Gravitational Time Dilation for a Free-Fall on Neutron Black Hole

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Abstract: Within the Scale-Symmetric Theory (SST) we showed that for a free-fall on neutron black hole (NBH), the relativistic mass is real so synchronization of clocks via the Lorentz Transformation is logically inconsistent. To obtain correct formula for gravitational time dilation, instead of using the Lorentz Transformation, we must start from the law of conservation of spin. Near and inside the Schwarzschild surface the gravitating grainy Einstein spacetime (ES) inspirals towards the centre of NBH (the ES leaks from NBH via the NBH jets). It causes that near the Schwarzschild surface down to the surface of NBH (its equatorial radius is two times smaller than the Schwarzschild radius) the time dilation does not follow from pure radial motions but from orbital motions as well. We showed that time practically stops when vector sum of orbital and radial velocities of freely falling body is close to the velocity of light in "vacuum" c. Due to the inspiralling ES, the trajectory of the body is deflected from the radial direction but trajectories of a freely falling initially radial photon and the body do not overlap. The inspiralling ES causes that for a distant observer, the radial speed on the Schwarzschild surface of a freely falling body is lower than c. For radii smaller than the equatorial radius of NBH, time is going as in frame of reference in the absolute rest - it follows from the fact that inside NBH both NBH and ES have the same angular velocities.

1. Introduction

In the Einstein Special Theory of Relativity (SR) is assumed that the relativistic mass, m_{rel}, is not real. Then, the rest mass m_o in all frames of reference is the same. The unreality of the relativistic mass in SR follows from the fact that we start from the Lorentz Transformation. The Scale-Symmetric Theory (SST) [1], [2], shows that the relativistic mass is not real only in some special cases. For example, relativistic mass of galaxy clusters in the expanding Universe is not real because the recessional velocities of both a galaxy cluster and local dark energy are the same – due to evolution of the Universe, the galaxy cluster knows what is state of the local dark energy but it does not know what is state of the gravitating grainy Einstein spacetime (ES) so we can neglect the ES in a SR analysis. The same concerns relativistic masses of neutrons in a rapidly rotating neutron black hole (NBH). Just due to very high surface density of the positive electric charge in baryons [1], both a rapidly rotating NBH and ES inside it have the same angular velocities i.e. rotating NBH is in the rest in relation to the rotating ES [2] i.e. the NBH knows the state of the rotating ES so we must take it into account.

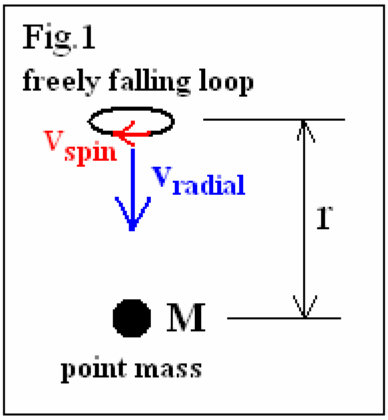
Within SST we showed that for a free-fall of a body on NBH, the relativistic mass is real so synchronization of clocks via the Lorentz Transformation is logically inconsistent [3]. To obtain correct formula for gravitational time dilation, instead of using the Lorentz Transformation, we must start from the law of conservation of spin [3].

Within SST we derived formula for the gravitational time dilation for freely falling body on a point mass M (instead point mass, there can be a NBH) for radii r much higher than the Schwarzschild radius r_S ($r >> r_S$). Starting from the law of conservation of spin, not from the Lorentz Transformation, we obtained [3]

$$\Delta t = \Delta\tau \,(1 - r_S / r)^{1/2}, \qquad (1)$$

where $r_S = 2\,G\,M / c^2$ is the Schwarzschild radius of the NBH with a mass of M. This formula is consistent with the formula obtained within the Einstein SR. In formula (1), the $\Delta t = 2\pi R / c$ is the definition of unit of time for resting spinning loop whereas $\Delta\tau = 2\pi R / v_{Spin}$ is the definition of unit of time for loop moving with velocity v and having spin speed v_{Spin}, where

$$c^2 = v_{radial}^{\ 2} + v_{Spin}^{\ 2}. \qquad (2)$$



Here we described problems concerning the gravitational time dilation near and inside the Schwarzschild surface of a NBH.

2. Problems concerning the gravitational time dilation near and inside the Schwarzschild surface of a NBH i.e. $r \approx < r_S$

Near and inside the Schwarzschild surface the gravitating grainy Einstein spacetime (ES) inspirals towards the centre of NBH (the ES leaks from NBH via the NBH jets) [4]. It causes that near the Schwarzschild surface down to the surface of NBH (its equatorial radius is two times smaller than the Schwarzschild radius [2]) the time dilation does not follow from pure radial motions but from orbital motions as well (Fig.2).

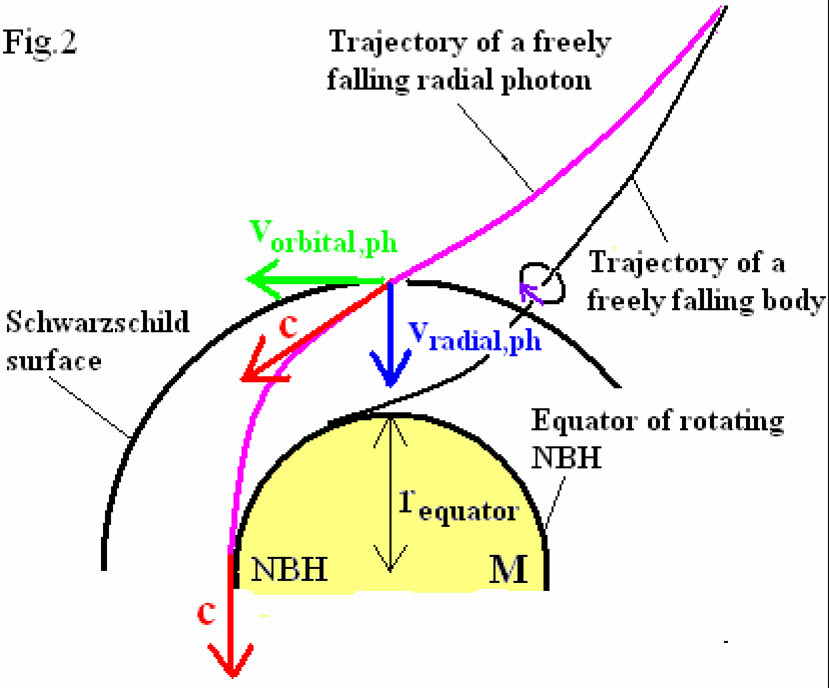
Time practically stops when vector sum of orbital and radial velocities of freely falling body is close to the velocity of light in "vacuum" c. The trajectory of the body is deflected from the radial direction by the inspiralling ES but the trajectories of a freely falling initially radial photon deflected by the inspiralling ES and of a freely falling body, both starting from the same point in ES spacetime, generally, due to the advection, do not overlap [4]. The inspiralling ES causes that for a distant observer not located on the axis of rotation of the NBH, the radial speed on the Schwarzschild surface is lower than c. In reality, time stops always on the equator of NBH i.e. for $r = r_{equator} = G\ M\ /\ c^{\ 2}$, not on the Schwarzschild surface i.e. not for $r_S = 2\ G\ M\ /\ c^{\ 2}$. Notice that radial velocity of a freely falling body can not be on the Schwarzschild surface lower than the radial velocity of a freely falling initially radial photon. The Newtonian dynamics leads to following values of velocities on the Schwarzschild surface of initially radial photons

$$v_{radial,ph} = v_{orbital,ph} = 2^{\,1/2}\ c\ /\ 2. \qquad (3)$$

It leads to conclusion that on the Schwarzschild surface of a rapidly rotating NBH, the radial speed of a free falling body can not be equal to c because of the orbital speed of the ES not equal to zero. But, of course, can be very close to c. Notice that deflection from the radial direction of freely falling initially radial photons is on the Schwarzschild surface very high because such photons must cross the surface at an angle of 45°.

For radii smaller than the radius of NBH ($r < r_{equator}$), time is going as in a frame of reference in the absolute rest – it follows from the fact that inside NBH both NBH and ES have the same angular velocities [4], [2].

Fig.2



3. Summary

Here we showed that time practically stops when vector sum of orbital and radial velocities of freely falling body is close to the velocity of light in "vacuum" c. The trajectory of the body is deflected from the radial direction by the inspiralling ES but the trajectories of a freely falling initially radial photon deflected by the inspiralling ES and of a freely falling body both starting from the same point in ES spacetime, generally, due to the advection, do not overlap. The inspiralling ES causes that for a distant observer not located on the axis of rotation of the NBH, the radial speed on the Schwarzschild surface is lower than c. In reality, time stops always on the equator of NBH i.e. for $r = r_{equator} = G\ M\ /\ c^{\ 2}$, not on the Schwarzschild surface i.e. not for $r_S = 2\ G\ M\ /\ c^{\ 2}$.

For radii smaller than the radius of NBH ($r < r_{equator}$), time is going as inside a frame of reference in the absolute rest – it follows from the fact that inside NBH both NBH and ES have the same angular velocities.

Here and in paper [3] we showed that sometimes relativistic mass is real. Then there are three causes that clocks are going in different way. First follows from the Lorentz Transformation, the second from the different masses and spin speeds of particles the clocks moving with different velocities are built of (just when we neglect relative velocities then the clocks in frames moving with different velocities are not identical), and the third from the orbital/transverse motions that appear in the free-fall on NBH so the Lorentz Transformation is incomplete.

References

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