Pis'ma v ZhETF, vol. 76, iss. 8, pp. 565 – 565

Is G a conversion factor or a fundamental unit?

G. Fiorentini[1)], *L. Okun*[+ 1)], *M. Vysotsky*[+ 1)]

INFN, Sezione di Ferrara, Ferrara, Italy

[+]*Institute of Theoretical and Experimental Physics, 117218 Moscow, Russia*

Submitted 16 September 2002

Resubmitted 23 September 2002

By using fundamental units $c, \hbar, G$ as conversion factors one can easily transform the dimensions of all observables. In particular one can make them all "geometrical", or dimensionless. However this has no impact on the fact that there are three fundamental units, G being one of them. Only experiment can tell us whether G is basically fundamental.

PACS: 06.20.Fn, 06.20.Jr

It is well known [1] that to each mass M there corresponds a characteristic length r_g, the so called gravitational radius (a body with radius $r = r_g$ forms a black hole):

$$r_g = 2GM/c^2,$$

where G is gravitational constant

$$G = 6.673(10) \cdot 10^{-11} \mathrm{m}^3/\mathrm{kg} \cdot \mathrm{s}^2,$$

while c is velocity of light. Thus in all physical equations M can be substituted by r_g so that mass can be "exorcised" from definitions of all physical observables. As a result everything can be measured in "geometrical" units of length L and time T instead of standard L, T, M units.

One can use $M' = GM$ instead of M in order to reduce all measurements in physics to measurements of space and time intervals and exorcise G from all equations of physics, thus reducing the number of fundamental dimensionful constants. We would like to make a few rather trivial remarks concerning this proposal.

First, it is obvious that in defining M' one can use $GMg(L,T)$ instead of GM, where g is an arbitrary function of geometric units L, T. In particular, in the standard case of gravitational radius $g = 2/c^2$.

Second, as is well known (see e.g. [2]), $c, \hbar, G$ are fundamental units in the sense that c represents relativity, $\hbar$ – quantum mechanics, while Planck mass $m_P = \sqrt{\hbar c/G}$ is connected with the space-time scales $l_P = \hbar/m_P c$ and $t_P = l_P/c$ at which gravity must become strong and of quantum character. Contrary to that, the units based on M' have no fundamental character.

Third, by using any of three fundamental units as a conversion factor one does not reduce the number of fundamental units and dimensions. E.g. when using c as a unit of velocity, one obviously preserves it as a fundamental unit. At the same time one can measure time in units of length, or length in units of time. However length remains length, while time remains time. Similar considerations are valid for mass M, G and gravitational radius r_g or any combination of the type $GMg(L,T)$.

Of course, if G turns out to be only an "effective constant" as is the case in theories in which gravity is modified at submillimeters distances (see e.g. [3]), then new physics will appear well below Planck mass, maybe even at a few TeV, thus changing the value of fundamental mass. In the case that G is only an effective constant, a new dimensionless parameter would appear in low-energy physics: $m_{\mathrm{Pl}}^{\mathrm{new}}/m_{\mathrm{Pl}}^{\mathrm{old}}$. Thus the question posed in the title of this letter could be answered by further study of the nature of gravity. Another approach to fundamental units, including G, one can find in [4].

This work was partly supported by RFBR grant # 00-15-96562.

[1)]e-mail: fiorentini@fe.infn.it; okun@heron.itep.ru; vysotsky@heron.itep.ru

1. L. D. Landau and E. M. Lifshits, *The classical Theory of Fields*, Oxford, 1961.
2. M. Duff, L. Okun, and G. Veneziano, physics/0110060.
3. V. Rubakov, Uspekhi Fiz. Nauk **171**, 913 (2001) (in Russian).
4. G. Volovik, JETP Lett. **76**, 89 (2002).