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# Why is the body gravitational mass equivalent to the inert one

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## Abstract

After Lorand Eotvos's experiments that confirmed the equivalence between the gravitational mass and the inert one with the accuracy up to $10^{-8}$ nobody has doubts about this fact. The similar fact was established by A. Einstein for General Relativity in 1918. However, up to date any common simple explanation of this fact is absent in physics. As I believe, the explanation has to be based on priority of the gravitational charge (i.e., gravitational mass) as a *source* of the attraction force. What about the inert mass of a particle, it represents a measure of backreaction from all the remaining Universe just due to the gravitational interaction between them.

## Inertness and Mach's principle

In the interesting and deep paper **[Anisowitch, 1996]** its author demonstrated the Mach's principle application to the Newton gravity theory and Einstein's General Relativity. He considered a physically isolated system containing several mass that are coupled by the gravity *only*, and derived the motion equations in an arbitrary reference frame based on the *linear and angular momentum conservation low* for the entire system. The deduced equations use the *relative* motions and accelerations only and are not based on this reference frame motion relative to an inertial one. Contrary, the concept of the inertial reference frame itself can be now defined trough a relative motion if angular displacement, angular velocity, and angular acceleration do not change during such a motion[1].

The above conclusion (like Mach's finalized hypothesis) have simple and clear physical sense. We actually have to consider in this problem the Universe as an isolated system, any interaction happens in the interior of it. Hence, the linear and angular momentum conservation low must lead to the system backreaction on the motion (acceleration) of one of its parts, i.e. a negative feedback must to exist. The measure of this feedback has to be proportional to the measure of interaction between a part and the entire system, i.e., to the gravitational charge of the part (see for more details my book **[Shulman, 2005]**).

As I believe, this fact understanding finds some difficulty due to enormous account of mass in the Universe. If some test particle is accelerated, then visible return acceleration of all other Universe parts turns out to be "spread" on these parts and seems to be pactically unnoticeable. It is not the case when a giant part of the Universe is syncronously accelerated. Or, contrary, one can consider the very symplified case when a toy universe contains only two nearly equal gravitating, in such the case the reaction of one of them onto another one's acceleration was easily visible for some neutral observer[2].

In fact, one cannot in principle neglect the gravitational interaction between some particle and the entire Universe. While considering some small physical objects (like two

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[1] In the cited paper it is shown that these conditions for a coordinate reference frame can be accomplished in the *local* spacetime region only. So, the *global* Newton's "absolute" space existence contradicts to the Mach's principle.

[2] If the toy universe contained only one particle, then its momentum and angular momentum change was impossible because the single particle had not a partner to interact.

coins), one may neglect the attraction between them. However, all of us feel the attraction of Earth, and we well know about planet orbital motion. For large enough astrophysical objects the gravitational interaction between different parts of the object (self-gravitation) plays the important role. This one leads particularly to the black holes formation. The more, the calculations show that entire Universe is specified by such relation between the size *R* and mean density *ρ* ($R \approx \sqrt{\frac{3}{8\pi G\rho}}$) that it is near to a black hole. So, its spatial curvature turns out to be a measure of the universal gravitational interaction – the Universe total mass. This curvature that determines inertial motion of a body along the geodesic line just connects the Universe total mass and the particle gravitational charge.

**Inertness and non-gravitational interactions**

However, there exist several non-gravitational interactions in our Universe. Have they some influence on the body inert properties? The negative answer is based on the fact that practically all of these interactions (excluding electromagnetic one) are specified by short interaction radius, and electromagnetic interactions are shield by opposite electromagnetic charges.

On the other hand, accordingly with the famous Fokker's idea the usual *vector-potential* of electromagnetic field represents the total inference of all the Universe electrical charges onto test charge. We easily can see here the analogy with above role of the gravitational potential.

For an electrical charged particle in electromagnetic field the *generalized* momentum **P** = **p** + e**A**/c should be conserved, i. e., the Lagrange function derivaive on velocity (**A** is the field vector-potential, c is velocity of light) should be constant. If electromagnetic field did not shield at the global scale of the Universe, then the body inertness was dtermined similarly by electrical charges of the given particle and the entire Universe.

**References**

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