The Hunt for Gravity Control Physics

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1. Introduction

In *The Hunt for Zero Point*, Nick Cook writes about his search for anti-gravity technology. His quest starts as an earnest outgrowth of his day job reporting on advanced aerospace systems, many of them classified. The hunt was driven by two factors: Nick had seen evidence that anti-gravity technology operated in the present day, and he found indications that large aerospace corporations were pursuing gravity control technology in the 1950s.

After reading *The Hunt for Zero Point* (HfZP), I realize that I have been on a parallel quest, a hunt for zero point *physics*. At the outset, let me identify "zero point physics" with "anti-gravity" or "gravity control" physics. Nick's book could have been called *The Hunt for Anti-Gravity Technology*, and my hunt has certainly been for anti-gravity physics. I am not sure what "zero-point physics" is, but I have a solid understanding of gravity control physics. My instinct as a physicist is to separate gravity control and zero-point: I consider gravity control a means of momentum transfer, and zero point a means of energy generation. The zero-point field is routinely proposed as an energy source, but the momentum would presumably come from some other, non-quantum mechanism, since the objects to be moved around are classical objects.

By *gravity control physics*, I specifically mean mathematical expressions that describe forces in terms of the fields that are manipulated and engineered, and allow calculation of force and energy requirements. Specifically, gravity control will involve manipulation of gravity or inertia somehow. We expect this physics to fit into the framework of known physics, and obey principles of energy conservation and general covariance. Presumably, gravity control devices, if they are possible at all, will not grow organically on trees; we will have to engineer them from raw materials. Therefore we will require a precise mathematical understanding of the gravity control phenomena in order to exploit it for propulsion. It is this thread in the mathematics that I have been hunting. Are gravity control effects, or effects allowing control of gravity or inertia, to be found anywhere in mathematical physical law? Is there a physics existent that allows or predicts gravity control? Could such a phenomena be undiscovered within existing physical law?

My own quest for this physics was not motivated by evidence that it must be possible. Rather, I started with a scientist's faith that it might be possible, and therefore asked, What modifications of the known laws of physics are necessary to realize it? The story of the pursuit of gravity control can be told as a hunt for technology, or it can be told as a hunt for mathematical physical law.

Like Nick, I was intrigued to learn that there was an optimism among gravitational physicists in the 1950s, that some sort of gravity control might be achievable. But paralleling the fizzle Nick found in the aerospace world, gravity control research was likewise abandoned. There is of course a rich literature of gravity-control physics, which I will summarize below. My own favored area of research

into the mathematics of gravity control dates from 1921. It seems the math was in place, possibly, for gravity control very early.

Was there a mathematical framework in place that could inform gravity control engineering as late as the 1950s? Or are we to assume, if we allow that gravity control technology has been demonstrated, that it is through an engineering based on a physics unknown to the open literature, unknown to all theorists and all experimentalists? My own view is that engineering can be hidden, and Nick describes how. But it is much harder to hide science. The nuclear chain reaction, for example, was understood conceptually early, even as research literature into particular engineering details, such as neutron absorption of carbon or the implosion design, was classified during the war. But the knowledge that a bomb was feasible could not be hidden.

A third option is that gravity control technology, if it exists today in a classified form, relies on an experimental effect discovered without the benefit of an underlying theory. But such effects, if they exist, are not physics. They are perhaps the beginning of new physics, but in the absence of a repeatable effect, there is no physics at all. Therefore, we pursue the reliable thread of mathematics.

2. Gravity control physics defined

There are two possibilities in gravity control physics. One is to find gravity control effects within known physical law. The other is to find an effect beyond known physical law. Because of the complexity of gravity, both of these avenues seem viable.

In the absence of an effect in known physical law, and in the absence of any repeatable experiment demonstrating new physics, then we want to consider extensions of physical law. We can constrain the form of any proposed modifications of the laws of physics that might account for an gravity control mechanism, using general principles:

1. the theory must be covariant
2. the theory must have an associated Lagrangian
3. the theory must involve coupling between electromagnetism, the force of nature we control, and gravity
4. the theory should treat gravity and inertia on an equal footing, because the equivalence of gravitational and inertial mass implies a link between them
5. the theory should be classical, because gravity and inertia are classical effects

The first two constraints, covariance and a Lagrangian, are adapted from Robert Dicke, who proposed them as part of a framework for considering modifications to the laws of gravity. During the time general relativity was being tested experimentally, it was necessary to interpret observations that

allowed alternative theories of gravity to general relativity. These two constraints can likewise anchor a hunt for gravity control physics.

The principle of covariance is fundamental to the mathematical form of physical law. All laws of physics, even the ones we haven't discovered yet, have to be generally covariant. That means they must be expressed as vectors or tensors that are invariant under Lorentz transformations. To give this up would be to abandon $E=mc^2$.

Another principle is that any law of physics must have an associated Lagrangian. The Lagrangian is a compact way to encode all the information in a theory, and it has properties that insure energy conservation and other essential features. The field equations and equations of motion are derivable from the Lagrangian. The process is the same, applied to any Lagrangian. But different Lagrangians yield different field equations.

The last 3 constraints, to classical electromagnetism and gravity, are to narrow the search to a realm of physics that addresses fundamental propulsion limitations using tools within the scope of human engineering. Considerations of the quantum vacuum, the true hunt for zero point, are outside the scope of this article.

With these 5 constraints, the possibilities for gravity control physics are greatly reduced. It becomes easy to triage various gravity control proposals in the literature, by measuring whether they have the price of admission, so to speak, to solve the gravity control problem. I am aware of only one theory that meets the requirements listed above, aside from possibly general relativity itself.

3. History of gravity control physics

Allow me to unspool the history of classical gravity control physics I have uncovered, and then comment on the physics in HfZP. Don't panic that I am starting with Newton :-) I will be brief.

3a. Newton's laws of gravity and inertia

Newton established the law of inertia in terms of applied forces:

$$\frac{d\,\boldsymbol{v}}{dt} = \frac{\boldsymbol{F}}{m_i}$$

which says that the acceleration from an applied force $\boldsymbol{F}$ is inverse to the inertial mass m_i , so that more force, and therefore more energy, is needed to accelerate heavier objects. This is the mathematical expression of inertia.

Newton also established the force of gravity from a mass M , experienced by an object with gravitational mass m_g , in terms of a scalar gravitational field Ψ and gravitational constant G :

$$\boldsymbol{F}_g = -m_g \nabla \Psi = -m_g \nabla \left(\frac{-GM}{r} \right) = -\frac{m_g GM}{r^2} \hat{\boldsymbol{r}}$$

This is the famous inward, 1-over-R-squared force. The corresponding Newtonian field equation, describing the gravitational field produced by matter of density ρ, where $\int \rho \, d^3x = M$, is:

$$\nabla^2 \Psi = 4\pi G \rho$$

It is a peculiar feature, noted by Newton, that $m_g = m_i$, and so gravitational acceleration is the same for all masses:

$$\frac{dv}{dt} = \frac{GM}{r^2}$$

Here is the link between inertia and gravity. Inertia must be connected to gravity, because inertial mass is gravitational mass. We suspect that inertia control and gravity control, if achievable, would be different aspects of the same phenomenon.

3b. Electromagnetic field and special relativity

The equations of the electromagnetic field were completed by Maxwell in 1865.

https://en.wikipedia.org/wiki/Maxwell's_equations

He assimilated Coulomb's Law, describing the electric field created by electric charge; Ampere's law, describing the magnetic field created by electric currents; and Faraday's law, describing the electric field created by a changing magnetic field. He added an additional term to Ampere's law, demanded by conservation of charge, that described a magnetic field created by a changing electric field.

This completed the equations of electromagnetism, and allowed Maxwell to predict electromagnetic (EM) waves, and relate their propagation speed to the permeability of free space and the permittivity of free space, $c^2 = 1/\epsilon_0 \mu_0$. Hertz experimentally demonstrated EM waves two decades later, in 1887. During the 1890s, Heaviside reformulated the then-incomprehensible Maxwell equations into the compact vector equations we know today.

By the turn of the 20th century, practical electromagnetic discoveries by Edison, Tesla, Marconi, and others began to unleash the modern technological society we know today, with electric power generation and distribution, wireless communication, and mastery of the electromagnetic spectrum from radio to gamma rays. It took 40 years to make the first practical discoveries from Maxwell's mathematical theory, and another 50 years for them to reach technological maturity.

Special relativity was discovered by Einstein in 1905, from the observation that the Maxwell equations behave differently under a coordinate transformation than do Newton's equations. The Maxwell equations are understood to be invariant under a Lorentz transformation, and Einstein reworked Newtonian mechanics to make it Lorentz invariant also, and thereby identified mass with energy.

The implication of the Lorentz transformation for electromagnetism is that the electromagnetic field is described in terms of a vector potential with 4 components, $A^{\mu} = (\varphi, A^x, A^y, A^z)$. The spatial components are the magnetic vector potential, and the time component is the Coulomb electric potential. The electric and magnetic fields that affect real objects result from gradients of the potential, but the potential is the fundamental mathematical expression of the electromagnetic field. Its Lorentz invariance is central to the physics.

3c. Nordstrom 1914

On the possibility of unifying the electromagnetic and the gravitational fields,
Phys. Zeits., 25, 504 (1914)

In 1914, Nordstrom provided an early 5-dimensional unification of gravity and electromagnetism by suggesting that there was a gravito-electric 5-vector potential $A^a = (\varphi, A^x, A^y, A^z, \Psi)$ that included the 4 components of the EM vector potential along with the Newtonian gravitational potential Ψ . The 5D Maxwell equations are applied to this potential, to yield coupled equations of EM and gravity. In retrospect, this might be considered today a post-Newtonian theory, since it is in terms of the Newtonian potential, but with other effects.

3d. Einstein field equations and general relativity

Soon after, in late 1915, Einstein and Hilbert finished their race to the gravitational field equations, and discovered what we know as the Einstein field equations of general relativity (GR):

$$G_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

This represents 10 equations in the 10 unknowns of the gravitational field $g_{\mu\nu}$. This is the relativistic generalization of the Newtonian field equation. Like the Newtonian field equation, it is of second order in the derivatives. But unlike Newton, it is non-linear. Because the gravitational field is a tensor field, with 10 components, the Nordstrom 1914 theory is invalidated.

In the weak-field and non-relativistic limit, the Newtonian field equation is recovered for the time-time component g_{tt} of the gravitational potential. That is, $g_{tt} \simeq 1 + \Psi / c^2$.

Unlike Newton, there is a coupling between gravity and EM in GR, in that EM energy-momentum $T^{EM}_{\mu\nu}$ is a source of gravitational field:

$$G_{\mu\nu}=\frac{8\pi G}{c^4}T^{EM}_{\mu\nu}$$

Generally, mass stores far more energy than EM fields, and is often the dominant source of gravitational fields. The key point is that any source of energy – mass, EM fields, heat – can be a source of gravity in the Einstein field equations.

3e. Kaluza theory: early 20th century

On the unity problem in physics,
Sitzungsber. Preuss. Akad. Wiss. Berlin. (Math. Phys.): 966–972 (1921)

In 1919, Einstein received the paper from Kaluza, eventually published in 1921, that noted the gravitational potential tensor $g_{\mu\nu}$ and the EM potential 4-vector A_ν could be understood as components of a 5-dimensional gravitational field potential $\tilde{g}_{ab}$, such that $\tilde{g}_{\mu\nu}\sim g_{\mu\nu}$, $\tilde{g}_{5\nu}\sim A_\nu$, and $\tilde{g}_{55}\sim\phi^2$, where ϕ is a new scalar field implied by the theory, but not identified with a known field. This is similar in spirit to the Nordstrom theory, but unlike Nordstrom, Kaluza accurately captures the degrees of freedom in the gravitational and EM fields.

At this point, a viable theory coupling gravity and electromagnetism was in hand, studied by Einstein, Pauli, and other great physicists of the era, yet it was abandoned. If ever there were hopes for electromagnetic control of gravity and inertia, it was here. Yet the theory was never explored for practical effects, and its field equations were finished only decades after Kaluza suggested them. Why? Could it be a cover-up, analogous to the ones Nick reported in HfZP? I don't believe it was, for several reasons.

Kaluza's paper was published in the calm immediately before the quantum storm that was to overtake physics: the discoveries of the de Broglie relations, Schroedinger wave mechanics, and Heisenberg matrix mechanics. In 1926, Klein extended a quantum interpretation to the Kaluza theory by proposing the fifth dimension was compact and microscopic. Predictions did not accord with measurement, and the 5D theory was abandoned as a viable quantum theory. Yet Klein's insight was capitalized upon, because it provided a way to generate complicated field equations: write simple field equations in higher dimensions. Higher numbers of compact dimensions have characterized unified field theory ever since.

The hunt for gravity control physics cannot be solved in the quantum realm, in my opinion. Therefore, we abandon quantum Kaluza theories as not relevant to the gravity control problem. We posit that this is a classical problem, since gravity and inertia are classical phenomena. Quantum considerations and

the zero-point vacuum may provide an energy source, but we suspect that a momentum source will turn out to be a classical problem.

The irony of the early abandonment of the classical Kaluza theory is two-fold. One is that the theory was abandoned decades before the full field equations of the theory were obtained. The other is that, while a quantum theory of electromagnetism was achieved, and is the most accurate mathematical theory obtained so far, the hunt for a theory of quantum gravity has been unsuccessful. This after attempts by the greatest minds of the 20th century: Einstein, Schroedinger, Dirac, Pauli, Feynman. Are we waiting for someone smarter? Should we give it another 100 years? Or can we conclude quantum gravity as a mathematical theory is not possible as conceived?

Kaluza had originally set the 15th field component, the scalar field, to a constant, and ignored its dynamics. Long after the Kaluza theory was abandoned in the rush to a quantum future, several independent research groups completed the field equations of the Kaluza theory, including the scalar field, during the 1930s and 1940s. Four of these groups were chronicled by the historian of science, Hubert Goenner, in *Some remarks on the genesis of scalar–tensor theories*

https://link.springer.com/article/10.1007/s10714-012-1378-8

There was a lone researcher, Scherrer, who worked in Switzerland; a group in France under Lichnerowicz, including his student, Thiry, who wrote his dissertation on the theory; and a group in Germany under Pascual Jordan, including Ludwig and Muller, with input from Pauli and Fierz. If this sounds like the description on the Kaluza-Klein Wikipedia page, it is because I helped write the Kaluza-Klein Wikipedia page! You can find more detail and further references there:

https://en.wikipedia.org/wiki/Kaluza-Klein_theory

Those 3 European groups worked more or less simultaneously through the 1930s to 1950s. Robert Dicke's group at Princeton began a famous investigation of scalar-tensor gravity theories in the 1950s, and they were first inspired by the work of Jordan's group. According to Goenner, Dicke was seemingly unaware of Lichnerowicz and Scherrer.

To these groups, I also add a group around Einstein at Princeton in the 1930s. They published extensively on higher-dimensional gravity. For example:

Peter Bergmann, *Unified field theory with fifteen field variables* (1946)
https://www.jstor.org/stable/1969126

It is widely known, almost stereotypically, that Einstein "wasted" the last years of his career in the fruitless hunt for a unified field theory. It was the receipt of the Kaluza manuscript that set him on this hunt, because the Kaluza theory had the remarkable property that it provided a source in the 4D gravity equations from 5D vacuum alone. Here was the seed of matter from geometry.

So it is true Einstein was searching for a “unified field theory”, but it was something more profound than usually understood. He was searching to explain matter as arising purely from fields, so that all nature, the matter and the forces between matter, could be understood as manifestations of a single field.

That is different than modern unified field theories. They accept the matter as given: quarks and electrons. The unification is in the force fields that affect the matter: gravity, electromagnetism, strong force, and weak force.

But that is not subtle enough to grasp Einstein’s quest. And here is something I have learned only through my own research. Einstein was not only hunting for matter from fields, he demanded that the fields gave non-singular solutions. Einstein was really searching for a field theory that described matter and the forces between matter as manifestations of the one field; for the field to give rise to matter, it had to support non-singular solutions. And unfortunately, none of the theories Einstein investigated did support non-singular solutions. So to that extent his quest was fruitless.

As far as I know, there was never any investigation of the practical or engineering implications of the Kaluza theory. The several research groups were all working on fundamental issues of unity of forces. Likewise for Dicke’s group in the 1950s: they were investigating scalar-tensor theories as an alternative to general relativity. Dicke was also a pioneer of cosmology, and predicted the cosmic background radiation. He was searching for it in microwaves at the time two radio engineers discovered it by accident; the discovery won them a Nobel Prize.

3f. T. T. Brown effect

T. T. Brown reported an “electro-gravitic” effect that he first detected in the 1920s, and experimented with over the succeeding decades. His discoveries and patents were purely empirical. He did not suggest any mathematical theory to quantify the phenomena. The operative element was a capacitor. Brown found a thrust effect on charged objects. He claimed it arose specifically with asymmetric capacitors. At the outset, this is the sort of effect we might expect from a coupling between gravity and electromagnetism.

Brown refined his ideas over the decades, and his “essential teaching on electrogravitics” was his patent no. 3187206 from 1958:

https://patents.google.com/patent/US3187206A

There is no discernible physics in this patent, just empirical effects for certain shaped dielectrics.

The modern consensus is that lift from the Brown effect is due to an ion wind generated by the high electric charge, so not viable in vacuum, and therefore not a true anti-gravity effect.

Miller, et al., *Force characterization of asymmetrical capacitor thrusters in air,* in *Frontiers of Propulsion Science*, M. Millis & E. Davis, editors, 2009, AIAA Press

While Brown claimed to have produced his effect immersed in oil, in plexiglass enclosures, and in vacuum, modern experimentalists claim the effect vanishes in vacuum, so it is not a true gravity control effect.

If there were a Brown electrogravitic effect, Brown never quantified it mathematically. Yet what Brown observed and reported has all the hallmarks of what one would expect from a coupling between gravity and electromagnetism. The Brown line of inquiry may be worth a re-look, but with a mathematical framework.

3g. Gravity Research Foundation

In spite of the rich literature in coupled gravity and electromagnetism described above, the research between 1925 and 1950 seems to have been devoted to fundamental physics only. Engineering implications were not considered by Kaluza, Klein, or by the research groups around Thiry, Jordan, Dicke, and Einstein.

Attempts at practical gravity control by industry, government, and academia appear to come together with the Gravity Research Foundation during the 1950s. As Nick found, there seems to have been a moment during the 1950s when optimism prevailed regarding the eventual control of gravity. After all, the preceding two decades had seen the development of atomic energy, radar, and ballistic missiles. The popular imagination had turned to the stars and propulsionless travel seemed inevitable. Why would we not master gravity, as we mastered electromagnetism and nuclear forces? During the early 1950s, this optimism was simultaneously expressed by aerospace companies, by gravity researchers, and by the military. Aerospace companies and the US Air Force both were active in gravity research.

The GRF runs an annual “essay” contest, and the evolution of mainstream thinking about gravity control emerges in the essays over time. The first essay winner was in 1949, on *“The possibility of discovering an absorber, insulator, or reflector for gravity waves”*

https://www.gravityresearchfoundation.org/s/wittry.pdf

The second essay winner, in 1950, on *“The possibility of new gravitational effects”*, was already committed to finding gravity control within the framework of general relativity.

https://www.gravityresearchfoundation.org/s/ferrell.pdf

The die was cast when Bryce Dewitt won the 1953 contest with *“New directions for research in the theory of gravitation”*. In this essay, Dewitt dispenses with the notion of any possibility for gravity

control within general relativity, and introduces quantum gravity as the next frontier of gravity research.

https://www.gravityresearchfoundation.org/s/dewitt.pdf

Allow me to quote Dewitt at length on gravity control:

> ...first fix our sights on those grossly practical things, such as “gravity reflectors” or “insulators”, or magic “alloys” which can change “gravity” into heat, which one might hope to find as the useful by-products of new discoveries in the theory of gravitation. The use of terms such as “reflector” or “insulator” clearly is based upon analogy with electromagnetism Now, it is quite true that gravitation is similar to electromagnetism in many ways. Just as the latter can be split into an electric and magnetic part, so can the former be split into two parts, one being that produced by static matter, and the other that produced by moving matter. The gauge group of electrodynamics has its counterpart in the coordinate transformation group of gravidynamics. The electromagnetic and gravitational fields both propagate with the speed of light.
>
> In other respects, however, the gravitational and electromagnetic fields differ profoundly. Of prime importance is the extreme weakness of gravitational coupling between material bodies, as compared with electromagnetic coupling. The weakness of this coupling has the consequence that schemes for achieving gravitational insulation, via methods involving fanciful devices such as oscillation or conduction, would require masses of planetary magnitude. And even if the necessary masses could be manipulated, these schemes would be doomed to failure … since non-gravitational force fields would have to be employed to move the matter. But the existence of such external fields would defeat its own purpose, because every stress, every force-potential, and indeed, every form of energy produces its own gravitational field. The gravitational field is all-pervading.
>
> ...These considerations are quite sufficient to enable one to state flatly that any frontal attack on the problem of harnessing the power of gravity along the above lines is a waste of time.

Dewitt was a great physicist who would go on to pioneering work in quantum gravity. His early work in the 1950s was instrumental in the elucidation and eventual discovery of gravitational waves.

http://konfluence.org/media/fun/APS-GravWaves-History.pdf

In 1954, the great German physicist Pascual Jordan won 5th place in the essay contest. His entry is of particular interest because he was working on a theory that was in effect the Kaluza theory of coupled gravity and electromagnetism, as described above. He presented his theory as one of a “variable gravitational constant”.

https://www.gravityresearchfoundation.org/s/jordan-z73g.pdf

Indeed, the scalar field in Kaluza theory can be identified with the scalar field that is a variable gravitational constant in conventional scalar-tensor theories of gravity, such as the Brans-Dicke theory:

C. Brans & R. Dicke
Mach's principle and a relativistic theory of gravitation
Phys. Rev., 124, 925 (1961)

Likewise, Brans and Dicke were inspired by Jordan's work. So a variable gravitational constant was explicitly on the minds of Jordan and Dicke. Yet Jordan was as pessimistic as Dewitt regarding gravity control using electromagnetic analogies

> Einstein's general theory of relativity … rules out any possibility of harnessing gravity. Nevertheless, in Einstein's theory many things may take place in the Field of Gravitation, far more complicated than those permitted by Newton's theory. For example, Einstein's theory calls for gravitational waves, just as Maxwell called for electromagnetic waves. But the connection between matter and the gravitational field, according to Einstein, is effected solely through the masses of its material parts, modified by their respective movements. … Chemical composition of matter, therefore, has no bearing on gravitation, and there is, therefore no substance, nor can any substance be discovered or compounded which could ever act as insulator, reflector, or absorber of gravitation. There can be no such substance under Einstein's theory.

In spite of that pessimism, Jordan suspects his theory provides an avenue for gravity control nonetheless. He goes on to describe the implications of a varying gravitational constant for geomagnetism, and it is not at all clear what this has to do with gravity control. He ends his essay cryptically by saying:

> I am convinced that further research in the direction of the mathematical theory of a varying constant of gravitation will provide us with the necessary background for solving the problem of terrestrial and stellar magnetism; and, if it is a fact that a varying constant of gravitation is the cause of magnetism in rotating celestial bodies, then, we must eventually succeed in artificially inducing substantial changes in the gravitational field of rotating masses, through electromagnetic experiments upon the same.

This is where the trail seems to run cold in terms of mainstream gravity control physics. I am very familiar with the mathematics of Jordan's theory, but I struggle to understand how the Kaluza scalar field (varying constant of gravitation) is linked to rotating masses. Nothing ever seems to have come from Jordan's work, even though he published a book on his theory. No laboratory experiments seem to have been developed.

It's odd that Jordan was not spirited back to the US along with the Paperclip scientists, as Nick described. It seems he alone was working in Germany on a viable, fully quantitative, theory of electromagnetic gravity control, yet he was not of interest to the US during or immediately after the

war. And his essay won only 5th place in 1954. If there was government interest in gravity control science of any sort, it was obviously not within the Kaluza framework. To suppose that such general interest existed yet simultaneously ruled out Jordan's theory, is to strain credulity. It seems more likely it didn't exist at all.

4. RIAC, Martin Company

The Glenn Martin Company was prominent in the gravity control media of the 1950s. Indeed, reporting around Martin gravity control activities helped to spur Nick's hunt for the present-day descendants of that technology. George Trimble headed up advanced propulsion at Martin, and he is a key figure in HfZP. Trimble formed a group at Martin called *Research Institute for Advanced Studies* (RIAS), to pursue gravity control and other propulsion breakthroughs.

Recently, someone sent me the link to a web article describing the history of government pursuit of gravity control technology. This article by Brett Tingley is quite good. It parallels much of the history that HfZP describes, and includes links to some of the reports mentioned in HfZP.

https://www.thedrive.com/the-war-zone/30499/

Tingley includes an interview video featuring a physicist named Louis Witten, who worked at RIAS. His demeanor among the other physicists in the video is one of amusement, that he was funded to pursue a silly thing that is now understood to be impossible. However, he made the best use of the situation and commenced research in general relativity. Tingley links to several technical papers by Witten, and they are all legitimate research papers in general relativity. They are theoretical and highly mathematical, as one would expect for modern gravity research. I reviewed the one most relevant to gravity control physics, *Geometry of gravitation and electromagnetism* (1959)

https://journals.aps.org/pr/abstract/10.1103/PhysRev.115.206

This is a straightforward calculation of the combined field equations of the gravitational and electromagnetic fields. The coupling between gravity and EM emerges "normally", as described above in the section on general relativity. That is, the EM field is a source of gravitational field. Witten solves the combined equations in the absence of any matter sources. It is a pure field description. He finds some interesting results relating to the invariants of the EM field, which may have relevance for the Kaluza theory, since there, too, invariants of the EM field enter in unusual ways. However, there is no experimental implication for the results reported by Witten, and one might expect that astrophysically-large EM energy densities would be required to generate significant gravitational fields.

In summary, judged by the interview and writings of this one RIAS member, RIAS was not in possession of any gravity control physics beyond known physics.

Interestingly, Witten also discussed how the moves by Martin Company led the Air Force to establish parallel efforts at Wright-Patterson AFB.

5. Aerospace Research Laboratories, Wright-Patterson AFB

Tingley provides a nice discussion of Joshua Goldberg, and the Aerospace Research Laboratories established at Wright-Patterson AFB in the 1950s. The papers by Goldberg that Tingley links to are in family with mainstream gravitational research, but none appear to have implications for gravity control theory, and none are laboratory-based.

I had the opportunity to meet Josh Goldberg at the APS meeting in 2018. He was attending celebratory sessions around the discovery of gravitational waves. Goldberg and the Air Force, along with the GRF, were instrumental in starting the very early conceptual work that ultimately led to the detection of gravitational waves.

http://meetings.aps.org/Meeting/APR18/Session/Y06.4

It was rare to see an Air Force employee as an esteemed scientist among his university colleagues. Tingley noted that even the famous relativist Roy Kerr was at ARL. This practice of hiring career scientists was effectively ended by the Mansfield Act in the 1960s, at a loss to the Air Force and the country.

We can only conclude that the ARL at Wright-Patterson was a mirror image of RIAS at Martin. There was an investigative effort, but no apparent gravity control physics, just conventional research in gravitational physics and general relativity. Both RIAS and ARL accepted the intractability of gravity control expressed in the quotation of Dewitt above, and pursued mainstream gravitational research instead.

6. Electrogravitic Systems Report, 1956

Electrogravitic Systems, An examination of electrostatic motion, dynamic counterbary, and barycentric control, Gravity Research Group, Report GRG-013/56 (1956)

This report is a breathless collection of “reports from the front lines”, so to speak, of gravity research. Again, there is absolutely no math, just lists of wonderful possibilities. The author obviously surveyed a wide field and spoke with a wide number of people.

There is a lot of name-dropping, akin to who was walking the red carpet on Oscar night. There is some descent into incomprehensible word salad, e.g., “there was no detailed explanation of gravity in project Winterhaven, but it was assumed that particle dualism in the subatomic structure of gravity would

coincide in its effect with the issuing stream of electrons from the electrostatic energy source to produce counterbary."

Yet at the end, the author gives an honest appraisal that is still true today: "Progress in electrogravitics probably awaits a new genius in physics who can find a single equation to tie up all the conflicting observations and theory… ." We are still waiting.

7. Air Force propulsion studies, Edwards AFB

A series of propulsions studies referring to gravity control technology emerged from Edwards AFB over the course of two decades. All were created under the auspices of Frank Mead at Edwards AFB.

7a. Mead report, 1972, Air Force – Advanced Propulsion Concepts

Advanced Propulsion Concepts – Project Outgrowth, F. Mead, editor
Technical Report AFRPL-TR-72-31 (1972)
Air Force Rocket Propulsion Laboratory, Edwards AFB
https://apps.dtic.mil/dtic/tr/fulltext/u2/750554.pdf

This was a look-ahead by the Air Force, to assess aerospace innovations in the coming decades. There was a chapter on anti-gravity, but it was of very poor quality, and naively unaware of the basic challenges described by Dewitt and Jordan above. One finds many problematic statements that betray a lack of understanding of gravitational physics, or even an awareness that we have a theory of gravity called general relativity:

- "a concept of gravitational absorption"
- it is unknown "what causes gravity….Einstein attempted to explain this inexplicable phenomenon."
- "scientists assume a link between gravity and electromagnetism because they both share inverse square laws"

There is no relevant mathematics presented, and we must conclude this is absolutely not evidence for government awareness of anti-gravity technology. Rather, it is evidence of government ignorance.

7b. Talley report, 1988, Air Force – 21st Century Propulsion Concept

21st Century Propulsion Concept, R. Talley
AD-A197 537 (1988)
Air Force Astronautics Laboratory, Edwards AFB
https://apps.dtic.mil/dtic/tr/fulltext/u2/a197537.pdf

This was a report of a Phase I SBIR effort, to verify the Brown effect. This effort *confirmed* the Brown effect in vacuum down to 1 millibar, and recommended further exploration. The author was familiar with the ion wind phenomena, and claims Brown was as well. The results reported control for ion wind. There is no indication of a broader industrial effort using this technology. It is difficult to reconcile this study with the opposite results of similar studies.

Taken at face value, it appears to be experimental evidence for a gravito-electric effect of the sort investigated by Brown. But there is no evidence this technology is matured in any part of the government or industry.

7c. Cravens report, 1990, Air Force – Electric Propulsion Study

Electric Propulsion Study, D. Cravens
AD-A227 121
Astronautics Laboratory, Edwards AFB
https://apps.dtic.mil/dtic/tr/fulltext/u2/a227121.pdf

This is a creative and thorough report, among the best I've seen on mathematical gravity control physics. Dennis Cravens is the main investigator, and Pharis Williams is credited as a co-investigator. The report combines an excellent discussion of theory, with a list of 15 different possible experiments to test the theories. The overall area of investigation is inductive coupling between gravity and electromagnetism.

Unlike other works, the author develops a theory to act only as a general framework for the experiments, but is agnostic as to what the proper theory may actually be. The generalized electro-gravitic theory framework is used to calculate modifications of the Maxwell equations. Cravens implies that any theory coupling gravity and electromagnetism should be expressible in terms of the 5-dimensional Kaluza theory.

Using the theory framework, the author reviews several different expressions for the self-energy of a particle that could be experimentally compared. But a non-standard fetish is introduced that compromises some later results, when the author identifies the source term for the 5th component of the metric with "mass". This is an arbitrary choice, made by some authors, but not natural to the Kaluza theory. The derived Maxwell equations seem specific to the identification with "mass", and perhaps this is not as general for any electro-gravitic theory as they had hoped.

The best part of the report is its presentation of multiple experimental configurations with which we might test various theories of electro-gravitic coupling. Interestingly, the author includes the Woodward Fullerton concept of exchange of momentum with the gravitational field of the universe in the family of electro-gravitic coupling, presumably because the Woodward device is electrically operated, and so in that way bears a similarity to the Brown devices.

This report forms an excellent reference and guide for the development of experiments to test electro-gravitic coupling. But it does not give any evidence that this technology is matured, or anything beyond speculative.

8. Physics in *Hunt for Zero Point*

The Hunt for Zero Point (HfZP) is a hunt for technology, not mathematics. But there are a few instances where Nick reports some of the explanations or concepts that he pursues. In fact, he numbers 5 potential paths to gravity control suggested by his sources (p 117): manipulating mass or inertia, exploitation of zero point energy, “perturbations of the spacetime continuum”, faster-than-light travel, and gravity shielding.

Gravity shielding should be impossible according to the understanding of general relativity that emerged at GRF in the 1950s. HfZP investigates the claims of Podkletnov, which appear to be some sort of gravity shielding, but they have not been reproduced. If verified, gravity shielding would be one of the landmark discoveries in gravitational physics. Conversely, it seems unlikely that someone has accomplished gravitational shielding, as general relativity has been verified experimentally in numerous ways.

“Faster-than-light” (FTL) is a goal, but not a mechanism or an engineering approach. FTL is likewise understood to be impossible according to the known laws of physics. There are FTL solutions to the Einstein field equations, but they require astronomical amounts of negative energy. The solutions exist mathematically, but they are as impractical as creating a Jupiter mass in the lab. If FTL is possible, it almost certainly implies gravitational physics beyond general relativity.

In one sequence, Nick reports something that seems like physics, but is like no physics we know of: the purported “implosion” device by Schauberger. It was based on an organic, spiral concept for interacting with nature. No mathematics was reported for this, but it sounds unlike anything from the known world of differential equations.

In another sequence, Nick’s source reveals that a device uses a “torsion field”. The source goes on to say “*If you generate a torsion field of sufficient magnitude the theory says you can bend the 4 dimensions of space and time around the generator. The more torsion you generate, the more space you perturb*.” This is a meaningless word salad to a physicist. There is no widely accepted understanding of

what a torsion field is. There are modifications of general relativity called “torsion” that allow for antisymmetry in the connections, but this amounts to a new theory of gravity. Later, Podkletnov speculates his effect might be caused by “a torsion excitation of the physical vacuum ...”. Nick’s source later verifies that “torsion” is to be imagined as a spinning whirlpool that can redirect vacuum energy in an almost-magical way. Somehow, spinning whirlpools evidently connect to the quantum vacuum and release free energy.

Whatever torsion is, as the word “torsion” alone, it is empty of content. These simple pictures don’t provide a quantitative prediction for lift or thrust or energy consumption. In the absence of a working implosion or vortex device, it must be considered an unproven concept.

The subsequent discussion of a time machine seems similarly fantastic. There are so many issues with the very concept of a time machine that its mention by the source naively and without qualification seems to betray either ignorance or misdirection. No physicist just says “I have a time machine, it works great. How ‘bout those Mets?”

The time machine, implosion, and vortex machinery described by Nick’s sources would presumably need some engineering specification to describe their performance, and the physical principle that provides lift or energy. But the implication of such detail seems missing entirely. The absence of quantitative physics to describe such machinery is, I think, the strongest evidence for its absence. Likewise, it is suspicious that Nick’s sources did not bother to tie their exotic physics back to textbook physics. I think a true physicist speaking with a layman would find it difficult to conceal the missing link, the key concept, whatever it is, that makes the whole thing hang together. Great discoveries typically have simple, linchpin concepts that are easily explainable once they are realized and proven.

Perhaps the most constructive insight into “the physics” comes from Boyd Bushman, who told Nick “Nature does not speak English...if we verbalize it, we’re probably approximating, but not telling the truth. Math comes close...What nature tells us must be honored. It has been talking to us on many domains...I can’t talk to theoreticians because there don’t exist theories where I am.” One hopes there are at least experiments, then!

Near the end of the book, Nick’s source discusses “mutant non-linear physics”, which sounds like more word salad. The source says the Germans developed a unique approach to science and engineering separate from the rest of the world. This seems impossible, because German physics is the world’s physics. Many great physicists were German, Planck to Einstein to Heisenberg. Mathematical physical law does not fly a flag. There must be something written down, or do they communicate their physics via telepathy? It sounds good to say that there is physics we can’t imagine, but why don’t we see even the slightest clue it exists?

It is feasible that there are physical effects that are not expressible in the language of mathematics, as Bushman suggests, and so that is why there is no gravity control physics for them. But then likewise,

there cannot be engineering with this effect, and there cannot be technology. It is more like unicorn rodeo.

9. Kaluza research: late 20th century

As mentioned previously, the full field equations of the Kaluza theory were not developed until 20 years after the theory was abandoned by Einstein and the rest of mainstream physics. According to Goenner, we might presume that by 1950, Scherrer in Switzerland, Thiry in France, and Jordan in Germany, had all completed the field equations for the scalar-vector-tensor theory of Kaluza. But none of that work was translated into English. The concept of a scalar field additional to the metric of gravity had spread from Jordan to Dicke, and the scalar field was thoroughly analyzed at cosmological scale by Dicke's group circa 1960, giving the first English-language description of something akin to the full Kaluza theory.

The first appearance in English of the full, coupled, scalar-vector-tensor equations of the Kaluza theory, albeit the vacuum equations only, was a translation of a paper by Thiry:

M. Thiry, *The equations of Kaluza's unified theory*, (1948)

This translation was presented along with English translations of Kaluza's 1921 paper, and reprints of related papers by Klein, Einstein, Bergmann, and Nordstrom, in a volume edited by Applequist, Chodos, & Freund:

T. Applequist, A. Chodos, P. Freund, *Modern Kaluza-Klein Theories*, Addison:Wesley (1987)

A slew of papers emerged in the 1980s and 1990s that treated various aspects of the Kaluza theory, such as an investigation of the Kaluza-modified equation of motion:

G. Gegenberg & G. Kunstatter, *The motion of charged particles in Kaluza-Klein spacetime*, Phys. Lett., 106A, 410 (1984)

If the Kaluza theory does indeed describe a Brown-like electrogravitic coupling, then it would appear in the force equation investigated by Gegenberg & Kunstatter and other authors.

Another key paper was a solution for the "Kaluza-monopole", or 5D Schwarzschild solution:

A. Chodos & S. Detweiler, *Spherically symmetric solutions in five-dimensional general relativity*, Gen. Rel. Grav., 14, 879 (1982)

A group around Paul Wesson began to promote a return to the classical viewpoint of the Kaluza theory, and treat the 5th dimension as a macroscopic, classical dimension; not as a compact, microscopic dimension, as had been assumed since Klein in the 1920s.

J. Overduin & P. Wesson, *Kaluza-Klein gravity*, Phys. Rep., 283, 303 (1997)

Wesson's group extended the Kaluza theory to abandon the cylinder condition, and allow in the mathematics for the fields to depend on the 5th coordinate. When one does so, the complexity of the theory explodes, and an enormous number of terms enter the field equations. Wesson identifies these extra terms as matter sources in the field equations, the $T_{\mu\nu}$ in the Einstein field equations above. In this way, Wesson realizes Einstein's dream to reduce all physics to fields.

But we know Einstein was looking for non-singular solutions to the field equations; would he approve of Wesson's approach? Or did he already consider it in his long post-Kaluza journey? While there is a philosophical allure to relaxation of the cylinder condition, it results in nightmarish algebraic complexity. There seems to be a loss of true quantitative predictability, and we have traded the immaculate conception of $T_{\mu\nu}$ in the field equations with immaculate identification of complex non-linear derivatives of the fields.

Among all this work, there has been no consideration of the practical, engineering applications. The focus is instead on fundamental physics, unification of forces, and cosmology.

10. The unique Kaluza theory

At the outset of our consideration of gravity control physics, we set 5 constraints on a viable theory: covariant formulation, derivable from a Lagrangian, a classical theory, couples gravity and electromagnetism, and treats inertia and gravity. These criteria set a high bar for consideration as an gravity control physics. Only the Kaluza theory meets these criteria.

The full, coupled scalar-vector-tensor field equations of the Kaluza theory have been investigated in many forms by many research groups. Upon close inspection, one finds differences in the literature. After some fits and starts, I found the algebra too complicated to reliably verify by hand, to choose among the various references. Therefore I began a project to verify the Kaluza field equations using tensor algebra software. My results are here:

https://www.hindawi.com/journals/jgrav/2015/901870/

This work allowed me to verify the unique Kaluza field Lagrangian, and therefore the unique field equations. Other authors may have used a Brans-Dicke Lagrangian, or simply made errors in the algebra. Since that work, I have found two previous references that had the field equations and Lagrangian correct, along with the 5D Ricci tensors and the 5D Einstein tensors. That is a relatively small number out of the dozens of papers I have looked at.

J. Ferrari, *On an approximate solution for a charged object and the experimental evidence for the Kaluza-Klein theory*, Gen. Rel. Grav., 21, 683 (1989)
https://link.springer.com/article/10.1007/BF00759078

This work by Ferrari is the only one I have found with the correct Lagrangian, field equations, Einstein tensors, Ricci tensors, equations of motion, and identification of electric charge. Furthermore, Ferrari also examines the equations of motion and finds significant modifications to the Coulomb electrostatic force.

That same year, Ferrari used the Kaluza theory in a creative way to examine the pure 4-dimensional limit. He claimed to find the Aharonov-Bohm effect in the Kaluza theory by positing a 5-dimensional de Broglie relation.

J. Ferrari, J. Griego, & E. Falco, *The Kaluza-Klein theory and four-dimensional spacetime*, Gen. Rel. Grav., 21, 69 (1989)

The second previous correct reference for the Kaluza field equations is:

R. Coquereaux & G. Esposito-Farese, *The theory of Kaluza-Klein-Jordan-Thiry revisited*, Ann. d. H.Poincare, sec. A, 52, 113 (1990)

They present the correct Einstein tensors, equations of motion, and definition of electric charge. They make some minor errors in the Ricci tensors. But their analysis is not useful because they go into a conformal frame that transforms the scalar field away.

Many references explicitly assume the 5^{th} dimension is compact, including Ferrari, but they derive the same classical field equations as under the cylinder condition. The compact assumption does not change the mathematics, and is more of a philosophical fig leaf for the cylinder condition. Whatever the authors think about the 5^{th} dimension, they implicitly or explicitly enforce the classical cylinder condition.

Aside from the field equations, there are also divergences in the literature regarding the identification of electric charge, and the source of the scalar field. Those issues will not be addressed here, except to say that, even with the correct Lagrangian and field equations, the Kaluza literature is still confused.

In summary, it seems that while the actual coupled equations of electromagnetism and gravity have been in the literature for decades, they are confused by algebraic errors and conflicting assumptions among authors, and have never been applied to laboratory configurations, save for the work of Ferrari. It seems that gravity control physics could exist, but it has been difficult to distinguish from related but erroneous studies. If the mainstream scientific literature is this confused, it seems logical that private and classified government scientists could be confused as well.

11. Pais Navy patents

I have recently learned about a series of curious patents assigned to Salvatore Pais. They are in the area of exotic physics of all sorts. At least one of them is assigned to the Secretary of the Navy, meaning that the highest levels of the Navy are aware of this work and approve it.

https://patents.google.com/patent/US10144532B2

According to the USPTO, this patent was initially rejected, but the Chief Technical Officer of the Navy intervened to get the patent approved on national security grounds.

Ostensibly, this patent relies on a zero-point effect of the kind pursued in HfZP. Pais invokes work by Puthoff on the relation of the quantum vacuum to inertial mass, e.g.,

https://link.springer.com/chapter/10.1007/978-94-017-0990-3_21

And there is a famous paper by Sakharov that connects gravity to vacuum flucutations.

A. Sakharov, Vacuum quantum fluctuations in curved space and the theory of gravitation, Dok. Adkad. N. SSSR, 177, 70 (1967)
http://ayuba.fr/pdf/sakharov_qvf.pdf

While the Sakharov picture may have explanatory power, it has no predictive power.

Even so, Pais's reasoning seems very simple-minded, and free of mathematics. He apparently extrapolates the negative pressure observed between Casimir plates to the skin of an enclosure containing EM waves. The waves are presumed to alter the quantum vacuum around the skin in a way that alters the mass. Yet I am not aware that (i) EM waves alter the quantum vacuum, (ii) the quantum vacuum determines inertial mass (apologies to Puthoff and Sakharov), (iii) inertial mass of a body is determined at its boundary, not its center, (iv) the Casimir effect applies to an open boundary.

I looked closely at Pais's work and his patents, and taken as a whole, they had my BS sniffers blinking red. It is claimed that Pais has discovered an effect in nature that will allow control of inertial mass, create sustained nuclear fusion, enable undersea propulsion, enable room temperature superconductivity, deflect Earth-approaching asteroids, provide radar stealth, protect Earth from coronal mass ejections, make an impenetrable defensive missile shield, focus gravity waves, and enable anti-satellite abilities. If a cure for male pattern baldness were among its charms, I would be a believer, too. Perhaps the list of charms is designed to enchant another audience.

All of these wonders are achieved without engineering, equations, or mathematics. Curiously, all results rely on Pais's central claimed result, having to do with electromagnetic energy fluxes of $10^{24} W/m^2$. These are very high fluxes. One could conceivably get such high power by delivering just 1 watt in 10^{-24} seconds, but such short durations seem like a cheat. The inertial confinement

fusion ignition facility at Livermore delivers 10^6 joules for 10^{-8} seconds, for 10^{14} watts delivered to the head of a pin. The Pais number seems unphysical, as the USPTO originally noted.

12. Conclusions

There is a presumption among the lay public that, if the government or a big corporation is spending money on something, it must be worth spending money on. Perhaps that is too naive, and this skeptical correspondent might even conclude the opposite. Yet the “where there is smoke there is fire” mindset informs the honest investigative work of Cook and Tingley and others. After all, what other evidence do they have to go on, if they do not understand physics themselves? They follow the money. The hunt for gravity control is taken as evidence of its existence. If miners are digging in a mountain, doesn’t that mean there must be gold there?

It appears to me, based on the evidence, that, while there was reason to investigate gravity control technology during the post-war years, no gravity control physics was discovered with the exception of the Kaluza theory. And no gravity control effect was discovered, with the possible exception of the Brown effect. Since the Kaluza theory has not been pursued for engineering applications, it seems reasonable to conclude that no government or corporation discovered gravity control physics at all. General relativity prohibits gravitational shielding or reflecting. There is a possibility of a black-world project of the kind described in HfZP, whether private or government, that relies on an empirical effect without a basis in anything recognizable as mathematical physical law. But it seems implausible that advanced engineering could be undertaken without a mathematical basis that allows for calculation of lift, and thereby, allows for performance design.