Understanding confirmed predictions in quantum gravity

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Abstract

Feynman's relativistic path integral replaces the non-relativistic 1st quantization indeterminancy principle (required when using a classical Coulomb field in quantum mechanics) with a simple physical mechanism, multipath interference between small *mechanical* interactions. Each mechanical interaction is represented by a Feynman Moller scattering diagram (Fig. 1) for a gauge boson emitted by one charge to strike an effective interaction cross-section of the other charge, a cross-sectionl that is proportional to the square of the interaction strength or running coupling. Each additional pair of vertices in a Feynman diagram reduce its relative contribution to the path integral by a factor of the coupling, so *for a force with a very small couplings like observable (low energy) quantum gravity,* only the 2-vertex Feynman diagram has an appreciable contribution, allowing a very simple calculation to check the observable (low energy) quantum gravity interaction strength. Evidence is given that quantum gravity arises from a repulsive U(1) gauge symmetry which also causes the cosmological acceleration.

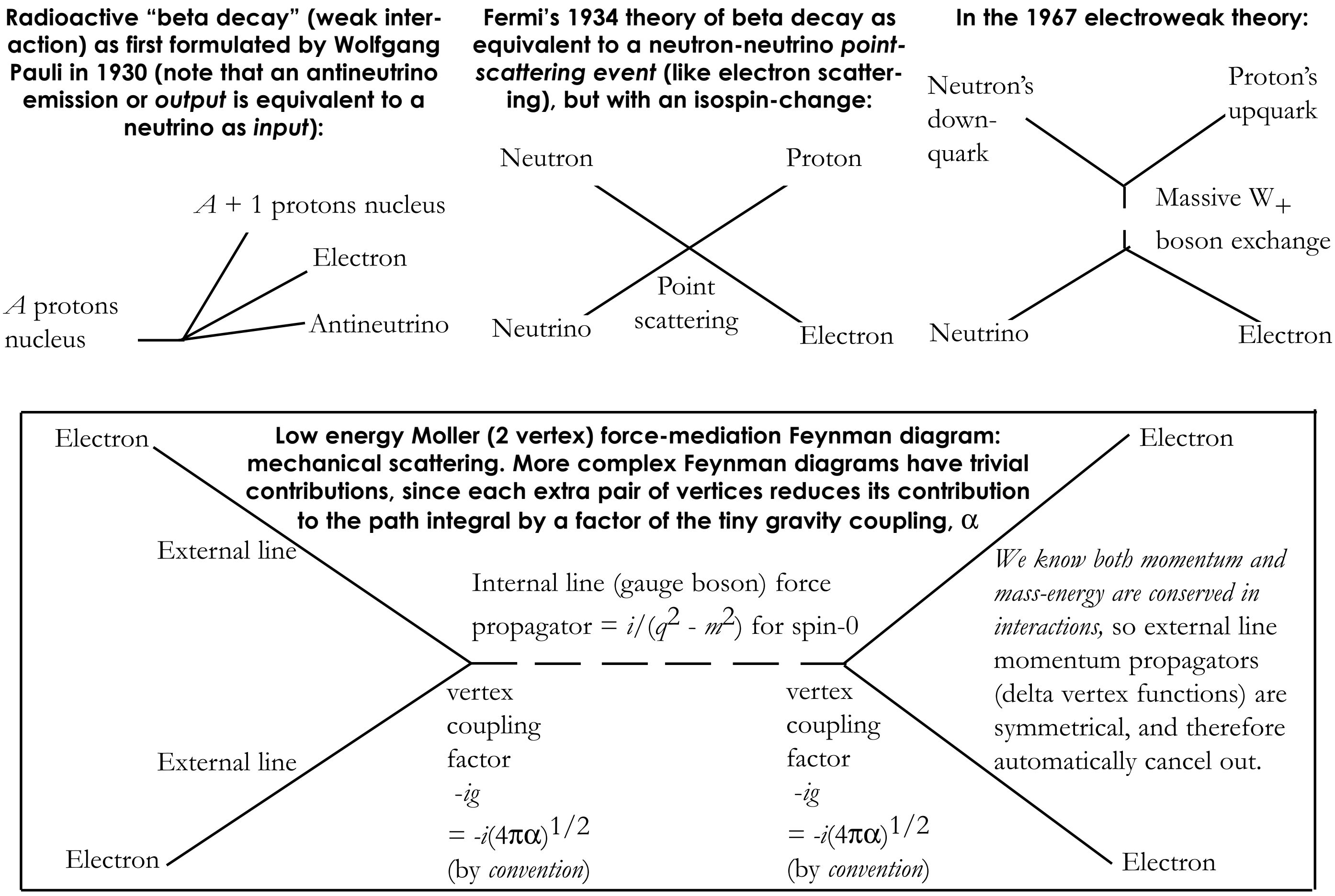
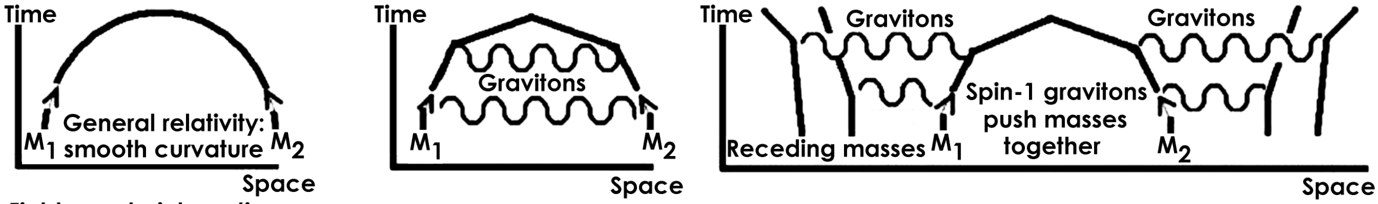


Fig. 1: Weak isospin theory and the electromagnetic low-energy Moller scattering Feynman diagram, which by "crossing-symmetry" has the same cross-section as Bhabha's $p + e$ attraction. In more complex Feynman diagrams, each additional pair of vertices (due to a loop) reduces the contribution of the diagram to the path integral by a coupling factor α, thus making their contributions to the path integral trivial if α is very small (observable gravity has the smallest coupling α). For this reason, only the simplest diagram need be considered for low energy quantum gravity, where the theory can be easily checked by predicting the observable strength of gravity. These diagrams depict simple 2-vertex Moller type scattering diagrams, where forces are physically caused by the momentum exchanged by gauge boson being transferred between the charges, like bullets delivering forces. Using Feynman's rules for Feynman diagram contributions to the perturbative expansion of the path integral, we correctly predicted the cosmological acceleration of the universe (published in 1996, two years ahead of observational confirmation). Gravity was correctly predicted as the asymmetry in the total isotropic inward graviton exchange force $F_{total} = ma$, caused by a particle's gravitational coupling cross-section σ at distance R from the observer, which blocks a fraction of F_{total} equal to the fraction of sky blocked, $\sigma/(4\pi R^2)$, so $F_{gravity} = ma\,\sigma/(4\pi R^2)$.



Field quanta interactions are simply ignored

Spin-2 graviton theory ignores other masses

Spin-1 graviton theory shows that exchange of gravitons causes both dark energy and gravitation effects

Fig. 2: the predominant interaction is the single propagator Feynman diagram with two vertices, in which the cross-section is proportional to the square of the coupling. This scaling uses Feynman's diagram calculating rules: two-vertex interaction probability and cross-section are proportional to (coupling)^2. It empirically extrapolates the cross-section of a proton for scattering a graviton *independently of any assumed graviton spin:* $\sigma_{\text{gravition-proton}} = \sigma_{\text{neutrino-proton}} (G_N / G_{\text{Fermi}})^2 \approx (10^{-11})(10^{-38}/10^{-5})^2 = 10^{-77}$ mb or 10^{-80} barns (1 barn = 10^{-28} m^2). G_N is the gravity coupling, *in the same* m_{proton}^2 *units as the weak coupling,* G_{Fermi} and using the $\hbar = c = 1$ convention. *This approximation (protons are not fundamental) is the black hole event horizon size,* $\pi(2Gm_{\text{proton}}/c^2)^2 = 1.93 \times 10^{-79}$ barns.

(From *Los Alamos Science*, Summer/Fall 1984, p. 23, Table 1.)

WEAK INTERACTION:

Neutrino-Proton Scattering

$$v + p \rightarrow v + p \qquad \sigma \sim 10^{-11} \text{ mb}$$

$$G_{\text{Fermi}}\, m_{\text{proton}}^2 = 2^{1/2} g^2\, m_{\text{proton}}^2 / (8M_w^2) \sim 10^{-5}$$

GRAVITATIONAL INTERACTION:

Graviton-Proton Scattering

$$g + p \rightarrow g + p \qquad \sigma \sim 10^{-77} \text{ mb}$$

$$G_{\text{Newtonian}}\, m_{\text{proton}}^2 \sim 10^{-38}$$

1. Feynman's rules (Fig. 2) prove that the graviton scatter cross-section area is: $\sigma_{\text{gravity}} = \sigma_{\text{weak}} (G_{\text{Newton}} / G_{\text{Fermi}})^2 \approx \pi(2GM/c^2)^2 \approx 2 \times 10^{-79}$ barns. (The nuclear cross-section unit is: 1 barn = 10^{-28} m^2.) The probability of hitting cross-section σ (in area units) from distance R when firing radiation out isotropically is $\sigma/(4\pi R^2)$, which is equal to the fraction of the total isotropic radiation which is actually received by cross-section σ. (See Reference 1.)

2. Isotropic cosmological acceleration a (the dark energy produced cosmological acceleration, first observed in 1998) of the universe's mass m produces from our perspective an effective radial outward force by Newton's 2nd law $F = dp/dt \approx ma \approx [3 \times 10^{52}\text{ kg}][7 \times 10^{-10}\text{ ms}^{-2}] \approx 2 \times 10^{43}$ N, and Newton's 3rd law of motion (the rocket principle), in our frame of reference as observers of that acceleration predicts an equal and opposite (inward directed) reaction force (see Figures 2, 4, 5 and 6 in Reference 1.). Hence $g \approx Mc^4/(amR^2)$, predicting $a \approx c^4/(Gm) = 7 \times 10^{-10}$ ms^{-2}, or $\Lambda = c^4/(G^2m^2)$, which was confirmed by observations of supernovae two years later in 1998, so G and Λ are *not* independent as assumed in general relativity, but are instead *interdependent*. The Lambda-CDM FRW metric based on general relativity ignores this dynamic mechanism where the dark energy *causes* gravity, so it falsely treats Λ and G as *independent variables*. But since momentum is conserved, a falling apple cannot gain momentum (accelerate) from a purely "geometric spacetime" *without a backreaction upon the field* (Newton's 3rd law). (Objections to LeSage-type gravity like heating or drag are inapplicable to all *offshell field quanta,* which in the Casimir force push metal plates together without any heating or drag, while the small cross-section of $\sigma \approx 2 \times 10^{-79}$ barns prevents the LeSage "overlap" problem; see Reference 1.)

Boson exchanged between charges to produce fundamental interactions have been detected, e.g. weak bosons (Fig. 1) have been detected as neutral currents and their masses were found at CERN in 1983. It's a fact that Feynman's rules work for all three Standard Model forces, so their use for the fourth force, gravity, in $\sigma_{\text{gravity}} = \sigma_{\text{weak}} (G_N / G_{\text{Fermi}})^2$ is based on the general, empirically confirmed Feynman rules. It's a fact that an *acceleration of mass is a force by Newton's 2nd law* (thus the outward acceleration of 3×10^{52} kg in the universe constitutes a radial outward force $\approx 2 \times 10^{43}$ N), and that Newton's 3rd law *predicts an equal inward force.* It's not speculative to suggest that this inward radial force of 2×10^{43} N is carried by gravitons, because this prediction was confirmed in 1998 by Saul Perlmutter's discovery of supernovae accelerating away from us with acceleration around 7×10^{-10} ms^{-2}. This gravity prediction is not a speculation but a *confirmed fact, based on consistent empirical physics.* This predicted the cosmological acceleration in 1996, two years before confirmation by Perlmutter's automated software analysis of CCD telescope output, unlike *spin-2 graviton speculation in unpredictive string theory.*

Implications for physics

The application of general relativity to cosmology, i.e. the Friedmann-Robertson-Walker metric of general relativity, is plain wrong in the sense that it lacks the quantum gravity dynamics for gravity being the product of the surrounding acceleration of matter, so Friedmann cannot be used as a basis for analyzing the Hubble recession, big bang or any other large-scale (cosmological) features. General relativity is not an empirically validated prediction system for cosmology anyway since relies in any case upon ad hoc adjustable parameters, such as its cosmological constant which is not fixed by gneral relativity (unlike the situation in quantum gravity), but is adjusted to fit observations. However, general relativity does include energy conservation and corrects defects in Newtonian gravitation, allowing confirmed local (non-cosmological) predictions like the correct deflection of light by gravity, gravitational time dilation and redshift, etc.

Production of the useful predictions from general relativity

The basic method used by Einstein to arrive at the field equation of general relativity in 1915 can still be used for the local (non-cosmological) confirmed predictions; basically this is a matter of taking the low-energy Newtonian approximation we have derived from quantum gravity (based entirely on observables), converting it into tensor field form, and introducing field energy conservation.

The Einstein-Hilbert gravitational field Lagrangian

The Einstein-Hilbert action, $S = \int L dt = \int \mathcal{L} d^4x = \int R(-g)^{1/2} c^4/(16\pi G) d^4x$, when "varied" to find its minima, i.e. for the condition $dS = 0$ (the Euler-Lagrange law), gives the basic field equation of general relativity). However, this free field Lagrangian $\mathcal{L} = R(-g)^{1/2}c^4/(16\pi G)$ (see Reference 2 for its derivation) is geometrically *contrived to model accurately only the classical path of least action (i.e. the real or onshell path in a path integral), unlike quantum field theory Lagrangians which must be generally applicable for all paths*. The way that general relativity is mathematically made into the Holy Grail of quantum gravity is obfuscating and misleading, spuriously focussing on a search for spin-2 graviton theories (which are merely consistent with the rank-2 field tensors of general relativity's field description), rather than on a search for theories which are consistent with the physical content of general relativity, i.e. the use of the metric in the relativistic correction to Newtonian gravitation which is required for conservation of energy. This relativistic correction produces the essential experimental checks on general relativity. Whether gravitation is *described* by curved spacetime using rank-2 tensors or with curved field lines using rank-1 tensors (vector calculus) is not empirically defensible physics. There is a confusion in the literature over which parts of general relativity are experimentally defensible; spin-2 gravitons are not experimentally defensible. We show how the metric can be used with rank-1 tensors and spin-1 or even spin-0 gravitons to produce the same relativistic corrections to Newtonian gravity as are usually done using general relativity with rank-2 tensors and assumed spin-2 gravitons.

Action is the Lagrangian energy density integrated over spacetime, which for a free field (with no matter) is given by gravitational field energy density (see Reference 2):

$$S = \int \mathcal{L} d^4x = \int R(-g)^{1/2} c^4/(16\pi G) d^4x,$$

and the law of least action states that classical laws are recovered in the limit of least action, which must be an action minima where $dS = 0$ (the Euler-Lagrange law):

$$dS = \int \{d[R(-g)^{1/2}c^4]/(16\pi G dg^{\mu\nu})\} dg^{\mu\nu} d^4x = 0,$$

hence the derivative $d[R(-g)^{1/2}]/dg^{\mu\nu} = 0$. Employing the product rule of differentiation gives:

$$d[R(-g)^{1/2}]/dg^{\mu\nu} = (-g)^{1/2} dR/dg^{\mu\nu} + (-g)^{-1/2} R d(-g)^{1/2}/dg^{\mu\nu}.$$

Therefore, in order that $dS = 0$, it follows that $(-g)^{1/2}dR/dg^{\mu\nu} + (-g)^{-1/2}Rd(-g)^{1/2}/dg^{\mu\nu} = 0$, where the partial derivative of the Ricci scalar is $dR = R_{\mu\nu}dg^{\mu\nu}$, and by Jacobi's formula $dg = gg^{\mu\nu}\ dg_{\mu\nu}$, so that $(-g)^{-1/2}Rd(-g)^{1/2}/dg^{\mu\nu} = -\frac{1}{2}Rg_{\mu\nu}$. Thus,

$$d[R(-g)^{1/2}]/dg^{\mu\nu} = R_{\mu\nu} - \tfrac{1}{2}Rg_{\mu\nu}.$$

This $R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu}$ rigorously corrects $R_{\mu\nu} = 4\pi GT_{\mu\nu}/c^2$. The celebrated $8\pi G/c^2$ multiplication factor of Einstein's field equation is not a G prediction, but is just the Newtonian law normalization for weak fields. Set $R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = \kappa T_{\mu\nu}$ and multiply out by $g^{\mu\nu}$ (to give contractable tensor products):

$$g^{\mu\nu}R_{\mu\nu} - \frac{1}{2}Rg^{\mu\nu}g_{\mu\nu} = \kappa g^{\mu\nu}T_{\mu\nu}.$$

Introducing the scalars $T = g^{\mu\nu}T_{\mu\nu}$ and $R = g^{\mu\nu}R_{\mu\nu}$ and the identities $g^{\mu\nu}g_{\mu\nu} = \delta_\mu{}^\mu = 4$ (for 4-dimensional spacetime) and $T = g^{00}T_{00} = \rho$, yields:

$$R - 4(\tfrac{1}{2}R) = \kappa T$$

$$R = -\kappa T = -\kappa g^{00}T_{00} = -\kappa\rho.$$

Putting this scalar curvature result into $R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = \kappa T_{\mu\nu}$ and repeating the contraction procedure by multiplying out by g^{00} (note of course that $g^{00}T_{00} = \delta_0{}^0 = 1$):

$$R_{\mu\nu} = \tfrac{1}{2}(-\kappa\rho)g_{\mu\nu} + \kappa T_{\mu\nu}$$

or

$$R_{00} = \tfrac{1}{2}(-\kappa\rho) + \kappa\rho = \tfrac{1}{2}\kappa\rho.$$

Thus, in the Newtonian (non-relativistic) limit, $R_{00} = \frac{1}{2}\kappa\rho = \nabla^2 k = 4\pi G\rho/c^2$, so $\frac{1}{2}\kappa\rho = 4\pi G\rho/c^2$, or $\kappa = 8\pi G/c^2$.

If a term for the kinetic energy of matter, L_m is added to the free field Lagrangian for the action, the variation of the Lagrangian by amount $dg^{\mu\nu}$ then produces a formula for the contributions by matter to the stress-energy tensor, $T_{\mu\nu} = -2(dL_m/dg^{\mu\nu}) + g_{\mu\nu}L_m$. Einstein's "cosmological constant," Λ (lambda), is included by changing the free field part of the Lagrangian to $L = (R - 2\Lambda)c^4(-g)^{1/2}/(16\pi G)$, which yields:

$$R_{\mu\nu} - \tfrac{1}{2}Rg_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi GT_{\mu\nu}/c^2.$$

But Λ is not a checkable prediction in this equation, because it is not mechanistically linked to G, but instead is just an adjustable *ad hoc* parameter *which reduces the checkable falsifiability of the theory.* Einstein in his 1917 paper "Cosmological Considerations on the General Theory of Relativity" added Λ with a large positive (outward acceleration) value, to just cancel out gravity at the average distance between galaxies, to keep the universe static (as then allegedly observed by astronomers). Beyond the average distance of separation of galaxies, repulsion predominated in Einstein's model. There are serious falsehoods in Einstein's Λ-based static universe. First, Alexander A. Friedmann in 1922 showed it to be theoretically unstable: *any perturbation would cause the expansion or contraction of such Einstein's universe.*

Second, in 1929 Einstein's static universe was shown by Edwin Hubble's expansion evidence to be observationally false. Einstein then set $\Lambda = 0$, adopting the Friedmann-Robertson-Walker solution for the uniform curvature of a homogeneous, isotropic universe: $k = R^2[8\pi G\rho/3) - H^2]$ where H is Hubble's recession law parameter, $H = v/R$, and $R = ct$ is the scale factor. In flat spacetime, $k = 0$, and the Einstein-de Sitter critical density (needed to just make the universe collapse, *if gravity were a universal attractive force, rather than a mechanistic result of cosmological acceleration*) is $\rho_{\text{critical}} = 3H^2/(8\pi G)$, so that the ratio of the actual mass density to the critical density in flat spacetime is $\Omega = \rho/\rho_{\text{critical}} = 8\pi G\rho/(3H^2)$. The Friedmann-Lemaitre equation states:

$$a = RH^2 = (R/3)(\Lambda - 8\pi G\rho)$$

We define Λ as positive for outward acceleration. Readers will find other versions, where Λ is defined negative and multiplied by c^2 to give energy density (not mass density), or where the geometric multiplier is 4π (for Newtonian non-relativistic motion) rather than 8π (for relativistic motion).

Einstein's heuristic derivation of the basic field equation of general relativity

Einstein, however, initially used an heuristic method to obtain and understand the basic field equation. In the Newtonian (or weak field) limit, gravitation is given by the scalar *traces of the Ricci and stress-energy tensors* (top-left to bottom-right diagonal sums of the tensor matrices):

$$R = g^{\mu\nu}R_{\mu\nu} = R_{00} + R_{11} + R_{22} + R_{33},$$
$$T = g^{\mu\nu}T_{\mu\nu} = T_{00} + T_{11} + T_{22} + T_{33}.$$

For the non-relativistic Newtonian fall of an apple, Ricci's curvature is approximated by Poisson's law, $R_{00} \approx \nabla^2 k = 4\pi G\rho/c^2$, while $T = g^{00}T_{00} = \rho$. For radial symmetry about radius r, the Laplacian of k is $\nabla^2 k = (a/r_x) + (a/r_y) + (a/r_z) = 3a/r$.

Einstein's field equation is derived by transforming Newton's law into a tensor spacetime curvature, with a correction for energy conservation.

(1) Convert Newtonian gravity's Poisson law, $\nabla^2 k = 4\pi G\rho/c^2$, into a tensor equation by substituting $\nabla^2 k \rightarrow R_{00} \rightarrow R_{\mu\nu}$ and $\rho \rightarrow T_{00} \rightarrow T_{\mu\nu}$, so that $R_{\mu\nu} = 4\pi GT_{\mu\nu}/c^2$ (note that $E = mc^2$ converts energy density ρ to *mass density* ρ/c^2).

(2) Recognise the local energy conservation error: *both* sides must have zero divergence, and while this is true for the Ricci tensor, $\nabla^\mu R_{\mu\nu} = 0$, it is not correct for the stress-energy tensor, $\nabla^\mu T_{\mu\nu} \neq 0$.

This makes $R_{\mu\nu} = 4\pi GT_{\mu\nu}/c^2$ fail a self-consistency test, since both sides must have *identical* divergence, but they don't: $\nabla^\mu R_{\mu\nu} \neq \nabla^\mu(4\pi GT_{\mu\nu}/c^2)$. To give an example, the free electromagnetic field energy density component of the gravitational field source tensor is $T_{00} = (\varepsilon E^2 + B^2/\mu)/(8\pi)$, which generally has a divergence.

(3) Correct $R_{\mu\nu} = 4\pi GT_{\mu\nu}/c^2$ for local energy conservation by recognising that Bianchi's formula allows the replacement of the wrong divergence, $\nabla^\mu T_{\mu\nu} \neq 0$, with: $\nabla^\mu(T_{\mu\nu} - \frac{1}{2}Tg_{\mu\nu}) = 0$, implying the stress-energy tensor correction, $T_{\mu\nu} \rightarrow T_{\mu\nu} - \frac{1}{2}Tg_{\mu\nu}$.

The term $T_{\mu\nu} - \frac{1}{2}Tg_{\mu\nu}$ has zero divergence because subtracting $\frac{1}{2}Tg_{\mu\nu}$ removes non-diverging components from the stress-energy tensor, giving the correct formula, $R_{\mu\nu} = (8\pi G/c^2)(T_{\mu\nu} - \frac{1}{2}Tg_{\mu\nu})$, which is exactly equivalent to field equation $R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = 8\pi GT_{\mu\nu}/c^2$.

Einstein originally used trial and error to discover this. In his 11 November 1915 communication to the Berlin Academy[5] Einstein suggested that the solution is that the scalar trace, T, has zero divergence. But after correspondence with Hilbert who had ignored the physics and concentrated on the least action derivation, Einstein around 25 November 1915 realized from Bianchi's identity was compatible with Hilbert's tentative more abstract and guesswork mathematical approach, and the *simplest* correction is $T_{\mu\nu} \rightarrow T_{\mu\nu} - \frac{1}{2}Tg_{\mu\nu}$, which gives zero divergence. In this nascent approach, Einstein was *exploring various possibilities and trying out general ideas to solve problems, not working on an axiomatic proof.* After Einstein had the insight from Bianchi's identity, he able to grasp the *physical significance* of the result from finding the least action to free-field "proper path" Lagrangian, $Rc^4(-g)^{1/2}/(16\pi G)$. This crucial background is often eliminated from textbooks on general relativity.

The Einstein-Hilbert Lagrangian is that for *relativistic Newtonian gravity,* dealing with *particles following the path of least action,* on the relativistic mass shell, i.e. where *curvature (field) always results from energy. By contrast, Lagrangians for fields in tested quantum field theories are based on non-classical Maxwell-Einstein and Yang-Mills field field potential amplitudes, which the Aharonov–Bohm effect justifies, allow field energy to exist in space even where there is no directly measurable (onshell) electromagnetic field present, just energy due to can-*

celled-amplitude offshell field quanta.

General relativity: energy always contributes to the gravitational field, hence all of it always flows along the path of least action. There is therefore deliberately no incorporation of other paths (hidden energy) in the Einstein-Hilbert Lagrangian of general relativity. This delusion is summed up in the field equation of general relativity, where all energy contributes to the field (curvature): no presence of energy is possible unless it contributes to the gravitational field. The whole definition of gravitational energy in general relativity limits the Lagrangian to describing only onshell energy and paths of least action. The Einstein-Hilbert Lagrangian is completely contrived and deluded, since it misses out all interference paths, which are all of the paths off the path of least action.

Quantum field theory (path integral): energy doesn't always contribute to a *field,* because *amplitudes* far off the path of least action cancel one another, although offshell *energy* exchange still occurs along such paths, as shown by the Aharonov–Bohm effect. Although the original Maxwell-Heaviside equations were analogous to Newtonian gravity in so much as they merely modelled observable fields, Einstein in 1916 reformulated them into vector potential form, which includes hidden energy where amplitudes cancel, but particle paths (offshell energy) is still present. In understanding quantum force fields, the presence of the "cancelled" non-least action paths (ignored in general relativity) are vitally important.

We in 1996 predicted the isotropic cosmological acceleration outwards $a \approx Hc$ where H is Hubble's empirical parameter (from his empirical law of galaxy cluster recession velocities, namely $v = HR$, where R is distance) from Hubble's law:

$$v = HR = Hct_{\text{past}} = Hc\,(H^{-1} - t_{\text{since big bang}}),$$

$$a = dv/dt_{\text{since big bang}} = d\,[\,Hc\,(H^{-1} - t_{\text{since big bang}})\,]/dt_{\text{since big bang}} = -Hc = -6.9 \times 10^{-10}\ \text{ms}^{-2}.$$

Because we have found that $F_{\text{gravity}} = ma\,\sigma/(4\pi R^2)$, introduction of $a = -Hc$ and $\sigma_{\text{gravity}} = \pi(2GM/c^2)^2$ from the observations in Fig. 2 give:

$$F_{\text{gravity}} = ma\,\sigma/(4\pi R^2) = -mH\,(G^2M^2/(R^2c^3).$$

Comparison of this result, $F_{\text{gravity}} = -mHc\,(G^2M^2/(R^2c^4)$, with the Newton-Laplace law $F_{\text{gravity}} = M_1M_2G/R^2$, shows that $G = c^3/(mH)$ and $M^2 = M_1M_2$, quantizing mass into similar fundamental units (http://vixra.org/abs/1111.0111).

This equation $G = c^3/(mH)$ has been investigated by others independently since our publication in 1996. Louise Riofrio empirically formulated it as $Gm = tc^3$ where t is the age of the universe ($t = H^{-1}$) without the quantum gravity theory, which shows that it is a valid and interesting result. She has suggested that the right hand side of $Gm = tc^3$ is a constant, so that light velocity varies as inversely as the cube of time, $c = (Gm/t)^{1/3}$. This is problemmatic theoretically and our approach is different, in that the time variation in $Gm = tc^3$ is due to a direct proportionality between G and t. Gravitational interaction strength is predicted here to be increasing in direct proportion to the age of the universe, as demonstrated by evidence from the small fluctuations in the cosmic background radiation proving the flatness of the universe at early times.

This flatness is due simply to a roughly 1,000 times weaker gravitational coupling at the 300,000 years CBR decoupling time, not to the theory of "inflation" which tried to reduce gravitational curvature by dispersing matter faster than the speed of light. Dirac investigated a time-varying G theory but assumed (wrongly) that it varied independently of the electromagnetic and strong couplings, which led Teller to point out in 1948 that the variation in forces in the sun would affect fusion rates incorrectly. All of the "checks" for time-variance of G are false because they make Teller's assumption (implicitly) that the gravitational coupling varies independently of the other force couplings, like electromagnetism. Force unification evidence suggests that all of the couplings vary in the same way. This negates the "no-go" G variation data of Teller and others.

For example, the fusion rate in the sun depends on gravitational compression of protons overcoming their Coulomb repulsion. if you merely vary G then fusion rates are affected, but if you double both gravity and Coulomb (both inverse square law forces), *the relative increase in gravitational compression is offset by the relative increase in Coulomb repulsion.*

Implications for dogmatically believed classical approximations like general relativity

Whenever a radically new idea that works comes along, people's first defense against progress is to point out that the new idea is "wrong" as judged from the standpoint of the previous theory. In fact, disagreements between a new theory and an old theory are not detrimental *if the new theory reproduces the empirically-confirmed predictions from the old theory in a new way.* It is not true that every new theory must contain the old theory as a subset (e.g., thermodynamics doesn't include caloric).

General relativity is today the gold standard in empirically validated gravitation, just as the Standard Model is the gold standard in empirically validated electroweak and strong interactions. It is therefore important to set out precisely what parts of these theories, general relativity and the Standard Model of particle physics, are empirically defensible and how the new theory retains those empirically-defensible predictions from the older theories.

General relativity survives as a classical approximation to gravity which makes Newtonian gravitation relativistic. All of the falsifiable predictions from general relativity such as light deflection, clock slowing in gravitational fields, excess radius, and gravitational redshift, stem from this relativistic correction, which exists in the mechanism of quantum gravity. General relativity does not correctly predict cosmological acceleration for the simple reason that it is based on Newton's delusion that gravity is a universal force, rather than being a Casimir type "attraction" due to repulsive effects originating in the distant universe pushing together local masses (which non-receding relative to one another). This mechanism for quantum gravity invalidates the application of general relativity to cosmology. Although Einstein included an ad hoc "cosmological constant" in general relativity in 1917 to try to make it model the universe, this differs from the quantum gravity mechanism we offer, which links together dark energy and gravitation, $a \approx c^4/(Gm) = 7 \times 10^{-10}$ ms^{-2}, or $\Lambda = c^4/(G^2m^2)$.

Feynman's "path integral" represents all of quantum mechanics complexity by interferences between amplitudes for small *mechanical* interactions, each represented by a Feynman diagram consisting of the exchange of a gauge boson which hits an effective interaction cross-section which is proportional to the square of the running coupling. The probability or relative cross-section for a reaction is proportional to $|\psi_{\text{effective}}|^2 = |\psi_1 + \psi_2 + \psi_3 + \psi_4 + ...|^2 = |\int e^{iS/\hbar} Dx|^2$, where ψ_1, ψ_2, ψ_3, and ψ_4 are individual wavefunction path amplitudes representing all the different ways that gauge boson exchanges mediated forces between charges in the path integral, $\int e^{iS/\hbar} Dx$. The complex wavefunction amplitude e^{iS} where S is the path action in quantum action units, is unjustified by the successes of quantum field theory where measurables (probabilities or cross-sections) are *real* scalars. So the observable resultant arrow for a path integral on an Argand diagram must be always parallel to the real axis, thus instead of e^{iS} as a unit length arrow with variable direction, can replace it by a single variable scalar quantity, $e^{iS} \rightarrow \cos S$, eliminating Hilbert space and Haag's theorem to renormalization. This reduction of quantum field theory to real space gives a provably self-consistent, experimentally checked quantum gravity. Path integral $\int e^{iS/\hbar} Dx$ is a double integral because action S is itself the integral of the lagrangian energy for a given Feynman diagram, which must be integrated over all paths not merely the classical path of least action, which only emerges classically as a result of multipath interferences, where paths with higher than minimal action cancel out.

Lagrangian for quantum gravity and SU(2) Yang-Mills mechanism for electromagnetism

Quantum gravity is a U(1) Abelian theory with only a single charge sign, which bypasses renormalization loop problems; *there is no antigravity charge,* preventing gravity-polarized pair production loops, so there is no running of the gravity coupling, thus quantum gravity renormalization is not required. Electromagnetism employs massless Yang-Mills SU(2) *charged bosons* (off-shell Hawking radiation). Cancellation of magnetic self-inductance for charged massless boson propagation necessitates a two-way exchange equilibrium of massless field quanta *charge* (the charge exchange equilibrium obviously doesn't extend to energy, since a particle's frequency can be redshifted to lower *energy* without any loss of electric *charge*), constraining to zero the Yang-Mills *net charge*-transfer current, $2\varepsilon A_\nu \times F_{\mu\nu} = 0$, reducing the total Yang-Mills current $J_\mu + (2\varepsilon A_\nu \times F_{\mu\nu}) = -dF_{\mu\nu}/dx_\nu = -d_\nu F_{\mu\nu}$ to Maxwell's $J_\mu = -d_\nu F_{\mu\nu}$, so the Yang-Mills field strength $F_{\mu\nu} = d_\mu W^a{}_\nu - d_\nu W^a{}_\mu + g\varepsilon_{abc} W^b{}_\nu W^c{}_\mu$ loses its term for the *net* transfer of charge, $g\varepsilon_{abc} W^b{}_\nu W^c{}_\mu = 0$, yielding Maxwell's $F_{\mu\nu} = d_\mu A_\nu - d_\nu A_\mu$. Notice that the weak coupling, g, occurs in the disappearing charge transfer term. The mechanism eliminates the weak dependence on mass, turning a Yang-Mills theory into an *effective* Abelian one. (See References 1, 2 and 3.)

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