PROBLEM OF PHYSICS

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ABSTRACT

The center of mass and the center of gravitation of a mass distribution are defined. It is pointed out that, apparently, the center of gravitation has not been defined or used in the published physics literature so far.

The center of mass is defined in all physics textbooks as the point with respect to which the mass moment of the observed mass distribution is zero. On the other hand, the center of gravity is defined in some textbooks, but not mentioned at all in many other textbooks. The center of gravity in the textbooks where it is mentioned and defined is shown to be in fact the center of weight and identical to the center of mass of the observed mass distribution in the uniform external gravitational field. As such, the center of gravity is totally unnecessary and should not be even mentioned at all. It is obvious that *gravity* in the expression *center of gravity* in the textbooks where it is mentioned means nothing else but *weight*, i.e., identically as in the expression *specific gravity.*

However, the language is a living tool, and it changes in time. The word *gravity* has assumed for quite some time also the meaning of the gravitation or the gravitational field as evident, for example, from the name of a scientific journal CLASSICAL AND QUANTUM GRAVITY, where GRAVITY obviously does not refer to WEGHT but certainly to GRAVITATIONAL FIELD. The expressions – words *gravity, gravitation* and *gravitational field* are fully interchangeable according to any college edition of the Webster dictionary, including also the American Heritage Dictionary, electronic version. Thus, the expression *center of gravity* may be misleading in some situations. So the textbooks, which omit altogether that expression *center of gravity*, are certainly justified.

Hence, the expression *center of gravity* may be sometimes interpreted erroneously as the center of the gravitational field, or simply, the center of gravitation. However, it is interesting to note that the center of gravitation is not mentioned or defined or used in the published physics literature so far to the best of knowledge of this author. Consequently, the question is raised what is the meaning of the expression the center of gravitation and how that term should be defined?! The only logical definition is that the center of gravitation (or self gravitation for emphasis) is the point at which the gravitation, i.e., the gravitational field of the observed mass distribution is zero.

It is easily concluded from those definitions that the center of mass and the center of self gravitation are the two distinctly different points which coincide only in the case of the absolute symmetry of the observed mass distribution. Those two points are the characteristic invariants of the observed mass distribution, which obviously vary if the observed mass distribution changes.

As an illustrative example, consider the simplest mass distribution consisting of the two point masses m_1 and m_2 at a distance d from each other. Let d_{cm} designate the distance of the center of mass measured from the mass point m_1 along the line connecting these two point masses, then $m_1 d_{cm} = m_2 \left(d - d_{cm}\right)$, which yields $d_{cm} = dm_2 / \left(m_1 + m_2\right)$. On the other hand, let d_{cg} designate the distance of the center of gravitation measured from the same point mass m_1 along the line connecting these two point masses, then applying the Newton's law of gravity we write $Gm_1 / d_{cg}{}^2 = Gm_2 / \left(d - d_{cg}\right)^2$, which yields the expression $d_{cg} = d\sqrt{m_1} / \left(\sqrt{m_1} + \sqrt{m_2}\right)$. G is, of course, the universal gravitational constant. For $m_1 > m_2$, it is easily proved that $d_{cg} > d_{cm}$. It is obvious from the obtained expressions that these two centers coincide, if and only if those two point masses become equal, in which case that simplest mass distribution becomes symmetrical evidently.

It must be mentioned that the calculation of the center of gravitation is not a simple task. In the general case when the mass distribution is defined by the volume mass density ρ_m, the center of gravitation $\vec{r}_{cg}$ is the solution of the integral equation

$$\vec{g}(\vec{r}_{cg}) = G\int \frac{(\vec{r}_{cg} - \vec{r}\,')\rho_m dV'}{\left|\vec{r}_{cg} - \vec{r}\,'\right|^3} = 0 \qquad , \qquad (1)$$

where the notation is customary. It is evident from this equation that the problem of calculating the center of gravitation of a general mass distribution is far from simple, while the calculation of the center of mass is relatively a simple task of the integrations. That may be the explanation of the fact that the center of gravitation was never defined or used so far in the published physics literature to the best of knowledge of this author, to repeat once more. Of course, the center of mass $\vec{r}_{cm}$ is in the general case defined by

$$\int (\vec{r}\,' - \vec{r}_{cm})\rho_m dV' = 0 \qquad \text{i.e.} \qquad \vec{r}_{cm} = \left(\int \rho_m dV'\right)^{-1} \cdot \int \vec{r}\,'\rho_m dV' \qquad . \qquad (2)$$

This obvious deficiency in the physics textbooks - literature should be eliminated.