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Graviton-Based Derivation of Relativistic Mass and Mercury's Orbital Precession: An Explanation Without Relativity Postulates

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1. Motivation and Context

Relativistic mass and Mercury's anomalous perihelion precession are traditionally explained by Special and General Relativity, relying on postulates about spacetime geometry and the invariance of the speed of light.

Here we explore an alternative, graviton-based picture in which:
- Gravity is mediated by quanta ("gravitons") traveling at a finite speed c.
- The effective gravitational interaction depends on the Doppler modulation of this flux.
- Relativistic formulas emerge as *consequences* of signal propagation and aberration, rather than as postulates.

We refer to this framework as the *Quo Vadis effect* (QVE), where the observer infers mass and energy from the continuous "rain" of gravitational quanta.

2. Aberration Analogy: Running in the Rain

A simple way to visualize the effect of gravity aberration is the rain seen by a runner:

- Rain falls vertically in the ground frame.
- A person running with velocity $\vec{v}_{\text{runner}}$ sees the rain coming from an angle:

$$\tan\theta = \frac{v_{\text{runner}}}{v_{\text{rain}}}.$$

- To stay dry, the umbrella must be tilted forward, even though the rain is vertical.

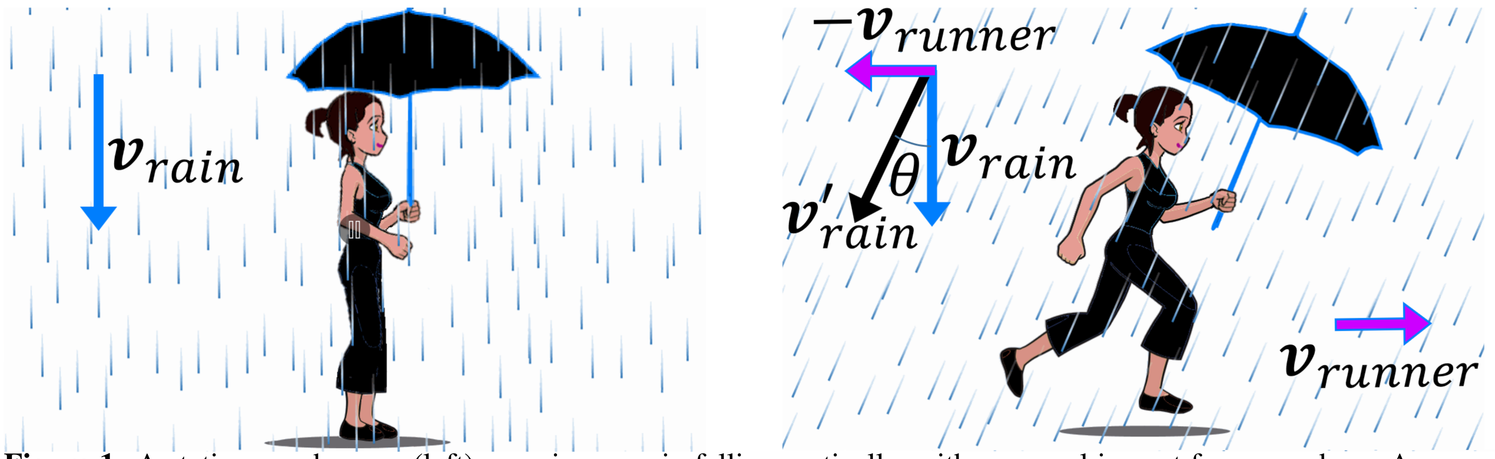

Figure 1. A stationary observer (left) experiences rain falling vertically, with a normal impact force per drop. A moving observer (right) perceives rain arriving faster and at an angle, with more raindrops per second and each drop hitting with greater force due to relative motion.

In our graviton picture:

- The "rain" is a flux of gravitons from the central mass.
- A moving planet or detector sees an *aberrated* flux and energy distribution.
- Both flux and energy per graviton are modified by Doppler factors, leading to an *effective* gravitational mass.

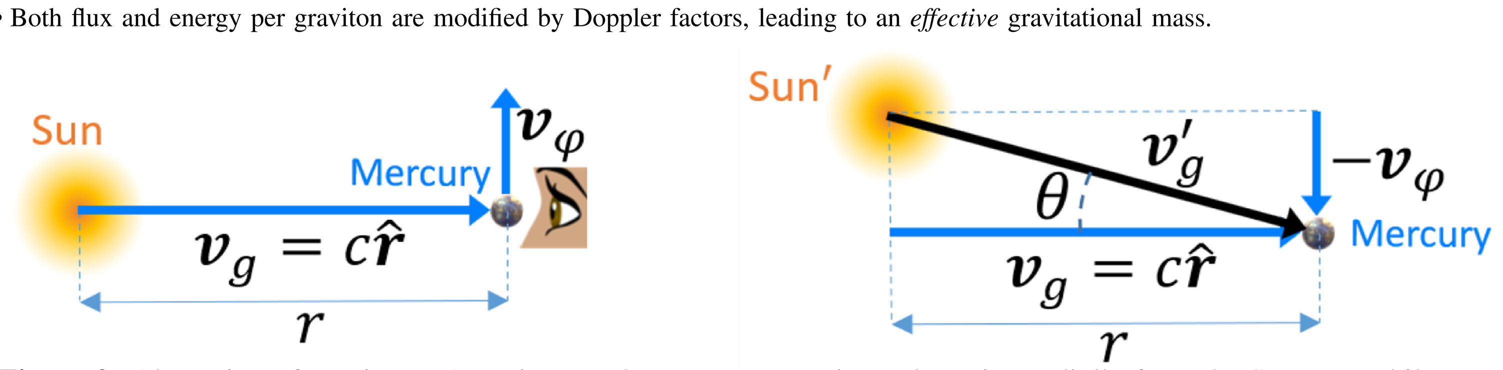

Figure 2. Aberration of gravitons. A stationary observer sees gravitons departing radially from the Sun at c, while Mercury moves at v_ϕ. From Mercury's frame, gravitons seem to originate from an apparent position (*Sun*′) and arrive with an effective speed v'_g, increasing both flux and momentum transfer.

Quantity	Inertial Frame (Observer at Rest)	Moving Frame (Mercury's Perspective)
Arrival Velocity	$v_g = c$	$v'_g = \sqrt{c^2 + {v_\varphi}^2} = c\sqrt{1 + {v_\varphi}^2/c^2}$
Graviton Flux (Number per unit time)	N	$N' = N\sqrt{1 + {v_\varphi}^2/c^2}$
Force per Graviton	$F_{single} = F/N$	$F'_{single} = F_{single}\sqrt{1 + {v_\varphi}^2/c^2}$
Total Force	$F = \frac{G\,m\,M}{r^2}$	$F' = F'_{single}N' = F\left(1 + {v_\varphi}^2/c^2\right)$

Figure 3. Summary of key quantities for a stationary versus an orbiting observer: graviton speed, flux N, force per graviton F_{single}, and total force F, highlighting the QVE correction due to transverse motion.

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3. Mercury's Perihelion Precession from Graviton Aberration

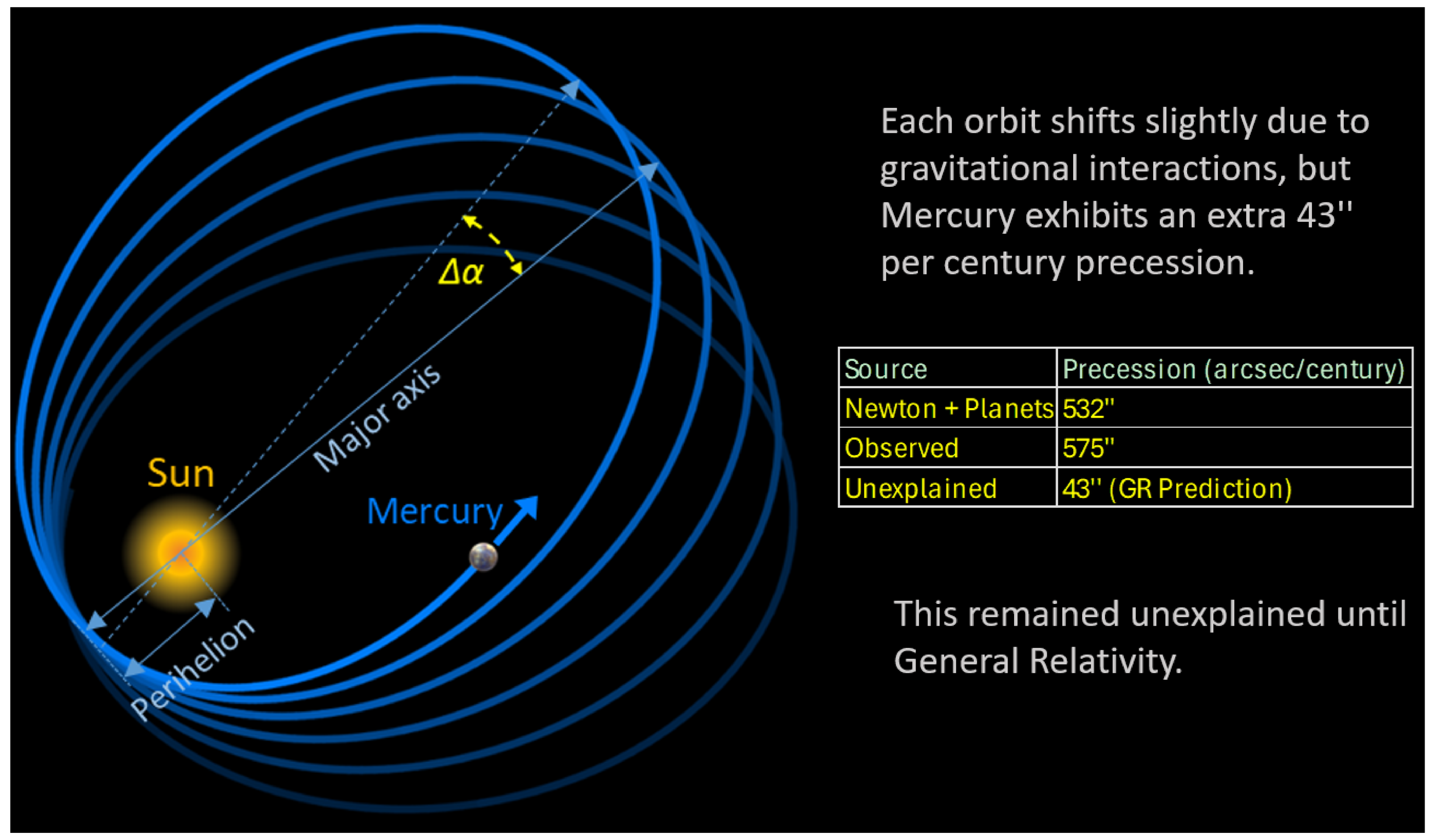

Figure 4. Schematic of Mercury's orbit and its precessing ellipse.

We model the effect of graviton aberration on the effective gravitational force felt by Mercury. Starting from the Newtonian force $F = GmM/r^2$, the QVE correction introduces a transverse-velocity term:

$$F' = F\left(1+\frac{r^2\dot{\phi}^2}{c^2}\right), \tag{1}$$

where r is the orbital radius, $\dot{\phi}$ the angular velocity, and c the graviton speed.

The corresponding gravitational potential energy is obtained by integrating the force:

$$U' = -\int F'\,dr \tag{2}$$

$$U' = -\int \frac{GmM}{r^2}\left(1+\frac{r^2\dot{\phi}^2}{c^2}\right)dr \tag{3}$$

$$U' = -\frac{GmM}{r} - \frac{GmM}{c^2}\dot{\phi}^2 r \tag{4}$$

$$U' = -\frac{GmM}{r}\left(1+\frac{r^2\dot{\phi}^2}{c^2}\right) \tag{5}$$

$$L = \mu r^2\dot{\phi} \tag{6}$$

$$r^2\dot{\phi}^2 = \frac{L^2}{\mu^2 r^2} \tag{7}$$

$$E = T + U \tag{8}$$

$$E = \frac{1}{2}\mu\dot{r}^2 + \frac{L^2}{2\mu r^2} - \frac{GmM}{r}\left(1+\frac{L^2}{\mu^2 r^2 c^2}\right) \tag{9}$$

$$E = \frac{1}{2}\mu\dot{r}^2 + \frac{L^2}{2\mu r^2} - \frac{GmM}{r} - \frac{GmM}{r}\frac{L^2}{\mu^2 r^2 c^2} \tag{10}$$

$$E = \frac{1}{2}\mu\dot{r}^2 + \frac{L^2}{2\mu r^2} - \frac{GmM}{r} - \frac{GML^2}{mc^2 r^3} \tag{11}$$

The last term in Eq. (11) reproduces the weak-field GR correction to the orbital energy. Thus, the standard GR derivation of perihelion precession applies, yielding:

$$\Delta\phi = \frac{6\pi GM}{ac^2(1-e^2)}, \tag{12}$$

where a is the semi-major axis and e the orbital eccentricity. In the QVE framework, this famous GR result emerges from graviton aberration and Doppler-modulated flux, without invoking relativistic postulates.

4. From Apparent Force to Apparent Mass

In the QVE picture, the extra term in the effective force for Mercury

$$F' = \frac{GmM}{r^2}\left(1+\frac{r^2\dot{\phi}^2}{c^2}\right)$$

can be reinterpreted as an *apparent* increase of the source mass:

$$F' = \frac{GmM_{\text{eff}}}{r^2}, \qquad M_{\text{eff}} = M\left(1+\frac{r^2\dot{\phi}^2}{c^2}\right).$$

From Mercury's point of view, the aberrated graviton rain makes the Sun behave as if it were more massive. This raises a natural question:

> **Can a similar "apparent mass" interpretation explain the relativistic mass formula $m(v) = \gamma(v)\,m_0$ found in Einstein's theory?**

To address this, we turn to a laboratory test: the **Bertozzi experiment**, where electrons are accelerated to relativistic speeds and stopped in a calorimeter.

5. Bertozzi Experiment as a QVE Testbed

In the Bertozzi experiment, electrons accelerated up to several MeV arrive at a calorimeter:

- Classically, the velocity would continue to grow with energy.
- Experimentally, the velocity saturates near c.
- Special Relativity explains this with $m(v) = \gamma(v)m_0$.

In the QVE framework:
- The calorimeter "sees" the electrons through a flux of finite-speed gravitons.
- During the rapid deceleration $v \to 0$, the perceived mass is *not* constant: it evolves with the instantaneous velocity.
- The net effect of approach + slowdown can be summarized by an effective mass $m_{\text{eff}}(v)$.

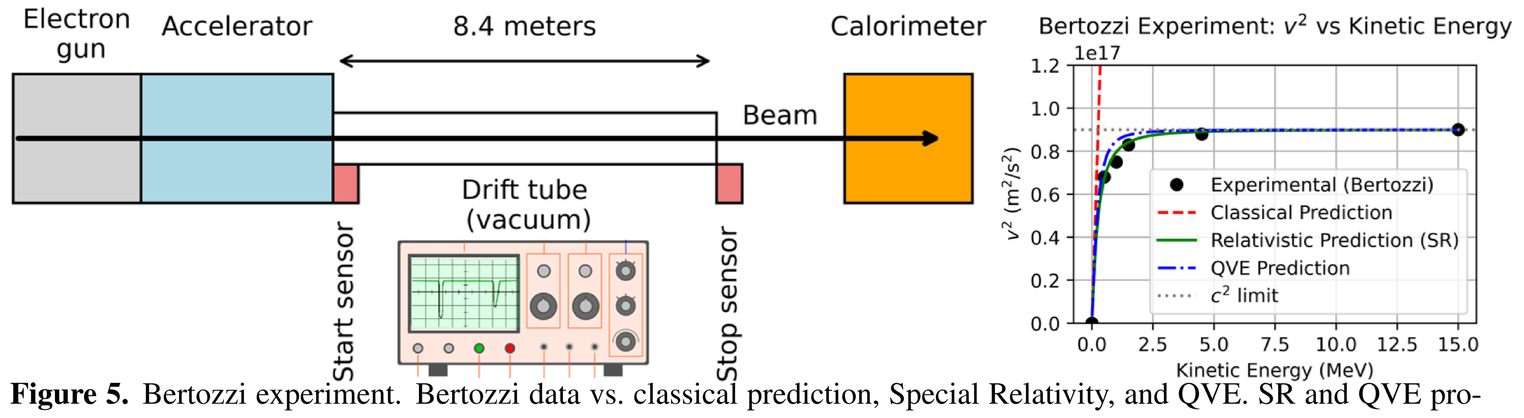

Figure 5. Bertozzi experiment. Bertozzi data vs. classical prediction, Special Relativity, and QVE. SR and QVE produce the same $v(E)$ curve, matching the observed saturation.

6. Two-Phase Doppler Interaction and Effective Mass

QVE resolves the deceleration as two complementary Doppler-like phases in the graviton signal perceived by the calorimeter:

Phase I: Blue-shift (Mustard Seed Effect)

During approach, graviton arrivals are compressed:

$$f_1 = \frac{1}{1-v/c}f_0.$$

The detector interprets this enhanced flux and momentum transfer as an *apparent mass amplification*.

Phase II: Red-shift compensation

During the rapid slowdown inside the calorimeter, the Doppler amplification fades:

$$f_2 = \frac{1}{1+v/c}f_0.$$

This compensates the blue-shifted signal without implying real mass accumulation.

Since the detector integrates both symmetric, multiplicative effects, the appropriate combination is the geometric mean:

$$f_{\text{total}} = \sqrt{f_1 f_2} = \frac{1}{\sqrt{1-v^2/c^2}} = \gamma(v).$$

Thus the detector responds *as if* the particle had a constant effective mass

$$m_{\text{eff}} = \gamma(v)m_0,$$

recovering the relativistic formula without invoking spacetime geometry.

7. Recovering Relativistic Energies from QVE

Once the effective mass satisfies $m_{\text{eff}}(v) = \gamma m_0$, the work–energy relation $\mathrm{d}E = \vec{v}\cdot\mathrm{d}\vec{p}$ with $p = \gamma m_0 v$ gives: $\mathrm{d}E = v\,\mathrm{d}(\gamma m_0 v) = m_0c^2\,\mathrm{d}\gamma$. Integrating yields:

$$K(v) = (\gamma-1)m_0c^2, \qquad E(v) = \gamma m_0 c^2,$$

so the rest energy follows immediately:

$$E_0 = m_0c^2.$$

Thus the relativistic energy formulas arise directly from the velocity-dependent inertial response encoded by QVE, without invoking relativity postulates.

8. Broader Implications (Exoplanets and Beyond)

The same graviton-aberration mechanism operates wherever there is motion through a finite-speed graviton "rain":

- **Solar System:** Mercury's perihelion precession arises from transverse graviton aberration and appears as an effective mass enhancement of the Sun.
- **Exoplanet systems:** Close-in, high-velocity planets are natural laboratories. Extra precession $\propto (v/c)^2$ could be probed via:
  - transit timing variations,
  - long-term evolution of the argument of periastron.
- **High-energy interactions:** Laboratory tests (à la Bertozzi) compare QVE-based predictions directly with SR at particle-physics energies.

9. Conclusions and Outlook

- A finite-speed, graviton-based description of gravity:
  - explains Mercury's anomalous precession via graviton aberration,
  - reproduces the relativistic mass $m(v) = \gamma(v)m_0$ through geometric averaging of Doppler-like phases,
  - and recovers $K = (\gamma-1)m_0c^2$ and $E_0 = m_0c^2$ without invoking SR postulates.
- In this QVE framework, "mass increase" is an *apparent* effect: a re-interpretation of how motion through a graviton rain modulates flux and momentum transfer.
- Exoplanetary systems and precise orbital measurements provide a promising arena to test graviton-based versus geometric (GR-like) explanations.
- Future work: extend QVE applications to strongly eccentric exoplanets, multi-planet resonant chains, and galactic-scale dynamics where velocity-dependent effects may accumulate.

10. Acknowledgments

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