CAN CONFORMAL GRAVITY MIMIC KERR BLACK HOLES

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INTRODUCTION

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:

Now we will consider orbits of test particles to be circular, or more specifically the innermost stable circular ones. Using following standard conditions

$$V_{eff} = \mathcal{E}^2, \quad V_{eff}{}'(r) = 0, \quad V_{eff}{}''(r) = 0 \qquad (1)$$

One can easily find the values of ISCO radius. Angular momentum for circular orbits can also be found from the equations above that reads

$$\mathcal{L}^2 = \frac{r^2(L^2(4MN+M-2Nr)+Mr^2)}{r(L^2(-M(4N+3)+2Nr+r)+r^2(r-3M)} \qquad (2)$$

Now we will analyze the distance where Lcr is always positive i.e. circular motion can occurs in equatorial plane. The energy of the charged particle at circular orbits will have the following form

$$\mathcal{E}^2 = \frac{(L^2+r^2)(r-2M)^2\left(\frac{L^2}{r^2}+1\right)^{2N}}{r(L^2(-M(4N+3)+2Nr+r)+r^2(r-3M)} \qquad (3)$$

Here we will study radial dependence of the energy in equatorial plane.

Fig. 1 illustrates the radial profiles of the charged particle angular momentum and energy at circular orbits on equatorial plane. One can see that the angular momentum and the energy of the particles decrease in the presence of conformal parameters. It can be also seen that the plots are shifted to the left which corresponds the decrease the radius of minimal value of circular orbits. Using the condition for the stability of circular orbits ($\partial rVeff \geq 0$ and $\partial_\theta Veff \geq 0$) one may obtain the condition for the obtaining the radius of innermost stable circular orbits (ISCO) at the equatorial plane in the following form.

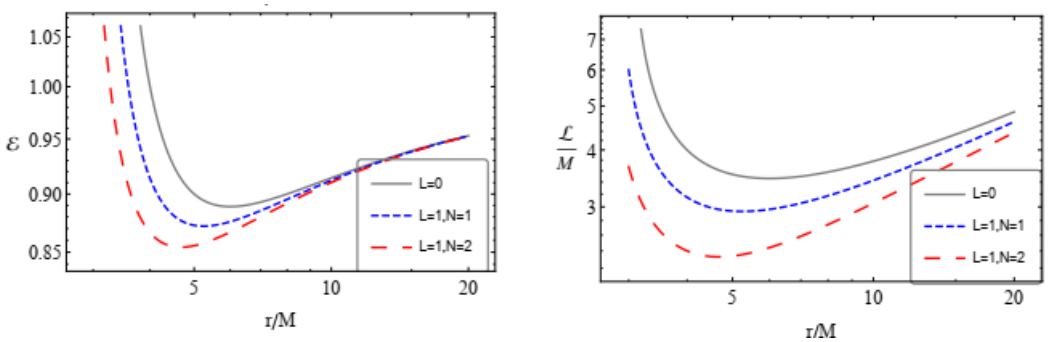

FIG. 1: Redial dependence of specific angular momentum (L at the left panel) and energy (E at the right panel) of the particles for circular stable orbits

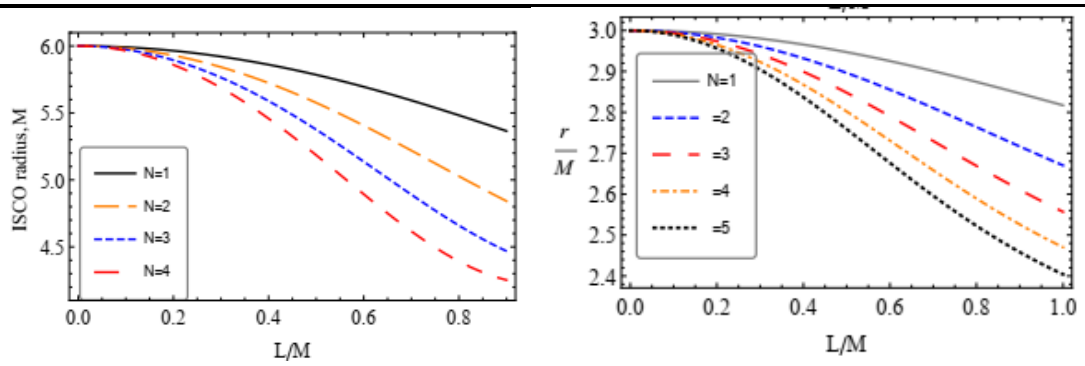

FIG. 2: Comparison of ISCO radius of charged particle around Kerr black hole and Schwarzschil black hole in conformal gravity and scale parameters (at the left panel) and relations minimum radius where stable orbits are allowed.

$$2L^2Mr^2(-2M(4N+3)+4Nr+r)+Mr^4(r-6M)$$
$$+L^4(-2M^2(4N+1)(4N+3)+M(8N(4N+3)+1)r-4N(2N+1)r^2)$$
$$\gg 0 \qquad (4)$$

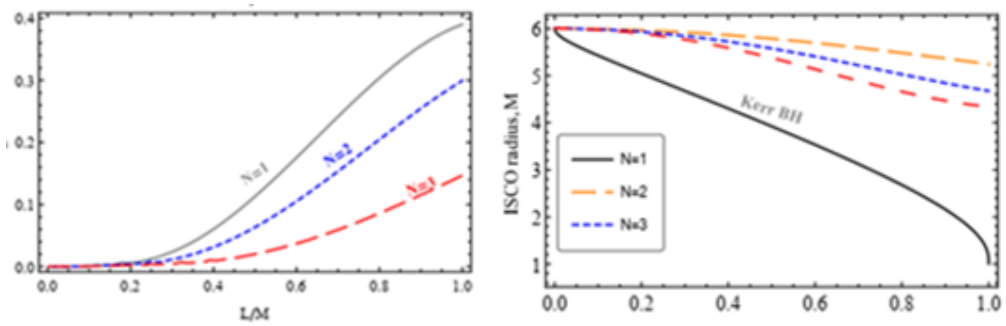

FIG. 3: Dependence of ISCO radius of charged particle on magnetic parameter for various values of conformal and scale parameters (at the left panel) and relations of rotation and conformal parameters giving the same ISCO radius.

CONCLUSIONS

In this work, we have studied circular motion of test particles around Schwarzschild black hole in conformal gravity. Analysis of the studies of specific energy and angular momentum for circular stable orbits show that the increases of both conformal parameters cause to decrease of the energy and angular momentum.

References

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