Journal of Theoretics
Volume 6-2, April/May 2004

General Relativity: Energy-Momentum Tensor Depends on a Gravitational Potential

V.N. Strel'tsov
Laboratory of High Energies
Joint Institute for Nuclear Research
Dubna, Moscow Region 141980, RUSSIA
strlve@sunhe.jinr.ru

Abstract: Attention is given to serious difficulties of general relativity conditioned by the ascription of the role of gravitational charge to energy. It is emphasized again that the formula for energy obtained on the basis of Minkowski's equation (for the contravariant 4-vector of energy-momentum) describes a gravitational repulsion.
Keywords: general relativity, gravity.

The "gravity" mass E/c^2 is ascribed to energy E in general relativity (GR) [1]. Thus, the energy plays the role of gravitational charge in GR. As early as 1919, the French astronomer Deslanders summarized the subject of Einstein's theory with his remark that energy attracts energy [2]. Since E is a component of the energy-momentum 4-vector p^i (i=0,1,2,3), then just p^i becomes in general a gravitational charge in GR. As a consequence of this, the energy-momentum tensor (that figures on the right side of Einstein-Gilbert's equation) is the source of the gravitational field for a continuous distribution of matter.

Consider now the known Minkowski equation

$$p^i=mu^i, \tag{1}$$

where $u^i=dx^i/d\tau$ is the 4-velocity and τ the invariant (proper) time. Emphasizing that u^i is the contravariant 4-vector by definition (as the derivative from coordinates by scalar). In particular, for the time component (energy) we have

$$E=p^\circ c=mu^\circ c=m\gamma c^2=mc^2(1-v^2/c^2)^{-1/2} \quad . \tag{2}$$

Here u° is the time component of 4-velocity, γ Lorentz-factor, and v the motion velocity of a material body. As seen, Einstein's quantity $m_E=E/c^2$ depends not only on the previous (Newtonian) gravitational charge-mass but also on velocity. Thus, we have as if there are two "gravitational sub-charges".

The gravitational charge (energy) of a free body was considered above. However, the picture changes significantly for the totality of material bodies. The energy of a certain body defends on the gravitational field created by neighboring bodies. So, in the simplest ease of the resting body, based upon the Schwarzschild solution, we have

$$c^2d\tau^2=(1+2\Phi/c^2)(dx^\circ)^2, \tag{3}$$

where Φ is the potential of a gravitational field. Whence for the body energy we obtain

$$E = mc\frac{dx^0}{d\tau} \cong mc^2 - m\Phi \quad . \tag{4}$$

As a result, for the continuous distribution of substance, the corresponding "energy-momentum tensor of matter" turns out to be dependent on the gravitational potential in spite of its name. On the other hand, the negative sign of the second term of expression (4) means that the contravariant form of energy in GR describes gravitational repulsion [3]. Thus, if the particle as a de Broglie wave (described by the covariant 4-vector of energy-momentum p_i) is attracted by a gravitational field, then it as a particle (described by the contravariant 4-vector p^i) tries a gravitational repulsion. The ascription of the role of gravitational charge to energy led to such strange consequence.

Conclusion

Energy takes on, in GR, the role of gravitational charge that depends on two sub-charges: mass and velocity. What is more, the energy-momentum tensor of matter also depends on the gravitational potential.

References

[1] Einstein A., Jahrb.Radioakt.Elect. **4**, 411(1907).
[2] Pais A., **"Subtl is the Lord…"**. The Science and the Life of Albert Einstein, p.308 (Oxford Univ.Press, N.Y., 1982).
[3] Strel'tsov V.N., Apeiron **6**, 245 (1999); J. of Theoretics **4**, No.3 (2002).

Received March 2003