

## General Relativity || Gravitational Repulsion

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**Abstract:** It can be shown that the contra-variant component of the material body energy in GR, describes a gravitational repulsion.

It has been ascertained previously [1] that the formula

$$h\nu_G \cong h\nu(1 - \Phi / c^2) \quad (1)$$

is the consequence of the ascription of a potential energy to the photon in general relativity (GR).[2] This formula can actually show gravitational repulsion. According to (1), the light frequency (energy) increases as the absolute value of the gravitational field potential increases (i.e., when approaching the bodies that are creating the field) and visa versa.

Below we show that a similar situation also takes place in GR for the energy of a material body (particle) which is defined by the time component of the contra-variant 4-vector energy-momentum

$$p^i = mu^i \quad (2)$$

Here  $i=0,1,2,3$ ;  $m$  is the mass of particle; and  $u^i$  its 4-vector velocity component. As far as we know, this equation is the generalization of the known non-relativistic formula

$$\vec{p} = m\vec{v} \quad (3)$$

Based on (2), we have for the particle energy

$$E = p^0 c = mu^0 c = mc dx^0 / d\tau \quad (4)$$

where  $x^0 = ct$  and  $\tau$  is the proper time.

The interval  $c\tau$  depends on the gravitational potential in GR. In particular, based on the known Schwarzschild solution, in the simplest case of immovable particle, we have

$$c^2 d\tau^2 = g_{00} (dx^0)^2 = (1 + 2\Phi / c^2) c^2 dt^2 \quad (5)$$

After substituting eq.(5) into eq.(4), we can obtain the particle's energy in a gravitational field [1]

$$E^G \cong mc^2 (1 - \Phi / c^2) = mc^2 - m\Phi \quad (6)$$

As seen, this can be a **gravitational repulsion!**

The conventional use of the covariant component [3]

$$E_G = g_{00} E^G \cong mc^2 + m\Phi \quad (7)$$

does not remove this difficulty. It is astonishing that this serious inner contradiction of GR has not been discovered before.

**Conclusion:** Gravitational repulsion, as shown here, is an indubitable consequence of general relativity.

**References:**

- [1] V.N. Strel'tsov, "General Relativity: Incompatibility of two formulae for frequency shift", *Apeiron* **6**, 133-4 (1999).
- [2] S. Weinberg, **Gravitation and Cosmology**, p.85 (John Wiley & Sons, New York, 1972).
- [3] L.D. Landau & E.M. Lifshitz, **The Theory of Field**, Sec. 88 (Nauka, Moscow, 1988).

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