Energy Flow as the Cause of Inertia

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The ‘reaction force’ caused by acceleration, which is understood as the specific cause of inertia in current theories, is deduced to be a useless concept. It is shown that the only and sufficient cause of inertia is the relativistic increase of energy caused by the energy flow from the potential to kinetic form.

There is no common ground with regard to the origin of inertia. From among several conceptions concerning this issue the two are most widely recognized: D. Sciama theory [1] based on Mach’s principle, and the zero-point field (ZPF) theory [2], formulated by A. Rueda, B. Haisch and H.E. Puthoff which refers to the properties of quantum vacuum. In spite of differences as to the postulated ultimate source of inertia, both theories agree at one point. Namely, they assume that inertia consists in a kind of force (‘inertial reaction force’) that is acceleration-dependent. In other words, both theories interpret inertia as a specific resistance raised by acceleration, either caused by gravitational interaction with a distant matter of Universe, or by interaction with virtual particles of quantum vacuum in the close neighbourhood of a body. At the same time, acceleration is regarded by these theories as a separate element that can be assumed without giving an adequate explanation.

Instead, we assume here that inertia manifests itself through acceleration, which means that acceleration is the right symptom of inertia, and that acceleration must be explained within the frame of inertia theory. The 'resistance' that describes inertia in its common intuitive definition is comprehended not as a separate element caused by acceleration but as a dynamical sign (aspect) of acceleration, tightly connected with the third law of dynamics. From this point of view, the question of 'reaction force' proves to be a trivial consequence of this law, instead of being an external factor specifically attributed to inertia. In other words, the fulfilment of the third law of dynamics in the case of inertia is not conditioned by the presence of any specific force raised by acceleration. We may say that the hitherto existing approach to the problem expresses itself in the question: "Why the acceleration of a body causes a 'reaction force', and therefore, to be maintained, needs an equal force oppositely directed?" Meanwhile, the approach presented here can be formulated as: "Why the force acting on a free body causes its acceleration?"

We postulate that inertia is determined by a process of energy flow between the energy source and the accelerated body, governed by the conservation of energy principle. Since inertia expresses itself properly in the relativistic formulation of the second law of dynamics, then this law should be an ultimate result of deduction.

The above postulate implies the transformation of energy form, which can be defined as $E_P \to E_K$, with E_P the potential energy of the source, and E_K the kinetic energy of accelerated body, where $E_K = E - E_0$ and $E_0 = m_0 c^2$. The increase of kinetic energy in reference to time is determined by the power of energy source ($\Delta E_K \propto P$) and does not depend on the rest mass/energy of a body.

In other words, if an equal force acts on different bodies, they increase in energy in the same degree.

Let P be the power of energy source in the part that is absorbed by the motion of an accelerated body. Let us assume that the energy source is at rest to laboratory.

The increase in energy of an accelerated body can be expressed by a quotient of total and initial energy:

$$q_E = \frac{E}{E_0}. \tag{1}$$

Considering the power of energy source, this means that

$$q_E = \frac{Pt + E_0}{E_0}. \tag{2}$$

It is clear that (2) must be identical with the increase of energy defined by the Lorentz factor $\gamma = 1\big/\sqrt{1 - v^2/c^2}$, *i.e.* that $q_E \equiv \gamma$. The difference between q_E and γ consist on the angle that the increase of energy is considered; q_E refers directly to energy, while γ, as being kinetically determined, refers to energy (beside its other references) in the indirect way. The other difference is that, contrary to γ, q_E is expressed in (2) as a variable in reference to time.

Since γ is the function of velocity, then velocity can be written as a function of γ:

$$v = \sqrt{c^2 - c^2/\gamma^2}. \tag{3}$$

By substituting (2), the velocity becomes the function of time in which energy is supplied to the body in kinetic form:

$$v = \sqrt{c^2 - \frac{E_0^2 c^2}{(Pt + E_0)^2}} \,. \tag{4}$$

Differentiating (4), one gets the function of acceleration in reference to time:

$$a = \frac{d}{dt}\sqrt{c^2 - \frac{E_0^2 c^2}{\left(Pt + E_0\right)^2}} = \frac{E_0^2 P c^2}{\left(Pt + E_0\right)^3 \sqrt{c^2 - \frac{E_0^2 c^2}{\left(Pt + E_0\right)^2}}} \,. \tag{5}$$

Hence:

$$\begin{aligned} a &= \frac{P}{\sqrt{c^2 - \frac{E_0^2 c^2}{(Pt + E_0)^2}}} \times \frac{c^2}{E_0} \times \left(\frac{E_0}{Pt + E_0} \right)^3 = \\ &= \frac{P}{v m_0 \gamma^3} = \frac{F}{m_0 \gamma^3} \end{aligned} \,. \tag{6}$$

This equals to $\vec{F} = m_0 \gamma^3 d\vec{v} / dt$, which is the correct relativistic form of the second law for the case when $\vec{F} \parallel \vec{v}$.

References

[1] D.W. Sciama, "On the origin of inertia", *Monthly Notices of the Royal Astronomical Society*, Vol. 113, (1953) p.34

[2] B. Haisch, A. Rueda & H.E. Puthoff, "Inertia as a zero-point-field Lorentz force", *Physical review A*, Vol. 49, No. 2, (1994) pp. 678-694