BASIC PHYSICAL IDEAS OF EINSTEIN'S GENERAL RELATIVITY

The mathematics has obscured the essential physics meaning of Einstein's theory of spacetime.

The basic problem of Einstein's 1905 Special Theory (SR) is two observers Alice and Bob. Each of them are idealized as point like free "test particles" obeying Newton's first law of motions (now called the "geodesic equation"). They are weightless. Technically they are called "inertial observers". Accelerometers clamped to them read ZERO. Technically Alice and Bob are confined to slower-than-light motion on "timelike geodesic world lines."

They need not be close to each other (because spacetime is flat - there are no real gravity fields in the sense of Einstein's 1915 General Theory GR).

Both Alice and Bob use light signals to eavesdrop on what Eve is doing. Eve may be far away from both of them, but need not be.

The only physics assumption (aka organizing idea) needed here is that the speed of light in vacuum is the same for both Alice and Bob measuring the same actions of Eve with their radars etc.

Alice and Bob make independent measurements on Eve. This is all classical. There are no quantum limits to Alice and Bob's measurements on Eve in this approximation.

Einstein's SR is then an ALGORITHM for computing (processing) numbers from their two sets of raw data. The meaning of OBJECTIVE REALITY is that both Alice and Bob get the same numbers for the same observed activities of Eve.

These numbers are called INVARIANTS.

The reference frame invariants are Plato's Ideas or Forms. The raw frame-dependent data are the "shadows" on the walls of Plato's Allegory of The Cave.

The whole objective of all theoretical physics is to find the INVARIANT STRUCTURES that define OBJECTIVE PHYSICAL REALITY.

Any theory that says REAL is NOT REAL is not KOSHER PHYSICS. It is fantasy, it is pseudo-physics. That is the way Einstein saw the universe. I agree with Einstein.

We can generalize SR to include Local Non-Inertial Frames of Reference (LNIFs) which will

almost be GR. In this case, Alice and Bob need not obey Newton's first law.

They must obey Newton's second law. When they violate Newton's first law, they will feel weight. Their accelerometers will read OFF-ZERO. Physically, Alice and Bob are on arbitrary off-geodesic timelike world lines in 4D spacetime.

They can still be far away from each other because there is no real gravity as yet. Spacetime is still globally flat. However, there will be fake gravity also called non-tidal first order gravity. After all, Alice and Bob feel weight that is proportional to their total localized energy = mass(speed of light)^2. More to the point, using light signals, Eve's motion will appear to Alice and/or Bob be under the action of a mysterious (gravity force) that Eve does not feel. This is Newton's "gravity force" and it is called a "fictitious" or "pseudo-force" because Eve's relative motion to Alice and/or Bob is independent of her total mass-energy.

There are real forces causing Alice and/or Bob off their former weightless timelike geodesic worldlines in 4D spacetime.

These real forces on the LNIF observers Alice and/or Bob are described by the Levi-Civita connection and they are equivalent to the fictitious Newtonian gravity force on weightless Eve who actually, in this example, is assumed to obey Newton's first law.

But, so far, we are still doing special relativity. It's not good enough because it is lacking a second organizing idea called the Einstein Equivalence Principle (EEP). The physical meaning of EEP is incredibly simple. Imagine you are in a rocket ship in outer space. When your rocket motor is firing you are in a LNIF and you feel artificial gravity i.e. "weight". Then when you shut off the engine, you are in a LIF and are weightless.

Next suppose Alice and Bob are standing on the opposite poles of a spherical planet. Each of them are LNIF and they have a real proper acceleration away from each other even though their relative distance from each other is not changing. This would be impossible if space obeyed Euclidean geometry. In fact, the spacetime here obeys a non-Euclidean geometry.

Now for a bit of math.

The proper acceleration of a test particle as measured locally by a near EM field (virtual photons) accelerometer in the rest frame of the test particle is

DV/ds = dV/ds - {Levi-Civita}VV

V = 4-velocity of test particle

dV/ds = kinematic acceleration of test particle relative to the observer as measured by light signals from the test particle to the observer.

{Levi-Civita}VV =/= 0 is caused by real forces acting NOT on the test particle, but on the observer.

Newton's first law is

DV/ds = 0 (geodesic equation)

The orbits of planets around the Sun obey the geodesic equation.

Newton's pseudo-force -GM**r**/r^3 is a piece of {Levi-Civita}VV.

Newton's second law of off-geodesic motion is

mDV/ds = F

dm/ds = 0 assumed here for simplicity

F = real mostly EM force (+ quantum corrections ultimately, for now neglect weak and strong forces)

The non-Euclidean geometry is the curvature given by the covariant tensor curl of the Levi-Civita connection.

The Levi-Civita connection is essentially the first-order non-tidal Newtonian gravity pseudo-force field that encodes the proper accelerations of the detector/observers.

It is not a tensor, but its covariant curl is.

A few remarks on the metric tensor.

Static LNIF observers at fixed r (not a timelike geodesic) from a static uniform density sphere of rest mass M have a metric tensor component

g00 = 1 + 2(Newton's potential energy per unit mass)/c^2

= 1 - 2GM/c^2r = 1 - rs/r

Let r = R + x

$x/R << 1$

$rs/(R + x) = rs/R(1 + x/R) \sim (rs/R)(1 - x/R) = (rs/R) - rsx/R^2 = (rs/R) - gx$

$g = - rs/R^2$ = Newton's universal gravity acceleration.

Therefore, the variable part of the metric tensor looks like a

UNIFORM GRAVITY FIELD as seen by a static LNIF ~ x = radial height above the surface R.

In fact, it is the observer at fixed r who is really accelerating (without moving relative to the sphere) because spacetime is curved by mass energy M.

In the SMALL APPROXIMATION above, the static LNIF observer experiences a uniform Newtonian gravity field that is mathematically similar to a Rindler observer in flat spacetime within the context of this simple approximation.

https://en.wikipedia.org/wiki/Rindler_coordinates#The_Rindler_observers

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