A SPECIAL-RELATIVISTIC APPROACH TO GRAVITATION AND ITS ASTROPHYSICAL CONSEQUENCES

(Letter to the Editor)

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Abstract. In the framework of Rastall's conservative program for the construction of gravitation theory we present a variant of modified classical gravitation theory based on Einstein's energy-mass equivalence principle. We pursue further the special-relativistic arguments and obtain a theory for the static spherically-symmetric gravitation field that is based only on the well-established physical principles and accounts for all experimental tests known in gravitation. Some astrophysical consequences of the modified classical gravitation theory (e.g., the non-existence of black holes, the creation of real particles in a strong gravitation field) are also discussed.

Recently Rastall and some other authors have constructed such theories of gravitation in which the original Newton's gravitation law is combined with the arguments of special relativity (Rastall, 1966, 1975, 1978, 1979; Majerník, 1971; Leiby, 1972). In what follows we present a variant of such modified classical gravitation theory based on the energy-mass equivalence principle which tells us that the work done by a massive body in a gravitation field goes at the expense of its rest mass. We pursue the special relativistic arguments and obtain, via equation for energy conservation and relativistic line element, the natural unit of energy (and some other physical quantities) derived by Rastall from the experimental redshift and other conservative theoretical arguments. We arrive then at the formulae for the static spherically-symmetric gravitation field that are based on the well-established physical principles. A generalisation of this theory on the general gravitation fields leads to the Rastall's theory of gravitation that is able to describe all experimental tests known in gravitation (Rastall, 1979).

Since the measure of the work being done in a gravitation field by a massive body is its potential energy, we suppose that the passive gravitational mass of the body represents a function of this energy. The sum of the passive gravitational mass in a space point $r$ and the work being done by the translation of a massive body from the infinity to the point $r$ must be equal to the rest mass $m_0$ occurring in the infinity - i.e.,

$$m_0 = m(r) + \Delta m(r) = m(r) + \frac{1}{c^2} \int_{\infty}^{r} F(r') \, dr'$$

(1)

or

$$m(r) = m_0 - \frac{1}{c^2} \int_{\infty}^{r} F(r') \, dr',$$

(2)

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where $F$ represents the force acting on the massive body. If we denote by $E$ the force acting on the mass unit (intensity of gravitational field) then we can rewrite Equation (2) into the form

$$m(r) = m_0 - \frac{1}{c^2} \int_\infty^r m(r')E(r') \, dr' ,$$

Equation (3) is an integral equation whose solution has the form

$$m(r) = m_0 \exp \left\{ \frac{\Phi(r)}{c^2} \right\} ,$$

where

$$\Phi(r) = -\int_\infty^r E(r') \, dr'$$

is the gravitational potential. The factor $\exp \{\Phi/c^2\}$ is typical for the Rastall's Newtonian theory of gravitation (Rastall, 1979) that he has obtained using the results of gravitational red-shift experiment and some other theoretical arguments. The factor $\exp \{\Phi/c^2\}$ follows, however, quite naturally from the mass-energy equivalent principle.

So far we supposed that only the mass object occurring in the gravitation field of a central large body changes its gravitation mass. Since any central body finds itself in the gravitation field of the neighbouring mass objects, its mass should change as well. This can be demonstrated by the interaction of two bodies of equal mass $M$. The mass of each body will change according to the formula

$$M(r) = M - \frac{1}{c^2} \int_\infty^r F(r') \, dr' ,$$

where $F(r)$ is force acting between these bodies. Substituting $M(r)$ into Newton's gravitation law, we get the following integral equation for $F(r)$

$$r^2 F(r) = -G \left( M - \frac{1}{c^2} \int_\infty^r F(r') \, dr' \right)^2 .$$

The solution to Equation (5) has a very simple form

$$F = \frac{GM^2}{(r + \lambda)^2} , \quad \lambda = \frac{GM}{c^2} .$$