The Quo Vadis Effect: A Graviton-Based Explanation of Mercury's Perihelion Precession

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Abstract

We propose the Quo Vadis Effect (QVE), a velocity-dependent correction to Newtonian gravity arising from gravitational aberration. Unlike General Relativity (GR), which explains Mercury's perihelion precession via space-time curvature, the QVE operates within a Newtonian framework without modifying the geometry of space-time.

The core mechanism of the QVE is that an orbiting body perceives gravitons arriving at an apparent velocity greater than $\boldsymbol{c}$ due to aberration. This results in two simultaneous effects: (1) an increased flux of gravitons and (2) an enhanced force per graviton, leading to a total gravitational force correction proportional to $\boldsymbol{(1+(r\dot{\phi}/c)^2)}$. This correction modifies the gravitational potential energy, reproducing the standard GR prediction for Mercury's perihelion precession.

A similar velocity-dependent correction was previously explored by Wayne (2015), albeit without a clear physical derivation, speculating on possible friction-like effects. In contrast, the QVE provides a well-defined mechanism based on gravitational aberration.

Beyond Mercury's orbit, the QVE may have broader implications, including potential corrections to GPS satellite clocks and alternative explanations for galaxy rotation curves without invoking dark matter. Additionally, it may offer insights into cosmic acceleration if graviton propagation exhibits similar aberration effects at cosmological scales.

Given the ongoing debate surrounding modified gravity theories, this work aims to contribute to the discussion by demonstrating that a Newtonian approach incorporating gravitational aberration can recover key relativistic results. The

QVE suggests a possible bridge between classical mechanics and quantum gravity, warranting further investigation.

Keywords: Classical Mechanics, General Relativity Alternatives, Quo Vadis Effect (QVE), Mercury Orbital Precession, Gravitational Aberration, Quantum Gravity

1 Introduction

Newtonian gravity has successfully explained a wide range of gravitational phenomena, from planetary motion to tidal forces. However, deviations from its predictions have emerged at higher precision and larger scales. One of the most well-known cases is Mercury's anomalous perihelion precession, which remained unexplained until Einstein's General Relativity (GR) provided a correction.

Despite its successes, GR faces several unresolved challenges. The observed anomalies in galaxy rotation curves [1] and the accelerated expansion of the universe [2] have led to the introduction of hypothetical components such as dark matter and dark energy. These elements account for 96% of the total mass-energy budget of the universe, yet their nature remains unknown. Furthermore, discrepancies in the measurements of the Hubble constant, known as the Hubble tension [3], suggest that our current understanding of gravity may be incomplete. As a result, various alternative models, including Modified Newtonian Dynamics (MOND) [4], Conformal Gravity [5], Quantum Gravity [6], and other modified gravity theories, have been proposed to address these issues.

To explain Mercury's perihelion precession without invoking spacetime curvature, Wayne [7] introduced a velocity-dependent correction to Newton's law of gravitation. Although his model successfully reproduced the observed precession, its underlying physical principles remained unclear, leading him to speculate about possible friction-like effects. This gap in fundamental understanding motivates the need for a more physically grounded explanation.

In this context, we introduce the Quo Vadis Effect (QVE), a novel framework that modifies gravitational interactions by incorporating velocity-dependent effects. Unlike GR, which describes gravity through spacetime curvature, the QVE remains within a Newtonian framework while introducing corrections that emerge at different scales. This approach is motivated by the fact that gravitational waves travel at the speed of light c, as confirmed by LIGO [8] and Virgo [9], suggesting that gravity may exhibit velocity-dependent effects that alter its classical behavior. Furthermore, if gravitons exist, they may exhibit quantum-like statistical behaviors that influence their effective propagation, leading to emergent gravitational phenomena.

By applying the QVE, we demonstrate that it provides an alternative explanation for Mercury's perihelion precession, offering a correction that aligns with observations without invoking spacetime curvature. Additionally, the QVE could naturally account for the observed rotation curves of galaxies and the universe's accelerated expansion without requiring dark matter or dark energy. This suggests that gravitational interactions at cosmic scales may emerge from underlying quantum-statistical effects rather than modifications of spacetime geometry.

These findings suggest that the QVE framework could provide an alternative perspective on gravitational physics, offering insights into topics ranging from planetary dynamics to cosmology. This work aims to contribute to the ongoing discussion on possible extensions or modifications to gravitational theory while remaining consistent with observational data.

We structure this paper as follows: In Section 2, we review the classical explanation of Mercury's perihelion precession. Section 3 outlines the General Relativity solution to this problem. In Section 4, we introduce the QVE framework and apply it to gravity. We explore other potential applications in Section 5. Finally, in Section 6, we summarize our findings and discuss their implications in the context of gravitational theory and astrophysical phenomena.

2 Perihelion Precession of Mercury

In Newtonian mechanics, a two-body system follows elliptical orbits, with one focus at the system's center of mass, as dictated by Newton's Law of Universal Gravitation [10]. The gravitational force between two masses is given by:

$$F = \frac{Gm_1 m_2}{r^2} \tag{1}$$

where F represents the gravitational force, m_1 and m_2 are the masses of the two objects, G is the gravitational constant, and r is the distance between their centers of mass.

When one mass is significantly greater than the other, we can approximate the center of the heavier mass to be at one of the foci of the elliptical orbit of the lighter object. We denote these masses as M (heavier) and m (lighter). If no external forces act on the system, the elliptical shape of the orbit remains unchanged, and both the total energy (E) and the angular momentum (L) are conserved [10].

$$E = T + U \tag{2}$$

where T and U are the kinetic and potential energies, respectively. The angular momentum in polar coordinates is given by:

$$L = \mu r^2 \dot{\phi} \tag{3}$$

where ϕ is the angular coordinate (azimuth), r is the radial distance between m and M, and μ is the reduced mass, defined as $\mu = mM/(m+M)$. Notice that when $m \ll M$, we can approximate $\mu \approx m$.

Since the kinetic energy is given by:

$$T = \frac{1}{2}\mu v^2 = \frac{1}{2}\mu\left(\dot{r}^2 + \left(r\dot{\phi}\right)^2\right), \tag{4}$$

where $v^2 = \dot{r}^2 + \left(r\dot{\phi}\right)^2$ (see Figure 1), and the gravitational potential energy is:

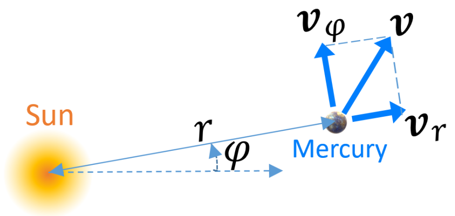

Fig. 1 Mercury's velocity relative to the Sun. Here, r is Mercury's distance from the Sun, ϕ is the angular position, $\mathbf{v}$ is its velocity, and $\mathbf{v}_r = \dot{r}\hat{r}$ and $\mathbf{v}_\phi = r\dot{\phi}\hat{\phi}$ are the radial and azimuthal components of $\mathbf{v}$ in cylindrical coordinates. The Sun is at the origin, and Mercury's orbit lies in the $z = 0$ plane.

$$U = -\frac{GmM}{r}, \tag{5}$$

the total energy equation becomes:

$$E = \frac{1}{2}\mu\dot{r}^2 + \frac{L^2}{2\mu r^2} - \frac{GmM}{r}. \tag{6}$$

From Equation (3), we obtain $r\dot{\phi} = L/\mu r$. Substituting this into (6), we derive the equation for the orbital shape [10]:

$$r(\phi) = \frac{L^2}{\mu GmM\,(1 - e\cos\phi)} \tag{7}$$

which describes an elliptical orbit with eccentricity e, where:

$$e = \sqrt{1 + \frac{2EL^2}{\mu\,(GmM)^2}}. \tag{8}$$

However, in the Solar System, gravitational perturbations from other planets cause a slow precession (rotation) of planetary orbits. Mercury's orbit exhibits such an effect (see Figure 2), where the perihelion (the point of closest approach to the Sun) shifts slightly each revolution by an angle $\Delta\alpha$. In 1859, the French astronomer Urbain Le Verrier observed that, beyond the precession caused by planetary perturbations, Mercury's perihelion exhibited an additional precession of approximately 38 arcseconds per century [11], later refined to about 43 arcseconds per century [12], which Newtonian mechanics could not fully explain. Several hypotheses were proposed, including the existence of an undiscovered planet, *Vulcan*, orbiting closer to the Sun [13], but no such planet was ever found.

The only successful explanation to date comes from General Relativity, which describes gravity as the curvature of spacetime.

3 General Relativity Solution

Newton recognized that small perturbations in the gravitational force (and hence the potential energy) could account for orbital precession [10, 14]. In GR, this idea is extended through the energy equation derived from the Lagrangian of the geodesic

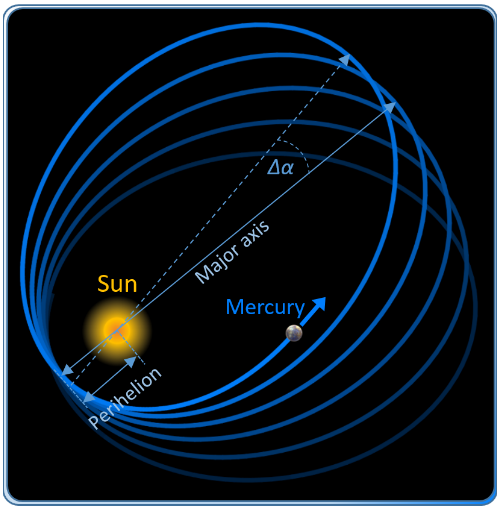

Fig. 2 The precession of Mercury's perihelion, where $\Delta\alpha$ represents the shift in the perihelion position after each orbit. This effect, exaggerated for clarity, corresponds to the precession described by Equation (11).

equation, as detailed in Cheng [15] and Eigenchris [16]. The GR-corrected energy equation is:

$$E = \frac{1}{2}\mu\dot{r}^2 + \frac{L^2}{2\mu r^2} - \frac{GmM}{r} - \frac{GML^2}{mc^2r^3}, \tag{9}$$

where the additional term $-GML^2/mc^2r^3$ represents the relativistic correction, modifying the orbit's angular frequency and leading to the observed precession of Mercury's perihelion.

Applying the same methodology as in the Newtonian case [10], but incorporating the relativistic term, the modified orbit equation becomes:

$$r(\phi) = \frac{L^2}{\mu GmM\,(1 - e\cos((1-\eta)\phi))}, \tag{10}$$

where $\eta = 3\,(MGm/cL)^2$ introduces the relativistic shift. The cumulative advance of the perihelion per orbital revolution is:

$$\Delta\phi = \frac{6\pi MG}{ac^2\,(1-e^2)}, \tag{11}$$

which successfully explains the observed $\sim 43''$ per century shift in Mercury's perihelion. This derivation follows from detailed treatments in Cheng [15] and Eigenchris [16].

4 Methodology

The Quo Vadis Effect (QVE) modifies Newtonian gravity by incorporating relativistic effects of gravitational aberration. However, unlike General Relativity (GR), the QVE operates in a Newtonian space-time framework, where absolute space and time exist. In this framework, the speed of gravity remains constant relative to the emitting source. Still, the relative velocities between observers and the propagation fronts can differ from c. Importantly, this approach does not rely on space-time curvature or relativistic geodesics, reinforcing its purely Newtonian nature.

4.1 Aberration and the apparent velocity of gravitons

To understand this effect, we use an analogy with rain. Figure 3 illustrates how a runner perceives falling rain at an apparent angle due to her motion. Likewise, if gravity is mediated by gravitons traveling at a finite speed rather than acting instantaneously, an orbiting planet would not perceive gravitons arriving directly from their source (e.g., the Sun) but rather from an apparent shifted source due to aberration. This effect is analogous to the aberration of light described by Bradley [17].

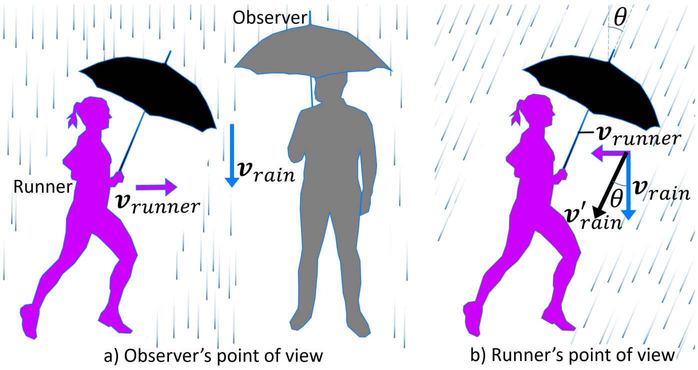

Fig. 3 Aberration of rain: (a) A stationary observer sees the rain falling vertically, while a moving runner (magenta) passes through it. (b) From the runner's perspective, the rain appears to arrive at an angle, requiring her to tilt the umbrella

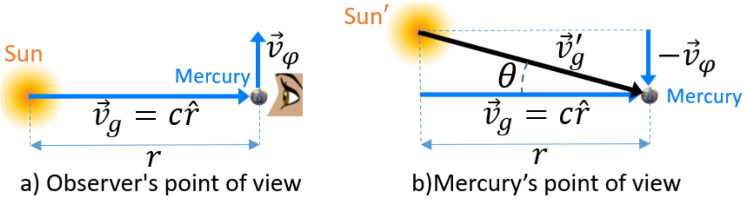

Fig. 4 Aberration of gravitons: (a) A stationary observer sees gravitons departing from the Sun at speed c, while Mercury moves transversally at v_ϕ. (b) From Mercury's frame of reference, gravitons appear to originate from an apparent shifted position (Sun') and arrive at an increased speed $v'_g = \sqrt{c^2 + (r\dot{\phi})^2}$ due to aberration.

As illustrated in Figure 4(a), a stationary observer perceives gravitons departing from the Sun at $v_g = c$, while Mercury moves transversally at $v_\phi = r\dot{\phi}$, where $\dot{\phi}$ is Mercury's angular velocity. However, from Mercury's perspective, Figure 4(b), gravitons appear to arrive from an apparent source (Sun') at a velocity:

$$\mathbf{v}'_g = \mathbf{v}_g - \mathbf{v}_\phi \tag{12}$$

The magnitude of $\mathbf{v}'_g$ is:

$$|\mathbf{v}'_g| = \sqrt{|\mathbf{v}_g|^2 + |\mathbf{v}_\phi|^2} = \sqrt{c^2 + (r\dot{\phi})^2} = c\sqrt{1 + (r\dot{\phi}/c)^2} \tag{13}$$

Thus, from the moving observer's frame, gravitons appear to arrive at an increased velocity due to aberration.

4.2 Increase in the flux of gravitons

Since gravitons arrive faster from the observer's perspective, the number of gravitons detected per unit time increases. We define the *graviton flux* N as the number of gravitons reaching the observer per unit time in a stationary frame. Due to the increased arrival speed, the flux perceived by a moving observer N' is given by:

$$N' = N\sqrt{1 + \frac{r^2\dot{\phi}^2}{c^2}} \tag{14}$$

4.3 Increase in the force per graviton

Each graviton also carries more momentum due to its increased velocity. Since force is the rate of momentum transfer, the force exerted by a single graviton is denoted as F_{single}, and its modified version in the moving frame is:

$$F'_{\text{single}} = F_{\text{single}}\sqrt{1 + \frac{r^2\dot{\phi}^2}{c^2}} \tag{15}$$

Thus, each graviton contributes a slightly stronger force due to the increase in velocity.

4.4 Total force correction due to QVE

The total gravitational force F' experienced by the moving observer is determined by the combined effect of (i) a greater number of gravitons arriving per unit time, and (ii) each graviton exerting a stronger force. Since the total force is given by the sum of individual forces:

$$F' = N' F'_{\text{single}} \tag{16}$$

Substituting Equations (14) and (15):

$$F' = (N\sqrt{1 + \frac{r^2\dot{\phi}^2}{c^2}}) \times (F_{\text{single}}\sqrt{1 + \frac{r^2\dot{\phi}^2}{c^2}}) \tag{17}$$

Since $F_{\text{single}} = F/N$ in the stationary frame, we obtain:

$$F' = F\left(1 + \frac{r^2\dot{\phi}^2}{c^2}\right) \tag{18}$$

where $F = \frac{GmM}{r^2}$ is the standard Newtonian gravitational force experienced in the absence of motion-induced corrections.

4.5 Energy Equation Correction

The corresponding gravitational potential energy can be obtained by integrating the force [18]:

$$U' = -\int F' dr \tag{19}$$

Substituting F' from Eq. (18):

$$U' = -\int \frac{GmM}{r^2}\left(1 + \frac{r^2\dot{\phi}^2}{c^2}\right) dr \tag{20}$$

Splitting the integral:

$$U' = -GmM\int \frac{1}{r^2} dr - \frac{GmM}{c^2}\int \frac{r^2\dot{\phi}^2}{r^2} dr \tag{21}$$

Evaluating the integrals:

$$U' = -\frac{GmM}{r} - \frac{GmM}{c^2}\dot{\phi}^2 r \tag{22}$$

Factoring out the common term:

$$U' = -\frac{GmM}{r}\left(1 + \frac{r^2\dot{\phi}^2}{c^2}\right) \tag{23}$$

From this, the total energy equation follows:

$$E = \frac{1}{2}\mu\dot{r}^2 + \frac{L^2}{2\mu r^2} - \frac{GmM}{r}\left(1 + \frac{r^2\dot{\phi}^2}{c^2}\right) \tag{24}$$

Since the angular momentum is defined as:

$$L = \mu r^2\dot{\phi} \tag{25}$$

we can express $r^2\dot{\phi}^2$ in terms of L:

$$r^2\dot{\phi}^2 = \frac{L^2}{\mu^2 r^2} \tag{26}$$

Substituting Equation (26) into Equation (24):

$$E = \frac{1}{2}\mu\dot{r}^2 + \frac{L^2}{2\mu r^2} - \frac{GmM}{r}\left(1 + \frac{L^2}{\mu^2 r^2 c^2}\right) \tag{27}$$

Expanding the terms:

$$E = \frac{1}{2}\mu\dot{r}^2 + \frac{L^2}{2\mu r^2} - \frac{GmM}{r} - \frac{GmM}{r}\frac{L^2}{\mu^2 r^2 c^2} \tag{28}$$

Since $\mu \to m$ when $m \ll M$, we simplify:

$$E = \frac{1}{2}\mu\dot{r}^2 + \frac{L^2}{2\mu r^2} - \frac{GmM}{r} - \frac{GML^2}{mc^2 r^3} \tag{29}$$

Since Eq. (29) matches the weak-field energy equation of GR, the standard derivation of orbital precession in GR applies [15, 16]. Specifically, using the effective potential approach, the additional term $-\frac{GML^2}{mc^2 r^3}$ leads to the well-known first-order correction to the orbital motion, resulting in the classical GR prediction for the perihelion shift:

$$\Delta\phi = \frac{6\pi GM}{ac^2(1-e^2)} \tag{30}$$

4.6 Applicability to Both Ballistic and Wave Interpretations

The methodology presented here applies equally to both ballistic and wave-like interpretations of gravitons, as long as the radial velocity remains negligible. The key aspect of the QVE is the observer's relative motion with respect to the source, leading to an increased arrival rate of gravitons and an effective enhancement of the gravitational interaction.

In the ballistic interpretation, this effect manifests through the increased arrival of gravitons, each contributing more gravitational pull. In the wave interpretation, it results in a frequency shift that effectively amplifies the gravitational potential. Despite their conceptual differences, both perspectives yield the same velocity-dependent correction to the Newtonian energy equation, leading to the same precession result.

This suggests that the QVE is a fundamental consequence of gravity's propagation, independent of the specific nature of the graviton. Whether gravity is mediated by discrete particles (ballistic view) or continuous waves, the aberration-induced velocity correction remains unchanged, reinforcing the effect's robustness.

However, the graviton's true nature could be determined in scenarios where the radial velocity component becomes significant. In such cases, potential deviations between the ballistic and wave interpretations may arise, offering a means to distinguish between them. Exploring these high-velocity regimes (such as in binary pulsars, gravitational wave propagation, or extreme astrophysical environments) could provide valuable insight into the fundamental nature of gravity.

4.7 Comparison with Previous Work

A similar velocity-dependent correction was explored by Wayne [7], but it lacked a clear physical derivation, speculating on possible friction-like effects in gravitational interactions. In contrast, the QVE provides a direct mechanism based on gravitational aberration, offering a well-defined interpretation of the velocity-dependent correction.

4.8 Summary of the QVE Mechanism

The Quo Vadis Effect (QVE) introduces a velocity-dependent correction to Newtonian gravity by incorporating a finite propagation speed for gravity, leading to gravitational aberration. Unlike Newtonian gravity, where gravitational effects are instantaneous, the QVE assumes that gravitons—if they exist—propagate at a finite speed, similar to light. This results in two key effects:

1. **Gravitational aberration:** The finite speed of gravitons causes an apparent shift in their source position as seen by a moving observer. For an orbiting body, this shift leads to an increase in the perceived speed of gravitons:

$$v'_g = c\sqrt{1 + (r\dot{\phi}/c)^2}. \tag{31}$$

2. **Modification of the gravitational interaction:** Due to this increased velocity, both the number of gravitons reaching the observer per unit time and the force exerted by each graviton are enhanced, leading to a total force correction of

$$F' = F\left(1 + \frac{r^2\dot{\phi}^2}{c^2}\right). \tag{32}$$

This effect depends on the observer's motion. In the case of an orbiting body, where the motion is primarily transverse, the apparent velocity of gravitons increases. A similar increase occurs for an observer in free fall towards the source. However, for an observer moving radially away, the opposite effect takes place: the apparent velocity of gravitons decreases, leading to a reduction in the effective gravitational force. Investigating these cases in more general gravitational scenarios could provide further insights into the nature of gravitational propagation.

The velocity-dependent correction derived from the QVE leads to an energy equation that is mathematically identical to the weak-field approximation of General Relativity, thereby offering a Newtonian-based explanation for Mercury's perihelion precession without requiring spacetime curvature.

Beyond planetary motion, the increased graviton flux predicted by the QVE suggests a potential connection between gravity and quantum mechanics. This could imply that gravitational interactions are mediated by discrete quanta (gravitons) whose effective density and momentum transfer are influenced by motion-related effects. While speculative, this perspective opens new possibilities for understanding gravity beyond Newtonian and relativistic frameworks.

5 Other Potential Applications of the QVE

If the Quo Vadis Effect (QVE) is a fundamental property of gravity, its implications could extend beyond Mercury's perihelion precession. In this section, we explore two concrete applications where the QVE may play a significant role: corrections to the clocks of the Global Positioning System (GPS) and the rotation of galaxies. Additionally, we briefly discuss its potential relation to the accelerated expansion of the universe.

5.1 Correction of GPS Clocks Using the QVE

The Global Positioning System (GPS) relies on precise time corrections due to both gravitational time dilation and motion-induced effects. In standard relativistic treatments, these corrections arise from the Schwarzschild metric, leading to a frequency shift of approximately 5.3×10^{-10}, which translates into a daily adjustment of 45.8 μs for GPS satellite clocks [19].

Within the QVE framework, a similar gravitational correction emerges due to the velocity-dependent modification of the gravitational potential. This effect leads to an effective frequency shift that closely aligns with standard relativistic predictions. While this suggests that the QVE could provide an alternative formulation for satellite-based timekeeping, a more detailed analysis (including second-order velocity-dependent corrections) would be necessary to fully assess its implications for practical applications in global navigation systems.

5.2 Galaxy Rotation and Velocity Curves

Another phenomenon where the QVE could have significant implications is the rotation of galaxies. Traditionally, galaxy rotation curves have been one of the primary arguments for the existence of dark matter [1]. However, preliminary analysis suggests that incorporating the correct Newtonian velocity profile, without invoking dark matter, may already provide a more accurate fit to observed galactic rotation curves. A detailed presentation of these results is currently in preparation for a future article.

The QVE introduces a slight increase in the velocities of stars within a galaxy due to gravitational aberration. While this effect is small compared to the standard Newtonian profile, it contributes to a differential precession of stellar orbits. Over cosmological timescales, this phenomenon could influence the formation and stability of spiral arms in galaxies such as the Milky Way. Further analysis is required to determine whether this mechanism could account for observed rotation curves without additional dark mater.

5.3 Expansion of the Universe

Finally, the Quo Vadis Effect (QVE) may offer new insights into the accelerated expansion of the universe. In standard cosmological models, this acceleration is attributed to dark energy [2]. However, if gravitons propagate at a finite speed and experience an analogous aberration effect on cosmological scales, this could lead to modifications in large-scale gravitational interactions.

The key aspect of the QVE is that the apparent velocity of gravitons depends on the observer's motion relative to the source. In most local gravitational systems, this results in an enhancement of the gravitational interaction. However, for objects receding from each other (such as distant galaxies following the Hubble flow) the opposite effect could occur: the apparent velocity of gravitons would decrease, effectively weakening gravitational attraction over large distances.

This suggests a possible connection between the QVE and cosmic acceleration. If gravitational interactions become weaker at cosmological scales due to aberration effects, this could mimic the repulsive influence attributed to dark energy. While this idea remains speculative, future observations of large-scale structure formation, gravitational wave propagation across cosmological distances, or precise measurements of cosmic expansion could help determine whether the QVE contributes to this phenomenon.

6 Discussion and Summary

In this paper, we have proposed an alternative explanation for Mercury's anomalous perihelion precession, a phenomenon traditionally explained only by General Relativity (GR). Our approach is based on the Quo Vadis Effect (QVE), which introduces a finite speed for gravitational interactions, leading to gravitational aberration while remaining within a Newtonian framework, without invoking space-time curvature.

Unlike Newtonian gravity, where gravitational effects are instantaneous, the QVE assumes that gravity propagates through discrete gravitons at a finite speed, analogous to light. This leads to an important consequence: the apparent velocity of gravitons depends on the motion of the observer.

In the specific case of an orbiting body with a dominant transverse velocity, gravitons appear to arrive at a speed greater than c. This results in two simultaneous effects:

- **Increased graviton flux:** Due to the relative motion between the source and observer, the number of gravitons reaching Mercury per unit time increases by a factor of $\sqrt{1 + (r\dot{\phi}/c)^2}$.
- **Enhanced force per graviton:** Since gravitons arrive with a higher velocity, they transfer more momentum, strengthening the gravitational interaction by the same factor.

As a result, the total gravitational force is modified by a factor of $(1 + (r\dot{\phi}/c)^2)$, leading to a correction in the gravitational potential energy. Remarkably, this correction exactly reproduces the GR prediction for Mercury's perihelion precession, yet it emerges entirely within a Newtonian framework. This suggests that certain relativistic effects may be explained not through space-time curvature but rather as a consequence of gravitational aberration, potentially hinting at a deeper connection with quantum gravity.

A similar velocity-dependent correction was previously explored by Wayne [7], but it lacked a clear physical derivation and speculated on possible friction-like effects. In contrast, the QVE provides a direct mechanism based on gravitational aberration, offering a well-defined interpretation of the effect.

Beyond Mercury's perihelion precession, we briefly explored broader astrophysical implications of the QVE. In particular, we discussed its potential relevance to galaxy rotation curves, which are often cited as evidence for dark matter [1]. While a detailed analysis is beyond the scope of this paper, preliminary results suggest that a corrected Newtonian velocity profile (without invoking dark matter) may already provide a better fit to observations. A more comprehensive study of this effect will be presented in future work.

In summary, the QVE offers a classical yet powerful explanation for Mercury's perihelion precession and other astrophysical phenomena, remaining fully within a Newtonian perspective while naturally reproducing key relativistic results. Unlike GR, it does not rely on space-time curvature, instead suggesting that apparent relativistic corrections emerge due to the finite propagation speed of gravity. This perspective may serve as a step toward a more complete understanding of gravity, potentially bridging classical and quantum descriptions.

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