

# Inertial and gravitational mass (field model)

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## Abstract

We have built a model of the mass of the photon field, which fully reflects the inertial and gravitational properties of matter. It is shown that the model of mass can not move faster than light.[1]

## 1 Model of mass

We consider a thought experiment. Let weightless cylinder is located in the reference frame  $K'$  (axis X, Y, Z). The height of the cylinder is equal to  $h$  (Fig 1). The top cover of the cylinder is denoted by the letter  $S_2$ , and the bottom cover is denoted by the letter  $S_1$ .

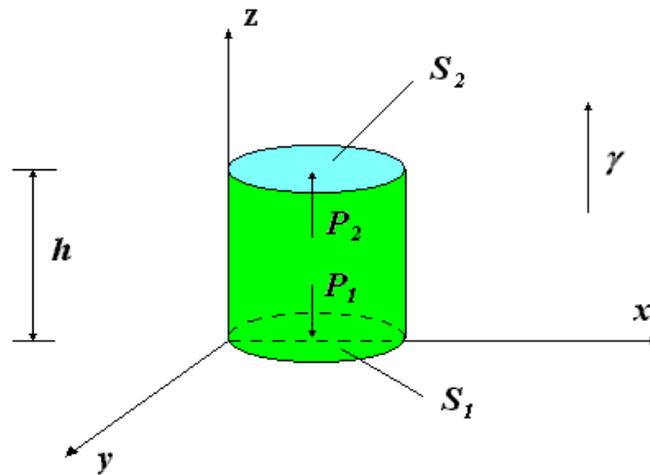


Figure 1: Model of mass

Let the system of reference  $K'$  (cylinder) is moving with uniform acceleration in the direction of positive values of  $Z$  (acceleration  $\gamma$ ). Let from  $S_2$  to  $S_1$  emitted quantum of light - a photon with energy  $E_0$ . We consider this process in the system  $K_0$ , which has

no acceleration. Assume that at the moment when the radiation energy  $E_0$  is transferred from  $S_2$  to  $S_1$ ,  $K'$  system has a speed equal to zero (with respect to system  $K_0$ ). Light quantum will appear in  $S_1$  after time  $h/c$  (in first approximation), where  $c$  is the velocity of light. At this time, the bottom of the cylinder  $S_1$  has a speed  $v = \gamma h/c$ . Therefore, according to special relativity, reaching  $S_1$  radiation has an energy  $E_1$ , which is equal to

$$E_1 \approx E_0 (1 + v/c) = E_0 (1 + \gamma h/c^2) \quad (1.1)$$

Momentum is

$$P_1 = E_1/c = E_0 (1 + \gamma h/c^2)/c \quad (1.2)$$

Let the light quantum with the same energy  $E_0$  is emitted from  $S_1$  in the direction  $S_2$ . Then the energy of the radiation reaching the wall  $S_2$  and momentum are of the form

$$E_2 \approx E_0 (1 - v/c) = E_0 (1 - \gamma h/c^2) \quad (1.3)$$

$$P_2 = E_2/c = E_0 (1 - \gamma h/c^2)/c \quad (1.4)$$

If we simultaneously send two light quanta of equal energy - one in the direction of  $S_1$  and the second in the direction  $S_2$ , the recoil momenta mutually balanced by, and will play a major role (1.2) and (1.4). Then we get

$$\Delta P = P_1 - P_2 = (2E_0/c^2)(\gamma h/c) = 2m \Delta v \quad (1.5)$$

where  $2m = 2E_0/c^2$  is inert mass; coefficient 2 corresponds to two photons.

Weightless cylinder in which there is radiation, as a result of the acceleration behaves as if it has an inertial mass  $2m$ , and the momentum  $\Delta P$  this inert mass, as is easily seen from Fig 1, is directed in the direction opposite the acceleration vector  $\gamma$ . Cylinder with photons within it resists an accelerating force. It is one of the characteristic manifestations of the physical property, which is called "mass".

Model inertial mass indicates that the inertia of the material bodies is their intrinsic property and Mach's principle does not apply to material bodies.

Next. Let weightless cylinder (Fig 1) is not accelerating, and is on stand and it is in a weak gravitational field of the Earth. Downstairs field potential is zero, at the height  $h$  it equals  $\varphi$ . Taking into account the principle of equivalence can be written  $\gamma h = \varphi$ . Let from  $S_2$  to  $S_1$  sent a photon of energy  $E_0$ . The energy and momentum of the photon will change according to the formulas

$$E_1 \approx E_0 (1 + \varphi/c^2) \quad (1.6)$$

$$P_1 = E_1/c = E_0 (1 + \varphi/c^2)/c \quad (1.7)$$

On the other hand, emitting a photon of energy  $E_0$  from  $S_1$  to  $S_2$  we obtain

$$E_2 \approx E_0 (1 - \varphi/c^2) \quad (1.8)$$

$$P_2 = E_2/c = E_0 (1 - \varphi/c^2)/c \quad (1.9)$$

As a result, the difference of  $P_1$  and  $P_2$  is equal to

$$\Delta P = P_1 - P_2 = (2E_0/c^2)(\Delta\varphi/c) = 2m(\Delta\varphi/c) \quad (1.10)$$

and directed towards the center of the Earth. Here  $2m = 2E_0/c^2$  - a heavy mass. Therefore, the force acting on  $S_1$ , is

$$F_z = \Delta P/\Delta t = -2m(\Delta\varphi/c \Delta t) \quad (1.11)$$

For light in the field of the Earth vertically  $c \Delta t = \Delta z$ , then  $F_z = -2m(\Delta\varphi/\Delta z)$  or, more generally

$$F(\vec{r}) = -2m \text{grad} \varphi(\vec{r}) \quad (1.12)$$

where  $\varphi(\vec{r}) = -GM/r$ ;  $G$  - gravitational constant;  $M$  - mass of the Earth.

We have received expression for the force of gravity acting on the cylinder, it follows from Newton's theory of gravitation.

The model implies that the free movement of the material structure in the gravitational field is a consequence of the constant redistribution of impulses of massless quanta of energy in relation to the body structure.

Thus, the model adequately reflects the inertial and gravitational properties of massive bodies.

Next. The system of two coupled photons, as we have shown above, has inertial properties and will therefore move with a speed less than the speed of light, or rest. The velocity of light for such a system would be at maximum speed. If the body is made of light, it can not move faster than light.

Thus massless form of matter is primary and fundamental. The massive form of matter is secondary, derivative form.

## References

- [1] Klimets A.P. Inertial and gravitational mass (field model), russian

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