hypothetical meta-material containing the virtual photon coherent Bose-Einstein condensate sandwiched between two parallel oppositely charged conducting plates – a new kind of electrical capacitor where

$$\begin{aligned} &\tilde{\chi}_E\left(\omega,\vec{k}\right) << 0 \\ &\omega \sim 0 \\ &\omega \neq c\left|\vec{k}\right| \end{aligned} \tag{1.13}$$

The key point for warp drive is repulsive antigravity like the cosmological dark energy accelerating the expansion rate of our observable universe, that Einstein's field equation (1.1) together with WMAP and Type 1a supernovae z data say, is sandwiched between our Friedman-Walker-Robertson particle horizon and our future de Sitter event horizon. Our past particle horizon is the future light cone of the moment of inflation whose released energy made the hot Big Bang. Our future event horizon is the past light cone of our world line that we imaginatively stretch to infinite metric proper time that corresponds to a finite conformal clock time. We approach our future event horizon and recede from our past particle horizon.
Let's simplify (1.6) to the case $\vec{B} \to 0$

$$T^{EM}_{\sigma\nu} \underset{\vec{B}\to 0}{\to} \begin{matrix} \frac{1}{2}\varepsilon_{vac}\left(1+\chi_E\right)E^2 & 0 \\ 0 & \varepsilon_{vac}\left(1+\chi_E\right)E_iE_j - \frac{1}{2}\varepsilon_{vac}\left(1+\chi_E\right)E^2\delta_{ij} \end{matrix} \tag{1.14}$$

When the response is strongly negative, we have

$$T^{EM}_{\sigma\nu} \underset{\vec{B}\to 0}{\to} \begin{matrix} -\frac{1}{2}\varepsilon_{vac}\left|\chi_E\right|E^2 & 0 \\ 0 & -\varepsilon_{vac}\left|\chi_E\right|E_iE_j - \frac{1}{2}\varepsilon_{vac}\left|\chi_E\right|E^2\delta_{ij} \end{matrix} \tag{1.15}$$

Einstein's gravity field equation in this hypothetical desired limit is

$$\begin{pmatrix} G_{00} & G_{0i} \\ G_{io} & G_{ij} \end{pmatrix} + 8\pi\chi_E^2\left(1+\chi_B\right)^2 G \begin{pmatrix} -\frac{1}{2}\varepsilon_{vac}\left|\chi_E\right|E^2 & 0 \\ 0 & -\varepsilon_{vac}\left|\chi_E\right|E_iE_j - \frac{1}{2}\varepsilon_{vac}\left|\chi_E\right|E^2\delta_{ij} \end{pmatrix} \sim 0 \quad (1.16)$$

generating a universally quasi-static repulsive non-propagating confined gravity field.

The weak field Newtonian gravity limit gives an approximate Poisson equation

$$\nabla^2\phi \to 4\pi G\left(\rho + \frac{3p}{c^2}\right) \quad (1.17)$$

That in our case becomes

$$\nabla^2\phi - 12\pi\chi_E^3\left(1+\chi_B\right)^2 G\varepsilon_{vac}E^2 \sim 0 \quad (1.18)$$

In the linear regime of (1.9) suppose we can slow down the speed of light to 3 cm/sec keeping the magnetic response χ_B close to 1. Therefore, since c scales as the inverse square root of χ_E, we have a dimensionless amplification of the repulsive anti-gravity field of order 10^{60}. The nonlinear regime may improve on this linear result. This is uncharted territory since (1.9) is new to the literature.

For example, from (1.9) it may be possible to engineer a metamaterial described by

$$\nabla^2\phi - e^{\kappa\chi_E^3\left(1+\chi_B\right)^2 G\varepsilon_{vac}E^2}\, 12\pi\chi_E^3\left(1+\chi_B\right)^2 G\varepsilon_{vac}E^2 \sim 0 \quad (1.19)$$

2. Energy Conservation

There is no problem with energy conservation.

$$\begin{aligned} &U_i + W_{in} = U_f + W(Q)_{out} \\ &U_i > 0 \\ &U_f < 0 \\ &W(Q)_{out} > W_{in} > 0 \end{aligned} \quad (1.20)$$

The initial and final internal energies of the metamaterial's near electromagnetic fields are $U_{i(f)}$. The external work input done by system A in switching on the electromagnetic field is W_{in}. The work/heat output from the electromagnetic field-metamaterial on system B is $W(Q)_{out}$. We can arrange A = B with more work/heat output than input. Of course, the energy is coming from the meta-material so that the process is limited. Some kind of phase transition in the meta-material will be induced and the effect will saturate.

3. Energy Requirements

James Woodward [4] estimates a Jupiter mass scale 10^{27} kgm of total energy needed to engineer artificial warping of Einstein's metric field assuming the normal weak coupling of stress-energy current density to curvature. If we could cut that down by a factor of 10^{60} we would obviously be in good shape. We could even do with a lot less than that optimistic first estimate.

The mass of the Earth is $\sim 10^{25}$ kgm (10^{42} Joules). Therefore, we would not need impractically large electric fields to neutralize the Earth's gravity around the ship if we could achieve large resonances in the low frequency dielectric susceptibility response functions of metamaterials. The amplification scales as χ_E^3, so if we only want to store say one Joule total in the slowly varying near electric fields of the metamaterial capacitor, we need a resonance of $-|\chi_E|^3 \sim 10^{42}$. Therefore, $\chi_E \sim -10^{14}$. Consequently, the required index of refraction in the non-radiative near field ELF range that scales as $\chi_E^{-1/2}$ is $\sim 10^7$ i.e., a metamaterial speed of light ~ 30 meters/sec.

Thanks to Professor James Woodward for useful suggestions.

1. R.C. Tolman, “Relativity, Thermodynamics and Cosmology”, Oxford Clarendon Press, 1934. VIII Relativistic Electrodynamics, Part 1, The Covariant Generalization of Electrical Theory, #105 The Generalized Macroscopic Theory (Book)

2. Zachary Dutton, Naomi S. Ginsberg, Christopher Slowe, and Lene Vestergaard Hau (2004). "The art of taming light: ultra-slow and stopped light". *Europhysics News* **35**

3. Wentao T. Lu, Savatore Savo; B. Didier F. Casse, Srinivas Sridhar (2009). "Slow microwave waveguide made of negative permeability metamaterials". Microwave and Optical Technology Letters 51 (11): 2705–2709.

K.L. Tsakmakidis, O. Hess; A.D. Boardman (2007). "Trapped rainbow storage of light in metamaterials". Nature 450 (7168): 397–401.

C. J. Chang-Hasnain, "Slowing and Stopping Light", SPIE Photonics West, Optoelectronics Symposium, January 2005.

Bala Pesala, Forrest Sedgwick, Alexander Uskov, and Connie Chang-Hasnain, “Ultrahigh-bandwidth electrically tunable fast and slow light in semiconductor optical amplifiers”, JOSA B, Vol. 25, Issue 12, pp. C46-C54 (2008)

P.C. Ku, C. J. Chang-Hasnain and S.L. Chuang, “Slow light in semiconductor heterostructures”, J. Phys. D, January 2007.

C. J. Chang-Hasnain and S.L. Chuang, “Slow and Fast Light in Semiconductor Quantum-well and Quantum-dot Devices”, IEEE Journal of Lightwave Communications, Special Issue on Optoelectronics, 24, 12, pp. 4642-4654, December 2006.

Lukas Chrostowski, Xiaoxue Zhao, Connie J. Chang-Hasnain, “Microwave Performance of Optically Injection-Locked VCSELs”, IEEE Transactions on Microwave Theory and Techniques, Volume 54, Issue 2, Part 2, pp.788 – 796, Feb. 2006

C. J. Chang-Hasnain, P.C. Ku, J. Kim, S.L. Chuang, " Variable Optical Buffer Using Slow Light in Semiconductor Nanostructures," Proceedings of the IEEE,

Special Issue on Nanoelectronics and Nanoscale Processing, Vol. 91, 11, pp. 1884-97, Nov. 2003.

4. J. Woodward, "Making the Universe Safe for Historians: Time Travel and the Laws of Physics," Foundations of Physics Letters, vol. 8, pp. 1 - 40 (1995).

"Twists of Fate: Can We Make Traversable Wormholes in Spacetime?" Foundations of Physics Letters, vol. 10, pp. 153 - 181 (1997).

End Notes

[i] Henry Dwight Sedgwick, Apology for Old Maids, House of Sorrow (1908).

[ii] Simon & Schuster, 1993.

[iii] "The Queen bawled out, 'He's murdering the time! Off with his head!' Lewis Carroll

General relativity even permits sufficient warping to allow "closed time-like curves". These seemingly perverse trajectories describe paths through space-time that always move forward in local time (i.e. an observer's watch always runs forward), but eventually end up back where and when they started. A space-time that contains closed time-like curves, localized in one region, can be said to have a "time machine". … Closed time-like curves appear in explicit analytical solutions to the Einstein equation of general relativity. Previously such solutions were deemed "unphysical", simply because they contained closed time-like curves. Nevertheless, since these solutions obey the field equations, they should not be rejected out of hand. Indeed, interest in closed time-like curves has increased in the past decade. The reasons for this are varied, ranging from the practical (if time machines can be built, they would have a lot of potential uses), to the theoretical (perhaps quantum gravity can say something about the existence of closed time-like curves, or vice versa) to the philosophical (do the laws of physics allow or prohibit closed time-like curves?). …

High-energy particle showers formed in the upper atmosphere by cosmic rays contain particles whose lifetimes are much shorter than the time it takes them to reach ground level, but whose speeds are extremely close to the speed of light. The very fact that we observe these particles at ground level means that their rate of time passage has dilated or, equivalently, that they have travelled into their future. … (Note that there is a distinction between going back into the past, discussed here, and going "backwards in time", that is having one's watch tick backwards, which is a separate issue with its own physics).

What about the paradoxes of time travel? Can they be used as evidence against the existence of closed time-like curves? The most serious of these is the "grandparent" paradox. In this scenario a time traveller goes back in time and kills his or her grandparent before he or she has any children. This would be a true paradox. One resolution to this paradox is to postulate that only self-consistent histories are allowed. With this postulate the rules of the game are turned around. We can ask whether a particular physical theory allows self-consistent evolution that is also consistent with its equation of motion …

We should also be aware that many physical theories with different equivalent formulations (such as the Schrodinger and Feynman formulations of quantum mechanics) can give different results in the presence of closed time-like curves. Therefore when determining the effect of closed time-like curves on a particular theory, we have to define the theory very carefully. In avoiding the grandparent paradox, the self-consistency postulate at first seems to violate our concept of free will. It is difficult to imagine oneself as a time traveller when one is not allowed to make choices, which might cause a paradox. But this is a bit of a red herring - this same lack of free will already exists in ordinary Newtonian mechanics, or in any deterministic theory: once the initial values of the fields and derivatives are specified, there is no room for

free will. …

As a simple example of a time machine, due to Joseph Polchinski …we use a specialized billiard table with two pockets. Any object that falls into the right-hand pocket at time t is shot out of the left-hand pocket at an earlier time, t - dt, with the same speed but a new direction … This time machine could be implemented using a space-time "wormhole" - a shortcut in spacetime (of non-trivial topology) which connects two distant points by a shorter path. The points connected may be separated in time as well as space … It turns out that every initial condition for this model has a self-consistent solution. In fact, for many initial conditions there is more than one self-consistent solution, and often an infinite number, which all obey Newton's laws of classical mechanics. … Fields have properties similar to particles. Non-interacting fields, such as electromagnetism in the absence of charges, are free from multiple solutions (and paradoxes). However, fields can also destabilize a time machine by propagating through it an infinite number of times, and adding their field strengths in each passage. If the time machine has a focusing effect, this infinite build-up of field energy would back-react on the time machine. … It turns out that quantum mechanics gives a more definite answer than classical mechanics. However, one must first pick a definite formulation of quantum mechanics to get a definite answer, and there are several distinct formulations of quantum mechanics which are equivalent without closed time-like curves, but which are not equivalent in their presence." The physics of time travel JONATHAN Z SIMON Physics World Dec 1994

[iv] [4] S. Lloyd, L. Maccone, R. Garcia-Patron, V. Giovannetti, and Y. Shikano, Phys. Rev. D 84, 025007 (2011).
[5] S. Lloyd, L. Maccone, R. Garcia-Patron, V. Giovannetti, Y. Shikano, S. Pirandola, L. A. Rozema, A. Darabi, Y. Soudagar, L. K. Shalm, and A. M. Steinberg, Phys. Rev. Lett. 106, 040403 (2011).
[6] S. Lloyd, L. Maccone, R. Garcia-Patron, V. Giovannetti, Y. Shikano, S. Pirandola, L. A. Rozema, A. Darabi, Y. Soudagar, L. K. Shalm et al., arXiv:1108.0153 [quant-ph].
We show that it is possible to clone quantum states to arbitrary accuracy in the presence of a Deutschian closed timelike curve (D-CTC), with a fidelity converging to one in the limit as the dimension of the CTC system becomes large ... Furthermore, our results show that Deutsch's model for closed timelike curves is in fact a classical model, in the sense that two arbitrary, distinct density operators are perfectly distinguishable (in the limit of a large closed timelike curve system); hence, in this model quantum mechanics becomes a classical theory in which each density operator is a distinct point in a classical phase space ... Our results imply that, in a particular sense, Deutsch's model is actually a classical model for CTCs rather than a quantum model. ... Deutsch's model originates from the way that it combines quantum features (density operators and unitary evolutions) with nonquantum ones (nonlinear evolution) in an ad hoc way. T.A. Brun, M.M. Wilde, A. Winter, PRL 111, 190401 (2013).

[v] PHYSICAL REVIEW VOLUME 44, NUMBER 10
Quantum mechanics near closed timelike lines
15 NOVEMBER 1991
David Deutsch
Oxford University Mathematical Institute, 24-29 St Giles, Oxford OXI 3LB, England
(Received 9 April 1991)
"The methods of the quantum theory of computation are used to analyze the physics of closed timelike lines. This is dominated, even at the macroscopic level, by quantum mechanics. In classical physics the existence of such lines in a spacetime imposes "paradoxical" constraints on the state of matter in their past and also provides means **for knowledge to be created in ways that conflict with the principles of the philosophy of science**. In quantum mechanics the first of these pathologies does not occur. The second is mitigated, and may be avoidable without such spacetimes being ruled out. Several novel and distinctive (but nonparadoxical) quantum-mechanical effects occur on and near closed timelike lines, including **violations of the correspondence principle and of unitarity**. It becomes possible to "clone" quantum systems and to measure the state of a quantum system. A new experimental test of the Everett interpretation against all others becomes possible. Consideration of these and other effects sheds light on the nature of quantum mechanics.

[vi] "Deutsch offered a quantum-mechanical account of CTCs that was intended to rule out such paradoxes from the outset. On the Deutsch model, a quantum system traversing a closed timelike curve (the CTC system) must satisfy a fixed-point consistency condition. If we think of the CTC system as entering the future mouth of a "wormhole" in spacetime in a state ρ_{CTC} and emerging from the past mouth … It follows that the time traveller on the CTC cannot enter the loop in Grandpa's future, travel to the past, and prevent her own birth by killing Grandpa. CTCs satisfying Deutsch's condition are referred to as D-CTCs. Since the interaction is a completely positive map with at least one fixed point, a suitable state ρ_{CTC} always exists … In any case, since ρ_{CTC} depends both on ρ_{CR} and itself, the resulting evolution is nonlinear. As we will see, this can produce surprising behavior. … Bennett and Schumacher and, independently, Svetlichny, offered an alternative model of CTCs, which was further developed by Seth Lloyd et al. This account simulates CTC interactions by quantum teleportation combined with postselection: hence, P-CTCs. … Alice measures qubits A and C in the Bell basis and communicates the result to Bob, who applies an appropriate unitary depending on which of the four outcomes occurred. Should the outcome of the Bell measurement correspond to the original Bell state … however, there is nothing Bob needs to do. Seth Lloyd et al. offered this comment:

"In this case, Bob possesses the unknown state even before Alice implements the teleportation. Causality is not violated because Bob cannot foresee Alice's measurement result, which is completely random. But, if we could pick out only the proper result, the resulting "projective" teleportation would allow us to travel along spacelike intervals, to escape from black holes, or to travel in time."

Thus, P-CTCs model CTCs as cases of teleportation in which nature, as it were, picks out the projection onto the appropriate entangled state. This induces a different nonlinear evolution in the state of the CR system and can be interpreted as creating a quantum channel to the past. Here the idea is that paradox is avoided because anything that could happen in a P-CTC interaction does happen with some nonzero probability in an ordinary quantum teleportation circuit. As Lloyd et al. saw it; this approach has many advantages, one of which is that it leads to testable predictions. What would happen in each case if we were in possession of a genuine P-CTC happens (in our simple case) for one quarter of the equally probable outcomes of the Bell measurement. This means that teleportation experiments combined with conventional postselection can be used to test and illustrate predictions about CTCs.it leads to testable predictions. What would happen in each case if we were in possession of a genuine P-CTC happens (in our simple case) for one quarter of the equally probable outcomes of the Bell measurement. This means that teleportation experiments combined with conventional postselection can be used to test and illustrate predictions about CTCs. …We conclude that signaling together with relaying yields a procedure for signaling to the past. D-CTCs were designed to ensure the existence of a fixed-point solution that evades classical time travel paradoxes. Assuming that measurements have definite outcomes, relaying allows classical information to be sent around a spacetime loop and used to trigger classical devices, opening the door to paradoxes in the classical domain. For example, a D-CTC relay circuit could mimic any classical grandfather paradox scenario. We know in advance that we will not kill Grandpa (logic assures us of that), but D-CTCs do not provide any systematic explanation of why we fail. Deutsch would presumably resist this conclusion. His consistency condition comes with a caveat [1], p. 3206: Now recall the consistency condition for the evolution round a closed timelike line. In the quantum case I have taken it to be that the density operator of each chronology-violating bit must return to its original value at a given event, as expressed by (15). That is the correct condition under the unmodified quantum formalism, but it is either wrong or insufficient under every other version of quantum theory, just as under classical physics. … The reference to Eq. (15) here is to our Eq. (1). The "unmodified quantum formalism" is Deutsch's term for the Everett interpretation of quantum mechanics: he regards other interpretations as modified versions of the theory. On Deutsch's view [1], p. 3207: **"Closed timelike lines would provide gateways between Everett universes."** We do not take a position here on the issue of interpretation. There is a rich literature of results about the information theoretic seminal paper, and none of this hinges on anything more than operational features of quantum mechanics. Here we take note of these results and demonstrate some further unexpected consequences. Perhaps more to the point, our consistency condition shows how Deutsch's model of quantum CTC interactions can avoid the sort of inconsistency pointed out by Lobo et-al without presupposing an

Everettian interpretation. … We note that Deutsch is particularly concerned to show that his fixed point consistency condition excludes the possibility of an **unproved theorem paradox**: Bob reads the proof of a theorem in a journal and sends it back to Alice in the past, who publishes the proof in the journal that Bob subsequently reads. **The "paradox" is that the theorem comes from nowhere, without any intellectual effort from Alice or Bob.** Deutsch regards this ("paradox 4") as **"a far more serious paradox"** than the grandfather paradox [1], p. 3202. **The unproved theorem paradox is associated with the network in** Fig. 2 for finding the fixed point of a function f in one step (where the − 1 represent a negative temporal increment, i.e., **time travel to the past**). Our relay procedure shows that precisely such a circuit can be achieved with D-CTCs. …. Deutsch's model of quantum CTC interactions was designed to avoid imposing gratuitous constraints to thwart time travel paradoxes like the grandfather paradox or the **unproved theorem paradox.** Logic tells us that such paradoxical situations cannot occur, but in a classical theory the only explanation available for the nonoccurrence of paradox is a **"banana peel" explanation: something happens**, like slipping on a banana peel that just happens to be conveniently placed so that the paradoxical event fails to occur. P-CTCs are supposed to avoid paradox because anything that could happen in a P-CTC circuit does happen with some probability in an ordinary teleportation circuit. As Lloyd et al. [4], p. 025007 emphasize: "Because the theory of P-CTCs rely on postselection, they provide self-consistent resolutions to such paradoxes: anything that happens in a P-CTC can also happen in conventional quantum mechanics with some probability." We have shown that both P-CTCs and D-CTCs allow the possibility of a "radio to the past" that operates in the classical domain, in which there is no systematic fix to time-travel paradoxes. As a consequence, it follows that CTC-enhanced quantum computers have the power of PSPACE, for both DCTC and P-CTC quantum interactions." Quantum interactions with closed timelike curves and superluminal signaling, Jeffrey Bub and Allen Stairs, PHYSICAL REVIEW A 89, 022311 (2014)

[vii] http://en.wikipedia.org/wiki/Daryl_Bem
See also:
Postcorrection and mathematical model of life in Extended Everett's Concept
Michael B. Mensky
(Submitted on 21 Dec 2007)
Extended Everett's Concept (EEC) recently developed by the author to explain the phenomenon of consciousness is considered. A mathematical model is proposed for the principal feature of consciousness assumed in EEC, namely its ability (in the state of sleep, trance or meditation, when the explicit consciousness is disabled) to obtain information from all alternative classical realities (Everett's worlds) and select the favorable realities. To represent this ability, a mathematical operation called post-correction is introduced, which corrects the present state to guarantee certain characteristics of the future state. Evolution of living matter is thus determined by goals (first of all by the goal of survival) as well as by causes. The resulting theory, in a way symmetrical in time direction, follows from a sort of anthropic principle. Possible criteria for post-correction and corresponding phenomena in the sphere of life are classified. Both individual and collective criteria of survival are considered as well as the criteria providing certain quality of life and those, which are irrelevant to the life quality. The phenomena of free will and direct sighting of truth (e.g. scientific insight) are explained in these terms. The problem of artificial intellect and the role of brain look differently in the framework of this theory. Automats may perform intellectual operations, but not post-correction, therefore artificial intellect but not an artificial life can be created. The brain serves as an interface between the body and consciousness, but the most profound level of consciousness is not a function of brain. http://xxx.lanl.gov/abs/0712.3609
Mensky is aware of Aharonov's "post-selection," which, he writes, is not quite the same as his "post-correction."
"A mathematical operation called postcorrection is introduced, which corrects the present state to guarantee certain characteristics of the future state. … The phenomena of free will and direct sighting of truth (e.g. scientific insight) are explained in these terms."
However, Mensky may not mean advanced retrocausation the way I, Aharonov and others mean it because he wrote: *"Indeed, the essence of the phenomenon of life reduces to a strategy of survival, and the efficient survival is provided only by estimating the future of a living system (from the point*

of view of its survival) and by the corresponding correction of the system's present state." That is a computation made today changes present mental state via free will to achieve the goal. Nothing seems to be new there. However, Mensky does say elsewhere that present state is fixed in the future, indicating the same advanced Wheeler-Feynman influence I am advocating.

Remark 7 "A future state" of a system has been used by Y. Aharonov, P.G. Bergmann and J.L. Lebowitz in the paper published in 1964 [7] and by Y. Aharonov with other coauthors in the subsequent works (see for example [8, 9]) under name of the formalism of postselection or the two-vector formalism. In this formalism the states of a system at both initial time and some later moment of time ("final time") are fixed. In [7] the formula for the probabilities of various outputs of the measurement performed at an intermediate time (between the initial and final times), given the initial and final states, was derived. The above-defined operation of post-correction differs from the two-vector formalism (postselection) both formally and essentially. The formal difference is that in the post-correction 1) not a single state but a subspace (of an arbitrary dimension) is ***fixed in the future*** *(at the "final time"), and 2) the initial state undergoes a correction. The essential difference is in the physical interpretation (sphere of application) suggested for these two formalisms. The two-vector formalism was applied for analyzing events predicted by conventional quantum mechanics for usual material systems. In the paper [9] the two-vector formalism was exploited to formulate a novel interpretation of quantum mechanics, in which the various outputs of a measurement were associated with various future state vectors. In contrast with this, the post-correction describes (in the framework of EEC) not a usual material system, but a "living system", or, more precisely, the image appearing in the consciousness of living being."*

Mensky and I do agree that this future influence is the essence of consciousness – the elan vital perhaps.

[viii] http://en.wikipedia.org/wiki/Wheeler–Feynman_absorber_theory

[ix] To get the most value, the reader while reading should have immediate access to the Web at their fingertips to look up unfamiliar words and to click on the hyperlinks mostly in the extensive endnotes – in the e-book version. This book is not meant for people who have no familiarity whatsoever with high school mathematics including multi-variable partial differential and integral calculus, vector calculus, matrix algebra, or who have never had at least a high school physics course from a competent teacher and are unfamiliar with basic symbols like c for the speed of light in vacuum, or G for Newton's gravity constant, or h for Planck's quantum of action, or k_B for Boltzmann's constant of entropy etc. Engineers and computer programmers should be able to understand most of this book easily. This is not a traditional orthodox boring textbook teaching basic physics, nor is it a watered down pop physics book. Rather it is a supplement for physics textbooks and hopefully a useful guide to online sources of mainstream information organized according to my eclectic nonlinear stream of consciousness "beat" point of view connecting many different branches of physics in a way not familiar to the average physicist. Finally I recommend "The Feynman Lectures on Physics" are now free online.

[x] Post-correction and mathematical model of life in Extended Everett's Concept, Michael B. Mensky P.N. Lebedev Physical Institute, Russian Academy of Sciences 53 Leninsky prosp., 119991 Moscow, Russia August 20, 2007. Thanks to Gary Bekkum for bringing Mensky's papers to my attention.

[xi] The concern with falsifiability gained attention by way of philosopher of science Karl Popper's scientific epistemology "falsificationism". Popper stresses the problem of demarcation—distinguishing the scientific from the unscientific—and makes *falsifiability* the demarcation criterion, such that what is unfalsifiable is classified as unscientific, and the practice of declaring an unfalsifiable theory to be scientifically true is pseudoscience. This is often epitomized in Wolfgang Pauli famously saying, of an argument that fails to be scientific because it cannot be falsified by experiment, "it is not only not right, it is not even wrong!" http://en.wikipedia.org/wiki/Falsifiability

[xii] **Dark matter** is a type of matter hypothesized in astronomy and cosmology to account for a large part of the mass that appears to be missing from the universe. Dark matter cannot be seen directly with telescopes; evidently it neither emits nor absorbs light or other electromagnetic radiation at any significant level. It is otherwise hypothesized to simply be matter that is not reactant to light.[1] Instead, the existence and properties of dark matter are inferred from its gravitational effects on visible matter, radiation, and the large-scale structure of the universe. According to the Planck mission team, and based on the standard model of cosmology, the total mass–energy of the known universe contains 4.9% ordinary matter, 26.8% dark matter and 68.3% dark energy. http://en.wikipedia.org/wiki/Dark_matter

[xiii] http://en.wikipedia.org/wiki/Michelson–Morley_experiment

[xiv] http://en.wikipedia.org/wiki/Hard_problem_of_consciousness

[xv] http://www.tcm.phy.cam.ac.uk/~mdt26/pilot_waves.html

[xvi] http://en.wikipedia.org/wiki/Henry_Stapp

[xvii] http://en.wikipedia.org/wiki/No-communication_theorem

[xviii] http://en.wikipedia.org/wiki/Stuart_Hameroff

[xix] http://en.wikipedia.org/wiki/Hawking_radiation

[xx] We conjecture that Vasiliev's theory of higher spin gravity in four-dimensional de Sitter space (dS4) is holographically dual to a three-dimensional conformal field theory (CFT3) living on the spacelike boundary of dS4 at future timelike infinity. ...The AdS/CFT correspondence provides a non-perturbative holographic definition of anti-de Sitter (AdS) quantum gravity in terms of a CFT living on the timelike conformal boundary of AdS. Our own universe is unlikely to have an anti-de Sitter boundary, but may well have a de Sitter (dS) boundary in the far future. This dS boundary shares a number of mathematical properties with the AdS boundary. Hence it is natural to try to define dS quantum gravity in terms of a CFT living on the future conformal boundary of dS [1, 2, 3, 4, 5, 6]. One key difference is that in AdS/CFT, the radial direction emerges holographically from the CFT, while in dS/CFT time itself must be holographically emergent. It is challenging to reconcile this with our usual quantum notions of unitary time evolution. … A second key difference is that we have had no useful microscopically complete examples of the dS/CFT correspondence. This has stymied progress in the subject and at times rendered the discussions somewhat formal.[1] It is the purpose of this paper to begin to fill this gap. … Specifically, we conjecture that Vasiliev's higher spin gravity [7, 8] in dS4 is holographically dual to the three-dimensional conformal field theory (CFT3) with anticommuting scalars and Sp(N) symmetry studied by LeClair and collaborators in [9, 10, 11, 12]. This is a de Sitter analogue of the conjectured Giombi-Klebanov-Polyakov-Yin (GKPY) duality relating the O(N) CFT3 to Vasiliev gravity in AdS4, whose remarkable properties have received much recent attention [13, 14, 15, 16, 17, 18, 19]. The Sp(N) CFT3 dual to de Sitter space has anticommuting scalar fields **and is therefore non-unitary**. This peculiarity does not rule out the duality because in dS/CFT, the CFT is Euclidean and never continued to Lorentzian signature. On the other hand, the good properties of ordinary time evolution in the bulk must be encoded somehow in the CFT. Indeed the Sp(N) CFT3 turns out to have a "pseudo-unitary" structure [11] which may be relevant." Dionysios Anninosa, Thomas Hartmanb and Andrew Stromingerc http://arxiv.org/abs/arXiv:1108.5735

[xxi] More precisely, all physical theories are descriptions of measurements aiming for a coherent intelligible narrative of how the universe works. All measurements are a relationship between the object and the observer.

[xxii] Einstein means "curvature" by "special" in which the special relativity Cartesian metric (1) does not work globally over a large region of spacetime. It continues to hold locally in the sense of tangent

spaces of a fiber bundle for those who know advanced mathematics. Indeed, one can always find local frames of reference in which the metric tensor "gravity potentials" has the Taylor perturbation series expansion out to second order

$$g_{ik}(P + dP) \sim \eta_{ij}(P) + \Gamma(P)_{ijk}\, dx^k + R(P)_{ijkl}\, dx^k\, dx^l + ...$$

Where $\eta_{ij}(P)$ is the special relativity metric diagonal in Cartesian coordinates that have immediate ruler/clock measurement significance. The non-tidal first order "special" gravity fields are the Christoffel symbols $\Gamma(P)_{ijk}$ their physical meaning is two-fold. First they describe all the universal fictitious forces on the observed object independent of the object's inertia m that in field theory is a test particle. A test particle's self-field can be ignored. The second meaning of the $\Gamma(P)_{ijk}$ is the non-universal real force on the observer. There is also a third mathematical meaning to $\Gamma(P)_{ijk}$ as the Levi-Civita zero torsion metric connection for parallel transport of geometric objects through spacetime along world lines. Finally, $R(P)_{ijkl}$ is the Riemann curvature tensor that are Einstein's "general" gravity fields describing stretch-squeeze Weyl tensor vacuum tidal effects as well as Ricci tensor expansion-contractions of matter in the curvature field. In an intuitive sense the curvature tensor is the "curl" of the connection Christoffel symbol with respect to itself. When $\Gamma(P)_{ijk} =/= 0$ the local frame with the detector/observer at its origin is a non-inertial LNIF on an off-geodesic world line in the actual gravitational field. We can always find local inertial frames LIFs coincident with the LNIF that have $\Gamma(P)_{ijk} = 0$. The transformation that does that is called the tetrad transformation. Physically, it's trivial, we simply switch off the external real force that pushed the observer off its natural geodesic. The geodesic path is the real force-free motion in four-dimensional space-time. The tangent vector of the object is parallel transported with respect to itself. We will come back to this in more detail. Real forces as opposed to fictitious forces push test objects off the geodesics of the gravitational field. We only know of three kinds of real forces, electromagnetic, weak and strong. In contrast, the fictitious forces are an aspect of Einstein's "special" gravitational field that does not require curvature according to his equivalence principle.

[xxiii] The same can be said for David Bohm's quantum potential information field Q. The "test particle" is a useful essential approximation that violates Einstein's generalized action-reaction principle. Curiously enough, orthodox quantum theory also violates Einstein's action-reaction principle. It is the violation of the generalized, indeed meta-theoretical philosophical, action-reaction principle that leads to the several no-go theorems prohibiting the use of entanglement as a direct command-control-communication channel without the need of a past to present classical retarded signal to decrypt messages secretly coded and stored in the nonlocal entanglement pattern connecting several space-time separated parts of the whole. Indeed, orthodox quantum theory's "unitarity of the S-Matrix" in the black hole information "firewall" puzzle, and in quantum encryption financial and military operations is like special relativity in relation to general relativity. David Bohm and Basil Hiley showed that all the no-go theorems derive from the violation of action-reaction in which the nonlocal entangled quantum potential Q of complex systems pilots the worldliness x(t) of fermion particles as well as the classical boson field configurations, without direct back-reaction of these particles and classical fields on Q itself. Michael Towler in his Lecture 8 online at Cambridge University describes my use of this Bohm-Hiley insight to formulate a post-quantum or general quantum theory with entanglement signal nonlocality violating all the no-go theorems of the orthodox special quantum theory that only works for simple quantum systems. Indeed, I propose this as a mechanism for the emergence of consciousness with the "presponse" measured by Libet, Radin, Bierman and Bem. Antony Valentini has come to the same conclusions as I did by a slightly different route using Bohm's formulation. Brian Josephson also independently suggested entanglement signaling in biological systems.

[xxiv] *"finite regions, where, with respect to a suitably chosen space [frame] of reference, material particles move freely without acceleration, and in which the laws of special relativity ... hold with remarkable accuracy..."* pp 58-59, "The Meaning of Relativity" Centennial Ed 1979, Princeton

[xxv] "Black Holes and Time Warps", P. 484 (1994) W.W. Norton, New York

http://en.wikipedia.org/wiki/Kip_Thorne

[xxvi] http://www.fourmilab.ch/documents/comp_mem_nat_life/

[xxvii] http://ricochet.com/member-feed/Saturday-night-science-Signature-in-the-Cell

[xxviii] http://en.wikipedia.org/wiki/Bootstrap_paradox

[xxix] The following paper has a few simple pictures that describe the basic experiment and the results (with pupil dilation as the measure):
http://deanradin.com/evidence/Radin2009SeerSees.pdf

[xxx] http://www.fourmilab.ch/rpkp/stapp.html

[xxxi] *Contrary to what I originally thought, one can define a large, natural class of discrete norm-preserving nonlinear gates. … when p =/= 2, the only p –norm preserving linear transformations are permutations of diagonal matrices. In other words, if you want to base quantum mechanics on a p -norm other than the 2-norm, then you'll need to include some sort of "manual normalization." However, manual normalization brings with it most of the hazards of nonlinearity: superluminal signalling, distinguishability of non-orthogonal states, and polynomial-time solubility of "obviously hard" problems … by using the concept of postselection to study the computational power of alternative quantum theories. The punch line, which might be of independent interest to computer scientists, is that all the alternative theories considered have at least the power of the complexity class PP and many have exactly the power of PP* .http://arxiv.org/pdf/quant-ph/0401062v2.pdf *In complexity theory, **PP** is the class of decision problems solvable by a probabilistic Turing machine in polynomial time, with an error probability of less than 1/2 for all instances. The abbreviation **PP** refers to probabilistic polynomial time. The complexity class was defined by Gill in 1977.* http://en.wikipedia.org/wiki/PP_(complexity)

[xxxii] Information Preservation and Weather Forecasting for Black Holes

S. W. Hawking1
1DAMTP, University of Cambridge, UK

Abstract

It has been suggested [1] that the resolution of the information paradox for evaporating black holes is that the holes are surrounded by firewalls, bolts of outgoing radiation that would destroy any infalling observer. Such firewalls would break the CPT invariance of quantum gravity and seem to be ruled out on other grounds. A different resolution of the paradox is proposed, namely that gravitational collapse produces apparent horizons but **no event horizons** behind which information is lost. This proposal is supported by ADS-CFT and is the only resolution of the paradox compatible with CPT. The collapse to form a black hole will in general be chaotic and the dual CFT on the boundary of ADS will be turbulent. Thus, like weather forecasting on Earth, information will effectively be lost, although there would be no loss of unitarity.

[xxxiii] http://en.wikipedia.org/wiki/Unitarity_(physics)

[xxxiv] http://en.wikipedia.org/wiki/Chronology_protection_conjecture

[xxxv] This is the basic idea of Francis Ford Coppola's sci-fi TV series "4400". This is no accident since I influenced his interest in UFOs and the paranormal in the mid-1970's.
http://en.wikipedia.org/wiki/The_4400 Details are given by Saul-Paul Sirag in my biographical book Destiny Matrix.

[xxxvi] http://www.princeton.edu/~achaney/tmve/wiki100k/docs/Novikov_self-consistency_principle.html

[xxxvii] http://en.wikipedia.org/wiki/I_Am_a_Strange_Loop

[xxxviii] http://en.wikipedia.org/wiki/Bootstrap_paradox
Quantum computational complexity in the presence of closed timelike curves
Dave Bacon*
Institute for Quantum Information, California Institute of Technology, Pasadena, California 91125, USA
and Department of Physics, California Institute of Technology, Pasadena, California 91125, USA
(Received 28 October 2003; published 13 September 2004)
Quantum computation with quantum data that can traverse closed timelike curves represents a new physical model of computation. We argue that a model of quantum computation in the presence of closed timelike curves can be formulated which represents a valid quantification of resources given the ability to construct compact regions of closed timelike curves. The notion of self-consistent evolution for quantum computers whose components follow closed timelike curves, as pointed out by Deutsch [Phys. Rev. D 44, 3197 (1991)], implies that the evolution of the chronology respecting components which interact with the closed timelike curve components is nonlinear. We demonstrate that this nonlinearity can be used to efficiently solve computational problems which are generally thought to be intractable. In particular we demonstrate that a quantum computer which has access to closed timelike curve qubits can solve NP-complete problems with only a polynomial number of quantum gates. PHYSICAL REVIEW A 70, 032309 (2004)
http://pra.aps.org/pdf/PRA/v70/i3/e032309
Quantum Interactions with Closed Timelike Curves and Superluminal Signaling
Jeffrey Bub1, 2 and Allen Stairs1
1Philosophy Department, University of Maryland, College Park, MD 20742, USA
2Institute for Physical Science and Technology, University of Maryland, College Park, MD 20742, USA
(Dated: October 23, 2013)
There is now a significant body of results on quantum interactions with closed timelike curves (CTCs) in the quantum information literature, for both the Deutsch model of CTC interactions (D-CTCs) and the projective model (P-CTCs). As a consequence, there is a prima facie argument exploiting entanglement that CTC interactions would enable superluminal and, indeed, effectively instantaneous signaling. In cases of spacelike
separation between the sender of a signal and the receiver, whether a receiver measures the local part of an entangled state or a disentangled state to access the signal can depend on the reference frame. We propose a consistency condition that gives priority to either an entangled perspective or a disentangled perspective inspacelike separated scenarios. For D-CTC interactions, the consistency condition gives priority to frames of reference in which the state is disentangled, while for P-CTC interactions the condition selects the entangled state. Using the consistency condition, we show that there is a procedure that allows Bob to signal to Alice in the past via relayed superluminal communications between spacelike separated Bob and Clio, and spacelike separated Clio and Alice. This opens the door to time travel paradoxes in the classical domain. Ralph [18] first pointed this out for P-CTCs, but we show that Ralph's procedure for a 'radio to the past' is flawed. Since both D-CTCs and P-CTCs allow classical information to be sent around a spacetime loop, it follows from a result by Aaronson and Watrous [3] for CTC-enhanced classical computation that a quantum computer with access to P-CTCs would have the power of PSPACE, equivalent to a D-CTC-enhanced quantum computer.
http://arxiv.org/pdf/1309.4751v2.pdf

[xxxix] http://en.wikipedia.org/wiki/Teleology

[xl] http://en.wikipedia.org/wiki/Scientific_revolution

[xli] Max Heirich, "Cultural Breakthroughs," American Behavioral Scientist, Vol 19, No. 6 July/August 1976 on line at:
http://deepblue.lib.umich.edu/bitstream/handle/2027.42/66669/10.1177_000276427601900602.pdf?sequence=2

[xlii] "Aharonov was one of the first to take seriously the idea that if you want to understand what is happening at any point in time, it's not just the past that is relevant. It's also the future," Tollaksen says. In particular, Aharonov reanalyzed the indeterminism that forms the backbone of quantum mechanics … There is nothing to explain the different behaviors of the two atoms, no way to predict when they will decay by looking at their history, and—seemingly—no definitive cause that produces these effects. This indeterminism, along with the ambiguity inherent in the uncertainty principle, famously rankled Einstein, who fumed that God doesn't play dice with the universe. … [Aharonov's] answer—which seems inspired and insane in equal measure—was that we cannot perceive the information that controls the article's present behavior because it does not yet exist. 'Nature is trying to tell us that there is a difference between two seemingly identical particles with different fates, but that difference can only be found in the future,' he says. If we're willing to unshackle our minds from our preconceived view that time moves in only one direction, he argues, then it is entirely possible to set up a deterministic theory of quantum mechanics. … By the late 1980s, Aharonov had seen a way out: He could study the system using so-called weak measurements. (Weak measurements involve the same equipment and techniques as traditional ones, but the "knob" controlling the power of the observer's apparatus is turned way down so as not to disturb the quantum properties in play.) In quantum physics, the weaker the measurement, the less precise it can be. Perform just one weak measurement on one particle and your results are next to useless. You may think that you have seen the required amplification, but you could just as easily dismiss it as noise or an error in your apparatus.

The way to get credible results, Tollaksen realized, was with persistence, not intensity. By 2002 physicists attuned to the potential of weak measurements were repeating their experiments thousands of times, hoping to build up a bank of data persuasively showing evidence of backward causality through the amplification effect. …

For Tollaksen, though, the results are awe-inspiring and a bit scary. "It is upsetting philosophically," he concedes. "All these experiments change the way that I relate to time, the way I experience myself." The results have led him to wrestle with the idea that the future is set. If the universe has a destiny that is already written, do we really have a free choice in our actions? Or are all our choices predetermined to fit the universe's script, giving us only the illusion of free will?

Tollaksen ponders the philosophical dilemma. Was he always destined to become a physicist? If so, are his scientific achievements less impressive because he never had any choice other than to succeed in this career? If I time-traveled back from the 21st century to the shores of Lake Michigan where Tollaksen's 13-year-old self was reading the works of Feynman and told him that in the future I met him in the Azores and his fate was set, could his teenage self—just to spite me—choose to run off and join the circus or become a sailor instead? …

In other words, you can see the effects of the future on the past only after carrying out millions of repeat experiments and tallying up the results to produce a meaningful pattern. Focus on any single one of them and try to cheat it, and you are left with a very strange-looking result—an amplification with no cause—but its meaning vanishes. You simply have to put it down to a random error in your apparatus. You win back your free will in the sense that if you actually attempt to defy the future, you will find that it can never force you to carry out post-selection experiments against your wishes. The math, Tollaksen says, backs him on this interpretation: The error range in single intermediate weak measurements that are not followed up by the required post-selection will always be just enough to dismiss the bizarre result as a mistake."
By Zeeya Merali| Thursday, August 26, 2010, Discover Magazine

[xliii] "The past influences the future but the future does not influence the past; that is the essence of causality. ... Unitary evolution leads to causality. ... Conventional formulations of the quantum mechanics of matter fields in a curved background spacetime require that this spacetime be foliable by a family of spacelike surfaces. A family of spacelike surfaces is needed just to define a state of the matter fields on a spacelike surface and the progress of this state into the future by either unitary evolution between spacelike surfaces or by "state vector reduction" on them. However, not all

spacetimes admit a foliation by spacelike surfaces. For example, spacetimes with closed timelike curves, such as would be produced by the motion of wormhole mouths, permit no foliating family of spacelike surfaces [1]. The quantum mechanics of matter fields in spacetimes with such nonchronal regions therefore cannot be formulated in terms of the evolution of states on spacelike surfaces. Rather, a more general formulation of quantum mechanics is required. ... Specifically, we explore the notions of unitarity and causality and the connections between them in this class of generalizations. ... Feynman's sum-over-histories formulation of quantum mechanics is a natural route to a generalized quantum mechanics of matter fields in spacetimes with nonchronal regions because, with it, quantum mechanics may be cast into a fully spacetime form that does not employ a notion of state that evolves through a foliating family of spacelike surfaces It is straightforward to see that the generalized quantum mechanics of matter fields described in the previous section is not causal in this sense if the evolution through nonchronal regions is not unitary. ... If X is not unitary, then the probabilities defined by (4.1) depend on the future geometry of spacetime. ... Experiments could, in principle, detect the existence of nonchronal regions in our future ... the existence of nonunitary evolution in the future not only acausally affects the probabilities of present alternatives, it also affects their decoherence. ... The generalization of Banks, Peskin, and Susskind suffers from energy nonconservation while that of Weinberg can permit communication between alternative branches of the universe in situations that have been called the "Everett phone" by Polchinski [33]. ... Decoherence prohibits energy nonconservation and Everett phones. Our arguments apply to all generalized quantum theories although we shall describe them here for the particular case of the generalized quantum mechanics of fields in nonchronal spacetimes. We also describe how signaling faster than light is possible. ... When spacetime geometry is time dependent we do not expect conservation of the total energy of matter fields ... In a theory which permits signals to travel backward in time along closed timelike curves, it is perhaps not surprising that it is possible to signal outside the light cone. What is less evident is that in the present generalized quantum mechanics this can be done utilizing observers who are outside the nonchronal region as the following example of Friedman and Papastamatiou [36] shows ... whether the predictions of quantum mechanics are consistent with a notion of causality is, of course, an empirical question that is accessible to experimental test. This generalized quantum mechanics permits definite predictions of the magnitude of any causality violation once the initial condition is given and the background spacetime geometry is specified. Violations of causality may not be so very large if the number and volume of nonchronal regions in our future is small."
PHYSICAL REVIEW D VOLUME 49, NUMBER 12 15 JUNE 1994
Unitarity and causality in generalized quantum mechanics for nonchronal spacetimes
James B. Hartle*
Department of Physics, University of California, Santa Barbara, California 93106
(Received 14 September 1993)

Weak measurements happen when the decoherence functional D(a,a') has significant off-diagonal elements. What happens when it has ODLRO? That is when $D(a,a') = A(a)A'(a')$.

[xliv] http://en.wikipedia.org/wiki/Grok

[xlv] http://www.princeton.edu/~achaney/tmve/wiki100k/docs/Novikov_self-consistency_principle.html

[xlvi] *"Unitarity in a quantum theory determines how probabilities are calculated from quantum amplitudes (normally by calculating the modulus squared of the amplitude). The mathematical definition of probability ensures that the sum of the probabilities always equals one, but the sum of the squared amplitudes depends on the physics of the theory. The usual cause of non-unitarity is that some information has been ignored. For example, transition amplitudes for the scattering of free electrons and protons into free electrons and protons will not be unitary unless bound states, that is hydrogen atoms, are also included. In the case of closed time-like curves, however, unitarity is violated in an unusual way: the sum of amplitudes squared (the norm) of the states genuinely changes. ... . If the theory is unitary, the proportionality factor is*

constant (and equal to one). Non-unitarity requires some additional rule of how to compute probability. However, the factor of proportionality will no longer be universal. The simplest way to "reconnect" the probability to the squared amplitude is to divide the amplitude by the norm of the initial state evolved in time (i.e. to "renormalize" the amplitude). This norm is not constant in time and also depends on the initial state. This method uniquely determines the probability from the amplitude, but has two disturbing features. First, quantum mechanics is no longer linear, so the cherished principle of superposition is lost. Secondly, because the probabilities depend on the future value of the norm of the initial state, probabilities of events that take place before the formation of closed time-like curves depend on what happens once the closed time-like curves form. This gives an extra form of causality violation before the closed timelike curves form, independent of any causality violations occurring after they form." Jonathan Simon, Physics World 1994

[xlvii] https://www.youtube.com/watch?v=ypEaGQb6dJk opening of Kubrick's film Space Odyssey

[xlviii] http://www.bbc.com/news/science-environment-16427876

http://www.starpod.us/2011/10/06/ufos-crash-and-burn-at-100-year-starship-symposium/#.Uy9eq9yFEVw

[xlix] http://ricochet.com/member-feed/Saturday-night-science-Starship-Century

[l] http://kepler.nasa.gov
http://en.wikipedia.org/wiki/Kepler_(spacecraft)

[li] http://en.wikipedia.org/wiki/Extrasolar_planet

[lii] http://en.wikipedia.org/wiki/Alcubierre_drive

[liii] http://en.wikipedia.org/wiki/John_Archibald_Wheeler

[liv] What is the real genuine truth? Is spacetime really flat … or is it really curved? To a physicist … that is an uninteresting question because it has no physical consequences. … Since the two viewpoints agree on the results of all experiments, they are physically equivalent. P. 400 KT

[lv] http://en.wikipedia.org/wiki/Global_financial_crisis_in_September_2008

[lvi] Washington Post, By Anne Gearan and Joby Warrick, Published: November 23 | Updated: Sunday, November 24, 2013, 8:40 AM
GENEVA — Iran and six major powers agreed early Sunday on a historic deal that freezes key parts of Iran's nuclear program in exchange for temporary relief on some economic sanctions.
The agreement, sealed at a 3 a.m. signing ceremony in Geneva's Palace of Nations, requires Iran to halt or scale back parts of its nuclear infrastructure, the first such pause in more than a decade.
[lvii] "Numerous groups have emerged seeking new meaning for this shattered world (and world view) ... Two of these, the 'futurists' and the 'counter-cultural physicists' will be examined in more detail. ... they offer promise of being more than intellectual fads ... One of the most interesting cultural developments ... has been the emergence of a group of scientists who describe themselves as 'counter-cultural physicists' ... they are involved in extending ... Einstein's theory of relativity. Their focus, however, is upon *consciousness* ... They stem from experiences that a few years ago would simply have served to label the participants as mentally deranged (c.f. Finkelstein, 1972, Taylor, 1974) ... This has included 'energy flows' experienced directly between people, unusual experiences of time and space; experiences or observations of precognition, telepathy, clairvoyance, and/or psychokinesis: and shatteringly new senses of how organic and inorganic life are related through time and space ... The most influential ... assume that gravitation can be treated as synonymous with the curvature of time and space. This means that all physical systems behave as though events were

taking place in non-Euclidean space-time … The counter-culture physicists have gone a step further. They suggest that *negative mass* contributes to the shape of space … (Sciama, D, Sarfatti 1974b) … Time for example flows in two directions … there are many more possibilities for interconnection in space that seemed true before … And various combinations of gravitational fields should allow interactions that seem to contradict our present understanding of physical principles. Such 'altered states of consciousness,' as telepathy, precognition, and even psychokinesis and astral projection become describable in terms of the principles of physics (Walker 1970, Sarfatti 1974a)"
Sarfatti, J. (1974a) "Implications of meta-physics for psycho-energetic systems," Psychoenergetic Systems, Vol 1, London Gordon and Breach
(1974b) "The eightfold way as a consequence of the general theory of relativity," Collective Phenomena, I
"Cultural Breakthroughs" American Behavioral Scientist, Vol 19, No. 6, July/August 1976

[lviii] http://plato.stanford.edu/entries/spacetime-iframes/

[lix] Email Nick Herbert to Jack Sarfatti Nov 26, 2013

[lx] http://areeweb.polito.it/ricerca/relgrav/solciclos/gron_d.pdf Øyvind Grøn

[lxi] J. Foster, J.D. Nightingale, *A Short Course in General Relativity*, Springer 1998 2nd Ed 2.9

[lxii] http://www.ipod.org.uk/reality/reality_wigner.pdf

[lxiii] http://www.cpt.univ-mrs.fr/~rovelli/book.pdf Chapter 2

[lxiv] http://www.feynmanlectures.caltech.edu/I_05.html

[lxv] http://www.feynmanlectures.caltech.edu/I_12.html

[lxvi] We are doing foundations of theoretical physics here. The test particle is considered a point particle in these gedankenexperiments (thoughtexperiments). Relative motions of parts of an extended rigid physical object about its center of mass will of course be off geodesic in the local curvature field from unbalanced electrical forces of constraint. That is irrelevant to the basic principle. So, for example, on the International Space Station in free float orbit around the Earth, an accelerometer placed at its center of mass will show zero continuously at all times in the orbit. Of course, other accelerometers clamped to different parts of the station will generally show non-zero readings from electrical forces of constraint because the internal motions of parts of the station relative to the center of mass are not timelike geodesics in the local curvature gravity field of the Earth and Moon etc. Indeed, this is a practical way to locate the center of mass of a starship on a timelike geodesic free float line – look for the null reading on an accelerometer.

[lxvii] http://www.feynmanlectures.caltech.edu/I_07.html

[lxviii] http://en.wikipedia.org/wiki/Principle_of_least_action

[lxix] http://en.wikipedia.org/wiki/Fictitious_force
[lxx] http://en.wikipedia.org/wiki/Induced_gravity

[lxxi] http://en.wikipedia.org/wiki/False_vacuum

[lxxii] http://en.wikipedia.org/wiki/Spin_(physics)

[lxxiii] http://en.wikipedia.org/wiki/Standard_Model_(mathematical_formulation)

[lxxiv] http://en.wikipedia.org/wiki/Invariant_mass

[lxxv] http://en.wikipedia.org/wiki/Multiplet

[lxxvi]http://en.wikipedia.org/wiki/Goldstone_boson
http://en.wikipedia.org/wiki/Higgs_mechanism

[lxxvii] http://arxiv.org/pdf/cond-mat/9204009v3.pdf

[lxxviii] http://en.wikipedia.org/wiki/Quantum_noise

[lxxix] http://en.wikipedia.org/wiki/Quantum_fluctuation

[lxxx] http://en.wikipedia.org/wiki/Minimal_coupling

[lxxxi] http://en.wikipedia.org/wiki/Introduction_to_gauge_theory
http://www.scholarpedia.org/article/Gauge_invariance

[lxxxii] http://en.wikipedia.org/wiki/Principle_of_locality
"We will briefly mention the most interesting case, that of the application of the principle of relativity to electrodynamics, which is one of the most discussed subjects by historians (e.g., Goldberg 1967; Paty 1993; Miller 1996a; Zahar 2001; Darrigol 2004; Rouché 2008; Walter 2011)—not least because Poincaré and Einstein did not cite each other on relativity despite the fact that Einstein read Poincaré's *Science and Hypothesis* before 1905 and Poincaré wrote Einstein a recommendation letter sometime after their only meeting at the first Solvay Congress in 1911 (Walter 2007: chap. 59.3). What is uncontroversial is that Poincaré discovered salient points of the special theory of relativity, such as an operational definition of clock-synchronization to first order in v/c, and a relativistic formula of the composition of speed, the determination of the structure of the Lorentz-group. Since the Maxwell-Lorentz equations for electromagnetics are not Galileo-covariant, the classical principle of relativity according to which measurement in one inertial reference frame can be converted to another by Galilean transformation is called into question. Using in his famous St. Louis lecture of 1904 the designation (physical) "principle of relativity" (Poincaré 1905a: 607), which does not apply "to finite equations that are directly observed, but to differential equations" (Poincaré 1913a: 103; 1963: 19), Poincaré reports that Lorentz introduces the conjectures (i.e., the *ad hoc* hypotheses) of "local time" and of "uniform contraction in the direction of motion" in an attempt to save the principle in its application to the electromagnetic domain (see Poincaré 1905b: 132 ff.; 1913b: 305 ff.)."

[lxxxiii] "Gerard 't Hooft and I had been talking on and off about black holes for a number of years by 1994. He and I seemed to be the only two people who were completely convinced that the basic quantum laws of information and entropy must be respected by black holes. … Gerard wanted to think about it from an S-matrix[lxxxiii] point of view like in quantum field theory.[lxxxiii] He wanted to construct a unitary S-matrix that would evolve an in-going state to an out-going state on the horizon of a black hole. I certainly agreed that an S-matrix should exist but it seemed to me hopeless to actually compute it. I thought that trying to construct an S-matrix would be a lot harder than discovering the underlying microstructure. I had formulated the idea of Black Hole
Complementarity, which stated that from the outside perspective, the (stretched) horizon of a black hole is composed of microscopic degrees of freedom that absorb, thermalize, and re-emit all information. But I had also argued that from the infalling point of view, the horizon was just empty space with no special properties. Think of an observer in a free falling elevator: as long as the elevator is freely falling, and up till the point when it hits the ground, she won't be able to tell the difference between the laws of physics inside the small elevator and those inside a space-ship out in space. So will, for an observer who is freely falling into a black hole, and up till the point when she is crushed by tidal forces or absorbed in the singularity, the physics around her be the physics of empty space. Yet we know that for an observer who stays outside or is trying to escape from the black hole – like in an accelerator that is going up –, the region near the horizon is

strongly gravitating and in fact it has membrane-like properties like an electric surface resistivity of 377 ohms and viscosity. I argued that the discrepancy of the two different descriptions is only apparent – only in the case that we think in terms of some super observer, who somehow has access to both the freely falling and the accelerated system near the black hole, do we get any contradictions. That such a description should be precluded is what I called Black Hole Complementarity. Like in quantum mechanics, where we can't measure both position and momentum at the same time without disturbing the system, we can't measure both the inside and the outside of the black hole without using signals of energy of the order of the Planck scale. This way Black Hole Complementarity argues that the two seemingly contradictory views can be reconciled; if we just agree on which observable we decide to measure." Lenny Susskind http://arxiv.org/pdf/physics/0611143v1.pdf

[lxxxiv] http://en.wikipedia.org/wiki/Unitarity_(physics)

[lxxxv] http://en.wikipedia.org/wiki/No-communication_theorem

[lxxxvi] There are two other possible loopholes: assumption of strong Von Neumann orthogonal projection operator measurements and the assumption that distinguishable non-orthogonal states are not possible. Aharonov's "weak measurements" are a loophole in the former, and Glauber's coherent states that are distinguishable eigenstates of non-Hermitian observables not allowed in orthodox quantum theory, is a loophole in the latter.

[lxxxvii] http://en.wikipedia.org/wiki/Fictitious_force

[lxxxviii] http://en.wikipedia.org/wiki/Levi-Civita_connection
http://en.wikipedia.org/wiki/Christoffel_symbols

[lxxxix] http://en.wikipedia.org/wiki/Parallel_transport

[xc] http://en.wikipedia.org/wiki/Riemann_curvature_tensor

[xci] http://en.wikipedia.org/wiki/Curl_(mathematics)

[xcii] http://en.wikipedia.org/wiki/Disclination

[xciii] http://en.wikipedia.org/wiki/Crystal_structure

[xciv] http://en.wikipedia.org/wiki/Geodesic_deviation

[xcv] http://en.wikipedia.org/wiki/Torsion_tensor

[xcvi] http://en.wikipedia.org/wiki/Spacetime

[xcvii] http://einstein.stanford.edu/SPACETIME/spacetime2.html
"Soon after completing his special theory, Einstein had the 'happiest thought of his life' (1907). It came while he was sitting in his chair at the patent office in Bern and wondering what it would be like to try to drop a ball while falling off the side of a building. Einstein realized that a person who accelerates downward along with the ball would not be able to detect the effects of gravity on it. An observer can "transform away" gravity (at least in the immediate neighborhood) simply by moving to this accelerated frame of reference — no matter what kind of object is dropped. … To understand how remarkable the equivalence principle really is, imagine how it would be if gravity worked like other forces. If gravity were like electricity, for example, then balls with more charge would be attracted to the earth more strongly, and hence fall down more quickly than balls with less charge. (Balls whose charge was of the same sign as the earth's would even 'fall' upwards.) There would be no way to transform away such effects by moving to the same accelerated frame of reference for all objects. But gravity is "matter-blind" — it affects all objects the

same way. From this fact Einstein leapt to the spectacular inference that gravity does not depend on the properties of matter (as electricity, for example, depends on electric charge). Rather the phenomenon of *gravity must spring from some property of spacetime*.

[xcviii] http://en.wikipedia.org/wiki/Kip_Thorne

[xcix] http://en.wikipedia.org/wiki/Quantum_gravity

[c] http://en.wikipedia.org/wiki/Quantum_field_theory

[ci] AKA "traversable wormhole" in the sense of the famous papers by Kip Thorne and students at Cal Tech.
Michael S. Morris and Kip S. Thorne, "Wormholes in Spacetime and Their Use for Interstellar Travel: A Tool for Teaching General Relativity," American Journal of Physics, **56**, 395-416 (1988).
Michael S. Morris, Kip S. Thorne, and Ulvi Yurtsever, "Wormholes, Time Machines, and the Weak Energy Condition," Physical Review Letters, **61**, 1446-1449 (1988).
http://en.wikipedia.org/wiki/Wormhole

[cii] "Paul Hill was a well-respected NASA scientist when, in the early 1950s, he had a UFO sighting. Soon after, he built the first flying platform and was able to duplicate the UFO's tilt-to-control maneuvers. Official policy, however, prevented him from proclaiming his findings. 'I was destined,' says Hill, 'to remain as unidentified as the flying objects.'"

For the next twenty-five years, Hill acted as an unofficial clearinghouse at NASA, collecting and analyzing sightings' reports for physical properties, propulsion possibilities, dynamics, etc. To refute claims that UFOs defy the laws of physics, he had to make "technological sense ... of the unconventional object."

After his retirement from NASA, Hill finally completed his remarkable analysis. In Unconventional Flying Objects, published posthumously, he presents his findings that UFOs "obey, not defy, the laws of physics." Vindicating his own sighting and thousands of others, he proves that UFO technology is not only explainable, but attainable." http://www.amazon.com/Unconventional-Flying-Objects-Scientific-Analysis/dp/1571740279 Paul Hill's book is reliable even though it is 50 years old.

See also http://www.sacred-texts.com/ufo/rufo/index.htm which opens with: This is Edward J. Ruppelt's memoir of his role in the seminal US Air Force UFO study projects: Projects Sign, Grudge and Blue Book. According to this account, he coined the acronym 'UFO' and put many of the official procedures for reporting and studying UFOs in place. An enjoyable read, this book captures the feel of working for the mid-20th century US military. He describes the changing attitudes of the USAF about UFOs during the early 1950s: wobbling between denial, ridicule, paranoia, and genuine inquiry. A key point of this book is to resolve doubts about the military's role. Ruppelt makes a strong case that UFOs weren't a top-secret weapons system; the reports were not disinformation by intelligence agencies; nor was there a concerted effort to cover up UFOs by the US government. Ruppelt does recount many times when the brass tried to dismiss reports without investigating them sufficiently. However, this comes across as simply standard-issue military 'cover-your-ass' behavior, not a vast conspiracy. He gives unique details on some of the most impressive sightings on his watch. Highly trained observers such as radar operators, fighter and commercial pilots, astronomers, and other scientists largely witnessed these, often during the course of their official duties. The Air Force group that Ruppelt worked for had access to data on top-secret balloon launches and test flights, so they were able to sort out which reports could be explained in this way. He consulted with a wide range of scientific specialists, many of whom were in favor of the extraterrestrial hypothesis, and some who were skeptics. Fully a quarter of the reports were still unexplained after this rigorous filtering. Ruppelt is decidedly agnostic, but open-minded, about the reality behind the 'unexplained' sightings. Unlike Keyhoe, he does not claim that UFOs are interplanetary spacecraft; only that this is one of the *possible*

explanations. --J.B. Hare, May 13, 2008.

[ciii] "For years it was thought that the Schwarzschild spacetime did in fact exhibit some sort of radial singularity at $r = 2GM/c^2$. Eventually physicists came to realize that it was not Schwarzschild spacetime that was behaving badly. It was his choice of coordinate system. … the true singularity at r = 0." P. 126, Enrico Rodrigo, "The Physics of Stargates" (Eridanus Press, New York, 2010). This is true, yet it also does not address an important question. While it is true that a freely falling observer Alice can pass through the event horizon of a large non-rotatingblack hole without feeling lethal tidal stretch-squeeze Weyl curvature tensor forces, nevertheless the universe will start to look weird to her. More importantly, if Bob is in a spaceship hovering at a fixed distance outside the event horizon with rockets firing radially inward, he will quickly find that there is a minimum distance he can get to without being sucked into the black hole. Indeed, if Bob does not want to exceed a 1g weight that minimum distance is even larger. This is because, the real proper acceleration of hovering, also called the "static LNIF" shoots up to a classical infinity at the event horizon because of the square root of the time-time component g_{00} that approaches zero at the event horizon in the denominator of the relevant equation in Einstein's General Relativity. One over zero is infinity. Of course quantum gravity will prevent an actual infinity, but practically speaking that does not change the basic situation. Not only that, but Bob will see a very hot thermal blackbody bath of real photons proportional to his actual tensor proper acceleration that will burn him to a cinder. This will be very peculiar and tragic to Alice who passes close by him in her radial free fall into the black hole. Alice will not feel the heat unless she catches fire etc. from Bob's burning ship that explodes and flings debris hitting her. This is related to recent speculations by Leonard Susskind et-al onblack hole **firewalls**.
There is a creative tension conflict between Gerard 't Hooft's pontifical proclamation that the S-Matrix must be unitary even in cosmology and Einstein's equivalence principle that nothing happens to a freely falling observer passing through a horizon $g_{00} = 0$ whether that of a black hole whose horizon is observer independent, or whether through our future dark energy de Sitter cosmological horizon, which is observer-dependent. Roughly, unitarity of the S-Matrix of the universe says that there is nothing new under the Sun that quantum information cannot be created or destroyed. This seems to fly in the face of human creativity. Does it really?
http://en.wikipedia.org/wiki/Firewall_(physics)
http://www.scientificamerican.com/article.cfm?id=black hole-firewall-paradox&print=true
http://www.kavlifoundation.org/science-spotlights/spotlight-live-falling-into-black holes
http://physics.aps.org/articles/print/v6/115

[civ] http://en.wikipedia.org/wiki/General_relativity

[cv] http://en.wikipedia.org/wiki/Quantum_mechanics

[cvi] http://arxiv.org/pdf/hep-th/9409089v2.pdf

[cvii] "What is it that breathes fire into the equations and makes a universe for them to describe? … However, if we discover a complete theory, it should in time be understandable by everyone, not just by a few scientists. Then we shall all, philosophers, scientists and just ordinary people, be able to take part in the discussion of the question of why it is that we and the universe exist. If we find the answer to that, it would be the ultimate triumph of human reason -- for then we should know the mind of God." (P.193, A Brief History of Time)

[cviii] http://en.wikipedia.org/wiki/The_Grand_Design_(book)

[cix] Einstein's view on this subject has significant similarities and differences with Hawking's: "For Tagore, all truth is human truth, if one is to take his claims literally. For Einstein, ultimate truth about the physical world transcends the human realm. Einstein was a "realist", but his realism was of a modest, or non-metaphysical kind. It is the job of physicists, he argued, to come up with models of a mind-independent reality that are explanatory of our phenomenological experiences of natural regularities, within the laboratory and without. However, whether such models, when judged successful, correspond to the way the

world "really" is, is a question Einstein thought best to leave aside. There are some philosophical questions for which Einstein thought the best response is a smile, and this was one of them. But Einstein stressed that even this weak, pragmatic take on truth involved a leap of faith. He made it clear, particularly in his 1949 Autobiographical Notes, that

Nature's connivance in allowing for the success in the scientific venture as he conceived it could not be a foregone conclusion. It was conceivable for Einstein that mind, say, could be the bedrock of reality, but he felt that there was no good reason to start with that premise, and good reasons not to. Realism for Einstein was more a program than a doctrine; it was a dogma about which he was careful not to be dogmatic."

Einstein, the reality of space, and the action–reaction principle

Harvey R. Brown, Faculty of Philosophy, University of Oxford & Dennis Lehmkuhl

http://philsci-archive.pitt.edu/9792/

[cx] http://tedyoung.me/2011/01/22/leonard-susskind-lectures/

[cxi] Wikipedia has now become quite reliable for physics/math articles after a rocky start of several years especially on biographies of living movers and shakers. Rather than repeat standard content on technical jargon that is prerequisite to understanding this book.

[cxii] Rodrigo shows that the classical energy conditions and chronology protection arguments against time travel to the past as well as the quantum inequality restrictions on negative energy balanced by positive energy are not likely to be fatal barriers against stargate technology.

[cxiii] http://en.wikipedia.org/wiki/Time_travel

[cxiv] http://en.wikipedia.org/wiki/Novikov_self-consistency_principle

[cxv] http://www.mirror.co.uk/news/world-news/uri-geller-psychic-spy-used-2063744
http://www.huffingtonpost.com/2013/06/17/uri-geller-documentary_n_3455410.html
http://www.bbc.co.uk/programmes/b037k0c5

[cxvi] http://plato.stanford.edu/entries/newton-principia/

[cxvii] http://en.wikipedia.org/wiki/Noether's_theorem

[cxviii] http://en.wikipedia.org/wiki/Maxwell's_equations

[cxix] http://en.wikipedia.org/wiki/Through_the_Looking-Glass

[cxx] http://en.wikipedia.org/wiki/Relationalism

[cxxi] http://en.wikipedia.org/wiki/Bucket_argument

[cxxii] http://en.wikipedia.org/wiki/Thought_experiment

[cxxiii] http://en.wikipedia.org/wiki/Light_cone

[cxxiv] http://en.wikipedia.org/wiki/Surface_gravity

[cxxv] Our Universe could be just one big projection.

In 1997, ... Juan Maldacena proposed that ... gravity arises from infinitesimally thin, vibrating strings .... which exist in nine dimensions of space plus one of time, would be merely a hologram: the real action would play out in a simpler, flatter cosmos where there is no gravity. ... It provided physicists with a mathematical Rosetta stone, a 'duality', that allowed them to translate back and forth between the two languages, and solve problems in one model that seemed intractable in the other and vice

versa ... Yoshifumi Hyakutake ... now provide, if not an actual proof, at least compelling evidence that Maldacena's conjecture is true. ... Hyakutake computes the internal energy of a black hole, the position of its event horizon (the boundary between the black hole and the rest of the Universe), its entropy and other properties based on the predictions of string theory as well as the effects of so-called virtual particles that continuously pop into and out of existence. In the other, he and his collaborators calculate the internal energy of the corresponding lower-dimensional cosmos with no gravity. The two computer calculations match.
...
"They have numerically confirmed... that the thermodynamics of certain black holes can be reproduced from a lower-dimensional universe," says Leonard Susskind, ...
Neither of the model universes explored by the Japanese team resembles our own, Maldacena notes. The cosmos with a black hole has ten dimensions, with eight of them forming an eight-dimensional sphere. The lower-dimensional, gravity-free one has but a single dimension, and its menagerie of quantum particles resembles a group of idealized springs, or harmonic oscillators, attached to one another.
Nevertheless, says Maldacena, the numerical proof that these two seemingly disparate worlds are actually identical gives hope that the gravitational properties of our Universe can one day be explained by a simpler cosmos purely in terms of quantum theory.
http://www.nature.com/news/simulations-back-up-theory-that-universe-is-a-hologram-1.14328
http://arxiv.org/pdf/1311.7526v1.pdf
The discovery of the fact that black holes radiate particles and eventually evaporate led Hawking to pose the well-known information loss paradox. This paradox caused a long and serious debate since it claims that the fundamental laws of quantum mechanics may be violated. A possible cure appeared recently from superstring theory, a consistent theory of quantum gravity: if the holographic description of a quantum black hole based on the gauge/gravity duality is correct, the information is not lost and quantum mechanics remains valid. Here we test this gauge/gravity duality on a computer at the level of quantum gravity for the first time. The black hole mass obtained by Monte Carlo simulation of the dual gauge theory reproduces precisely the quantum gravity effects in an evaporating black hole. This result opens up totally new perspectives towards quantum gravity since one can simulate quantum black holes through dual gauge theories.

In 1974 Hawking realized that a black hole should radiate particles as a perfect blackbody due to quantum effects in the surrounding space, and that the black hole should eventually evaporate completely ... This discovery made more accurate the close analogy between the laws of black hole physics and those of thermodynamics, which was pointed out originally by Bekenstein ... However, it also caused a long scientific debate … concerning the information loss paradox … which can be described roughly as follows. Suppose one throws a book into a black hole. While the black hole evaporates, all we observe is the blackbody radiation. Therefore, the information contained in the book is lost forever. This statement sharply conflicts with a basic consequence of the law of quantum mechanics that the information of the initial state should never disappear.
Then the question is whether the law of quantum mechanics is violated or Hawking's argument should somehow be modified if full quantum effects of gravity are taken into account. In order to resolve this paradox, it is necessary to construct microscopic states of the black hole and to give a statistical-mechanical explanation for the black hole entropy. This seems quite difficult within general relativity because of the no-hair theorem, which states that black holes are characterized by only a few parameters. In the mid 1990s, however, superstring theory succeeded in explaining the entropy of "extremal black holes", a special class of black holes, which do not evaporate ... Superstring theory contains not only strings but also soliton called D-branes … as fundamental objects. Bound states of D-branes can be so heavy that they look like "black objects" from a distant observer. In fact there are many bound states, which look like the same black hole. These bound states can be interpreted as the microscopic states of the black hole, and the number of such states has been shown to explain precisely the black hole entropy.
However, the paradox still remains since a complete description of an evaporating black hole has not yet been established. A key to really resolve the paradox is provided by Maldacena's gauge/gravity duality conjecture …(Fig. 1), which may be viewed as a concrete realization of the holographic principle proposed

by 't Hooft and Susskind. This conjecture relates various black holes made of D-branes in superstring theory to strongly coupled gauge theories, in which the absence of information loss is manifest. In this article we provide the first quantitative evidence for the gauge/gravity duality at the level of quantum gravity. We perform Monte Carlo simulation of the dual gauge theory in the parameter regime that corresponds to a quantum black hole. Our results agree precisely with a prediction for an evaporating black hole including quantum gravity corrections. Thus we find that the dual gauge theory indeed provides a complete description of the quantum nature of the evaporating black hole.
http://arxiv.org/pdf/1311.5607v1.pdf

[cxxvi] http://en.wikipedia.org/wiki/Michelson–Morley_experiment

[cxxvii] http://en.wikipedia.org/wiki/Novikov_self-consistency_principle
http://en.wikipedia.org/wiki/Remote_viewing

[cxxviii] http://plato.stanford.edu/entries/poincare/#SelWorPoi

[cxxix] http://en.wikipedia.org/wiki/Time_dilation_of_moving_particles

[cxxx] http://en.wikipedia.org/wiki/Feynman_diagram

[cxxxi] http://www.lassp.cornell.edu/sethna/OrderParameters/

[cxxxii] http://en.wikipedia.org/wiki/BCS_theory

[cxxxiii] http://en.wikipedia.org/wiki/Faddeev–Popov_ghost

[cxxxiv] http://en.wikipedia.org/wiki/Spin–statistics_theorem
http://en.wikipedia.org/wiki/Anyon
http://arxiv.org/pdf/hep-th/9209066v3.pdf

[cxxxv] http://en.wikipedia.org/wiki/Action_(physics)

[cxxxvi] http://en.wikipedia.org/wiki/Theoretical_physics

[cxxxvii] http://en.wikipedia.org/wiki/Topology

[cxxxviii] http://en.wikipedia.org/wiki/De_Broglie–Bohm_theory

[cxxxix] http://en.wikipedia.org/wiki/David_Finkelstein

[cxl] http://en.wikipedia.org/wiki/Leonard_Susskind

[cxli] http://en.wikipedia.org/wiki/Werner_Erhard

[cxlii] http://en.wikipedia.org/wiki/Martin_David_Kruskal

[cxliii] http://en.wikipedia.org/wiki/Roger_Penrose

[cxliv] http://en.wikipedia.org/wiki/Yakov_Borisovich_Zel'dovich

[cxlv] http://en.wikipedia.org/wiki/Cygnus_X-1

[cxlvi] http://en.wikipedia.org/wiki/Mixmaster_universe

[cxlvii] http://en.wikipedia.org/wiki/Fred_Alan_Wolf

[cxlviii] http://en.wikipedia.org/wiki/Accretion_disc

[cxlix] http://en.wikipedia.org/wiki/Black-body_radiation

[cl] http://en.wikipedia.org/wiki/EPR_paradox

[cli] http://en.wikipedia.org/wiki/Microwave

[clii] http://en.wikipedia.org/wiki/EPR_paradox

[cliii] http://en.wikipedia.org/wiki/Quantum_entanglement

[cliv] http://www.npl.washington.edu/AV/altvw48.html
Steven Weinberg, Physical Review Letters **62**, 485 (1989);
Joseph Polchinski, Physical Review Letters **66**, 397 (1991).

[clv] http://www.fourmilab.ch/rpkp/stapp.html

> This work concerns the possibility of causal anomalies. By a causal anomaly I mean a theoretical or empirical situation in which the occurrence or nonoccurrence of an observable event at one time must apparently depend upon a *subsequently* generated (pseudo) random number, or willful human act.
>
> Considerations of the Einstein-Podolsky-Rosen [1] and Bell's-Theorem [2] type entail [3] -- if many-world's interpretations are excluded -- the occurrence of causal anomalies on the theoretical level, provided certain predictions of quantum theory are at least approximately valid. However, those anomalies cannot manifest on the empirical level if the quantum predictions hold exactly [4]. On the other hand, slight departures from the exact validity of the quantum predictions [5] could lead to small but observable causal anomalies [6].
>
> Empirical causal anomalies have been reported in the past in experiments that appear, at least superficially, to have been conducted in accordance with scientific procedures [7], and the protocols are becoming ever more stringent [8]. I do not enter into the difficult question of assessing the reliability of these reports. The scientific community generally looks upon them with skepticism. But at least part of this skepticism originates not from specific challenges to the protocols and procedures of the works of, for example, Jahn, Dobyns and Dunne [7], but from the belief that such results are not compatible with well-established principles of physics, and hence to be excluded on theoretical grounds. However, it turns out that small modifications of the standard quantum principles would allow some of the most impossible sounding of the reported phenomena to be accommodated. According to the report in Ref. [8], it would appear that in certain experimental situations willful human acts, selected by pseudorandom numbers generated at one time, can shift, relative to the randomness predicted by normal quantum theory, the timings of radioactive decays that were detected and recorded months earlier on floppy discs, but that were not observed at that time by any human observer. Such an influence of an observer backward in time on atomic events seems completely at odds with physical theory. However, a slight modification of normal quantum theory can accommodate the reported data. In the scientific study of any reported phenomena it is hard to make progress without a theoretical description that ties them in a coherent way into the rest physics.
> The purpose of the present work is to construct, on the basis of an extension of Weinberg's nonlinear generalization of quantum theory [5], a theoretical model that would accommodate causal anomalies of the kind described above. Specifically, the present work shows that the reported phenomena, although incompatible with the main currents of contemporary scientific

thought, can be theoretically modeled in a coherent and relatively simple way by combining certain ideas of von Neumann and Pauli abut the interpretation of quantum theory with Weinberg's nonlinear generalization of the quantum formalism.
Henry Stapp *Physical Review A*, Vol.50, No.1, July 1994

[clvi] Holographic Dual of an Einstein-Podolsky-Rosen Pair has a Wormhole
Kristan Jensen and Andreas Karch, Phys Rev Lett, 111, 211602 (2013)

[clvii] http://arxiv.org/pdf/1308.0289v1.pdf
http://motls.blogspot.com/2013/07/papers-on-er-epr-correspondence.html Lubos Motl
http://quantumfrontiers.com/2013/06/07/entanglement-wormholes/

[clviii] http://www.biomindsuperpowers.com/Pages/CIA-InitiatedRV.html

[clix] http://physics.aps.org/synopsis-for/10.1103/PhysRevLett.111.211602

Quantum entanglement is weird enough, but it might get weirder still through a possible association with hypothetical wormholes. Over the past year, theorists have been hard at work exploring the entanglement of twoblack holes. A pair of papers in *Physical Review Letters* advances the story by showing that a string-based representation of two entangled quarks is equivalent to the spacetime contortions of a wormhole.

A common feature of entanglement and wormholes is that they both seemingly imply faster-than-light travel. If one imagines two entangled particles separated by a large distance—a so-called Einstein-Podolsky-Rosen (EPR) pair—then a measurement of one has an immediate effect on the measurement probabilities of the other, as if information travels instantaneously between them. Similarly, a wormhole—or Einstein-Rosen (ER) bridge—is a "shortcut" connecting separate points in space, but no information can actually pass through. The latest papers in this development extend the equivalence beyond black holes to quarks. As previous studies have shown, two entangled quarks can be represented as the endpoints of a string in a higher dimensional space, where certain calculations end up being easier. Kristan Jensen of the University of Victoria, Canada, and Andreas Karch of the University of Washington, Seattle, imagine the entangled quarks are accelerating away from each other, so that they are no longer in causal contact. In this case, the connecting string becomes mathematically equivalent to a wormhole. Using a different approach, Julian Sonner from the Massachusetts Institute of Technology, Cambridge, has derived the same result starting from quark/antiquark creation in a strong electric field (the Schwinger effect). The wormhole connection may provide new insights into entanglement, as suggested by calculations that equate the entropy of the wormhole to that of the quarks.

[clx] http://arxiv.org/pdf/1306.0533v2.pdf
http://motls.blogspot.com/2013/06/maldacena-susskind-any-entanglement-is.html

[clxi] http://arxiv.org/pdf/1311.3335v1.pdf
Alice and Bob, beloved characters of various thought experiments in quantum mechanics, are at a crossroads. The adventurous, rather reckless Alice jumps into a very large black hole, leaving a presumably forlorn Bob outside the event horizon — a black hole's point of no return, beyond which nothing, not even light, can escape.
Conventionally, physicists have assumed that if the black hole is large enough, Alice won't notice anything unusual as she crosses the horizon. In this scenario, colorfully dubbed "No Drama," the gravitational forces won't become extreme until she approaches a point inside the black hole called the singularity. There, the gravitational pull will be so much stronger on her feet than on her head that Alice will be "spaghettified."
Now a new hypothesis is giving poor Alice even more drama than she bargained for. If this alternative is correct, as the unsuspecting Alice crosses the event horizon, she will encounter a massive wall of fire that

will incinerate her on the spot. As unfair as this seems for Alice, the scenario would also mean that at least one of three cherished notions in theoretical physics must be wrong. …

According to Joseph Polchinski, a string theorist at the University of California, Santa Barbara, and the simplest solution is that the equivalence principle breaks down at the event horizon, thereby giving rise to a firewall. Polchinski is a co-author of the paper that started it all, along with Ahmed Almheiri, Donald Marolf and James Sully — a group often referred to as "AMPS." Even Polchinski thinks the idea is a little crazy. It's a testament to the knottiness of the problem that a firewall is the least radical potential solution.

There is more than one kind of entanglement associated with a black hole, and under the AMPS hypothesis, the two come into conflict. There is an entanglement between Alice, the in-falling observer, and Bob, the outside observer, which is needed to preserve No Drama. But there is also a second entanglement that emerged from another famous paradox in physics; one related to the question of whether information is lost in a black hole. In the 1970s, Stephen Hawking realized thatblack holes aren't completely black. While nothing might seem amiss to Alice as she crosses the event horizon, from Bob's perspective, the horizon would appear to be glowing like a lump of coal — a phenomenon now known as Hawking radiation. …

This radiation results from virtual particle pairs popping out of the quantum vacuum near a black hole. Normally they would collide and annihilate into energy, but sometimes one of the pair is sucked into the black hole while the other escapes to the outside world. The mass of the black hole, which must decrease slightly to counter this effect and ensure that energy is still conserved, gradually winks out of existence. How fast it evaporates depends on the black hole's size: The bigger it is, the more slowly it evaporates.

Hawking assumed that once the radiation evaporated altogether, any information about the black hole's contents contained in that radiation would be lost. "Not only does God play dice, but he sometimes confuses us by throwing them where they can't be seen," he famously declared. … Physicists eventually realized that it is possible to preserve the information at a cost: As the black hole evaporates, the Hawking radiation must become increasingly entangled with the area outside the event horizon. So when Bob observes that radiation, he can extract the information. …

But what happens if Bob were to compare his information with Alice's after she has passed beyond the event horizon? "That would be disastrous," Bousso explained, "because Bob, the outside observer, is seeing the same information in the Hawking radiation, and if they could talk about it, that would be quantum xeroxing, which is strictly forbidden in quantum mechanics."

Physicists, led by Susskind, declared that the discrepancy between these two viewpoints of the black hole is fine so long as it is impossible for Alice and Bob to share their respective information. This concept, called complementarity, simply holds that there is no direct contradiction because no single observer can ever be both inside and outside the event horizon. If Alice crosses the event horizon, sees a star inside that radius and wants to tell Bob about it, general relativity has ways of preventing her from doing so.

Bousso thought complementarity would come to the rescue yet again to resolve the firewall paradox. He soon realized that it was insufficient. Complementarity is a theoretical concept developed to address a specific problem, namely, reconciling the two viewpoints of observers inside and outside the event horizon. But the firewall is just the tiniest bit outside the event horizon, giving Alice and Bob the same viewpoint, so complementarity won't resolve the paradox. …

Polchinski argues persuasively that you need Alice and Bob to be entangled to preserve No Drama, and you need the Hawking radiation to be entangled with the area outside the event horizon to conserve quantum information. But you can't have both. If you sacrifice the entanglement of the Hawking radiation with the area outside the event horizon, you lose information. If you sacrifice the entanglement of Alice and Bob, you get a firewall.

"Quantum mechanics doesn't allow both to be there," Polchinski said. "If you lose the entanglement between the in-falling (Alice) and the outgoing (Bob) observers, it means you've put some kind of sharp kink into the quantum state right at the horizon. You've broken a bond, in some sense, and that broken bond requires energy. This tells us the firewall has to be there."

That consequence arises from the fact that entanglement between the area outside the event horizon and the Hawking radiation must increase as the black hole evaporates. When roughly half the mass has radiated away, the black hole is maximally entangled and essentially experiences a mid-life crisis. Preskill explained: "It's as if the singularity, which we expected to find deep inside the black hole, has crept right up to the event horizon when the black hole is old." And the result of this collision between the singularity and the event horizon is the dreaded firewall.

The mental image of a singularity migrating from deep within a black hole to the event horizon provoked at least one exasperated outburst during the Stanford workshop, a reaction Bousso finds understandable. "We should be upset," he said. "This is a terrible blow to general relativity."
https://www.simonsfoundation.org/quanta/20121221-alice-and-bob-meet-the-wall-of-fire/

[clxii] http://arxiv.org/abs/1308.0289

[clxiii] http://en.wikipedia.org/wiki/Instanton

[clxiv] http://en.wikipedia.org/wiki/AdS/CFT_correspondence

[clxv] http://arxiv.org/pdf/1307.6850v2.pdf

[clxvi] Can a wormhole be interpreted as an EPR pair? Hrvoje Nikoli´c Theoretical Physics Division, Rudjer Bo˘skovi´c Institute, P.O.B. 180, HR-10002 Zagreb, Croatia. _ (Dated: July 22, 2013) Recently, Maldacena and Susskind [1] conjectured that a wormhole could be interpreted as an EPR pair. Inspired by this conjecture, Jensen and Karch [2] attempted to make the conjecture more precise, by arguing that the holographic dual of an EPR pair has a wormhole. In this brief comment we argue that the results presented in those two papers are still very far from presenting convincing evidence that a wormhole can be interpreted as an EPR pair. The distinguished feature of an EPR pair is the existence of highly nontrivial correlations[clxvi] between two members of the pair. In particular, the EPR correlations violate Bell inequalities [3]. Unfortunately, no such nontrivial correlations have been calculated in [1] and [2]. In [2], it has been demonstrated that entanglement entropy[clxvi] associated with one member of the EPR pair coincides with entropy of the corresponding end of the wormhole. Even though this result is interesting and somewhat surprising, the entanglement entropy per se is a single number, which does not contain much information about the details of correlations between two subsystems. Two bipartite quantum systems may be characterized by the same entanglement entropy, and yet obey very different correlations between their respective subsystems. ... Moreover, entanglement entropy is a property of a *reduced* density matrix[clxvi], associated with one of the subsystems. Such a reduced density matrix describes what can be said about this subsystem if the other subsystem is not measured at all. By contrast, correlations describe the relations between measurements on *both* subsystems.
Just as a precise formulation of AdS/CFT correspondence[clxvi] requires a match between all correlation functions of the two theories [4], a similar precise formulation in terms of correlations should be required for the conjectured relation between wormholes and EPR pairs. Without any quantitative evidence for the match of correlations it is difficult to take the conjecture seriously.
If such a required match between the correlations would be established in a future work, that would be truly surprising; arguably even more surprising than the match between the correlation functions in AdS/CFT [4]. But as long as the existing results in [1] and [2] do not contain any direct evidence for such a match in terms of correlations, the conjectured interpretation of wormhole as an EPR pair does not seem sufficiently justified.

http://arxiv.org/pdf/1307.1604.pdf

[clxvii] http://arxiv.org/pdf/1311.4363.pdf

[clxviii] http://arxiv.org/pdf/0808.3773v4.pdf

[clxix] http://arxiv.org/pdf/gr-qc/0504039.pdf

[clxx] A firewall is a hypothetical phenomenon where an observer that falls into an oldblack hole encounters high-energy quanta at (or near) the event horizon. The "firewall" phenomenon was proposed in 2012 by Almheiri, Marolf, Polchinski, and Sully [1] as a possible solution to an apparent inconsistency…
Firewall (physics) - Wikipedia, the free encyclopedia

[clxxi] http://en.wikipedia.org/wiki/Susskind-Glogower_operator

On Nov 14, 2013, at 12:11 PM, Dean Radin wrote:
You might want to footnote my name, along with Bierman and Bem, with a pointer to the following article, which is a meta-analysis of presentiment experiments, starting with the first one I did in 1996:

[clxxii] Kip Thorne's version of this same story is in Chapter 14, of his excellent book Black Holes and Time Warps, Einstein's Outrageous Legacy written 20 years ago in 1993 six years before the discovery of exotic dark energy accelerating our universe. This is just the sort of exotic matter, when amplified, that we need for warp drive and stargate time travel and it is most of the (repulsive anti-gravitating) stuff in the universe. Obviously advanced civilizations have learned how to harness this cosmic energy that General Douglas Mac Arthur described clearly in his 1962 *Duty, Honor, Country* speech at West Point:
You now face a new world, a world of change. The thrust into outer space of the satellite, spheres and missiles marked the beginning of another epoch in the long story of mankind - the chapter of the space age. In the five or more billions of years the scientists tell us it has taken to form the earth, in the three or more billion years of development of the human race, there has never been a greater, a more abrupt or staggering evolution. We deal now not with things of this world alone, but with the illimitable distances and as yet unfathomed mysteries of the universe. We are reaching out for a new and boundless frontier. We speak in strange terms: of harnessing the cosmic energy; of making winds and tides work for us; of creating unheard synthetic materials to supplement or even replace our old standard basics; of purifying sea water for our drink; of mining ocean floors for new fields of wealth and food; of disease preventatives to expand life into the hundred of years; of controlling the weather for a more equitable distribution of heat and cold, of rain and shine; of space ships to the moon; of the primary target in war, no longer limited to the armed forces of an enemy, but instead to include his civil populations; of ultimate conflict between a united human race and the sinister forces of some other planetary galaxy; of such dreams and fantasies as to make life the most exciting of all time.

[clxxiii] http://tinyurl.com/k4mj79j Google e-book version of Emperor's New Mind

[clxxiv] http://www.quantumconsciousness.org/views/TimeFlies.html
http://cognet.mit.edu/posters/TUCSON3/BiermanRadin.html

[clxxv] http://en.wikipedia.org/wiki/Daryl_Bem
http://caps.ucsf.edu/wordpress/wp-content/uploads/2011/02/bem2011.pdf the paper
http://www.skeptic.com/eskeptic/11-04-13/ rebuttal
http://www.theguardian.com/commentisfree/belief/2011/jan/25/precognition-feeling-the-future
http://arxiv.org/pdf/1107.0885v1.pdf rebuttal
http://rationalwiki.org/wiki/Feeling_the_Future:_Experimental_Evidence_for_Anomalous_Retroactive_Influences_on_Cognition_and_Affect

[clxxvi] http://www.frontiersin.org/perception_science/10.3389/fpsyg.2012.00390/abstract

A colleague in Frontiers in Perception Science published this article, which is part of the Nature Publishing Group. So a case can be made that while still considered controversial, the evidence for presentiment is now solidly in the mainstream.
Best wishes,
Dean

Chief Scientist, Institute of Noetic Sciences
Co-Editor-in-Chief, *Explore: The Journal of Science and Healing*
Author, Supernormal and other books
Personal website

[clxxvii] http://en.wikipedia.org/wiki/Yakir_Aharonov

[clxxviii] http://en.wikipedia.org/wiki/Two-state_vector_formalism

[clxxix] http://en.wikipedia.org/wiki/Steven_Weinberg

[clxxx] http://en.wikipedia.org/wiki/Anthropic_principle

[clxxxi] http://www.itp.kit.edu/~sahlmann/gr+c_seminarII/pdfs/T3.pdf
Rev Mod Phys Vol 61, No. 1, January 1989 "The Cosmological Constant Problem"

[clxxxii] http://en.wikipedia.org/wiki/György_Paál

[clxxxiii] https://www.simonsfoundation.org/quanta/20121221-alice-and-bob-meet-the-wall-of-fire/

[clxxxiv]The Amplituhedron
Nima Arkani-Hameda and Jaroslav Trnkab
This has been best understood for maximally supersymmetric gauge theories in the planar limit. Planar N = 4 SYM has been used as a toy model for real physics in many guises, but as toy models go, its application to scattering amplitudes is closer to the real world than any other. For instance the leading tree approximation to scattering amplitudes is identical to ordinary gluon scattering, and the most complicated part of loop amplitudes, involving virtual gluons, is also the same in N = 4 SYM as in the real world. … This suggests that there must be a different formulation of the physics, where locality and unitarity do not play a central role, but emerge as derived features from a different starting point. … This picture builds on BCFW recursion relations for tree … and loop … amplitudes, and represents the amplitude as a sum over basic building blocks, which can be physically described as arising from gluing together the elementary three-particle amplitudes to build more complicated on-shell processes. These "on-shell diagrams" (which are essentially the same as the "twistor diagrams" … are remarkably connected with "cells" of a beautiful new structure in algebraic geometry, that has been studied by mathematicians over the past number of years, known as the positive Grassmannian … The on-shell building blocks can not be associated with local space-time processes. Instead, they enjoy all the symmetries of the theory, as made manifest by their connection with the Grassmannian{indeed, the infinite dimensional Yangian symmetry is easily seen to follow from "positive" diffeomorphisms … While these developments give a complete understanding for the on-shell building blocks of the amplitude, they do not go further to explain why the building blocks have to be combined in a particular way to determine the full amplitude itself. Indeed, the particular combination of on-shell diagrams is dictated by imposing that the final result is local and unitary, locality and unitarity specify the singularity structure of the amplitude, and this information is used to determine the full integrand. This is unsatisfying; since we want to see locality and unitarity emerge from more primitive ideas, not merely use them to obtain the amplitude. … the amplitude can be thought of as the volume of a certain polytope in momentum twistor space. However there was no a priori understanding of the origin of this polytope, and the picture resisted
a direct generalization to more general trees or to loop amplitudes. Nonetheless, the polytope idea motivated a continuing search for a geometric representation of the amplitude as "the volume" of "some canonical region" in "some space", somehow related to the positive Grassmannian, with different "triangulations" of the space corresponding to different natural decompositions of the amplitude into building blocks. … In this note we finally realize this picture. We will introduce a new mathematical object whose "volume" directly computes the scattering amplitude. We call this object the "Amplituhedron", to denote its connection both to scattering amplitudes and positive geometry. The amplituhedron can be given a self-contained definition in a few lines … Everything follows from generalizing the notion of the "inside of a triangle in a plane". The first obvious generalization is to the inside of a simplex in projective space, which further extends to the positive Grassmannian. The second generalization is to move from triangles to convex polygons, and then extend this into the Grassmannian. This gives us the amplituhedron for tree amplitudes, generalizing the positive Grassmannian by extending the notion of positivity to include external kinematical data. The full amplituhedron at all loop order further generalizes the notion of

positivity in a way motivated by the natural idea of “hiding particles".
Another familiar notion associated with triangles and polygons is their area. This is more naturally described in a projective way by a canonical 2-form with logarithmic singularities on the boundaries of the polygon. This form also generalizes to the full amplituhedron, and determines the (integrand of) the scattering amplitude. The geometry of the amplituhedron is completely bosonic, so the extraction of the super amplitude from this canonical form involves a novel treatment of supersymmetry, directly motivated by the Grassmannian structure. The connection between the amplituhedron and scattering amplitudes is a conjecture which has passed a large number of non-trivial checks, including an understanding of how locality and unitarity arise as consequences of positivity.

Sarfatti note: The more general theory with entanglement signal nonlocality extends to non-positivity like

Euclidean to Lorentzian signature using complex variable analytic continuation, e.g. the imaginary time

trick used by Hawking.

This paper has concerned itself with perturbative scattering amplitudes in gauge theories.
However the deeper motivations for studying this physics, articulated in … have to do with some fundamental challenges of quantum gravity. We have long known that quantum mechanics and gravity together make it impossible to have local observables. Quantum mechanics forces us to divide the world in two pieces {an infinite measuring apparatus and a finite system being observed. However for any observations made in a finite region of space-time, gravity makes it impossible to make the apparatus arbitrarily large, since it also becomes heavier, and collapses the observation region into a black hole. In some cases like asymptotically AdS or flat spaces, we still have precise quantum mechanical observables, that can be measured by infinitely large apparatuses pushed to the boundaries of space-time: boundary correlators for AdS space and the S-matrix for
flat space. The fact that no precise observables can be associated with the inside of the space-time strongly suggests that there should be a way of computing these boundary observables without any reference to the interior space-time at all. For asymptotically AdS spaces, gauge-gravity duality … gives us a wonderful description of the boundary correlators of this kind, and gives a first working example of emergent space and gravity. However, this duality is still an equivalence between ordinary physical systems described in standard physical language, with time running from infinite past to infinite future. This makes the duality inapplicable to our universe for cosmological questions. Heading back to the early universe, an understanding of emergent time is likely necessary to make sense of the big-bang singularity. More disturbingly, even at late times, due to the accelerated expansion of our universe, we only have access to a finite number of degrees of freedom, and thus the division of the world into “infinite" and finite" systems, required by quantum mechanics to talk about precise observables, seems to be impossible ... This perhaps indicates the need for an extension of quantum mechanics to deal with subtle cosmological questions. …
There is a powerful clue to the coming quantum mechanics hidden in the structure of classical mechanics itself. While Newton's laws are manifestly deterministic, there is a completely different formulation of classical mechanics {in terms of the principle of least action}, which is not manifestly deterministic. The existence of these very different starting points leading to the same physics was somewhat mysterious to classical physicists, but today we know why the least action formulation exists: the world is quantum-mechanical and not deterministic, and for this reason, the classical limit of quantum mechanics can't immediately land on Newton's laws, but must match to some formulation of classical physics where determinism is not a central but derived notion. The least action principle formulation is thus much closer to quantum mechanics than Newton's laws, and gives a better jumping off point for making the transition to quantum mechanics as a natural deformation, via the path integral. We may be in a similar situation today. If there is a more fundamental description of physics where space-time and perhaps even the usual formulation of quantum mechanics don't appear, then even in the limit where non-perturbative gravitational effects can be neglected and the physics reduces to perfectly local and unitary quantum field theory, this description is unlikely to directly reproduce the usual formulation of field theory, but must rather match on to some new formulation of the physics where locality and unitarity are derived notions. Finding such reformulations of standard physics might then better prepare us for the transition to the deeper underlying

theory.
In this paper, we have t
http://arxiv.org/pdf/1312.2007v1.pdf

[clxxxv] How I created the theory of relativity, Albert Einstein, Translated by
Yoshimasa A. Ono, Physics Today, pp. 45-47 (August 1982) cited by Peter Brown in
http://arxiv.org/pdf/physics/0204044v2.pdf

[clxxxvi] Gravitation, Misner, Thorne and Wheeler, (W.H. Freeman and Company, 1973) Observables must be defined by actual instruments. Newton's gravity field is a fictitious inertial pseudo-force that only appears to act on the test particle. In fact, it is merely a piece of the Levi-Civita connection that describes real forces pushing the LNIF detector off a local timelike geodesic in the ambient curvature field. The world line of the test particle under observation is doing its own thing on a completely independent timelike world line - unless a rigid constraint connecting them is imposed. The Levi-Civita connection {LNIF} is an observable measured directly and locally by accelerometers. This is real technology not "abstract differential geometry 101," which plays a secondary role - that of the "map" not the actual "territory" (A. Korzybski *General Semantics*).

An **accelerometer** is a device that measures proper acceleration. The proper acceleration measured by an accelerometer is not necessarily the coordinate acceleration (rate of change of velocity). Instead, the accelerometer sees the acceleration associated with the phenomenon of weight experienced by any test mass at rest in the frame of reference of the accelerometer device. For example, an accelerometer at rest on the surface of the earth will measure an acceleration $g = 9.81\ m/s^2$ straight upwards, due to its weight. By contrast, accelerometers in free fall or at rest in outer space will measure zero. Another term for the type of acceleration that accelerometers can measure is g-force acceleration.
Accelerometers have multiple applications in industry and science. Highly sensitive accelerometers are components of inertial navigation systems for aircraft and missiles. Accelerometers are used to detect and monitor vibration in rotating machinery. Accelerometers are used in tablet computers and digital cameras so that images on screens are always displayed upright.
Single- and multi-axis models of accelerometer are available to detect magnitude and direction of the proper acceleration (or g-force), as a vector quantity, and can be used to sense orientation (because direction of weight changes), coordinate acceleration (so long as it produces g-force or a change in g-force), vibration, shock, and falling in a resistive medium (a case where the proper acceleration changes, since it starts at zero, then increases). Micromachined accelerometers are increasingly present in portable electronic devices and video game controllers, to detect the position of the device or provide for game input.
Pairs of accelerometers extended over a region of space can be used to detect differences (gradients) in the proper accelerations of frames of references associated with those points. These devices are called gravity gradiometers, as they measure gradients in the gravitational field. Such pairs of accelerometers in theory may also be able to detect gravitational waves.
http://en.wikipedia.org/wiki/Accelerometer

In contrast, Einstein's real gravity curvature field sourced by mass-currents is measured by the gradiometers mentioned in the last paragraph above.
http://en.wikipedia.org/wiki/Gravity_gradiometry

[clxxxvii] Lectures on Gravitation p. 92.
Therefore, there is no non-zero tensor component in the Levi Civita connection field if the equivalence principle is correct. In particular the claim that there is such a tensor by Paul Zielinski is wrong.

[clxxxviii] http://en.wikipedia.org/wiki/Noether's_theorem

[clxxxix] http://en.wikipedia.org/wiki/Proper_acceleration

[cxc] http://en.wikipedia.org/wiki/Doppler_radar

[cxci] Sent to me by Paul Zielinsky on Oct 24, 2013

[cxcii] http://en.wikipedia.org/wiki/Bayesian_statistics

[cxciii] http://en.wikipedia.org/wiki/Frame_fields_in_general_relativity

[cxciv] Newton's artificial gravity force fields exist in real curvature gravity fields (and even in zero curvature). In, e.g., the real static gravity *near field* of a spherical mass M

$$g_{00} = 1 - 2GM/c^2r \text{ etc.}$$

$$2GM/c^2r < 1$$

With real Einstein gravity field curvature components $\sim GM/c^2r^3 \sim A_{horizon}^{1/2}/r^3$

For radii of curvature $A(r)^{1/2} \sim (c^2r^3/GM^{1/2} \sim$ square root of thermodynamic entropy (based on local Rindler horizon version of EEP - see Ted Jacobson's papers)

Newton's artificial gravity force field per unit mass is the *unbalanced* quantum electrical force (mostly molecular Van der Waals)

$$\mathbf{F}_e/m = +(1 - 2GM/c^2r)^{-1/2}GM\mathbf{r}/r^3$$

Needed to keep the test mass m stationary at fixed r in the curved spacetime g_{00} etc.

Note that this static electrical reaction force is classically infinite at the black hole horizon.

If you make the horizon Lp thick in the sense of r-coordinate thickness not proper thickness, then the Taylor series expansion to first order is

$$1 - A^{1/2}/(A^{1/2}+ Lp) \sim 1 - 1/(1 + Lp/A^{1/2}) \sim 1 - 1 + Lp/A^{1/2} \sim Lp/A^{1/2}$$

$$(1 - 2GM/c^2r)^{-1/2} \sim A^{1/4}/Lp^{1/2} >> 1$$

$$(GM/c^2)\,\mathbf{r}/r^3 \sim A^{-1/2}$$

Therefore,

$$(F_{em}/m)_{max} \sim c^2/(A^{1/2}Lp)^{1/2}$$

A = area-entropy of the correspondingblack hole horizon with Hawking temperature T

$$k_BT \sim hc/(A^{1/2}\,Lp)^{1/2}$$

T -> infinity in the classical limit $Lp = (hG/c\text{^}3)^{1/2}$ -> 0

[cxcv] In the rest frame of the LNIF, Newton's 2nd Law
$DU/dt = dU/d\,t - G_{LNIF}UU = F/m$
Simplifies for the **spacelike 3-vector** part
$\mathbf{F}/m = \mathbf{\Gamma}^{\mathbf{r}}{}_{00(LNIF)}$ = proper acceleration of the LNIF
Because $d\mathbf{U}/dt = 0$ and $\mathbf{U} = 0$ by definition of rest frame of the LNIF.
In this "Cantor diagonal" Gödel self-reference case, the test particle under observation and the reference frame/detector/observer are one and the same.
Good physics is about real objects and not about idealized mathematical ideas like "kinematical frames." Mathematics should only be idealized maps of real physical territory. Many theoretical physicists today are

really mathematicians and their papers have little contact with experimental physics. There is now a very intuitive easy way to understand the equivalence principle. When F = 0 the LNIF becomes a LIF. Newton's 2nd Law applied to the LNIF itself becomes Newton's 1st Law, aka "geodesic equation."

[cxcvi] http://en.wikipedia.org/wiki/Four-acceleration

[cxcvii] http://en.wikipedia.org/wiki/Terrell_rotation

[cxcviii] http://en.wikipedia.org/wiki/Weyl_tensor

[cxcix] http://en.wikipedia.org/wiki/Poincaré_group

[cc] http://en.wikipedia.org/wiki/Lorentz_group

[cci] The same idea appears in quantum theory in David Bohm's interpretation. Orthodox quantum theory violates Isaac Newton's philosophical **principle of action and reaction** that is more general than its particular application as Newton's third law of motion: If Alice exerts a real force on Bob, then Bob must exert an equal and opposite reaction real force on Alice.

"It is a venerable tradition in natural philosophy to assert that a substance is the seat of actions on other substances, and in turn subject to the actions of these other substances – the action–reaction principle (AR**)** … Newton is clearly appealing to a principle in the De Grav that is more fundamental and general than what he would later designate as his third law of motion in the Principia – though the latter is often referred to as the law of action–reaction. (We shall see shortly how space, for Newton, is a kind of exception to this fundamental principle.) Leibniz, whose views on the nature of space and time were so different to Newton's, nonetheless, shared the same intuition. In fact, when defining substance as that which acts and can be acted upon, he understood he was adopting the view of the scholastics… For his part, Einstein himself had already stated in 1922 that it is "contrary to the mode of scientific thinking to conceive of a thing . . . which acts itself, but which cannot be acted upon". The object of Einstein's ire in 1922 was NM and his own creation, SR. Yet there is no hint in his writings around the time of the development of SR in 1905 that Einstein considered either of these theories to incorporate a violation of the action–reaction principle; at any rate the explicit condemnation came later. Why? In all probability because it was part of an honest sales pitch for GR, his greatest and most radical contribution to science, after Einstein was reluctantly forced to concede, because of results by de Sitter, that the theory as a whole was not consistent with "Mach's Principle", even though special solutions are. It seems that this change of tack on Einstein's part was consolidated in the mentioned 1920 correspondence with the physicist-philosopher Moritz Schlick."
Einstein, the reality of space, and the action–reaction principle
Harvey R. Brown, Faculty of Philosophy, University of Oxford & Dennis Lehmkuhl
http://philsci-archive.pitt.edu/9792/

This only works locally from Noether's theorem connecting space translation symmetry to conservation of linear momentum in a closed system. More generally, the quantum information field Q living in quantum information Hilbert space acts on the classical particles and fields in their configuration space without any direct reaction of the latter beables (aka hidden variables) on the former. Then, and only then, is it impossible to use entanglement as a stand alone communication channel not requiring a classical signal key to decrypt the message at only one end of the entangled whole. In other words, "background independence" in Einstein's 1916 general relativity is equivalent to entanglement signal nonlocality violating orthodox quantum theory. The non-dynamical spacetime background of Einstein's 1905 special relativity is equivalent to the "no signaling" circular arguments of Abner Shimony's "passion at a distance."

[ccii] "Einstein regarded as one of the triumphs of his 1915 theory of gravity — the general theory of relativity — that it vindicated the action–reaction principle, while Newtonian mechanics as well as his 1905 special theory of relativity supposedly violated it. In this paper we examine why Einstein came to emphasize this position several years after the development of general relativity. Several key considerations are relevant to

the story: the connection Einstein originally saw between Mach's analysis of inertia and both the equivalence principle and the principle of general covariance, the waning of Mach's influence owing to de Sitter's 1917 results, and Einstein's detailed correspondence with Moritz Schlick in 1920. …

Several years after the development of his 1915 general theory of relativity (GR), Einstein began to stress that physical space, or rather the metric field, not only constitutes a fundamental, autonomous element of objective reality, it plays a causal role in accounting for the inertial motion of bodies. He compared this with the active role of space in the cases of Newtonian mechanics (NM) and special relativity (SR). In these cases, bodies or fields do clearly not reciprocate such putative action: they do not act back on space-time structure, so the so-called action–reaction principle is violated. In contrast, in his relativistic theory of gravity GR, Einstein was to see the vindication of the principle. The metric can have a dynamical life of its own in the absence of matter fields (though, as we shall see, this goes against Einstein's original expectations) but, more to the point, when the latter exist, the metric affects and is affected by them. In a Lagrangian framework (which Einstein started to use extensively from 1918 onwards), this mutual affection can be represented by the metric and the matter fields (both dynamical) coupling to each other. The stress-energy tensor, however, turns out to be a relational property of the matter fields, which they posses in virtue of their relations to the metric field. For a recent discussion of the relational significance of the stress-energy tensor, see Lehmkuhl [2011]; section 4.3 for different kinds of coupling. "
Einstein, the reality of space, and the action–reaction principle
Harvey R. Brown, Faculty of Philosophy, University of Oxford & Dennis Lehmkuhl
http://philsci-archive.pitt.edu/9792/

[cciii] http://www.skyandtelescope.com/news/84347742.html

[cciv] http://en.wikipedia.org/wiki/Light_cone

[ccv] http://en.wikipedia.org/wiki/Vacuum_state
Virtual particle : "The presence of virtual particles can be rigorously based upon the non-commutation of the quantized electromagnetic fields. Non-commutation means that although the average values of the fields vanish in a quantum vacuum, their variances do not.[14] The term "vacuum fluctuations" refers to the variance of the field strength in the minimal energy state,[15] and is described picturesquely as evidence of "virtual particles".[16] It is sometimes attempted to provide an intuitive picture of virtual particles based upon the Heisenberg energy-time uncertainty principle:"

This form of Heisenberg's uncertainty principle $\Delta E\, \Delta t > h$ for on-mass-shell real particle poles of the Feynman propagator http://en.wikipedia.org/wiki/Propagator in the complex energy plane. Real particles move along world lines of least action corresponding to constructive interference of the complex numbered Feynman path quantum amplitudes $\sim e^{\,i\text{Classical Action}}$. Virtual particle world lines are regions of destructive interference of the complex numbered quantum amplitudes and they can even be spacelike faster-than-light outside the local light cones of the classical metric spacetime. Indeed, all near field interactions are dominated by faster-than-light virtual spin 1 and spin 2 bosons connecting source charges. Furthermore, the other form of Heisenberg's uncertainty principle is

$$\Delta E\, \Delta t < h \text{ for off-mass-shell virtual particles.}$$

Quantum gravity distorts the above low energy limit for Heisenberg's principle because tiny quantumblack holes will form if you pump too much energy into too small a region of space. The result is:

$$\Delta t \sim h/\Delta E + (hG/c^5)\, \Delta E/h$$

Radiation reaction is an advanced back-from-the-future absorption effect in the Wheeler-Feynman theory.

http://en.wikipedia.org/wiki/Abraham–Lorentz_force

http://en.wikipedia.org/wiki/Wheeler–Feynman_absorber_theory

Hoyle, Narlikar (1995). "Cosmology and action-at-a-distance electrodynamics". *Reviews of Modern Physics* **67** (1): 113. Bibcode:1995RvMP...67..113H. doi:10.1103/RevModPhys.67.113.

[ccv] http://en.wikipedia.org/wiki/Virtual_particle
http://en.wikipedia.org/wiki/Feynman_diagram

[ccv] http://en.wikipedia.org/wiki/Lorentz_covariance

[ccviii] http://en.wikipedia.org/wiki/Green's_function
"In mathematics, a **Green's function** is the impulse response of an inhomogeneous differential equation defined on a domain, with specified initial conditions or boundary conditions. Via the superposition principle, the convolution of a Green's function with an arbitrary function f(x) on that domain, is the solution to the inhomogeneous differential equation for f(x). … In modern theoretical physics, Green's functions are also usually used as propagators in Feynman diagrams (and the phrase Green's function is often used for any correlation function)."

Real particles correspond to complex function theory pole singularities in the complex energy plane of the Fourier transforms of the Green's functions. The equation for the position of the pole singularities is called the mass-shell from Einstein's special theory of relativity formula $m^2c^4 = E^2 - p^2c^2$. Virtual particles contribute to the Green's function from regions in the complex energy plane away from the poles. You can roughly think of the real particle poles as signals and the virtual particles as random noise unless they are coherently organized in macro-quantum coherent non-orthogonal distinguishable Glauber (possibly squeezed) states.

http://en.wikipedia.org/wiki/Coherent_states

[ccviii] http://en.wikipedia.org/wiki/Geodesic
However, in special and general relativity with a non-positive definite light cone Lorentzian metric signature +---, the free-float zero g-force (weightless) timelike geodesics for test particles with rest mass are the longest proper time paths between two events relative to infinitesimally close paths with the same initial and final events. This is the calculus of variations and the action principle in a particular case.

[ccx] "Essentially by finding a way to bypass it! Einstein was to link the problem of inertial motion with a notion he expressed clearly in 1911, itself related to the equivalence principle: that a uniformly accelerating reference frame (which reproduces all the effects of a homogenous gravitational field) is no more absolute than an inertial frame."

There is still a lot of confusion among people who should know better about this. As I have already said, more than once, since the point bears emphasis and repetition, that all local frames, properly accelerating in various ways or not, equally well describe the laws of nature via the tensor/spinor covariant (algebraic form-invariance of the local Euler-Lagrange field equations, both classical c-number and second quantized creation and destruction operators in occupation number Fock space is a property of the "formal language" (David Bohm) of the theory, and in no way does it mean that local observers using accelerometers that measure objectively local tensor proper acceleration deviations away from timelike free-float geodesics cannot tell if they are LIF or LNIF. It is a common fact of experience that we do. Whenever, we feel weight, that tells us we are LNIF not LIF. We are static LNIF, from unbalanced electrical forces, when we are not moving relative to the mass-energy source of the curvature real gravity field. That is, our non-tensor kinematical acceleration is zero, though our proper tensor acceleration is non-zero. When Einstein formulated his equivalence principle, he means Newton's concept of gravitational field, which corresponds to a piece of the Levi-Civita connection in his 1916 tensor mathematics that he learned from Marcel Grossman of his Olympia Academy in the "Caffe Trieste" of his day. The modern concept of gravity field is the covariant curl of that Levi-Civita connection with itself – the 4th rank tensor curvature that consists of

matter Ricci part and a vacuum conformal Weyl part. Note that the Levi-Civita connection also contains the Coriolis, centrifugal, Euler and translational fictitious inertial pseudo-forces that are familiar even in the absence of curvature. That is they do not contribute to the self-referential curl of the connection with itself. To make an analogy with Maxwell's electrodynamics, the fictitious inertial pseudo-forces are analogous exact longitudinally polarized exact Cartan 1-form $A_{longitudinal}$ = df part of the 4-potential A that do not contribute to the 2-form F = dA since $d^2 = 0$.

Mach was concerned only with Newton's first law, i.e. the objective geodesic pattern of free-float timelike (and null) geodesic LIFs. Though, of course, he did not use that language. Mach was not at all concerned with Newton's second law in which the inertial rest masses m = F/a appear. Einstein, in 1912, did speculate that they too might be an emergent relational bootstrap of all the masses in the universe. That idea is wrong and Einstein abandoned it. Finally Newton's third law, a particular application of the more general action-reaction principle has nothing whatsoever to do with Mach's historical principle as some claim. Newton's third law is local and comes from an application of Noether's theorem connecting local translational symmetry with conservation of linear momentum in closed systems. Inertial, fictitious pseudo-forces are manifestations of real forces acting on LNIFs that are mistakenly attributed to the observed test particle motions (when not clamped to the LNIF). Back to Harvey Brown:

"Indeed, he hoped that his future theory of gravity would allow for a yet further generalisation of this putative extension of the Galilean-Einstein relativity principle – to all frames, such that the very distinction between inertial and non-inertial motion would become relative, non-absolute.42 By 1912, Einstein was convinced that the success of the complete "relativity of motion" would be guaranteed if the gravitational field equations turned out to be generally covariant.43 What is important for our purposes is that Einstein saw relativity of inertia, the principle of the relativity of motion and the equivalence principle as walking hand in hand. As Barbour has stressed:

'The drift of Einstein's thought is now clear. Whereas the logic of Mach's comments called for explicit derivation of the distinguished local frames of reference from a relational law of the cosmos as a whole, Einstein is working towards elimination of the problem of the distinguished frames by asserting that they are not really distinguished at all.'"

Again, the local frames are not distinguished in the mathematical maps of the phenomena, but they are distinguished operationally physically by the readings of pointers of accelerometers that measure the local objective deviations away from timelike weightless geodesics inside the local light cones at the classical level.

[ccxi] And possibly also chiral twisted (aka "torsion field") not only by the quantum spins of mass-energy stress currents, but also by their orbital angular momentum. However, this is very controversial considered fringe in mainstream physics. The Soviet military (e.g., Gennady Shipov) were working on alleged torsion weapons during the cold war. Indeed, we had Shipov and Vladimir Poponin from that project work with us 1999 – 2000 at Joe Firmage's ISSO. Richard Hammond here in America was also working on that idea. The issue is whether there are propagating torsion waves in addition to the propagating curvature waves? We also had Hammond visit us at ISSO. Ron Pandolfi of the Central Intelligence Agency Science and Technology Directorate monitored these activities, which also included trips to Eastern Europe connected with J. P. Vigier's "tight atomic states" experiments in Beograd. Vigier's idea was a possible mechanism for "cold fusion." http://gravityresearchfoundation.org/pdf/awarded/1996/hammond.pdf

Indeed, extra-dimensional superstring theory requires torsion in addition to curvature as part of the fabric of spacetime. The number of space dimensions depends on the scale of energy revealed in scattering experiments in that programme.

Reports on Progress in Physics Volume 65 Number 5
Torsion gravity
Richard T Hammond 2002 *Rep. Prog. Phys.* **65** 599. doi:10.1088/0034 4885/65/5/201 Received 21 November 2001, in final form 14 February 2002. Published 27 March 2002.

Abstract

"Theoretical and experimental research on general relativity with torsion is reviewed. An introductory section establishes definitions and notation, introduces tetrads, the anholonomic formulation and the Dirac equation in curved space with torsion. After that, gauge theories of gravitation are introduced, starting with local Poincaré gauge theory, in which the torsion arises as translational gauge field strength, and other gauge approaches are described. Torsion that is derived from a potential, including a scalar, vector, and tensor potential is discussed, with emphasis on the antisymmetric tensor of the string theory kind. Teleparallel theories are described, conformal invariance is discussed and a brief section on the equation of motion is presented. Experiments that have searched for, or bounded, torsion are described and the possible physical manifestations are broken down into the broad areas of quantum effects, laboratory scale phenomena and large-scale tests. Finally, a discussion of the relationship between string theory and torsion is presented."

[ccxii] "Second, it would seem that Mach's gravitation-like proposal for the origin of inertia, and the very existence of inertial frames, would involve action at a distance. In fact, it could be called super-action-at-a-distance; the inertial motion of a body is being attributed to the existence of celestial bodies so far away that their gravitational actions on it are negligible. The caveat is that Mach's own notion of causality was rather thin; Norton has called it "idiosyncratic". Mach saw physics as providing only functional dependencies between experiences; systematic correlations rather than causal interactions (in so far as the distinction is meaningful). The commitment to the notion that "the law of causality is sufficiently characterised by saying that it is the supposition of the mutual dependence of phenomena" on Mach's part perhaps explains why he was comfortable enough with Newton's picture of gravity to encourage the search of an analogous account of inertia. However all this may be, it seems reasonable to conclude that Mach was not obviously concerned, in the context of his analysis of inertia in NM, with the action–reaction principle or its violation, in anything like the ordinary sense. (It is true that Mach provided an operational reading of inertial mass based on Newton's third law of motion, one that proved to be influential. But as we have urged, the third law is not to be conflated with the AR principle.) In fact, a degree of resonance is discernible between Mach's view of the nature of causal connections and that of Leibniz, despite the chasm between their views on metaphysics. …

Einstein states in the 1912 paper that the results he has obtained give support to the (alleged) idea of Mach that the inertia of point masses is a result of the presence of other masses, that it rested on an interaction (Wechselwirkung) of the point particle with those other masses. (Recall that Mach himself did not use the term 'interaction' but spoke of mutual dependencies.) We find similar statements in the mentioned 1913 paper with Grossmann and another 1913 paper by Einstein; in each instance Einstein emphasizes that the inertia of a body should be derived as the result of an interaction of this body with other bodies. 37 Also in 1913, Einstein wrote two letters to Mach, the first in June, the second in December. In the June letter, Einstein writes enthusiastically that in his Entwurf theory, which he developed with Marcel Grossmann, "inertia has its origin in some kind of interaction of the bodies, completely in the sense of your considerations about Newton's bucket experiment." Despite the wording, careful reading of the letter makes it clear that again Einstein is thinking of inertial mass rather than the inertial frame.
37 Note that Einstein did not clearly distinguish between the relativity of inertia (the predecessor of 'Mach's principle' as defined only in Einstein [1918], and the relativity of motion, as he himself admits of not having done up until Einstein [1918]). For details on different versions of these principles and the development in Einstein's thought see the sources summarised in footnote 21. … When, in the context of discussions relevant to this essay, Newtonian space is assigned a causal role, it is usually to account for inertia, i.e. the privileged existence of inertial frames, or equivalently the special motions of force-free bodies. … Barbour indeed provides powerful textual evidence that Mach, on at least one occasion, was searching for an explanation of the inertia (as opposed to inertial mass**)** of a force-free body, i.e. its uniform, rectilinear motion, in terms of distant bodies, in analogy with the explanation of the acceleration of a body resulting from the gravitational influence of distant masses – an account which would yield the Newtonian predictions to a good approximation in the case of a universe populated to the extent ours is. … An important aspect of Mach's thinking about inertia is the emphasis on the cosmological nature of its origins. It is not some subset of distant bodies that determines the system of inertial frames; it is the totality of bodies in the universe. Barbour has aptly connected this cosmological strand of Mach's reasoning – the

requirement of self-referentiality in any adequate account of the observed world – with Kepler's 1609 theory of place and motion. Prior to 1917, the strand played only a minor role in Einstein's thinking."

[ccxiii] "In a homogeneous gravitational field (acceleration of gravity g) let there be a stationary systems of co-ordinates K, oriented so that the lines of force of the gravitational field run in the negative direction of the axis of z. In a space free of gravitational fields let there be a second system of co-ordinates K', moving with uniform acceleration (g) in the positive direction of the z axis… Relatively to K, as well as relatively to K', material points which are not subjected to the action of other material points, move in keeping with the equations

$$d^2x/dt^2 = 0,\ d^2y/dt^2 = 0,\ d^2z/dt^2 = -g$$

… we arrive at a very satisfactory interpretation of this law of experience; if we assume that the system K and K' are physically exactly equivalent, that is, if we assume that we may just as well regard the system K as being a space free from gravitational fields, if we then regard K as uniformly accelerated. This assumption of exact physical equivalence makes it impossible for us to speak of the absolute acceleration of the system of reference, just as the usual theory of relativity forbids us to talk of the absolute velocity of a system; and it makes the equal falling of all bodies in a gravitational field a matter of *course."* On the Influence of Gravitation on the Propagation of light, Albert Einstein, Annalen der Physik, 35, (1911), The Principle of Relativity, (Dover Publications, Inc 1952), pp. 99-108 Einstein elsewhere makes it clear that he means a homogeneous Newtonian gravity field in the infinitesimal sense of a first order Taylor series expansion of an arbitrary inhomogeneous gravity field. A global uniform field is irrelevant to the basic concept of the local equivalence principle.

[ccxiv] http://en.wikipedia.org/wiki/Levi-Civita_connection
"If the connection is a Levi-Civita connection, then these isomorphisms are orthogonal – that is, they preserve the inner products on the various tangent spaces."

The above orthogonality is also called metricity defining a metric connection with a vanishing non-metricity tensor. There are alternative formulations of gravity that are non-metrical in this sense. Einstein's theory is not one of them. There is no physical evidence for non-metric theories as far as I know. Metricity for the spacetime tangent bundle is analogous to unitarity in the quantum information dynamics of the Hilbert space bundle over the configuration space of entangled complex systems. Unitarity is associated with conservation of total probability and it seems to preclude the entanglement signal nonlocality required for consciousness in matter in my theory of the mind-matter "hard problem" (David Chalmers, Scientific American). There is an argument between Roger Penrose and Gerard 't Hooft on whether unitarity is violated in quantum gravity, in particular for the horizons ofblack holes and cosmology. Leonard Susskind has called this "the black hole war." Stephen Hawking was on Penrose's side but switched to 't Hooft's in 2004 at a meeting in Dublin, Ireland that I attended.

[ccxv] http://en.wikipedia.org/wiki/Covariant_derivative

[ccxvi] http://en.wikipedia.org/wiki/Riemann_curvature_tensor
Hagen Kleinert of the Free University of Berlin has shown that gravity's curvature is the smooth continuum approximation to disclination topological defects in a discrete four-dimensional "world crystal lattice." Torsion, though absent in Einstein's 1916 GR, would then correspond to dislocation defects. Kleinert supposed that the basic lattice length scale is the quantum gravity Planck length ~ 10-35 meters. However, the hologram universe conjecture connects the Planck length with dark energy density accelerating our "causal diamond" observable piece of the multiverse, giving a world crystal lattice length scale~ 10^-15 meters corresponding to the classical electron radius and the 1 Gev scale of nuclear physics. Therefore, one expects Abdus Salam's idea of a massive graviton with strong short-scale Yukawa gravity may have some validity as it naturally explains the universal slope of the hadronic Regge trajectories as I argued at Salam's Trieste Institute in 1973. The duality of strings toblack holes is also natural in this picture.
See also http://en.wikipedia.org/wiki/Introduction_to_mathematics_of_general_relativity
http://en.wikipedia.org/wiki/Ricci_decomposition

[ccxvii] http://en.wikipedia.org/wiki/Vector_calculus
Specializing to 3D space:
Gradf = df is an exact closed Cartan 1-form with f a Cartan 0-form measures the rate and direction of change of a spin 0 Higgs type vacuum superconductor field from spontaneous symmetry breaking mapping them to closed exact spin 1 vector fields that only have longitudinal polarization without the two transverse polarizations. The integral of an exact closed 1-form over a path is independent of the path connecting two fixed points. This is what happens in a conservative potential U in classical mechanics and in strictly reversible equilibrium thermodynamics. Conservative potentials also appear in toy model metrics of Einstein's GR, e.g., $g_{00} = 1 + U/c2$ where U is the Newtonian gravity theory's potential energy per unit test particle mass in what is called the static LNIF representation. These are properly accelerating observers firing rockets, for example, which allow them to hover at a constant distance from a spherical mass-energy source such as the Earth (approximately). Note that the true tensor proper acceleration in curved spacetime can be non-zero, whilst its kinematical acceleration measured by Doppler radars is zero. It can also be the other way with a zero proper acceleration on a free-float timelike geodesic in curved spacetime that has a non-zero kinematic acceleration relative to a LNIF observer. This distinction causes a lot of confusion especially for aerospace engineers who are only taught Newtonian mechanics of particles. In contrast, the path integral of a non-exact closed 1-form is path-dependent.

The Cartan exterior derivative operator d takes Cartan p-forms into p + 1 forms. Its dual boundary operator d^{-1} takes p + 1 co-forms into p co-forms. These are metric independent topological operations in the sense of Felix Klein's Erlangen Programme of 1872 with different layers of geometry defined by symmetry groups of frame transformations. The symmetry groups are like Russian dolls. De Rham integrals (p|p) of p forms over p co-forms.

Stoke's theorem is $(dp|p+1) = (p|d^{-1}p + 1)$.

http://en.wikipedia.org/wiki/Pseudovector

Div.F = *dF is a Cartan 0-form where F is a Cartan 2-form and * is the metric-dependent Hodge dual operator taking a p-form into a N – p form in an N-dimensional vector space. Here N = 3 and p = 3. This "divergence" measures the spin 0 scalar of a source or sink at a given point in a vector field mapping spin 1 vector fields to spin 0 scalar fields.

Maxwell's U1 spin 1 electromagnetic field equations in Cartan's notation are very elegant. Now N = 4 corresponding to Einstein's globally flat spacetime of his 1905 special relativity without any real gravity curvature field.

A is a non-exact 1-form if there are real transverse polarized zero rest mass photons propagating energy to infinity in the far field.

$$F = dA =/= 0$$

$dF = d2A = 0$ Faraday's law induced EMF & no magnetic monopoles

$d*F = *J$ Ampere's law including Maxwell's displacement current & Gauss's law

$d*J = d^2*F = 0$ local conservation of electric current density

Is there an analogous neat form for SU2 weak and SU3 strong Yang-Mills spin 1 fields and for Einstein's spin 2 gravity field?

On Oct 7, 2013, at 6:42 PM, jack <jacksarfatti@gmail.com> wrote:
Sent from my iPhone

On Oct 7, 2013, at 5:51 PM, Paul Z. wrote:

Thus by 1920 Einstein had understood that the guv were dynamical properties of a physical vacuum that are not fully determined by matter stress-energy.

Jack Sarfatti responded:

It's the curvature R that is dynamical (also possibly torsion K in Einstein-Cartan)

http://en.wikipedia.org/wiki/Differential_form

That is the transverse curl part of the spin connection that describes disclination defects aka curvature

The exact part of the spin connection 1-form

$$S_{exact} = df$$

f = 0-form

(Actually a set of 0-forms f_{IJ} where I, J are the LIF indices.

It's really S_{IJ} and R_{IJ}, but K_I and e_I.

Corresponds to artificial Newtonian gravity fields in Minkowski space

Technically GR in a nutshell

e is set of four tetrad Cartan 1-forms

S is the spin connection 1-form

The affine metric connection 1-form in general is

$$A = S + *(K/\backslash e)$$

$$K = De = de + S/\backslash e$$

= Torsion 2-form - corresponding to dislocation defects in Kleinert's world crystal lattice

$$R = DS = dS + S/\backslash S = \text{Curvature 2-form}$$

Einstein's 1916 GR is the limit

$$K = 0$$

Which gives LC = 0 in LIF EEP

$$D*R = 0 \text{ Bianchi identity}$$

$$*R + A\text{^}-1e/\backslash e/\backslash e = k*T = \text{Einstein field equation}$$

* = Hodge duality operator

$$D*(T - A^{-1}\, e/\backslash e/\backslash e) = 0$$

Is local conservation of stress-energy current densities

Note if there is torsion De = K =/= 0 then we have a direct coupling between matter fields T and the geometrodynamic field K - for warp drive & stargate engineering?

Einstein Hilbert action density including the cosmological constant $A^{-1}$is the 0 form

$$*R/\backslash e/\backslash e + *A^{-1}e/\backslash e/\backslash e/\backslash e$$

A = area-entropy

Of our dark energy future cosmological event horizon bounding our causal diamond.

A useful reference is Rovelli's review on quantum gravity
http://www.cpt.univ-mrs.fr/~rovelli/book.pdf

See figs 1.1 and 5.1 in
http://www.physics.uq.edu.au/download/tamarad/papers/thesis_complete.pdf

Gauge transformations (corresponding to general coordinate transformations) are

$$d^2 = 0$$

$$S \rightarrow S' = S + df'$$

$$S/\backslash f = 0$$

$$R = DS \dashrightarrow R' = DS'$$

$$R' = dS' + S'/\backslash S'$$

$$= dS + d^2f' + (S + df')/\backslash(S + df')$$

$$= dS + S/\backslash S + S/\backslash df' + df'/\backslash S + df'/\backslash df'$$

/\ is antisymmetric

$$df'/\backslash df' = 0$$

(Analogous to **A**x**A** = 0 in 3-vector analysis cross-product)

R' = R CURVATURE 2-FORM INVARIANT

Physically, the GR gauge transformations are

LNIF(Alice) < ---> LNIF(Bob)

Where Alice and Bob are "coincident" i.e. separations small compared to radii of curvature.

Paul Zielinski wrote:

"He tried to call this new ether "Machian", but it is hard to see what is Machian about it, other than that the guv field is at least partially determined by Tuv. But that is an action-reaction principle, not a Machian

relativity of inertia principle. So if this new ether is at all "Machian", it is only in the very weak sense that the spacetime geodesics depend on the distribution of matter according to the GR field equations (plus boundary conditions)."

Right.

On 10/7/2013 2:46 PM, Jack quoted Harvey Brown et-al
"The growing recognition, on Einstein's part, of the tension between the field equations in GR and his 1918 version of Mach's Principle led him, as we have seen, to effectively assign genuine degrees of freedom to the metric field in the general case (not for the Einstein universe). This development finds a clear expression in a 1920 paper, where Einstein speaks of the electromagnetic and the gravitational "ether" of GR as in principle different from the ether conceptions of Newton, Hertz, and Lorentz. The new, generally relativistic or "Machian ether", Einstein says, differs from its predecessors in that it interacts (bedingt und wird bedingt) both with matter and with the state of the ether at neighbouring points. There can be little doubt that the discovery of the partial dynamical autonomy of the metric field was an unwelcome surprise for Einstein; that as a devotee of Mach he had been reluctant to accept that the metric field was not, in the end, "conditioned and determined" by the mass-energy-momentum $T_{\mu\nu}$ of matter."

[ccxviii] http://en.wikipedia.org/wiki/Tensor
"I admire the elegance of your method of computation; it must be nice to ride through these fields upon the horse of true mathematics while the like of us have to make our way laboriously on foot."
—Albert Einstein, *The Italian Mathematicians of Relativity* [8]

[ccxix] http://en.wikipedia.org/wiki/Spinor

[ccxx] Newton's particle mechanics and Einstein's 1905 special theory of relativity violate the philosophical principle of action-reaction, which in the specific sense of mechanics is the result of linear momentum conservation in a closed system. Momentum conservation comes from symmetry under space translations. The general connection of continuous symmetries to conserved quantities is given in Emmy Noether's theorem. However, here we use the idea in a more general sense. Einstein's 1916 general relativity of gravitation obeys this action-reaction principle. Interestingly enough, orthodox quantum theory with its "passion at a distance" (Abner Shimony's term), i.e. no entanglement signals without a retarded light speed limited signal decryption key, like special relativity violates the action-reaction principle. This is seen most clearly, in David Bohm's pilot wave picture of quantum theory. Orthodox quantum theory is then, like special relativity, the limiting case in which all of the "beables," i.e. classical particles and classical EM-weak-strong vector and gravity tensor fields are test particles that are not sources of their pilot qubit information waves that live in higher dimensional Wigner phase space when there is entanglement.

I was the first, to suggest that living consciousness requires beable (aka hidden variable) direct back-reaction on their pilot waves. See Lecture 8 of Michael Towler's Cambridge Lectures for a concise description of my theory. http://www.tcm.phy.cam.ac.uk/~mdt26/pilot_waves.html
Towler's lectures are very good in spite his "celebrity nutjob" comment. As far as I know David Bohm never used the term "back-action" or "feedback control loops" to explain qualia in consciousness, although he did have the back-action idea - I got it from him - he did not connect those two dots in that way. That is my original contribution.
http://www.tcm.phy.cam.ac.uk/~mdt26/PWT/lectures/bohm8.pdf Towler wrote:

"The material in this lecture is largely derived from books and articles by David Bohm, Basil Hiley, Paavo Pylkkannen, F. David Peat, Marcello Guarini, **Jack Sarfatti**, Lee Nichol, Andrew Whitaker, and Constantine Pagonis. The text of an interview between Simeon Alev and Peat is extensively quoted. Other sources used and many other interesting papers are listed on the course web page
http:// www.tcm.phy.cam.ac.uk/~mdt26/pilot waves.html

Living matter and back-action In certain dark corners of the internet, can find speculation of the following nature: • Propose the wave function/pilot wave is intrinsically 'mental' and capable of qualia. • Equate the pilot wave with the mental aspect of the universe, generally: the particles are 'matter', and 'mind' the pilot wave. OK, who cares, except:

Mental' aspect of universe upgradeable to life/consciousness by self-organization. Happens when a physical system uses its own nonlocality in its organization. • In this case a feedback loop is created, as follows: system configures itself so as to set up its own pilot wave, which in turn directly affects its physical configuration, which then affects its non-local pilot wave, which affects the configuration etc.

Normally in QM this 'back-action' is not taken into account. The wave guides the particles but back-action of particle onto wave not systematically calculated. Of course, the back-action is physically real since particle movement determines initial conditions for next round of calculation. But there is no systematic way to characterize such feedback. One reason this works in practice is that for systems that are not self-organizing the back-action may not exert any systematic effect. Well, it's not obviously wrong.

Two-way traffic: Important to note that pilot-wave theory does not take into account any effect of individual particle on its own quantum field (though Bohm and Hiley briefly sketch some ideas about how this might happen, see e.g. Undivided Universe pp. 345-346).

Idea that particles collectively affect quantum field of a single particle is contained in the standard notion that shape of quantum field of a particle is determined by shape of environment (which consists of many particles, and is part of the boundary conditions put into the Schrodinger equation before solving it, even in conventional QM).

Celebrity nutjob Jack Sarfatti (see e.g., http://www.stardrive.org) in particular has emphasized the need for an explanation of how the individual particle influences its own field and has proposed mechanisms for such 'back-action', also emphasizing its importance in understanding the mind- matter relationship and how consciousness arises (see earlier slide).

Assuming that notion of such an influence of the particle on its field can be coherently developed, we can then have two-way traffic between the mental and the physical levels without reducing one to the other. Role of Bohm's model of the quantum system then would be that it provides a kind of prototype that defines a more general class of systems in which a field of information is connected with a material body by a two-way relationship.

Quantum theory is currently our most fundamental theory of matter and Bohm suggests that, when ontologically interpreted, it reveals a proto-mental aspect of matter. This is the quantum field, described mathematically by the wave function, which is governed by the Schrodinger equation. Bohm's suggestion is known as panprotopsychism so at least you learned a new word today!"

Such post-quantum back-reaction is dual to Antony Valentini's "signal nonlocality" that violates the Born probability density rule (squared modulus of the complex Feynman quantum amplitude that must summed over all indistinguishable histories before squaring).

Subquantum Information and Computation

Antony Valentini

(Submitted on 11 Mar 2002 (v1), last revised 12 Apr 2002 (this version, v2))
"It is argued that immense physical resources - for nonlocal communication, espionage, and exponentially-fast computation - are hidden from us by quantum noise, and that this noise is not fundamental but merely a property of an equilibrium state in which the universe happens to be at the present time. It is suggested that 'non-quantum' or nonequilibrium matter might exist today in the form of relic particles from the early universe. We describe how such matter could be detected and put to practical use. Nonequilibrium matter

could be used to send instantaneous signals, to violate the uncertainty principle, to distinguish non-orthogonal quantum states without disturbing them, to eavesdrop on quantum key distribution, and to outpace quantum computation (solving NP-complete problems in polynomial time)."
http://arxiv.org/abs/quant-ph/0203049

It turns out that **entangled Glauber coherent states** are distinguishably non-orthogonal and they appear to show the kind of signal nonlocality that Valentini above is writing about. Indeed, this mechanism when combined with topological computing must be ubiquitous in living matter in my opinion.

Review of Entangled Coherent States

Barry C. Sanders
(Submitted on 8 Dec 2011)
"We review entangled coherent state research since its first implicit use in 1967 to the present. Entangled coherent states are important to quantum superselection principles, quantum information processing, quantum optics, and mathematical physics. Despite their inherent fragility they have produced in a conditional propagating-wave quantum optics realization. Fundamentally the states are intriguing because they are entanglements of the coherent states, which are in a sense the most classical of all states of a dynamical system."
http://arxiv.org/abs/1112.1778

http://en.wikipedia.org/wiki/Topological_quantum_computer

http://en.wikipedia.org/wiki/Adiabatic_quantum_computation

http://en.wikipedia.org/wiki/D-Wave_Systems

[ccxxi] This geodesic premise is Newton's first law of motion most generally expressed.

[ccxxii] On the Relativity Principle and the Conclusions Drawn from It, Albert Einstein, Jahrbuch der Radioaktivitat und Electronik 4 (1907) – Re-Published in three parts. Am. J. Phys. **45**, Part I - (6), June 1977, pp. 512-517; Part II – (9), September 1977, pp. 811-816, Part III - (Gravitational Part) – (10), October 1977, pp. 899-902. This paper addresses only Part III – from Peter Brown's paper.

In this EARLY 1907 quote Einstein (who is still under Newton's magick without magic spell) means Newton's "accelerated frame", that is, dV(test particle)/ds in Newton's first law (geodesic equation) as written in modern POST-1907 GR language. Suppressing indices:

$$DV(\text{test particle})/ds = dV(\text{test particle})/ds - \{\text{LNIF detector}\}V^2(\text{test particle}) = 0$$

The "cancellation" is precisely

$$dV(\text{test particle})/ds - \{\text{LNIF detector}\}V^2(\text{test particle}) = 0$$

In other words, in the general case that even applies to Newton's 2nd and 3rd laws is:

Einstein's proper tensor acceleration = Newton's apparent acceleration - fictitious LNIF inertial pseudo fictitious forces per unit test particle rest mass = real applied force to the test particle per unit test particle mass

Fictitious forces on test particle = Real forces on LNIF detector of test particle's motion

---

In the case of Newton's 3rd law, when Alice and Bob form an isolated closed system

DP(Alice + Bob)/ds = DP(Alice)/ds + DP(Bob)/ds = 0

Both must be measured in the same frame by Eve, i.e.,

DP(Alice or Bob)/ds = dP(Alice or Bob)/ds + {Eve}V(Alice or Bob)P

"I continued my thought: A falling man is accelerated. Gravity and inertia are interrelated." Einstein

Here is the source of the confusion.

Einstein is naturally thinking in Newtonian terms.

However, in GR terms that he still had not invented back then in 1907: "acceleration" above means relative kinematical acceleration between test particle and local frame. It does not mean real (proper) acceleration (off-geodesic) as measured by an accelerometer.
The general law is:

Real acceleration on test particle = relative kinematical acceleration between test particle and local frame - real acceleration of local frame.

DP(test particle)/ds = dP(test particle-frame)/ds - DP'(local frame)/ds

P = mV for the test particle under observation by the local frame detector

V = dX/ds

X = relative kinematical displacement between test particle and local frame detector as measured by a Doppler radar clamped to the local frame.

D/ds = d/ds - {LC frame connection} dX/ds

DP(test particle)/ds

= dP(test particle)/ds - {LC frame connection}(dX/ds)P(test particle)

When dm/ds = 0, it follows that

$D^2X/ds^2 = d^2X/ds^2$ - {LC frame connection}$(dX/ds)^2$

{LC frame connection}$(dX/ds)^2 = M^{-1}$DP(frame)/ds

M = mass of frame/detector

{LC frame connection} has dimension 1/Length

ds is the PROPER TIME element along world line of object.

Each term has an independent measurement technique.

Real accelerations are measured by accelerometers attached to the objects.

http://en.wikipedia.org/wiki/Accelerometer

Accelerometers measure off-geodesic "pushes" by real forces.

Doppler radars measure the kinematic acceleration.

http://en.wikipedia.org/wiki/Doppler_radar

Therefore,

DV/ds is measured directly locally by an accelerometer clamped to the test particle - real measurement 1

$dV/ds = d^2X/ds^2$ is measured indirectly by the Doppler radar clamped to the local frame detector - real measurement 2

$M^{-1}DP(frame)/ds$ is measured directly by a second accelerometer clamped to the frame-Doppler radar - measurement 3

The BASIC LAW is

Measurement #1 = measurement #2 - measurement #3

Provided that test particle and frame Doppler radar are not far away from each other relative to the smallest local radius of curvature $A^{1/2}$. The curvature is of order A^{-1}
The geodesic equation is simply Newton's first law when

Measurement #1 = 0

Newton's second law is simply when

Measurement #1 =/= 0

There is never any cancellation of real forces on any one object in this context

The LNIF ---> LIF in measurement 3 simply means removing a real unbalanced force on the frame detector according to Newton's 1st law.

“Then what he feels and judges is happening in the accelerated frame of reference.” Einstein

Einstein's use of "accelerated" here is in Newton's sense - the rest frame of the freely falling man is kinematically accelerated relative to the Earth

I.e. d^2X/ds^2

The freely falling man's local frame is LIF - though Einstein did not yet discover that in 1907 and his informal language is still Newtonian because the modern GR informal language of 1916 and after is not yet emerged.

“There is a new gravitational field, which cancels the gravitational field due to the Earth.” Einstein

This is Einstein's remark that physics cranks pull out of proper context. Yes, Einstein wrote it back around 1907 before he understood the problem the way he eventually would in 1916 and later. In fact there is only one gravity field not two. The point is that there was never a real gravity force field on the test particle to begin with. Therefore, you don't need a second gravity force field to cancel what was never there! Indeed, there is no way to measure either of these alleged two real gravity forces to begin with. You can never separate them. Accelerometers on test particles always show zero. Therefore, like the Maxwellian 19th

century mechanical aether that acts without being reacted upon that Einstein eliminated in 1905, these two ghostly independently unobservable-in-principle forces are not independently measurable - they are errors of thinking - excess metaphysical informal language baggage. Even the great Einstein got muddled temporarily on this one, though with good reason. Unfortunately many people today who should know better remain muddled. If gravity is not a real force like the electro-weak-strong forces, then what does it mean to unify them?

[ccxxiii] http://en.wikipedia.org/wiki/Fictitious_force

[ccxxiv] http://en.wikipedia.org/wiki/Accelerometer

[ccxxv] http://relativity.livingreviews.org/Articles/lrr-2001-4/download/lrr-2001-4Color.pdf

[ccxxvi] http://www.fourmilab.ch/rpkp/

[ccxxvii] Wheeler–Feynman absorber theory
http://en.wikipedia.org/wiki/Retrocausality

[ccxxviii] "Aharonov was one of the first to take seriously the idea that if you want to understand what is happening at any point in time, it's not just the past that is relevant. It's also the future," Tollaksen says. In particular, Aharonov reanalyzed the indeterminism that forms the backbone of quantum mechanics … There is nothing to explain the different behaviors of the two atoms, no way to predict when they will decay by looking at their history, and—seemingly—no definitive cause that produces these effects. This indeterminism, along with the ambiguity inherent in the uncertainty principle, famously rankled Einstein, who fumed that God doesn't play dice with the universe. … [Aharonov's] answer—which seems inspired and insane in equal measure—was that we cannot perceive the information that controls the article's present behavior because it does not yet exist. 'Nature is trying to tell us that there is a difference between two seemingly identical particles with different fates, but that difference can only be found in the future,' he says. If we're willing to unshackle our minds from our preconceived view that time moves in only one direction, he argues, then it is entirely possible to set up a deterministic theory of quantum mechanics. … By the late 1980s, Aharonov had seen a way out: He could study the system using so-called weak measurements. (Weak measurements involve the same equipment and techniques as traditional ones, but the "knob" controlling the power of the observer's apparatus is turned way down so as not to disturb the quantum properties in play.) In quantum physics, the weaker the measurement, the less precise it can be. Perform just one weak measurement on one particle and your results are next to useless. You may think that you have seen the required amplification, but you could just as easily dismiss it as noise or an error in your apparatus.

The way to get credible results, Tollaksen realized, was with persistence, not intensity. By 2002 physicists attuned to the potential of weak measurements were repeating their experiments thousands of times, hoping to build up a bank of data persuasively showing evidence of backward causality through the amplification effect. …

For Tollaksen, though, the results are awe-inspiring and a bit scary. "It is upsetting philosophically," he concedes. "All these experiments change the way that I relate to time, the way I experience myself." The results have led him to wrestle with the idea that the future is set. If the universe has a destiny that is already written, do we really have a free choice in our actions? Or are all our choices predetermined to fit the universe's script, giving us only the illusion of free will?

Tollaksen ponders the philosophical dilemma. Was he always destined to become a physicist? If so, are his scientific achievements less impressive because he never had any choice other than to succeed in this career? If I time-traveled back from the 21st century to the shores of Lake Michigan where Tollaksen's 13-year-old self was reading the works of Feynman and told him that in the future I met him in the Azores and his fate was set, could his teenage self—just to spite me—choose to run off and join the circus or become a sailor instead? …

In other words, you can see the effects of the future on the past only after carrying out millions of repeat experiments and tallying up the results to produce a meaningful pattern. Focus on any single one of them and try to cheat it, and you are left with a very strange-looking result—an amplification with no cause—but its meaning vanishes. You simply have to put it down to a random error in your apparatus. You win back your free will in the sense that if you actually attempt to defy the future, you will find that it can never force you to carry out post-selection experiments against your wishes. The math, Tollaksen says, backs him on this interpretation: The error range in single intermediate weak measurements that are not followed up by the required post-selection will always be just enough to dismiss the bizarre result as a mistake."
By Zeeya Merali|Thursday, August 26, 2010, Discover Magazine

[ccxxix] Enrico Rodrigo's Stargate book updates the singularity problem and shows that there are now several ways of dealing with it since the classical energy conditions assumed by Penrose and Hawking are actually false in quantum theory. The discovery of anti-gravity dark energy accelerating the space expansion of our observable universe (aka "causal diamond") also is a game changer.

[ccxxx] My "Destiny Matrix" conjecture that we live inside of a hologram conscious computer simulation has the "brane of GOD(D)" (I. J. Good's "superluminal telepathic" cosmic consciousness) at our future de Sitter event horizon of asymptotic area-entropy A. The dark energy we see now in our past light cone is actually gravitationally redshifted back-from-the-future (as in Yakir Aharonov's post-selected destiny quantum wave and John Cramer's TI) Wheeler-Feynman Hawking black body gravity wave radiation from the Planck length thickness of that future horizon. The surface of the horizon is discrete pixelated into quantum area bits whose images are voxelated quantum volume bits of what Hagen Kleinert calls the World Crystal Lattice. However, the 3D lattice spacing is only Fermi 10^{-15} meters not the 2D lattice pixel spacing of 10^{-35} meters. The problem here is that we need w = pressure/energy density < - 1/3 for dark energy, whilst blackbody radiation has w = +1/3. This is because of the Einstein factor (energy density)(1 + 3w) in the stress-energy current density source of his geometrodynamic field equation. When w < - 1/3 the positive energy density giving universally attractive gravity switches over to the "exotic matter" regime of universally repulsive antigravity, which stops the crunch to oblivion of the black hole singularity. Now it may well be that back-from-the-future advanced Hawking radiation does have w < - 1/3 from the kinds of EPR correlations that Lenny Susskind talks about that cause deviations away from the Planck black body spectrum preserving the unitarity of the S-Matrix of the world. This is still, speculation of course. Another approach is the Unruh effect, which says w = -1 random zero point quantum vacuum fluctuations seen in LIFs morph to w = +1/3 black body radiation in a coincident LNIF and vice versa. The effective LNIF that we see in our detectors has a Hawking temperature that when raised to the fourth power according to Stefan-Boltzmann's law gives the correct number measured for dark energy density in the anomalous redshift data from Type 1a supernovae.

[ccxxxi] The recent book "Making Starships and Stargates" by James Woodward (Springer-Verlag) proposes a theory with an actual experiment based on Dennis Sciama's 1950s "vector theory of gravity". I consider this model to be ill posed, too simplistic, and from what I can understand of it, it presupposes an absolute inertial frame that conflicts with the gravimagnetism of Einstein's GR.

[ccxxxii] These classical spaces have an integer number of dimensions. However, quantum theory demand fractal spaces with non-integer dimensions. There is mathematics of spaces with real, complex, and hyper-complex (non-commuting matrix) dimensions, but there is no physical evidence that we need them that I know of.

[ccxxxiii] http://dbem.ws/FeelingFuture.pdf
http://www.skeptiko.com/daryl-bem-responds-to-parapsychology-debunkers/
http://firstsightbook.com/wp/?p=195

[ccxxxiv] **Gravity Probe B** (**GP-B**) is a satellite-based mission which launched on 20 April 2004 on a Delta II rocket.[3] The spaceflight phase lasted until 2005;[4] its aim was to measure spacetime curvature near Earth, and thereby the stress–energy tensor (which is related to the distribution and the motion of matter in

space) in and near Earth. This provided a test of general relativity, gravitomagnetism and related models. The principal investigator was Francis Everitt.
Initial results confirmed the expected geodetic effect to an accuracy of about 1%. The expected frame-dragging effect was similar in magnitude to the current noise level (the noise being dominated by initially unmodeled effects due to nonuniform coatings on the gyroscopes). Work continued to model and account for these sources of error, thus permitting extraction of the frame-dragging signal. By August 2008, the frame-dragging effect had been confirmed to within 15% of the expected result,[5] and the December 2008 NASA report indicated that the geodetic effect was confirmed to better than 0.5%.[6]
In an article published in the journal *Physical Review Letters* in 2011, the authors reported analysis of the data from all four gyroscopes results in a geodetic drift rate of −6, 601.8±18.3 milliarcsecond/year (mas/yr) and a frame-dragging drift rate of −37.2±7.2 mas/yr, to be compared with the general relativity predictions of −6, 606.1 mas/yr and −39.2 mas/yr, respectively (discrepancies of 0.07% and 5%, and uncertainties of 0.28% and 19%, respectively).[7] http://en.wikipedia.org/wiki/Gravity_Probe_B

[ccxxxv] 6.12 of Wheeler and Ciufolini "Gravitation and Inertia"

[ccxxxvi] http://en.wikipedia.org/wiki/Gyrocompass

[ccxxxvii] http://en.wikipedia.org/wiki/Lie_group

[ccxxxviii] http://en.wikipedia.org/wiki/Lie_algebra

[ccxxxix] http://en.wikipedia.org/wiki/Sagnac_effect

[ccxl] http://en.wikipedia.org/wiki/Conformal_symmetry

[ccxli] http://en.wikipedia.org/wiki/Tetrad_formalism

[ccxlii] http://en.wikipedia.org/wiki/Gauge_theory
http://en.wikipedia.org/wiki/Introduction_to_gauge_theory

[ccxliii] http://en.wikipedia.org/wiki/Lie_group

[ccxliv] http://en.wikipedia.org/wiki/Lie_algebra

[ccxlv] http://en.wikipedia.org/wiki/Coherent_states

[ccxlvi] http://www.lassp.cornell.edu/sethna/OrderParameters/Intro.html

[ccxlvii] http://en.wikipedia.org/wiki/Lorentz_group
http://en.wikipedia.org/wiki/Representation_theory_of_the_Lorentz_group

[ccxlviii] Jack Sarfatti (1974). "Eightfold way as a consequence of the general theory of relativity", *Collective Phenomena*, Vol 1, No. 3, pp. 169–172.
Jack Sarfatti (1974). "Speculations on the effects of gravitation and cosmology in hadron physics", *Collective Phenomena*, Vol 1. No. 3, January 1, 1974, pp. 163–167.
Jack Sarfatti (1973). "Regge Trajectories as Rotationblack holes in Strong Gravity", in H. Frohlich & F.W. Cummings (eds.). *Collective Phenomena*.

[ccxlix] http://www.scientificamerican.com/article.cfm?id=search-for-new-physics

[ccl]http://en.wikipedia.org/wiki/FermiWalker_differentiation#Fermi.E2.80.93Walker_differentiation

[ccli] http://edge.org/conversation/how-fast-how-small-and-how-powerful

http://arxiv.org/abs/quant-ph/9908043

[cclii] http://en.wikipedia.org/wiki/Limits_to_computation

[ccliii] New Direction for Gravity-Wave Physics via "Milikan Oil Drops"
Conceptual Tensions Between Quantum Mechanics and General Relativity: Are There Experimental Consequences?
Proposed Observations of Gravity Waves from the Early Universe via "Milikan Oil Drops"
Quantum Gravity: Planned Experiments at UC Merced
Can a Charged Ring Levitate a Neutral Polarizable Object? Can Earnshaw's Theorem Be Extended to Such Objects?
Time and Matter in the Interaction between Gravity and Quantum Fluids: Are There Microscopic Quantum Transducers between Gravitational and Electromagnetic Waves?
http://faculty1.ucmerced.edu/rchiao/2.cfm?pm=113&lvl=3&menuid=117

[ccliv] http://en.wikipedia.org/wiki/Rotating_reference_frame

[cclv] http://en.wikipedia.org/wiki/Non-inertial_reference_frame
http://en.wikipedia.org/wiki/Rindler_coordinates

[cclvi] http://en.wikipedia.org/wiki/Kerr_metric

[cclvii] http://en.wikipedia.org/wiki/Gödel_metric

[cclviii] http://en.wikipedia.org/wiki/Category:Diagram_algebras

[cclix] http://en.wikipedia.org/wiki/Commutative_diagram

[cclx] British Ministry of Defence (at a time when UFOs were very much in the news).
This is also when Phil Morrison at Cornell published a famous paper with Cocconi on contact with ETs using the 21 cm line. I was a student of Phil's at the time. Bondi and Ivor Robinson (they looked and acted like Twiddledum and Twiddledee in Alice in Wonderland) visited Cornell at that time to talk about negative mass antigravity. This was also when John Archibald Wheeler's attention was diverted from nuclear weapons physics to Einstein's gravity theory. While at Cornell he also wrote, with Philip Morrison, his most famous paper "Searching for Interstellar Communications", on the 21 cm Hydrogen line, which turned out to be of vital importance in the SETI program.[3]
http://en.wikipedia.org/wiki/Giuseppe_Cocconi

[cclxi] http://en.wikipedia.org/wiki/Spherical_coordinate_system

[cclxii] http://en.wikipedia.org/wiki/Unruh_effect

[cclxiii] http://en.wikipedia.org/wiki/Construction_of_a_complex_null_tetrad

[cclxiv] http://en.wikipedia.org/wiki/Newman–Penrose_formalism

[cclxv] http://en.wikipedia.org/wiki/Light_cone_coordinates

[cclxvi] http://en.wikipedia.org/wiki/Wheeler–Feynman_absorber_theory

[cclxvii] http://en.wikipedia.org/wiki/Two-state_vector_formalism

[cclxviii] http://en.wikipedia.org/wiki/Transactional_interpretation

[cclxix] http://en.wikipedia.org/wiki/Geometrodynamics

[cclxx] http://en.wikipedia.org/wiki/David_Bohm

[cclxxi] http://en.wikipedia.org/wiki/World_crystal

[cclxxii] http://arxiv.org/abs/hep--th/9409089

[cclxxiii] http://en.wikipedia.org/wiki/Causal_structure The causal diamond of a particle's world line is the set of all events that lie in both the past of some point and the future of that point on the world line.

[cclxxiv] http://salam.ictp.it/salam/bibliography/papers

[cclxxv] http://library.ictp.trieste.it/DOCS/P/70/108.pdf

[cclxxvi] http://en.wikipedia.org/wiki/Regge_theory

[cclxxvii] http://en.wikipedia.org/wiki/Hawking_radiation

[cclxxviii] http://en.wikipedia.org/wiki/Differential_form

[cclxxix] http://en.wikipedia.org/wiki/Lie_algebra_representation

[cclxxx] http://en.wikipedia.org/wiki/Lorentz_group

[cclxxxi] http://en.wikipedia.org/wiki/Unitary_group

[cclxxxii] http://en.wikipedia.org/wiki/Yang–Mills_theory

[cclxxxiii] http://en.wikipedia.org/wiki/Gamma_matrices

[cclxxxiv] http://www.cpt.univ-mrs.fr/~rovelli/book.pdf

[cclxxxv] http://en.wikipedia.org/wiki/Gravity_gradiometry

[cclxxxvi] It's even possible for "geons," i.e. nonlinear soliton warping of the geometrodynamic field to form in the absence of induction by mass-energy source currents.

[cclxxxvii] http://en.wikipedia.org/wiki/Supersymmetry

[cclxxxviii] *"There are two types of Lockheed Martin gravity gradiometers currently in operation: the 3D FTG, (Full Tensor Gravity Gradiometer, deployed in either a fixed wing aircraft or a ship) and the FALCON gradiometer (a partial tensor system with 8 accelerometers and deployed in a fixed wing aircraft or a helicopter). The 3D FTG system contains three Gravity Gradiometry Instruments (GGI's), each consisting of two opposing pairs of accelerometers arranged on a spinning disc with measurement direction in the spin direction. …*
Other Gravity Gradiometers
Electrostatic Gravity Gradiometer This is the gravity gradiometer deployed on the European Space Agency's GOCE mission. It is a three-axis diagonal gradiometer based on three pairs of electrostatic servo-controlled accelerometers.
ARKeX Exploration Gravity Gradiometer An evolution of technology originally developed for European Space Agency, the EGG (Exploration Gravity Gradiometer), developed by ARKeX, uses two key principles of superconductivity to deliver its performance: the "Meissner effect", which provides

levitation of the EGG proof masses and "flux quantization", which gives the EGG its inherent stability. The EGG has been specifically designed for high dynamic survey environments.
Ribbon Sensor Gradiometer The Gravitec gravity gradiometer sensor consists of a single sensing element (a ribbon) that responds to gravity gradient forces. It is designed for borehole applications.
UWA Gravity Gradiometer The University of Western Australia (aka VK-1) Gravity Gradiometer is a superconducting instrument that uses an orthogonal quadrupole responder (OQR) design based on pairs of micro-flexure supported balance beams.
Gedex Gravity Gradiometer The Gedex gravity gradiometer (aka High-Definition Airborne Gravity Gradiometer, HD-AGG) is also a superconducting OQR-type gravity gradiometer, based on technology developed at the University of Maryland." Wikipedia

[cclxxxix] Following here Rovelli's notation in his on-line Quantum Gravity lectures, I,J,K,L are the free-float LIF (zero local proper g-force tensor acceleration) geodesic indices of the local tangent space fiber, and the Greek m,n,s,w are the off-geodesic LNIF (non-zero proper g-force tensor acceleration) indices.

[ccxc] This mathematically is the reversible two-way mapping LNIF ⇔ LIF

Formally the middle expression looks like a cancellation of two fields - but it's just mathematical symbols describing possible physical situations.
Situation 1: Physically Alice is initially in a LNIF with rocket engine firing out in space. Alice switches off her rocket. She is now in a LIF.
Situation 2: Alice is out in space in a rocket firing engines in a LNIF. Bob is on a spacewalk outside the rocket in a LIF. Both Alice and Bob look at a nearby asteroid and make measurements on its motion with their Doppler radars. They then compare their measurements by computing invariants and communicating their numbers to each other.

[ccxci] James Overduin,
Relational or Absolute?
In 1918, Einstein described Mach's principle as a philosophical pillar of general relativity, along with the physical principle of equivalence and the mathematical pillar of general covariance. This characterization is now widely regarded as wishful thinking. Einstein was undoubtedly inspired by Mach's relational views, and he hoped that his new theory of gravitation would "secure the relativization of inertia" by binding spacetime so tightly to matter that one could not exist without the other. In fact, however, the equations of general relativity are perfectly consistent with spacetimes that contain no matter at all. Flat (Minkowski) spacetime is a trivial example, but empty spacetime can also be curved, as demonstrated by Willem de Sitter in 1916. There are even spacetimes whose distant reaches rotate endlessly around the sky relative to an observer's local inertial frame (as discovered by Kurt Gödel in 1949). The bare existence of such solutions in Einstein's theory shows that it cannot be Machian in the strict sense; matter and spacetime remain logically independent. The term "general relativity" is thus something of a misnomer, as pointed out by Hermann Minkowski and others. The theory does *not* make spacetime more relative than it was in special relativity. Just the opposite is true: the absolute space and time of Newton are retained. They are merely amalgamated and endowed with a more flexible mathematical skeleton (the metric tensor). Nevertheless, Einstein's theory of gravity represents a major swing back toward the relational view of space and time, in that it answers the objection of the ancient Stoics. Space and time *do* act on matter, by guiding the way it moves. And matter *does* act back on spacetime, by producing the curvature that we feel as gravity. Beyond that, matter can act on spacetime in a manner that is very much in the spirit of Mach's principle. Calculations by Hans Thirring (1888-1979), Josef Lense (1890-1985) and others have shown that a large rotating mass will "drag" an observer's inertial reference frame around with it. This is the phenomenon of frame dragging, whose existence Gravity Probe B is designed to detect. The same calculations suggest that, if the entire contents of the universe were to rotate, our local inertial frame would undergo "perfect dragging" — that is, we would not notice it, because we would be rotating too! In that sense, general relativity is indeed nearly as relational as Mach might have wished. Some physicists (such as Julian Barbour) have gone further and asserted that general relativity is in fact perfectly Machian. If one goes beyond classical physics and into modern quantum field theory, then questions of absolute versus

relational spacetime are rendered anachronistic by the fact that even "empty space" is populated by matter in the form of virtual particles, zero-point fields and more. Within the context of Einstein's universe, however, the majority view is perhaps best summed up as follows: S*pacetime behaves relationally but exists absolutely*. http://einstein.stanford.edu/SPACETIME/spacetime2.html

[ccxcii] Gravitational-wave detector - Wikipedia, the free encyclopedia
CLIO · GEO 600 · LCGT · LIGO · MiniGrail · New Gravitational wave Observatory Complications - Weber bars - Interferometers - High frequency detectors Various gravitational wave detectors exist. However, they have not yet succeeded in detecting such phenomena. A research published Oct 18, 2013 in the Gravitational-Wave Detectors Get Ready to Hunt for the Big Bang ... www.scientificamerican.com/article.cfm?
Sep 17, 2013 - As scientists prepare to catch their first gravitational waves, attention is turning to devices that will let astronomers peek into the invisible ...

[ccxciii] http://en.wikipedia.org/wiki/Near_and_far_field

[ccxciv] Coherent states - Wikipedia, the free encyclopedia
Review of Entangled Coherent States by BC Sanders - 2011 - Dec 8, 2011 - Abstract: We review entangled coherent state research since its first implicit use in 1967 to the present.

[ccxcv] "The issue of a more realistic general relativistic calculation of inertial forces can be addressed in two parts. First, the force produced (via frame dragging) by an accelerating sphere of matter with uniform density on its interior contents; and second, by calculation of the "Sciama force" produced by a realistic model of the contents of the universe. The first calculation can be found in a paper by Kenneth Nordtvedt on "gravitomagnetism" published in 1988.3 He found $4GM/R$ for the coefficient of the acceleration. That is, Sciama's calculation, in ignoring the geometric effects of general relativity, is off by a factor of 4. Sultana and Kazanas have recently shown that when realistic cosmological parameters (for example, replacing the Hubble sphere with that particle horizon) are used to calculate the value of ϕ/c^2 in Equation (3), one gets 0.23, rather than one. However, when this result is combined with Nordtvedt's, one finds 0.92 for the coefficient of the acceleration in Equation (4), that is, a value, well within observational error, of one. A value of 0.92, with some modest error, is consistent with the cosmic scale spatial flatness that follows from the Wilkinson Microwave Anisotropy Probe analysis, which implies that $\phi/c^2 = 1$. So, both observation and theory lead to the conclusion that inertial forces and the origin of inertia itself are consequences of the gravitational action of chiefly distant matter in our universe."
Recent Results of an Investigation of Mach Effect Thrusters
Heidi Fearn and James F. Woodward (email: Oct 29, 2013)

There is no frame dragging in the FLRW metric where $g_{0i} = 0$.
So I don't understand the reference to frame dragging below.

"First, the force produced (via frame dragging) by an accelerating sphere of matter with uniform density on its interior contents"

The entire universe simplistically pictured, as a rigid sphere does not accelerate.
This is not an acceptable argument. Only the test particle accelerates. Here I always mean "proper acceleration" i.e. off-geodesic motion of test particle relative to the local curvature field of the universe as a whole. Unlike geodesic inertial motion, off-geodesic motion is not physically relative, even though the local equations of physics are covariant, i.e., equally expressed in any local frame in arbitrary timelike motion using the tensor/spinor calculus. Accelerometers show zero on timelike geodesics (Einstein's "happiest thought").

[ccxcvi] http://en.wikipedia.org/wiki/Gauss's_law_for_gravity

[ccxcvii] http://en.wikipedia.org/wiki/Friedmann–Lemaître–Robertson–Walker_metric

[ccxcviii] Recent Results of an Investigation of Mach Effect Thrusters

Heidi Fearn1 and James F. Woodward2
California State University, Fullerton, CA, 92834

The theory underlying Mach effects – fluctuations of the rest masses of accelerating objects in which internal energy changes take place – and their use for propulsion is briefly recapitulated. Experimental apparatus based on a very sensitive thrust balance is briefly described. The experimental protocol employed to search for expected Mach effects is laid out, and the results of this experimental investigation are presented. A series of tests conducted to explore the origin of the thrust signals seen are described, and two of those tests – the most likely spurious sources of thrust signals – are considered in some detail. The thrust signals seen, if genuine Mach effects, suggest that "advanced and exotic" propulsion can be achieved with realistic resources. …

I. Introduction

In 1953, Dennis Sciama published a paper, "On the Origin of Inertia" in the *Monthly Notices of the Royal Astronomical Society* wherein he resuscitated Einstein's idea that the inertia of material objects should be accounted for by a field interaction with the chiefly distant matter in the cosmos.1 He did not use Einstein's theory of gravity, general relativity theory, to convey the interaction. Rather, he proposed a vector theory of gravity modeled on Maxwell's formalism for electrodynamics. Eventually, it was recognized that Sciama's vector formalism was just an approximation to Einstein's general relativity theory. But the simplicity and transparency of the vector formalism made plain what was involved in explaining inertial effects as gravitational interactions with chiefly distant "matter" in the universe."

I find the remark on internal energy changing very odd. The internal binding energies of matter are a small fraction of their rest masses. Even small changes in them will destabilize matter. For a more general discussion, of the delicate balance in the basic numbers of physics see Lord Martin Rees's book "Just Six Numbers."

Their basic idea, as far as I can understand them, which is not very far, is that the rest masses of elementary particles m and their composite bound states comes from the Higgs field, quantum chromodynamics, and low energy physics in the usual local way. However, in addition to all those local field effects, there is a cosmological effect of the form.

Momentum of an object = (Mach Cosmological Factor)(Rest Mass)(Velocity)

Their MET effect then comes from the time derivative of the Mach Cosmological Factor, though how they think their Rube Goldberg contraption in their lab does that is a mystery to me. I do not understand how their theory couples to real electromagnetism. However, I have not tried very hard and maybe one day I will change my mind. Therefore, while I cannot refute their claims with 100% certitude, my instinct tells me, that they are barking up the wrong tree.

[ccxcix] Matt Visser, Lorentzian Wormholes, From Einstein to Hawking, AIP 1995
http://homepages.mcs.vuw.ac.nz/~visser/

[ccc] This scheme has nothing whatsoever to do with the simulation of warp drives andblack holes in meta-materials as some pundits have mistakenly objected. The mathematics and the physics ideas are completely different.

[ccci] There are many layers of geometry defined by a nested sequence of symmetry groups.
http://en.wikipedia.org/wiki/Erlangen_program

[cccii] http://en.wikipedia.org/wiki/Fiber_bundle

[ccciii] "Feynman Lectures on Gravitation" 1995 Addison-Wesley & Cal Tech

[ccciv] Using scale-dependent wavelets as the basis functions rather than plane waves is really what is needed to do quantum field theory in curved spacetime.
http://en.wikipedia.org/wiki/Wavelet

[cccv] p. xxxiv by Brian Hatfield in Feynman Lectures on Gravitation.

[cccvi] http://en.wikipedia.org/wiki/Rindler_coordinates

[cccvii] "Any observer at rest in Rindler coordinates has constant proper acceleration, with Rindler observers closer to the Rindler horizon having greater proper acceleration. … Note that Rindler observers with smaller constant x LNIF coordinate are accelerating *harder* to keep up! This may seem surprising because in Newtonian physics, observers who maintain constant relative distance must share the *same* acceleration. But in relativistic physics, we see that the trailing endpoint of a rod which is accelerated by some external force (parallel to its symmetry axis) must accelerate a bit harder than the leading endpoint, or else it must ultimately break. This is a manifestation of Lorentz contraction. As the rod accelerates its velocity increases and its length decreases. Since it is getting shorter, the back end must accelerate harder than the front. Another way to look at it is: the backend must achieve the same change in velocity in a shorter period of time. This leads to a differential equation showing, that at some distance, the acceleration of the trailing end diverges, resulting in the Rindler horizon.
This phenomenon is the basis of a well-known "paradox", Bell's spaceship paradox. However, it is a simple consequence of relativistic kinematics. One way to see this is to observe that the magnitude of the acceleration vector is just the path curvature of the corresponding world line. But *the world lines of our Rindler observers are the analogs of a family of concentric circles* in the Euclidean plane, so we are simply dealing with the Lorentzian analog of a fact familiar to speed skaters: in a family of concentric circles, *inner circles must bend faster (per unit arc length) than the outer ones*." Wikipedia Rindler coordinates.

[cccviii] http://www.bibliotecapleyades.net/ciencia/negativeenergy/negativeenergy.htm

"In recent years there has been considerable interest in the topic of traversable wormholes, solutions of Einstein's equations which act as tunnels from one region of spacetime to another, through which an observer might freely pass [1, 2, 3]. Traversable wormhole spacetimes have the property that they must involve "exotic matter", that is, a stress tensor that violates the weak energy condition. Thus the energy density must be negative in the frame of reference of at least some observers. Although classical forms of matter obey the weak energy condition, it is well known that quantum fields can generate locally negative energy densities, which may be arbitrarily large at a given point. A key issue in the study of wormholes is the nature and magnitude of the violations of the weak energy condition which are allowed by quantum field theory."
http://xxx.lanl.gov/pdf/gr-qc/9510071v1.pdf

[cccix] There is a lot of excess mathematical baggage about "diffeomorphisms" that is almost always not needed operationally for experimental physicists and starship metric engineers.

[cccx] http://en.wikipedia.org/wiki/De_Sitter_invariant_special_relativity

[cccxi] *In mathematical physics, de Sitter invariant special relativity is the speculative idea that the fundamental symmetry group of spacetime is the Indefinite orthogonal group SO(4,1), that of de Sitter space. In the standard theory of General Relativity, de Sitter space is a highly symmetrical special vacuum solution, which requires a cosmological constant or the stress-energy of a constant scalar field to sustain. The idea of de Sitter invariant relativity is to require that the laws of physics are not fundamentally invariant under the Poincaré group of special relativity, but under the symmetry group of de Sitter space instead. With this assumption, empty space automatically has de Sitter symmetry, and what would normally be called the cosmological constant in General Relativity becomes a fundamental dimensional parameter describing the symmetry structure of space-time. First proposed by Luigi Fantappiè in 1954, the theory remained obscure until it was rediscovered in 1968 by Henri Bacry and Jean-Marc Lévy-Leblond. In 1972,*

Freeman Dyson popularized it as a hypothetical road by which mathematicians could have guessed part of the structure of General Relativity before it was discovered. [1] The discovery of the accelerating expansion of the universe has led to a revival of interest in de Sitter invariant theories, in conjunction with other speculative proposals for new physics, like doubly special relativity. (Wikipedia)

[cccxii] http://space.mit.edu/home/tegmark/PDF/multiverse_sciam.pdf

[cccxiii] http://www.dark-cosmology.dk/~tamarad/astro/papers.html

[cccxiv] http://en.wikipedia.org/wiki/Redshift

[cccxv] http://en.wikipedia.org/wiki/Light_cone

[cccxvi] http://en.wikipedia.org/wiki/Inflation_(cosmology)

[cccxvii] http://en.wikipedia.org/wiki/Spontaneous_symmetry_breaking

[cccxviii] http://en.wikipedia.org/wiki/Teleology
http://en.wikipedia.org/wiki/Retrocausality

[cccxix] John Walker, https://www.fourmilab.ch/documents/tipler.html

[cccxx] http://en.wikipedia.org/wiki/Penrose_diagram

[cccxxi] http://en.wikipedia.org/wiki/Hubble's_law

[cccxxii] http://en.wikipedia.org/wiki/Big_Bang

[cccxxiii] http://en.wikipedia.org/wiki/Weak_measurement

[cccxxiv] http://en.wikipedia.org/wiki/Taylor_series

[cccxxv] http://www.skinwalkerranch.org/images/Vallee-Davis-model.pdf

[cccxxvi] "100 Year Starship: NASA's plan to colonise galaxy", *The FirstPost*, October 27, 2010.
101. Weinberger, Sharon. "100 Year Starship: An interstellar leap for mankind?", BBC, March 22, 2012.
102. For the list of scientists in the working group, see "100 Year Starship Study Inaugural Meeting Attendees", 100yearstarshipstudy.com, accessed April 25, 2011.
Also see Millis, Marc. "100 Year Starship Meeting: A Report", centauri-dreams.org, January 28, 2011
http://www.starpod.us/2011/10/06/ufos-crash-and-burn-at-100-year-starship-symposium/#.UoQdLJFcKs0

[cccxxvii] http://tinyurl.com/kf2woof How Metamaterials Could Hold the Key to High Temperature Superconductivity
In the same way that metamaterials steer light around objects to hide them, they might also steer electrons through crystal lattices with zero resistance, say physicists.

Is there a metamaterial rout to high temperature superconductivity?
Igor I. Smolyaninov 1) and Vera N. Smolyaninova 2)
1Department of Electrical and Computer Engineering, University of Maryland, College Park, MD 20742, USA
2Department of Physics Astronomy and Geosciences, Towson University,
8000 York Rd., Towson, MD 21252, USA

Superconducting properties of a material, such as electron-electron interactions and the critical temperature of superconducting transition can be expressed via the effective dielectric response function $\varepsilon_{eff}(q,\omega)$ of the material. Such a description is valid on the spatial scales below the superconducting coherence length (the size of the Cooper pair), which equals ~100 nm in a typical BCS superconductor. Searching for natural materials exhibiting larger electron-electron interactions constitutes a traditional approach to high temperature superconductivity research. Here we point out that recently developed field of electromagnetic metamaterials deals with somewhat related task of dielectric response engineering on sub-100 nm scale. We argue that the metamaterial approach to dielectric response engineering may considerably increase the critical temperature of a composite superconductor-dielectric metamaterial.
http://arxiv.org/pdf/1311.3277v2.pdf Thanks to Creon Levit on Nov. 20, 2013.