Title: The Origin of Inertia

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Abstract: All scientific theories on nature of inertia could be divided into two categories: the inertia is a local, intrinsic property of body, and the inertia is a global property and stems from an interaction between a body and Universe. This article was written in attempt to prove that origin of inertia is the result of interaction between a body and its own gravitational field.

Main Text:

Introduction

The origin of inertia is still a mystery from Galileo Galilee's inertial concept as a state of either motion or rest. For instance, a ship in a calm sea "if all external and accidental obstacles were removed, it would thus be disposed to move incessantly and uniformly from an impulse once received" (*1*). Unfortunately, Galileo has never given to his term "massa" any inertial meaning; he used it only as a synonym for "matter" or "body".

Appeared since that time, all scientific theories on nature of inertia could be divided into two categories:

1. The inertia is a local, intrinsic property of body.

2. The inertia is a global property and stems from an interaction between a body and Universe.

The first category is associated with the names of Isaac Newton, Leonhard Euler and Max Abraham. Newton was the first who defined the notion of inertial mass in Definition 1: "Quantity of matter is a measure of matter that arises from its density and volume jointly" (*2*). Newton's theory of inertia is based on his second law of motion which in Euler's formulation states that the force F is a product of inertial mass m and acceleration a:

$$F = m \cdot a \tag{1}$$

Max Abraham wrote that "the mass of the electron is of purely electromagnetic nature" (*3*).

The second category is associated with the names of Ernst Mach, Albert Einstein and William Sciama. Criticizing Newton's laws of motion, Ernest Mach declared that the inertia of the particle depends on masses of all other particles in the Universe. Albert Einstein supported his ideas. He wrote: "Mach, in the nineteenth century, was the only one who thought seriously of an elimination of the concept of space, in that he sought to replace it by the notion of the totality of the instantaneous distances between all material points. (He made this attempt in order to arrive at a satisfactory understanding of inertia)" (*4*).

Albert Einstein thought that inertial mass is determined by all other masses in Universe and their accelerations. D. W. Sciama, analyzing the "Einstein's idea that inertial forces are actually gravitational forces exerted by accelerating stars" (*5*), formulated the law that determines the inertial force F exerted by one on another body of masses m_1 and m_2, located on a distance r and moving with relative acceleration a: (*6*)

$$F \propto \frac{m_1 \cdot m_2}{r} \cdot a \qquad (2)$$

if a mean density of matter in Universe is about $7 \cdot 10^{-30} gm \cdot cm^{-3}$.

Analyzing these statements, we may conclude that a particle will not have an inertia in an empty Universe or the inertial mass should depend on the position of all given particle in the Universe. It is a pretty complicated theory which takes into account the distribution of all particles, gasses, planets, stars, galaxies, in other words, all matter in the Universe to explain or calculate the inertia of single body.

The origin of inertia

To prove that origin of inertia is the result of interaction between a body and its own gravitational field, let's analyze the movement of a particle in gravitational field. Starting from rest, particle of mass *m* is moving with constant acceleration *a* from point A along the axis x. This particle will reach the point B in time *t* (see Figure 1 and 2).

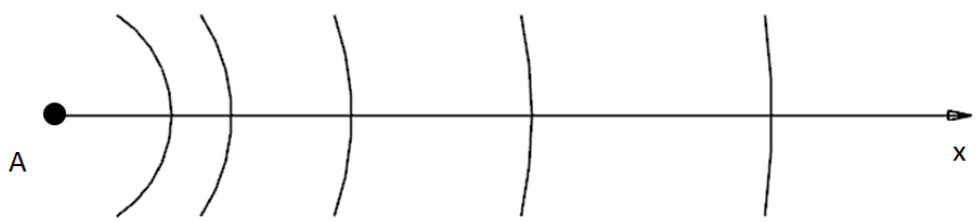

Figure 1

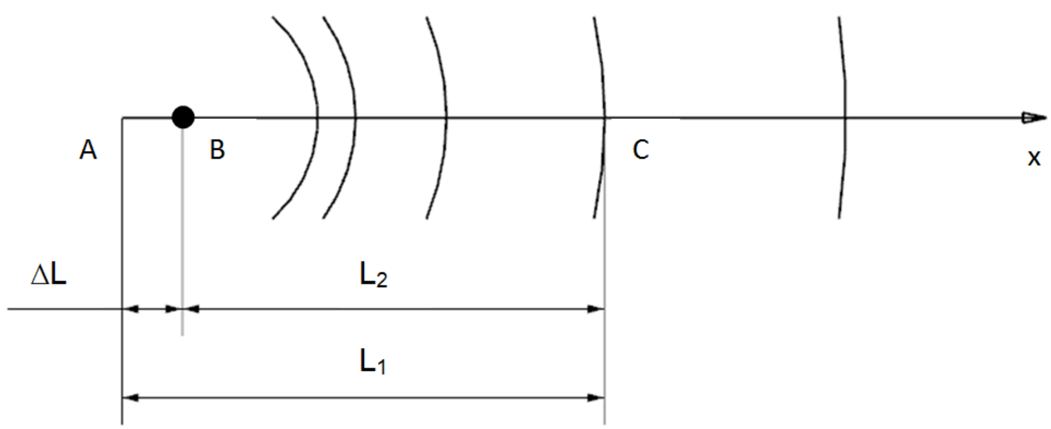

Figure 2

Two points A and B are separated by distance

$$\Delta L = \frac{a \cdot t^2}{2} \qquad (3)$$

The gravitational wave, moving with speed of light *c*, will be transmitted for time *t* from point A to point C, passing the distance L_1 in accordance with the corresponding formula:

$$L_1 = c \cdot t \tag{4}$$

The distance, the gravitational field is deformed; we can obtain from equation (3).
Solving equation (4) for *t* and substituting result in equation (3), we obtain:

$$\Delta L = \frac{a \cdot L_1^{\,2}}{2 \cdot c^2} \tag{5}$$

Let's assume that when the gravitational field is compressed or stretched, its force *F,* exerted on particle, is proportional to gravitational field deformation ΔL:

$$F = k \cdot \Delta L \tag{6}$$

The energy *E* of gravitational field before such deformation:

$$E = \int_0^{L_1} F \cdot dx = \int_0^{L_1} k \cdot x \cdot dx = \frac{k \cdot L_1^{\,2}}{2} \tag{7}$$

Also

$$E = m \cdot c^2 \tag{8}$$

By substitution the equation (8) in (7) and solving for *k*, we have the formula:

$$k = \frac{2 \cdot m \cdot c^2}{L_1^{\,2}} \tag{9}$$

And finally, by substitution equations (5) and (9) in equation (6), we obtain:

$$F = m \cdot a \tag{10}$$

Conclusion

The inertia stems from an interaction between a body and its own gravitational field.

References and Notes:

1. G. Galilei, *Dialogue Concerning the Two Chief World Systems – Ptolemaic & Copernican,* translated by S. Drake (Univ. of California Press, Berkeley, Los Angeles, London, ed. 2, 1967), p. 148
2. I. Newton, *The Principia. Mathematical Principles of Natural Philosophy*, translated by I. B. Cohen and A. Whitman, assisted by J. Budenz (Univ. of California Press, Berkeley, Los Angeles, London, 1999) p. 403
3. M. Jammer, *Concepts of Mass in Contemporary Physics and Philosophy* (Princeton Univ. Press, Princeton, New Jersey, 1999) p.144
4. A. Einstein, *Relativity. The Special and the General Theory*, translated by R. W. Lawson (Routledge Classics, London, New York, 1993) p.146
5. D. W. Sciama, *The Unity of the Universe* (Doubleday, Garden City, New York, 1959) p.131
6. D. W. Sciama, *The Physical Foundation of General Relativity* (Doubleday, Garden City, New York, 1969) p.33