# Single-Graviton Exchange as a Quantum-Gravity Check

How a shape built to explain particles reproduces gravity's quantum — at low energy

*— with an honest ledger of the Planck-scale gaps it does not close —*

*A mostly non-technical note for anyone who loves quantum physics*

*written to be checked by specialists, and read, equations and all, by everyone else*

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## Before we start

This note checks the quantum version of gravity in the simplest possible way. Classical gravity says two masses attract with $V(r) = -G_N m_1 m_2/r$. Low-energy quantum gravity says the very same force is carried by a single particle — the graviton, the massless spin-2 quantum of the gravitational field. We compute that result the standard way, then show the same low-energy graviton theory falling out of the thirteen-dimensional geometry, using the very same reduction that, in the companion gravity note, bent starlight by the right angle.

Two honest words first, and this note takes them more seriously than any other in the series. This is a **low-energy** check. It does not claim that the hard, Planck-scale problem of quantum gravity is solved — and the source corpus is emphatic on this point: it explicitly excludes quantum-gravity UV completion from what it claims. So the note has two halves. The first recovers the low-energy limit cleanly. The second is an honest ledger that classifies every remaining quantum-gravity gap as closed, conditional, scoped to low energy, inherited, or — by the corpus's own discipline — excluded. The whole value of this note is in not overclaiming. You can read every word skipping every equation.

## 1. Where this check fits, and why single-graviton exchange

This note is the fifth and last in a short series of consistency checks on one thirteen-dimensional geometry — after gravity (*The Sun as a Lens*), electromagnetism (*Hydrogen*), the weak force (*Muon Decay*), and the strong force (*The Color-Coulomb Potential*). The three force-carrier notes each showed a force emerging as the exchange of its quantum:

*one photon → the Coulomb force · one W → the muon's decay · one gluon → the color force*

Gravity completes the pattern: one graviton → Newton's force. This note is that calculation, from the same geometry. Single-graviton exchange is the clean example for the same reasons its cousins were: it uses only the low-energy gravitational zero mode; it avoids black holes, singularities, cosmology, and the Planck scale; it has a measurable classical limit (Newton's inverse-square law); it tests the genuine spin-2 structure of gravity, not merely a scalar attraction; and it is the exact gravitational echo of one-photon exchange. The question is whether the thirteen-dimensional reduction gives the same quantized four-dimensional spin-2 field, and hence the same one-graviton-exchange potential.

## 2. Route one: low-energy quantum gravity the standard way

In low-energy quantum gravity — the framework physicists call gravitational effective field theory — you start from the same Einstein–Hilbert action that governs classical gravity and expand the metric around flat spacetime, $g_{\mu\nu} = \eta_{\mu\nu} + \kappa h_{\mu\nu}$. The small fluctuation $h_{\mu\nu}$ is the graviton: a massless, spin-2 field. Expanding the matter action to first order shows how it couples — universally, to energy and momentum (the stress-energy tensor $T^{\mu\nu}$), not to any special gravitational charge:

$$L_{int} = -(\kappa/2)\, h_{\mu\nu} T^{\mu\nu}.$$

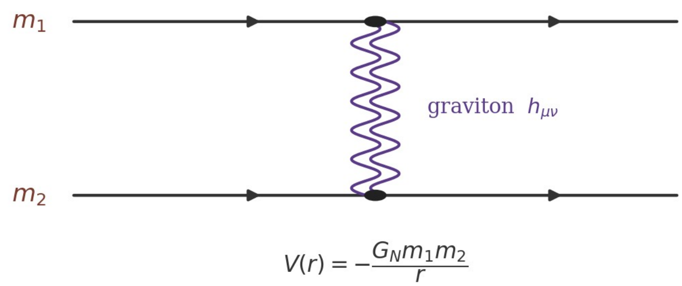


**Figure 1.** *One-graviton exchange between two slow, heavy masses. The graviton (drawn as a double wavy line, distinct from the photon and gluon) is massless and spin-2; its universal coupling to mass-energy and long-range $1/q^2$ propagator give Newton's potential.*

The graviton, being massless, carries a long-range $1/q^2$ interaction in momentum space — exactly as the massless photon does. Exchanging one virtual graviton between two slow, heavy masses and Fourier-transforming that $1/q^2$ into position space gives a $1/r$ potential, with the strength fixed by Newton's constant,

$$V(r) = -G_N m_1 m_2 / r,$$

and hence the inverse-square force $F = -G_N m_1 m_2/r^2$. Newton's law, recovered from the exchange of a single graviton — the exact gravitational echo of one-photon exchange giving Coulomb's law. Call it route one.

## 3. Route two: the same potential from the geometry

Now the same result from the thirteen-dimensional shape — and here much of the work is already done. In the companion gravity note, the shape's thirteen-dimensional Einstein–Hilbert action was reduced, on the frozen-volume branch, to the ordinary four-dimensional Einstein–Hilbert action for the massless spacetime metric, with Newton's constant fixed by the size of the internal space. That is exactly the starting action route one quantizes.

So the quantum step is identical. Expanding the reduced 4D metric around flat spacetime, $g_{\mu\nu} = \eta_{\mu\nu} + \kappa h_{\mu\nu}$, gives the graviton as the quantized fluctuation of the 4D metric's zero mode — not a particle added by hand, but the quantum of the geometry that was already there. Because the reduced action is Einstein–Hilbert, the graviton's quadratic action is the healthy massless spin-2 (Fierz–Pauli) form, its propagator is the same, and its coupling to matter is the same universal $L_{int} = -(\kappa/2) h_{\mu\nu} T^{\mu\nu}$. Every ingredient of route one is reproduced, so the one-graviton-exchange potential is the same:

$$V(r) = -G_N m_1 m_2 / r.$$

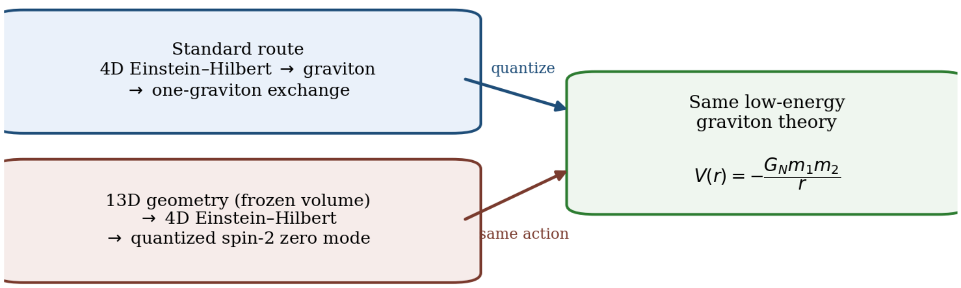


**Figure 2.** *Two routes, one low-energy graviton theory. The standard route quantizes the 4D Einstein–Hilbert action; the 13-dimensional reduction (frozen volume) gives the same action, so its quantized spin-2 zero mode reproduces the same graviton and the same Newtonian potential.*

The two routes meet at the same quantized four-dimensional Einstein–Hilbert theory.

## 4. The two routes meet

Step by step, the two routes line up on every ingredient of the low-energy theory:

| Quantity | Standard low-energy quantum gravity | 13D reduction route |
|---|---|---|
| **Starting action** | 4D Einstein–Hilbert | 13D Einstein–Hilbert → 4D (frozen volume) |
| **Quantum field** | graviton $h_{\mu\nu}$ | quantized 4D metric zero-mode fluctuation |
| **Spin / mass** | massless spin-2 | same |
| **Coupling** | universal $h_{\mu\nu} T^{\mu\nu}$ | same after reduction |
| **Propagator** | massless spin-2, $1/q^2$ | same |
| **Worked example** | one-graviton exchange | same |

| Quantity | Standard low-energy quantum gravity | 13D reduction route |
|---|---|---|
| **Potential** | −G_N $m_1 m_2$ / r | *same* |
| **Validity** | low-energy EFT below a cutoff | *same EFT, plus compactification scales* |

Once both routes reach the same 4D Einstein–Hilbert action, the same low-energy quantum-gravity predictions follow — not just Newton's potential but the whole low-energy gravitational effective theory: the graviton, its universal coupling, and a controlled tower of small corrections suppressed by high mass scales. The general statement is the same shape as for the other four forces: if the geometry reduces to the 4D Einstein–Hilbert action with frozen internal moduli and a healthy massless spin-2 zero mode, its low-energy quantum-gravity limit is ordinary perturbative quantum general relativity. But gravity carries a complication the other forces do not — and the rest of this note is devoted to being honest about it.

## 5. The honest ledger: how the Planck-scale gaps are closed, scoped, or left open

Quantum gravity differs from the other three quantum forces in one decisive way: treated as a fundamental theory valid to arbitrarily high energy, perturbative quantum general relativity is **non-renormalizable** — its short-distance behavior is not controlled the way QED's or QCD's is. The modern resolution is that it is an effective field theory: predictive and well-defined at low energy, below some cutoff, with the deep Planck-scale physics left to a separate UV completion. So a quantum-gravity 'check' must be scrupulous about which questions it answers and which it merely organizes or defers. What follows sorts every standard quantum-gravity concern into one of four honest categories: genuinely closed by the reduction, conditional on a stated assumption, scoped to the low-energy theory, or — following the corpus's own discipline — explicitly excluded.

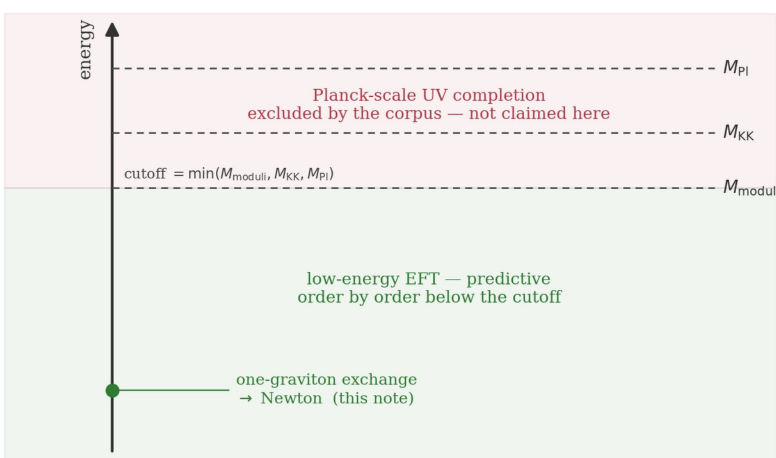

**Figure 3.** *Where the check lives. One-graviton exchange and Newton's law sit deep in the low-energy regime, where the effective theory is predictive order by order. Above the cutoff — the lowest of the moduli, Kaluza–Klein, and Planck scales — lies the Planck-scale UV completion, which the corpus explicitly excludes and this note does not claim.*

### 5.1 Where the graviton comes from, and why it is universal

In ordinary quantum gravity, one simply posits a spin-2 field. Here it is not posited: the metric is the fundamental object of the thirteen-dimensional geometry, and the graviton is the quantized fluctuation of its surviving four-dimensional zero mode. Universality comes for free in the same way — every low-energy matter sector, after reduction, lives on the one shared 4D metric, so all of it couples through the same $h_{\mu\nu} T^{\mu\nu}$. Both points are as solid as the reduction itself: solid, but conditional on the frozen-volume branch (next).

### 5.2 The fifth-force question (the key dependency)

Compactified theories famously tend to produce moduli — scalar fields measuring the size and shape of the internal space. A light modulus would mediate a long-range scalar force (a 'fifth force') and shift gravity away from pure Einstein form. This is the single most important condition in the whole gravity story, and it is the same one the companion gravity note flagged: the result holds on the frozen-volume (Einstein-frame) branch, where the internal volume is held fixed. If that modulus were instead light and dynamical, the theory would become scalar-tensor and the prediction would change measurably. The corpus carries this as a named, declared dependency (it calls it WL-1), not a closed theorem — which is exactly the right way to carry it: a falsifiable condition, not a hidden assumption.

### 5.3 Ghosts

A poorly-behaved spin-2 theory can harbor 'ghosts' — modes with wrong-sign kinetic energy that wreck quantum consistency. At leading order the reduced action is Einstein–Hilbert, whose quadratic expansion is the healthy Fierz–Pauli form with no such modes. The honest scope: this is a leading-order, low-energy statement; the higher-curvature corrections (next) are treated as small EFT terms, not as new fundamental propagating fields. Ghost-freedom is claimed for the low-energy theory around the stable branch, no more.

### 5.4 Non-renormalizability, the cutoff, and the wall

This is where honesty matters most, and where the corpus's discipline does the work. Perturbative quantum gravity is non-renormalizable as a fundamental theory, and this note does not pretend otherwise. What is recovered is the low-energy effective theory: the Einstein–Hilbert term plus a tower of higher-curvature operators ($R^2$, $R_{\mu\nu} R^{\mu\nu}$, …) suppressed by high mass scales, predictive order by order below a cutoff set by the lowest of the moduli, Kaluza–Klein, and Planck scales (Figure 3). The deep question — a finite, predictive theory valid *above* that cutoff — is the genuine Planck-scale problem of quantum gravity, and the source corpus explicitly does not claim to solve it: it lists quantum-gravity UV completion as an excluded sector, with a binding rule that forbids smuggling that difficulty back in to support any other claim. So this note inherits a clean boundary — the low-energy EFT is recovered and organized; the UV completion is, by the corpus's own statement, out of scope.

### 5.5 The classical limit, and quantum corrections

Two smaller points, handled quickly. The classical limit is not a separate assumption: the same reduced Einstein–Hilbert action gives Einstein's equations when varied (the classical reading, worked in the gravity note) and gravitons when expanded (the quantum reading) — two readings of one action. And low-energy quantum gravity predicts tiny, universal corrections to Newton's potential with specific numerical coefficients; those coefficients are standard results of the effective theory, inherited here, not separately derived by the geometry — and the note claims them only as inherited.

### 5.6 The ledger

Collected, the honest status of each standard quantum-gravity concern is this:

| Gap | Standard concern | How it is handled here | Status |
|---|---|---|---|
| **Graviton origin** | spin-2 inserted by hand | the quantized 4D metric zero mode | **closed*** |
| **Universality** | coupling could vary | all matter on the same 4D metric | **closed*** |
| **Fifth force** | light moduli → scalar force | frozen-volume (WL-1) branch | **conditional** |
| **Ghosts** | wrong-sign spin-2 modes | leading EH = Fierz–Pauli (healthy) | **conditional** |
| **Nonrenormalizability** | UV divergences | predictive EFT below cutoff | **scoped (EFT)** |
| **Cutoff** | unknown validity scale | min(M_Pl, M_KK, M_moduli) | **conditional** |
| **Classical limit** | must recover GR | same action → Einstein equations | **closed*** |
| **Quantum corrections** | loop coefficients | EFT structure inherited | **inherited** |
| **Moduli stabilization** | background must be stable | corpus certificate (Gate 6), inherited | **inherited** |
| **Black holes / UV** | high-curvature regime | not addressed; corpus excludes it | **excluded** |

(* closed *conditional on the frozen-volume reduction*.) A row marked conditional is not a failure; it is a named assumption a measurement could check. A row marked scoped means the claim is deliberately limited to the low-energy theory. A row marked excluded means the corpus, by its own rule, does not claim it — and neither does this note.

## 6. What this does, and does not, show

To size the claim with care: recovering the low-energy graviton and Newton's potential from one-graviton exchange is something any theory containing general relativity must do, and it is a real check — the spin-2 structure, the universal coupling, and the inverse-square law all had to come out right, and they do. But the list of what it does not show is, appropriately, the longest in the series: it does not prove the full Planck-scale theory; it does not establish UV finiteness or any UV completion; it does not solve black-hole entropy, evaporation, or the information problem; it does not derive the quantum-correction coefficients from the geometry; and it does not, on its own, prove that the internal moduli are stabilized — that is carried upstream in the corpus as a conditional certificate, not a theorem. It is a necessary low-energy consistency check, accompanied by an honest map of everything it leaves open.

The real evidence for the construction lives, as throughout, where it matches numbers it was never built to match — the structure of the forces, the three families, the particle properties from a handful of inputs. This last door opens onto a well-lit low-energy room and an explicitly dark Planck-scale corridor beyond it; the note's value is in marking the doorway honestly.

## 7. The seam, now closed (as far as it goes)

As with the companion notes, the step from 'the geometry contains gravity' to 'therefore the low-energy graviton theory comes out right' is written out in Appendix A — and most of it is already done, because the reduction to the 4D Einstein–Hilbert action is the same one derived in *The Sun as a Lens*. In one breath: the frozen-volume reduction gives 4D Einstein–Hilbert; expanding its metric zero mode gives a healthy massless graviton; its universal coupling and $1/q^2$ propagator give, by one-graviton exchange, $V = -G_N m_1 m_2/r$.

What the corpus establishes — at 'interface' confidence, conditional on the frozen-volume branch — is the 4D Einstein–Hilbert reduction and Newton's constant. What this note completes is the standard low-energy quantization: the graviton, its coupling, and the Newtonian potential. What is conditional is named (the modulus freeze; the leading-order, ghost-free EFT). And what is **excluded** — by the corpus's own scope discipline, not as an oversight — is the Planck-scale UV completion: the deep problem of quantum gravity is not claimed here. This note's honesty ledger exists precisely so that the strong, true statement (the low-energy limit is recovered) is never mistaken for the stronger, unproven one (quantum gravity is solved).

## Appendix A — The full chain, from the 13-dimensional action to the Newtonian potential

This appendix writes out the derivation summarized in Section 7. The reduction half is the same one derived in full in the companion note *The Sun as a Lens*; it is summarized here, and the quantization half — the new content — is written out in detail. Conventions: signature (−,+,+,+); natural units $\hbar = c = 1$ where convenient; $\mu,\nu$ = 0–3 are spacetime, a,b = 1–9 internal.

### A.1 The reduction: from 13 dimensions to 4D Einstein–Hilbert (summary)

Start from the 13D Einstein–Hilbert action and the frozen block-product geometry, with the internal volume held fixed:

$$S_{13}^{\text{grav}} = \frac{1}{2\kappa_{13}^2} \int d^{13}X \sqrt{-G}\, R_{13}[G]$$

$$X^A = (x^\mu, y^a), \qquad \mu,\nu = 0,1,2,3, \qquad a,b = 1,\ldots,9$$

$$ds_{13}^2 = g_{\mu\nu}(x)\, dx^\mu dx^\nu + \ell^2\, \gamma_{ab}(y)\, dy^a dy^b$$

$$K_9 = K_6 \times S^2 \times S^1_Y, \qquad V_9 = \ell^9 \int d^9y \sqrt{\gamma} = \text{const}$$

For the frozen product the determinant factorizes and the Ricci scalar splits, so integrating over the internal space leaves the 4D Einstein–Hilbert action with Newton's constant set by the internal volume:

$$\sqrt{-G} = \sqrt{-g}\, \ell^9 \sqrt{\gamma}, \qquad \int d^9y\, \ell^9 \sqrt{\gamma} = V_9$$

$$R_{13}[G] = R_4[g] + \ell^{-2} R_9[\gamma]$$

$$S_{13}^{\text{grav}} = \frac{1}{2\kappa_{13}^2} \int d^4x \sqrt{-g} \int d^9y\, \ell^9 \sqrt{\gamma} \left(R_4[g] + \ell^{-2} R_9[\gamma]\right)$$

$$= \frac{V_9}{2\kappa_{13}^2} \int d^4x \sqrt{-g}\, R_4[g] \; + \; \frac{1}{2\kappa_{13}^2} \int d^4x \sqrt{-g} \int d^9y\, \ell^7 \sqrt{\gamma}\, R_9[\gamma]$$

$$S_4^{\text{grav}} = \frac{V_9}{2\kappa_{13}^2} \int d^4x \sqrt{-g}\, R[g], \qquad \frac{1}{16\pi G_N} = \frac{V_9}{2\kappa_{13}^2}$$

$$S_4 = \frac{1}{16\pi G_N} \int d^4x \sqrt{-g}\, R[g] + S_{\text{matter}}[g,\Psi] + S_{\text{EFT}}$$

(The full step-by-step reduction, and its classical weak-field consequence — the bending of starlight — are in the companion gravity note. Here this reduced action is the input to quantization.)

### A.2 Quantizing the zero mode: the graviton

Expand the reduced 4D metric around flat spacetime; the fluctuation h_μν is the graviton:

$$g_{\mu\nu} = \eta_{\mu\nu} + \kappa\, h_{\mu\nu}, \qquad \kappa = \sqrt{32\pi G_N} \;\; (\hbar = c = 1), \qquad h_{\mu\nu} = \text{the graviton}$$

Because the reduced action is Einstein–Hilbert, its quadratic part is the Fierz–Pauli action — a healthy, massless, spin-2 kinetic term with no wrong-sign (ghost) modes:

$$\mathcal{L}^{(2)} = -\tfrac{1}{2}\partial_\lambda h_{\mu\nu}\partial^\lambda h^{\mu\nu} + \partial_\lambda h^\lambda{}_\nu \partial_\mu h^{\mu\nu} - \partial_\mu h^{\mu\nu}\partial_\nu h + \tfrac{1}{2}\partial_\lambda h\, \partial^\lambda h \quad \text{(Fierz\breve{}2013Pauli: massless spin-2)}$$

and after gauge fixing (for example de Donder gauge) the graviton propagator carries the long-range 1/q² of a massless field:

$$D_{\mu\nu,\alpha\beta}(q) = \frac{i}{q^2 + i\epsilon}\, P_{\mu\nu,\alpha\beta}, \qquad P_{\mu\nu,\alpha\beta} = \tfrac{1}{2}\big(\eta_{\mu\alpha}\eta_{\nu\beta} + \eta_{\mu\beta}\eta_{\nu\alpha} - \eta_{\mu\nu}\eta_{\alpha\beta}\big)$$

### A.3 Universal coupling to stress-energy

The matter stress-energy tensor is the response of the matter action to the metric,

$$T_{\mu\nu} = -\frac{2}{\sqrt{-g}}\frac{\delta S_{\text{matter}}}{\delta g^{\mu\nu}}$$

and expanding the matter action to first order in h_μν gives the universal graviton–matter coupling — to energy and momentum, not to a special charge; for slow heavy masses the dominant component is the mass-energy $T^{00}$:

$$\mathcal{L}_{\text{int}} = -\tfrac{\kappa}{2}\, h_{\mu\nu} T^{\mu\nu}, \qquad T^{00} \approx mc^2, \;\; T^{0i} \approx 0, \;\; T^{ij} \ll T^{00}$$

### A.4 One-graviton exchange and Newton’s potential

Exchanging one graviton between two nonrelativistic masses gives a tree-level amplitude carrying the 1/q² of the massless propagator:

$$\mathcal{M}(\mathbf{q}) \;\propto\; -\frac{4\pi G_N m_1 m_2}{\mathbf{q}^2}$$

and Fourier-transforming to position space turns that 1/q² into the 1/r Newtonian potential,

$$V(r) = -\int \frac{d^3\mathbf{q}}{(2\pi)^3}\, \frac{4\pi G_N m_1 m_2}{\mathbf{q}^2}\, e^{i\mathbf{q}\cdot\mathbf{r}} = -\frac{G_N m_1 m_2}{r}$$

with the corresponding inverse-square force:

$$F(r) = -\frac{dV}{dr} = -\frac{G_N m_1 m_2}{r^2}$$

This is Newton's law, recovered from quantum graviton exchange — identical between the two routes because the reduced action, propagator, and coupling are identical.

## A.5 The effective theory: corrections, cutoff, and the wall

The recovered theory is an effective field theory: the Einstein–Hilbert term plus higher-curvature operators with coefficients c_i,

$$S_{\mathrm{EFT}} = \int d^4x\, \sqrt{-g}\left[\frac{R}{16\pi G_N} + c_1 R^2 + c_2 R_{\mu\nu}R^{\mu\nu} + c_3 R_{\mu\nu\rho\sigma}R^{\mu\nu\rho\sigma} + \cdots\right]$$

predictive order by order below a cutoff set by the lowest internal scale, with corrections suppressed by powers of energy over that scale:

$$E \;\ll\; \min\bigl(M_{\mathrm{Pl}},\, M_{\mathrm{KK}},\, M_{\mathrm{moduli}}\bigr), \qquad \text{corrections} \;\sim\; \Bigl(\frac{E}{M_{\mathrm{Pl}}}\Bigr)^2,\; \Bigl(\frac{E}{M_{\mathrm{KK}}}\Bigr)^2$$

At this order the EFT also predicts small, universal quantum corrections to the Newtonian potential, whose coefficients A and B are standard results of low-energy quantum gravity (inherited here, not derived from the geometry):

$$V(r) = -\frac{G_N m_1 m_2}{r}\left[1 + A\,\frac{G_N(m_1+m_2)}{rc^2} + B\,\frac{G_N\hbar}{r^2c^3} + \cdots\right]$$

## A.6 What rests where — closed, conditional, scoped, inherited, excluded

- **What the corpus establishes directly.** The reduction of the 13D Einstein–Hilbert action to the 4D Einstein–Hilbert action for the massless metric zero mode, with Newton's constant from the internal volume — at 'interface' confidence, conditional on the frozen-volume (Einstein-frame, WL-1) branch.
- **What is completed in this note.** The standard low-energy quantization: the graviton as the Fierz–Pauli zero mode, the universal stress-energy coupling, the massless propagator, and one-graviton exchange giving $V = -G_N m_1 m_2/r$. Textbook gravitational EFT, not separately written out in the corpus.
- **What remains conditional.** The frozen-volume / modulus freeze (a light volume modulus would give a scalar-tensor fifth force); the leading-order,

ghost-free EFT statement; a defined cutoff = min(M_Pl, M_KK, M_moduli); and moduli stabilization, which the corpus carries as a certificate claim under declared assumptions (Gate 6), inherited rather than proved here.

— **What is excluded by name.** Planck-scale UV completion — a finite, predictive theory above the cutoff — together with black-hole entropy, evaporation, the information problem, and singularity resolution. The corpus explicitly lists quantum-gravity UV completion as an excluded sector, with a binding rule forbidding any claim from leaning on it. This note recovers the low-energy EFT only.

> **Closed result.** On the frozen-volume branch, the 13-dimensional Einstein–Hilbert action reduces to the 4-dimensional Einstein–Hilbert action; quantizing its massless spin-2 zero mode gives a healthy graviton with universal coupling $h_{\mu\nu} T^{\mu\nu}$ and a $1/q^2$ propagator, so one-graviton exchange reproduces $V = -G_N m_1 m_2/r$ and $F = -G_N m_1 m_2/r^2$. This is a necessary *low-energy* quantum-gravity consistency check, conditional on the frozen-volume reduction and a defined EFT cutoff — not a proof of Planck-scale quantum gravity, which the corpus explicitly excludes.

## Notes and sources

[1] The reduction of the 13D Einstein–Hilbert action to the 4D Einstein–Hilbert action — and Newton's constant from the internal volume — is in the source corpus, Paper II ('Forces'), §6.6, at interface grade conditional on the frozen volume modulus (WL-1): physics.magflowmeters.com/articles/Forces.html. The full step-by-step reduction and its weak-field consequence are written out in the companion note, *The Sun as a Lens*.

[2] The corpus explicitly excludes quantum-gravity UV completion from its claims (Paper I, 'GUT', scope ledger: "Quantum gravity UV completion — Excluded"), with a binding rule forbidding any required result from leaning on an excluded sector. This note respects that boundary: it recovers the low-energy EFT only.

[3] The frozen-volume (Einstein-frame) condition WL-1, and the quantum self-consistency / moduli-stabilization of the compactification background (a corpus certificate claim under declared assumptions, not a theorem), are discussed in Paper II §6.6–§6.8 and inherited from Paper I (Gate 6 / Appendix F).

[4] The graviton EFT — linearized Einstein–Hilbert as Fierz–Pauli, the universal $h_{\mu\nu} T^{\mu\nu}$ coupling, one-graviton exchange giving Newton's potential, and the higher-curvature corrections — is standard low-energy quantum gravity; see the gravitational effective-field-theory literature.

[5] Companion notes: *The Sun as a Lens* (gravity), *Hydrogen as a Quantum Electrostatic Check* (electromagnetism), *Muon Decay as a Weak-Force Check* (weak force), and *The Color-Coulomb Potential as a Strong-Force Check* (strong force).