DYNAMICS OF MAGNETIZED PARTICLE AROUND BLACK HOLES

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Abstract: We have shown that there is degeneracy between spin of SMBH and ambient magnetic field and consequently the interaction of magnetic field ~ 10^2 Gauss with magnetic moment of magnetized neutron star can in principle mimic spin of Kerr black holes up to 0.6.

Keywords: Black hole, magnetized particles, conformal transformation

One of the fundamental problems of general theory of relativity is the presence of singularity in almost all known exact analytical solutions of the gravitational field equations. For the black hole solutions, the central physical singularity with the infinite curvature is unavoidable. However standard understanding of the physics cannot accept the physical processes at the physical singularity, and it breaks out. There are several attempts to avoid the singularity: coupling with nonlinear electrodynamics [1–3], conformal transformations [4,5], quantum gravity corrections [4-7], etc.

One of the possible ways of excluding the physical singularity in the black hole solutions is using the conformal gravity where metric tensor is transformed as

$$g_{\mu\nu} \to g^{*}_{\mu\nu} = \Omega^2 g_{\mu\nu}\,, \qquad (1)$$

where $\Omega = \Omega(x)$ is a conformal factor of transformation.

In Schwarzschild coordinates (t, r, q, f) the space-time metric of the spherically symmetric static black hole in conformal gravity can be described as [6,7]

$$ds^2 = S(r)\left[-f dt^2 + \frac{dr^2}{f} + r^2(d\theta^2 + \sin^2 d\phi^2)\right] \quad (2)$$

where *f=1-2M/r* is the lapse function and the scaling factor *S(r)* has the following form

$$S(r) = S = \left(1 + \frac{L^2}{r^2}\right)^{2N} \quad (3)$$

In this note, magnetized particle motion around black holes in conformal gravity immersed in asymptotically uniform magnetic field has been studied. We have also analyzed the behavior of magnetic fields near the horizon of the black hole in conformal gravity and shown that with the increase of conformal parameters L and N the value of angular component of magnetic field at the stellar surface decreases. The maximum value of the effective potential corresponding to circular motion of the magnetized particle increases with the increase of conformal parameters. It is shown that in all cases of neutral, charged and magnetized particle collisions in the black hole environment the center-of-mass energy decreases with the increase of conformal parameters L and N. In the case of the magnetized and negatively charged particle collisions, the innermost collision point with the maximum center-of-mass energy comes closer to the central object due to the effects of the parameters of the conformal gravity. We have applied the results to the real astrophysical scenario when a pulsar treated as a magnetized particle is orbiting the super massive black hole (SMBH) Srg A* in the center of our galaxy in order to obtain the estimation of magnetized compact object’s orbital parameter.

The possible detection of pulsar in Srg A* close environment can provide constraints on black hole parameters. Here we have shown that there is degeneracy between spin of SMBH and ambient magnetic field and consequently the interaction of magnetic field ~ 10^2 Gauss with magnetic moment of magnetized neutron star can in principle mimic spin of Kerr black holes up to 0.6.

Fig. 1 illustrates the degeneracy between spin of black holes and magnetic interaction in black hole environments. It shows that for the cases when $b < 1$ the

degeneracy with the reasonable value of black hole spin up to 0.6 becomes very realistic.

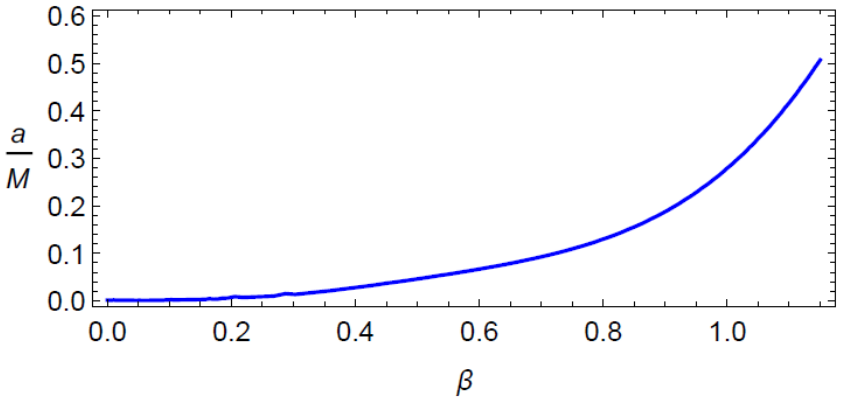

Fig.1 The degeneracy plot showing the dependence of rotation parameter *a* on *b*. The line corresponds to the matching values of parameters for the same values of ISCO.

References

6. Bardeen, J. Non-singular general-relativistic gravitational collapse. In Proceedings of the International Conference GR5, USSR, Tbilisi, Georgia, 9–13 September 1968; p. 174.

7. Hayward, S.A. Formation and Evaporation of Nonsingular Black Holes. Phys. Rev. Lett. 2006, 96, 031103.

8. Ayón-Beato, E.; García, A. Regular Black Hole in General Relativity Coupled to Nonlinear Electrodynamics. Phys. Rev. Lett. 1998, 80, 5056–5059.

9. Englert, F.; Truffin, C.; Gastmans, R. Conformal invariance in quantum gravity. Nucl. Phys. B 1976, 117, 407–432.

10. Narlikar, J.V.; Kembhavi, A.K. Space-time singularities and conformal gravity. Nuovo C. Lett. 1977, 19, 517–520.

11. Bambi, C.; Modesto, L.; Rachwał, L. Spacetime completeness of non-singular black holes in conformal gravity. J. Cosmol. Astropart. Phys. 2017, 2017, 003.

12. Bambi, C.; Malafarina, D.; Modesto, L. Black supernovae and black holes in non-local gravity. J. High Energy Phys. 2016, 2016, 147.