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On the Gravitational Waves Detected by the LIGO-Virgo Collaboration

V. A. Golovko*

Department of Science, Moscow Polytechnic University, Moscow, Russia

***Corresponding author:** V. A. Golovko, Department of Science, Moscow Polytechnic University, Moscow, Russia; E-mail: fizika.mgvmi@mail.ru

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Abstract

It can be clearly, simply and decisively explained that the Ehrenfest Paradox arises from an incorrect application of the length contraction rule, and that a correct analysis of the case of the rotating disk leads to the fact that the relationship between the radius and the circumference remains as usual.

Keywords: General relativity; Gravitational waves; LIGO-Virgo collaboration; Black holes

Introduction

The gravitational waves detected by the LIGO-Virgo collaboration are interpreted on the basis of post-Newtonian expansions [1,2]. For illustrative purposes, first we shall reason in terms of the Schwarzschild metric. The metric in an immobile coordinate system has a singular point at $r=r_g$ where $r_g=2Gm/c^2$ is the gravitational radius. Any series diverges in the vicinity of a singular point and thereby cannot be used in this vicinity. When two black holes are in contact, the contact occurs just at $r=r_g$ but the post-Newtonian expansions fail in this situation for the above reasons. Therefore, the merger of black holes cannot be described with use made of post-Newtonian methods [3].

This fact can be proven directly. Any process that happens at the surface of a black hole ($r=r_g$) can be seen by a remote observer only when his time $t \to \infty$ [7, § 102]. As a result, any movement of the surface and thereby the movement of the black hole itself can be observed at the Earth only when $t \to \infty$. The frequency of a signal emitted by the surface of the black hole is equal to zero [7, § 102]. As Landau and Lifshitz write all processes on the body appear to be “frozen” with respect to the external observer. Consequently, at the present time we cannot observe displacements of black holes let alone their merger. Up till now the merger has not yet begun for us at the Earth.

Description

Golovko were proposed metrics for the gravitational field of a point mass which are physically different from the Schwarzschild one. The metric the most adequate in this case is of the form

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$$ds^2 = e^{-r_g/r} c^2 dt^2 - \frac{r_g^4 e^{-r_g/r}}{r^4 \left(1 - e^{-r_g/r}\right)^4} dr^2 - \frac{r_g^2}{\left(1 - e^{-r_g/r}\right)^2} d\Omega^2, \qquad (1)$$

where $d\Omega^2 = d\theta^2 + \sin^2\theta d\varphi^2$. The metric is singular only at r=0. It follows from the metric that there are no black holes in nature.

Therefore, the mass of a neutron star, for example, can be arbitrary without formation of a black hole. Special investigation is required for neutron stars of large mass because up till now one believed that such stars do not exist owing to the gravitational collapse leading to formation of black holes. At the same time, it is clear that, when these stars' contract under action of gravity and do not give rise to black holes, they cannot contract endlessly and thereby there must exist a physical mechanism which stops contracting and determines the final size of the stars. It is quite possible that the neutron stars of large mass and the ones of small mass differ physically [4]. Seeing that the nature of the objects of large mass is unknown at the present time, we continue to call them the neutron stars.

For illustrative purposes we shall assume that the radius of a neutron star is of the order r_g.

The coefficient of c^2dt^2 in (1) at $r=r_g$ is ≈ 0.4 and the coefficient of cdt will be 0.6, which essentially differs from zero for the Schwarzschild metric. The velocity of a test particle falling towards the centre is given by Eq. of [5]:

$$v^2 = c^2 e^{-r_g/r} \left(1 - \frac{1}{\beta^2} e^{-r_g/r}\right), \qquad (2)$$

where $\beta = E_0/(\mu c^2)$ while E_0 and μ are the energy and mass of the test particle. The velocity is measured by an observer stationed at infinity. If β is not very small, we shall have for $r=r_g$ that the velocity v is of the order of the speed of light c, which is drastically different from the Schwarzschild metric for which v=0 at $r=r_g$ [6]. Therefore, the point $r=r_g$ for the metric of (1) is far from being singular and it is legitimate to use the post-Newtonian calculations in this case. Perhaps one should revisit the calculations in order to take the metric of (1) into consideration instead of the Schwarzschild metric if need be. The results, however, should not change appreciably seeing that the motion in the Schwarzschild metric between large r and $r=r_g$ is practically indistinguishable from the motion in the metric of (1) between large r and the singularity at r=0 [7].

When considering inspiralling binaries it is necessary to take the angular momentum into account. Golovko were proposed metrics for the gravitational field of a charged and rotating mass which are physically different from the Kerr-Newman one. The metric the most adequate in this case is given in Eq. of Golovko VA. The metric is singular only at the surface of a infinitely thin rotating disk that creates the gravitational field [8]. The noteworthy fact is that, if the disk is not charged, the metric is admissible for any angular momentum of the disk in contradistinction to the Kerr metric which is physically admissible only if the angular momentum is sufficiently small. The post-Newtonian methods are applicable in this case too because it is unnecessary to extend the calculations up to the singular surface of the disk since the sizes of the objects under study are finite [9].

It is worthy of remark that, if the rotation of an object under study is rapid, the gravitational field of the object can be essentially modified, which is demonstrated when considering the rotation of galaxies.

Conclusion

In conclusion, we see that the gravitational waves detected in the LIGO-Virgo observations can be emitted only in the process of the merger of neutron stars. Only in this case the post-Newtonian approximations used for the interpretation of the observations are applicable. Factually, the observations prove that there are no black holes in nature inasmuch as they show that there are small and very massive objects in the Universe which do not collapse into the black holes.

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