The Essence of Inertia –Mass is Merely a Practical Term

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Abstract

Acceleration in elementary particles exhibiting inertia is accompanied by an increase in their internal energy U and a concomitant decrease in the characteristic radii R and r, as prescribed by our particle model. This model yielded the derivation and accurate calculation of their masses (Appendix A). The external force required to produce acceleration performs work that enhances the local curvature of space, effectively reducing R and r. This process introduces additional stress and strain within the spatial structure, thereby amplifying curvature. Through this mechanism, Newton's Second Law is recovered, providing a geometric and energetic basis for the emergence of inertia.

Accordingly, mass should be interpreted not as a fundamental property, but as a derived, operational parameter. In inertial particles, it is the energy content that gives rise to resistance to acceleration, justifying the relation $m = U/c^2$ over the conventional form $U = mc^2$. (Here, U is used in place of E to avoid confusion with electric field strength). This distinction becomes particularly salient in the context of massless particles - such as photons and gravitons - which possess energy and momentum but do not exhibit inertial response, and hence, lack mass.

Keywords: Inertia; Mass; Speed of light; Charge; Special Relativity

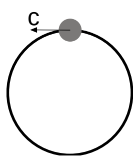
1 Introduction

Elementary particles **without inertia** travel through empty space at the speed of light, c, whereas particles **with inertia** move at a velocity v < c.

In the framework of the GeometroDynamic Model (GDM), the concept of "**rest**" corresponds to a situation where a wavepacket, like an electrical charge [1], follows a closed-loop trajectory. In this case, the geometric center of the circulating wavepacket remains stationary, and the particle—represented by this wavepacket—can be considered at **rest**. We interpret this intrinsic circular motion as **the particle's spin** [1].

2. The Velocity $v < c$ of a Particle with Inertia

For any elementary particle with inertia - which necessarily includes an elementary charge - the overall motion always involves a wave propagating at speed c. When the particle is at rest, this circulating charge motion forms a closed loop. However, when the particle moves with constant velocity v, the motion of the charge takes on a spiral form, combining the internal circular motion with translational movement, as illustrated in Fig. (1)

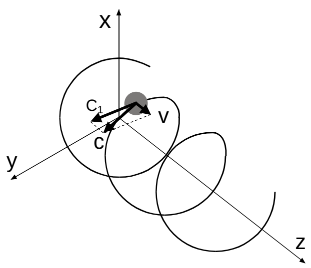


$$c_1^2 = c^2 - v^2 \quad \text{or:}$$

$$c_1 = c\left(1-\beta^2\right)^{\frac{1}{2}} = \frac{1}{\gamma}c$$

$$\text{where:} \quad \beta = \frac{v}{c}$$

$$\text{and:} \ \gamma = \left(1-\beta^2\right)^{-\frac{1}{2}}$$



"Rest" **Motion**

Fig. (1) Rest and Motion)

This uniform motion at velocity v occurs without the need for an external force; force is required only to change the velocity - that is, to accelerate the particle.

Newton's first law, and the **first postulate of the theory of relativity**, which implies that no particle or signal can move at a speed that exceeds the light/wave velocity c, are thus a natural result. The helical motion, which is an electric current formally in the direction -z, is related to the magnetic field **B** and the vector potential **A**. The Circular Track is stable since the centrifugal force is balanced by an equal but opposite centripetal force. The Lorentz force, created by the magnetic field of the circulating charge acting on itself, is the required centripetal force.

Fig. (1), on the right, describes motion. Motion is the situation in which the circle of revolution of a wavepacket becomes a spiral. The GDM considers the **length of the wavepacket** to be **retained**. From this conjecture alone we derive the results of the Theory of Special Relativity (SR). Since the length of the wavepacket is retained, the spiral radius R is smaller than R_0. This is analogous to a stretched spring. As Fig. (1) shows:

$R = 1/\gamma\ R_0$ **Microscopic Contraction** (1)

The resultant electron motion is always at the wave velocity c. Thus, a translatory motion at constant velocity, v, does not involve any exertion of force and necessarily $v \leq c$.

This understanding led to the derivation and accurate calculation of the masses of the leptons and quarks and their anti-particles [1], [2] see Appendix A.

3. The Elementary Particle Inertia and Length Contraction

At rest, the energy of the electron is U_0, linear momentum is $P_o = U_0/c$ and the angular momentum is $L_0 = P_oR_o$.

In motion, energy, linear momentum and angular momentum are U, $P = U/c$ and $L = PR$ respectively.

The conservation of angular momentum $L = L_0$ (which is $1/2\hbar$ for the electron) implies that:

$PR = P_oR_o$. Hence $UR = U_0R_0$, but $R = 1/\gamma \cdot R_0$, (1), thus:

$$U = \gamma U_0 \qquad (2)$$

Considering the energy as purely electromagnetic, where the elementary charge Q is a sphere of radius r_0 [3], the relations $U_0= Q^2/2r_0$, $U= Q^2/2r$ and (2) give:

$$r = 1/\gamma \cdot r_0 \qquad \textbf{Microscopic Contraction} \qquad (3)$$

For $v << c$ equation (3) is:

$$r = (1-v^2/2c^2)\, r_0 \qquad (4)$$

Acceleration is accompanied by an increase of energy U, and a reduction in the radii R and r. The applied force, needed to accelerate the particle, is doing work to curve space more strongly and thus to reduce r and R. This force is needed to increase stress and cause more strain in order to enlarge the curvature. Thus, we arrive at **Newton's Second Law** and understand where **Inertia** comes from.

Note that we have replaced Newton's axiomatic laws by our postulated model of an elementary particle. Some of the merits in this replacement, as we show, are:

- It leads to the proof of the equivalence of gravitational mass and inertial mass [3].
- It proves that mass is not a fundamental attribute of matter (Section 4).
- It proves that inertia is an intrinsic attribute of matter, with no need for an additional field to induce it (Higgs Field).

Note that the relations $L= 1/2\ \hbar$, $R=1/2\ \hbar c/ U$, $U_0= Q^2/2r_0$ and $r = Q^2/2U$ give:

$$\alpha = r/R = Q^2/\ \hbar c \qquad \textbf{Fine Structure Constant.} \qquad (5)$$

Note also that at "rest" the angular momentum can point in any direction, whereas in motion it can point, generally (see Section 2), in the direction of motion or opposite to it. This attribute is related to **Space Quantization**.

4. Inertia and Mass

Our “relativistic” relation (2) gives:

$$U = \gamma U_0 = U_0\left(1-\frac{v^2}{c^2}\right)^{-\frac{1}{2}} \simeq U_0 + \frac{\frac{1}{2}U_0 v^2}{c^2}$$ The second term: $$\frac{\frac{1}{2}U_0 v^2}{c^2} = ½(U_0/c^2)\, v^2,$$

is identified as the **kinetic energy** where:

$$M_0 = U_0 / c^2 \tag{6}$$

Thus, **inertial mass** becomes merely a **practical term.** We also get:

$$M = \gamma M_0 \tag{7}$$

The literature distinguishes between the **kinetic energy** $½\, M_0 v^2$, which a particle possesses by virtue of its motion, and its **internal energy** $M_0 c^2$. But here, the kinetic energy is also an internal energy of deformation (the reduction in size of r and R) that cannot be distinguished from the rest energy.

Note again that the electron model, presented here, is a simplified version of a much more detailed model that appears in [1] and yields the masses of the leptons and quarks.

The derived and calculated electron mass, is presented in Appendix A.

5. Summary

This paper challenges the conventional understanding of mass by presenting a novel interpretation grounded in the GeometroDynamic Model (GDM). It argues that **mass** is not an intrinsic property of matter but a **practical term** that encapsulates the resistance to deformation of space. Within this framework, inertia emerges naturally as a manifestation of the local geometry and elasticity of the deformed spatial lattice. The paper demonstrates that what we traditionally measure as mass is a convenient way to describe the dynamical response of space deformation to applied forces. By reframing mass as a derivative construct rather than a fundamental entity, this work offers a deeper geometric explanation for **inertia** and paves the way for a unified view of motion, force, and space deformation.

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Data available with the paper
The authors declare that the data supporting the findings of this study are available within the paper

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Appendix A The Electron/Positron Mass

Our geometry of deformed zones of space (Barak 2019), rather than Riemannian geometry of bent manifolds, enables us to attribute positive curvature to a contracted zone of space, i.e., to a positive charge, and negative curvature to a negative charge. This enables us to apply General Relativity (GR) in our derivations, and show that the positive elementary charge can be considered a kind of **black hole**, whereas the negative elementary charge - a **white hole**.

Based on the above we construct a model of the Electron (and other elementary particles) and derive and calculate its attributes, including inertial mass and spin. Neither the Standard Model nor String Theory has provided such results.

The equations for these masses contain only the constants G, c, $\hbar$ and α (the fine structure constant). Our calculated results comply with CODATA 2014.

Our result for the Inertial Mass of the Electron

$$M_e = \frac{s^2\sqrt{2}}{\pi(1+\pi\,\alpha)}\sqrt{G^{-1}\alpha\hbar c^{-3}} \qquad s = 1,\ [s] = LT^{-1}$$

M_e (calculated) = 0.910,36 10^{-27}g

M_e (measured) = 0.910,938,356(11) 10^{-27}g

A dimensionality check: $[G^{-1}] = ML^{-3}T^2$, $[\alpha] = 1$, $[\hbar] = ML^2T^{-1}$, $[c^{-3}] = L^{-3}T^3$. Thus:

$$M = \left[s^2\sqrt{G^{-1}\alpha\hbar c^{-3}}\right] = L^2T^{-2}(ML^{-3}T^2\cdot ML^2T^{-1}\cdot L^{-3}T^3)^{1/2} = L^2T^{-2}(M^2L^{-4}T^4)^{-1/2} = L^2T^{-2}ML^{-2}T^2 = M$$