Graviton-Based Mass Relativity via the Quo Vadis Effect

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Abstract

We present a graviton-based reinterpretation of relativistic mass increase grounded in the Quo Vadis Effect (QVE), a framework in which gravitational interactions are mediated by finite-speed messengers, without invoking spacetime curvature or Lorentz transformations. Applied to the Bertozzi experiment, where electrons accelerated through known voltages exhibit an asymptotic velocity limit, we show that the observed behavior arises from Doppler-like modulation of gravitational signaling.

In this view, the effective mass perceived by the calorimeter is not an intrinsic property, but a result of the timing and momentum of incoming gravitons. The familiar relativistic correction factor $\boldsymbol{\gamma(v)}$ emerges naturally as a geometric average of two distinct signal regimes: a blue-shifted approach phase, termed the *Mustard Seed Effect*, and a red-shifted attenuation phase during deceleration.

This mechanism reproduces the predictions of Special Relativity while offering a Newtonian interpretation rooted in finite-speed information transfer. The QVE also generalizes to other phenomena, such as Mercury's perihelion precession and cosmic expansion, where apparent mass varies with interaction geometry and duration. These findings suggest a broader framework in which relativistic-like effects emerge from the dynamics of signal perception, bridging classical, relativistic, and potentially quantum domains.

Keywords: Classical Mechanics, General Relativity Alternatives, Quo Vadis Effect (QVE), Bertozzi Experiment, Relativistic Mass, Mustard Seed Effect, Graviton

1 Introduction

The concept of mass increasing with velocity has historically been associated with Einstein's theory of Special Relativity (SR), where the inertial mass of a particle becomes a function of its speed via the Lorentz factor $\gamma(v) = 1/\sqrt{1 - v^2/c^2}$ [1]. However, this interpretation assumes a spacetime framework governed by Lorentz invariance and geometrical transformation laws.

In this work, we propose an alternative approach based on the *Quo Vadis Effect* (QVE), a velocity-dependent correction derived from gravitational aberration due to the finite speed of interaction propagation. The QVE remains within a Newtonian framework, yet introduces relativistic-like corrections without modifying the geometry of spacetime. This is achieved by modeling gravity as mediated by gravitons traveling at a finite speed (equal to c), whose angular distribution and apparent momentum change with the motion of the particle being observed. A first application of this framework was used to recover the relativistic perihelion precession of Mercury from Newtonian dynamics [2], suggesting that relativistic effects can emerge from aberration-driven corrections without invoking spacetime curvature.

A particularly striking manifestation of the QVE appears during high-speed collisions, where an approaching particle generates an intensified gravitational signal due to Doppler compression. This apparent mass amplification, later compensated during deceleration, forms what we refer to as the *Mustard Seed Effect*: a small intrinsic mass, when moving at relativistic speeds, produces a disproportionately large perceptual increase in inertia, much like a tiny seed growing into a vast result. This notion captures the conceptual departure from classical mechanics and lays the foundation for understanding relativistic mass within a Newtonian-like framework.

We focus on the classical experiment of Bertozzi [3], where electrons are accelerated through known electric potentials and their terminal velocities are measured. The results showed that, despite the continual increase in kinetic energy ($K = qV$), the velocity asymptotically approaches the speed of light, contradicting classical mechanics but in full agreement with SR predictions.

Our aim is to show that this behavior can also be explained by the QVE: as the electron accelerates, its velocity increases due to the electric potential, but the kinetic energy measured by the calorimeter reflects an effective mass that also increases due to gravitational (or field-like) perception effects. This provides a self-consistent explanation of the Bertozzi data without invoking spacetime curvature or relativistic postulates.

The document is structured as follows:

- Section 2 revisits the Bertozzi experiment and presents the derivation of effective mass from the Quo Vadis Effect using geometric averaging.
- Section 3 presents the derivation of effective mass from the QVE
- Section 4 discusses the broader implications of the QVE for gravitational theory, cosmology, and unification.
- Section 5 offers concluding remarks and outlines potential directions for future research.

This approach may offer a reinterpretation of relativistic phenomena and hint at possible bridges between classical and quantum-gravitational frameworks. By attributing relativistic mass variation to finite-speed signaling effects, rather than spacetime geometry, the QVE opens new conceptual pathways for unifying particle dynamics, field theory, and gravitational interaction under a common physical principle.

2 The Bertozzi Experiment Revisited

In 1964, William Bertozzi conducted a series of experiments [3] at MIT to investigate how the speed of electrons changes as they are accelerated through known electric potentials[1]. Electrons were passed through a series of accelerating electrodes, with their final velocity measured by time-of-flight between known distances, and their kinetic energy inferred calorimetrically upon impact.

Under classical Newtonian mechanics, the kinetic energy K of a particle is related to its velocity v by the expression:

$$K = \frac{1}{2} m_0 v^2,$$

so one would expect that increasing the potential V (and thus the energy $K = qV$ imparted to the electron) would result in a continuous and unbounded increase in v.

However, Bertozzi observed that as the applied voltage increased, the velocity of the electrons approached an asymptotic limit close to the speed of light, c, without ever exceeding it. The measured velocities plateaued even as the kinetic energy continued to increase well beyond what would be predicted classically.

According to Special Relativity, the kinetic energy of a particle is given by:

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

with the Lorentz factor defined as $\gamma(v) = 1/\sqrt{1 - v^2/c^2}$. Solving for $v(K)$ yields a curve in which $v \to c$ asymptotically, consistent with Bertozzi's results. This provided a strong empirical confirmation of the relativistic model.

Bertozzi published a table of measured velocities for various input energies. For instance, even with kinetic energies exceeding 15 MeV, the corresponding velocities remained just under 3×10^8 m/s. When plotted as v^2 versus K, the data diverge significantly from the linear classical prediction and align closely with the relativistic curve, as shown in Figure 1.

This behavior not only demonstrated the inadequacy of the classical kinetic energy expression at high speeds but also supported the relativistic view that the effective inertia of a particle increases with velocity, thereby limiting its acceleration under finite energy inputs.

[1] A historical video presentation of the experiment, narrated by William Bertozzi, is available on YouTube: https://www.youtube.com/watch?v=B0BOpiMQXQA

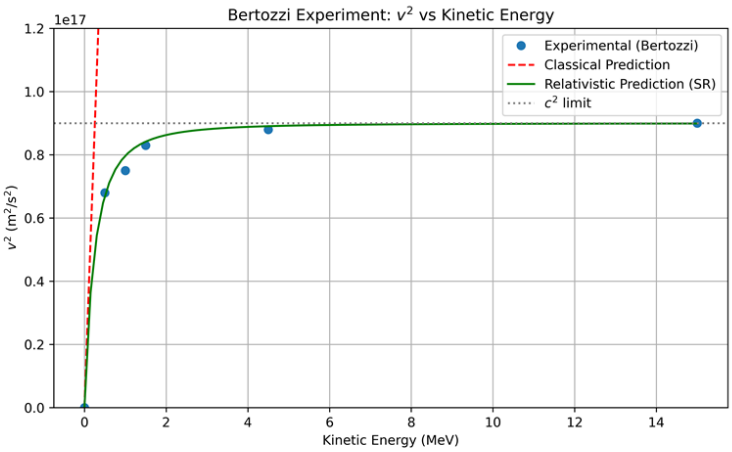

Fig. 1 Experimental values of v^2 as a function of kinetic energy from Bertozzi's experiment [3], compared to the classical (red dashed) and relativistic (green solid) predictions. The horizontal dotted line marks the relativistic limit c^2. While the classical curve diverges rapidly, the relativistic model matches the asymptotic trend observed in the experimental data.

In the next section, we present an alternative interpretation of this result using the Quo Vadis Effect (QVE), which retains Newtonian mechanics while introducing a velocity-dependent correction through finite-speed gravitational (or field-like) signaling.

3 Derivation of Effective Mass from QVE via Geometric Averaging

In this section, we derive the effective mass observed in high-speed interactions from the perspective of the Quo Vadis Effect (QVE), using Newtonian reasoning enriched by finite-speed interaction carriers. Our focus is on the deceleration process as perceived by the calorimetric detector in the Bertozzi experiment.

A central insight of the QVE is that mass is not perceived as an intrinsic quantity but through its gravitational interaction, specifically, through the flux of finite-speed messengers (gravitons) that inform the detector of the particle's presence. When the electron moves toward the detector, this flux is compressed: more gravitons arrive per unit time, and each carries more momentum due to Doppler-like effects. This results in an apparent increase in gravitational pull, which the detector interprets as an increase in effective mass.

Crucially, the detector does not observe an instantaneous collision, but a rapid deceleration from velocity v to rest. In classical mechanics, the mass remains constant during this process, while only the velocity changes. Special Relativity, in turn, predicts a fixed relativistic mass $\gamma(v)m_0$ if the particle arrives at velocity v. In contrast, the QVE posits that the perceived mass evolves dynamically during deceleration. Each incoming graviton reflects the instantaneous velocity of the electron, and the signal received by the detector varies accordingly throughout the process.

We now identify two distinct phases of mass perception, each governed by Doppler-like effects, but producing opposite corrections. The combined effect of these phases, one amplifying and one compensating, is what ultimately yields the observed result.

Blue-shifted mass phase: The Mustard Seed Effect

Before the collision, the particle is in a state of approach with velocity v. In this regime, the detector perceives a compressed flux of incoming messengers. Each graviton arrives more frequently and with increased momentum, producing an amplified signal analogous to a Doppler blue shift. The apparent increase in inertia is quantified using the classical Doppler formula (assuming the detector is stationary):

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

This corresponds to a state of *blue-shifted mass*, which we call **The Mustard Seed Effect**, as a metaphor for how a small, seemingly insignificant particle can exhibit an unexpectedly large inertial response when approaching at relativistic speeds. This perceived amplification may even exceed the relativistic prediction from Special Relativity prior to compensation by the deceleration phase.

Red-shifted mass phase

After the initial approach, the electron undergoes a rapid deceleration, where its velocity decreases from v to 0, and with it, the blue-shifted amplification diminishes. This attenuation acts as an effective red-shift compensation, balancing the previously enhanced inertial signal.

As in the blue-shifted case, we use the classical Doppler formula, now applied to the case of an emitter decelerating toward a stationary observer. Even though the electron never moves away from the sensor, the gradual reduction in relative velocity mimics a red-shifted modulation of the gravitational signal. The corresponding correction factor is:

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

This corresponds to a state of *red-shifted mass*, during which the inertial perception progressively returns to the rest mass value. The transition from the amplified to the neutral state is continuous, governed by the Doppler response to velocity decay.

Geometric averaging

Since the apparent mass enhancement is governed solely by the relative velocity at each instant, and not by cumulative exposure time, the detector perceives two opposing contributions: an initial amplification due to approach, and a symmetric attenuation as the velocity drops to zero. These two effects act multiplicatively and inversely, and are combined through a geometric average.

This method is commonly used in physics to balance symmetric but non-additive effects. For example, the geometric mean appears in the calculation of wave speeds in layered media [4], in coupled oscillator systems [5], and in impedance matching across interfaces in optics and acoustics [6].

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

Thus, although the perceived mass changes continuously during the deceleration, the total energy delivered to the calorimeter is equivalent to what would be expected if the particle had a constant effective mass throughout the process:

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

In this way, the QVE reproduces the relativistic prediction from Special Relativity without invoking spacetime curvature, offering a conceptually transparent mechanism grounded in Newtonian dynamics and Doppler-modulated signaling.

To summarize the results, Figure 2 illustrates the experimental data from Bertozzi alongside the theoretical predictions. Since both Special Relativity and the QVE yield the same functional form for $m_{\text{eff}} = \gamma(v) m_0$, they produce identical curves, accurately matching the observed saturation of velocity at high kinetic energies.

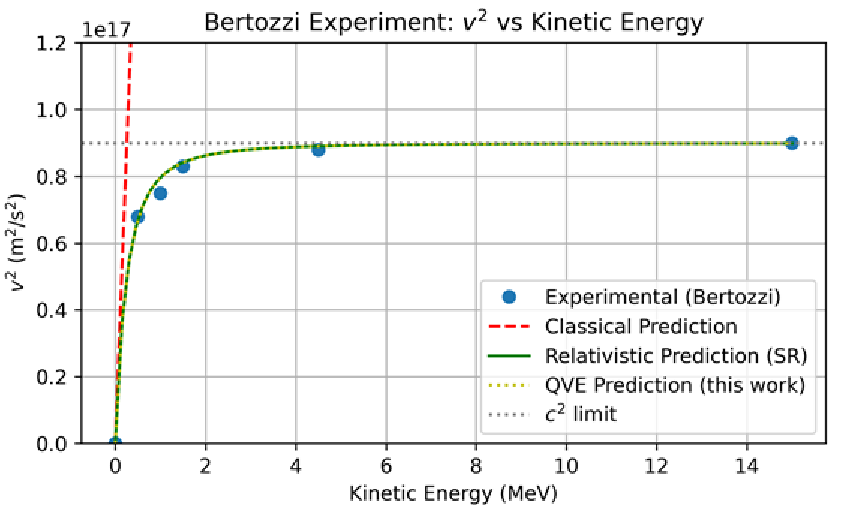

Fig. 2 Comparison between experimental data (Bertozzi), classical prediction (red dashed), relativistic prediction (green solid), and QVE prediction (yellow dotted). The SR and QVE curves coincide exactly, reinforcing the validity of the QVE as an alternative explanation.

4 Discussion

The results presented here show that the Quo Vadis Effect (QVE) can reproduce the same relativistic correction factor $\gamma(v)$ for mass as predicted by Special Relativity (SR), while operating entirely within a Newtonian framework. This is achieved by modeling gravity (and potentially other interactions) as mediated by finite-speed messengers, whose arrival rate and momentum depend on the relative motion between source and observer. In particular, our derivation of $m_{\text{eff}} = \gamma(v)m_0$ arises naturally by considering the Doppler-like modulation of gravitational information received by a detector during particle deceleration, without invoking Lorentz transformations or spacetime geometry.

A key insight is that, within the QVE, the observed increase in mass is not a property intrinsic to the object itself, but a relational effect that depends on how the observer perceives changes in the momentum transfer rate. In this view, a decelerating detector (such as a calorimeter in the Bertozzi experiment) receives updated gravitational signals at each instant, each reflecting the instantaneous velocity of the incoming particle. The net effect is equivalent to averaging the initial and final states via a geometric mean, leading precisely to the Lorentz factor $\gamma(v)$. This provides a physical mechanism, grounded in finite-speed information transfer, for the apparent inertia increase observed in high-velocity collisions.

It is important to distinguish this case from other applications of the QVE, such as Mercury's perihelion precession, currently under review at *Discovery Space Journal* [2]. In that scenario, the motion of Mercury is primarily transverse with respect to the incoming gravitational flux from the Sun. Due to aberration, the gravitons appear to arrive from a displaced position, and with an increased apparent velocity given by $v'_g = c\sqrt{1 + (v/c)^2}$. This leads to a double enhancement: each graviton carries more momentum, and the flux of gravitons per unit time also increases. Integrating the corrected force yields a gravitational potential of the form:

$$U' = U\left(1 + \frac{v^2}{c^2}\right)$$

This enhancement is interpreted as Mercury perceiving the Sun as having an increased mass:

$$M_{\odot}^{\text{apparent}} = M_{\odot}\left(1 + \frac{v^2}{c^2}\right)$$

Unlike the Bertozzi case, this effect remains approximately constant and leads to a sustained correction in the orbit, namely its precession. Moreover, all gravitational fronts contribute symmetrically, and the correction does not vary during the orbit.

A third important scenario arises when two bodies are moving apart radially, such as in the cosmological expansion of the universe. In this case, the observer perceives a reduced flux and red-shifted energy of incoming gravitational signals, resulting in a *decrease* of the apparent mass. This suggests that, over cosmological distances, gravitational interactions may weaken due to recession, potentially contributing to the observed acceleration of the universe without requiring dark energy.

This perspective connects to broader trends in gravitational physics, where alternative theories are being developed to address the shortcomings of General Relativity at large scales. Among these, massive gravity models, such as the de Rham–Gabadadze–Tolley (dRGT) framework [7], propose that gravitons may possess a small but finite mass, modifying gravitational behavior in the infrared. While conceptually distinct, these models share with the QVE the ambition to reformulate gravitational dynamics without invoking spacetime curvature or exotic components like dark energy.

Together, these cases demonstrate that the QVE does not predict a single, universal formula for relativistic mass correction. Instead, it provides a framework where the apparent mass varies depending on:

- The direction of relative motion,
- The type of interaction (continuous field vs instantaneous detection),
- And whether the interaction produces a sustained effect (as in orbits) or a momentary one (as in collisions).

Several early attempts to formalize the variation of mass with velocity anticipated this directional sensitivity. For instance, the classical works of Abraham and Lorentz introduced the ideas of longitudinal and transverse mass, depending on the direction of applied force relative to motion [8, 9]. These were later unified under Einstein's formulation using the Lorentz factor. More recent efforts, such as those by Sharma [10] and Kumar [11], revisit alternative expressions for mass variation, proposing exponential or context-dependent formulations. While these approaches differ in their mechanisms and predictions, they share with the QVE the goal of explaining relativistic behavior without relying on spacetime curvature.

While the QVE offers a coherent and intuitive physical explanation, it remains a developing theory. Several limitations must be acknowledged:

- A covariant mathematical formulation is not yet available.
- The extension of the QVE to accelerated systems, gravitational radiation, and quantum regimes remains an open challenge.
- Its compatibility with observational cosmology and wave-based gravitational phenomena requires further investigation.

Nonetheless, the QVE shows that relativistic-like corrections can emerge from a Newtonian perspective when finite propagation speed and observer-dependent flux are considered. It not only reproduces known results, such as the relativistic mass increase and Mercury's perihelion precession, but also offers a versatile framework for understanding how motion modulates interactions at both particle and cosmic scales.

5 Conclusion

In this work, we have presented a graviton-based reinterpretation of relativistic mass variation grounded in the Quo Vadis Effect (QVE). By modeling gravitational interactions as mediated by finite-speed messengers (gravitons), and analyzing how their frequency and momentum are perceived by moving observers, we have shown that the effective mass increase observed in high-speed collisions can emerge naturally within a Newtonian framework without invoking Lorentz transformations or spacetime curvature.

Applied to the Bertozzi experiment, this approach explains the asymptotic behavior of velocity as a consequence of signal-based inertia perception. We showed that the detector's measurement corresponds to a geometric average of two Doppler-shifted regimes: a blue-shifted amplification, what we term the *Mustard Seed Effect*, highlighting how small intrinsic mass can yield large inertial effects at high velocities, and a red-shifted attenuation during deceleration. This process yields the familiar relativistic expression for effective mass,

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

but derived here from the physics of signal propagation and momentum transfer.

We also emphasized that the QVE does not prescribe a single, universal formula for mass variation. Instead, it offers a flexible framework that adapts to the context of interaction. In orbital systems like Mercury's, a sustained transverse velocity leads to a constant enhancement of gravitational potential due to aberration. In contrast, during cosmic expansion, recession between masses leads to red-shifted gravitational signals and a decrease in apparent mass. These contrasting outcomes are unified by the same principle: mass is inferred through finite-speed signaling shaped by relative motion.

While this work focused on signal-based inertia perception, the broader QVE framework also invites reconsideration of wave propagation itself, suggesting that both gravitational and electromagnetic signals may travel through dynamically influenced media. In extreme regimes where one mass dominates the interaction, such as in planetary motion or laboratory detection, signals may behave effectively as ballistic, even if their fundamental nature is wave-like. This offers a potential bridge between classical field theories and wave-particle duality, meriting further investigation.

Overall, the QVE provides a conceptually transparent and operationally grounded explanation for relativistic phenomena, bridging classical and relativistic perspectives. It offers a fresh physical intuition for mass variation. not as a postulate, but as an emergent consequence of how observers perceive interaction messengers.

Future directions may include extending the QVE to quantum field interactions, gravitational wave detection, or black hole information dynamics, where finite-speed effects remain central but poorly understood. By retaining the structure of Newtonian mechanics while incorporating signaling constraints, the QVE opens a pathway toward a unified understanding of dynamics across classical, relativistic, and possibly quantum domains.

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