TEST PARTICLES AROUND HAYWARD BLACK HOLES SURROUNDED BY QUINTESSENTIAL MEDIUM

Xudoyberdieva Malika[1,] **Juraeva Nozima**[2]
[1]*National University of Uzbekistan, Tashkent 100174, Uzbekistan*
[2]*Ulugh Beg Astronomical Institute, Tashkent 100052, Uzbekistan*
Xudoyberdiyeva94@Inbox.Ru

Introduction. A spacetime singularity is the breakdown of the geome try or other physical structure related to the properties of the spacetime and gravity. Usually the breakdown of the geometry means thed edge or end of the spacetime. The general relativity proposed by the Albert Einstein not only predicts the singularity but it also claims that the existence of the singularity is unavoidable. Most of the singularity in general relativity appears when one con siders the solution of black holes which contains the cur vature singularity hidden by the event horizon. The un derstanding the nature of the physical singularities meets physical and philosophical problems. On the other hand there are several attempts to resolve the singularity prob lems within general relativity or using alternative theo ries of gravity. Particularly, the quantum gravity theory which is not yet constructed is also believed to resolve the fundamental problems of the general relativity.

In this section we study electromagnetic four potentials The line element of non rotating ABG regular black holes is given in.. as

$$f = 1 - \frac{2Mr^2}{r^3 + q^3} - \frac{c}{r^{3\omega+1}}$$

where c is a normalization factor and ω has the range $-1 < \omega < -1/3$. For the Schwarzschild black hole surrounded by quintessence $\varepsilon = 0$. We present new static spherically-symmetric exact solutions of Einstein equations with the quintessential matter surrounding a black hole charged or not as well as for the case without the black hole. A condition of additivity and linearity in the energy-momentum tensor is introduced, which allows one to get correct limits to the known solutions for the electromagnetic static field implying the relativistic relation between the energy density and pressure, as well as for the extraordinary case of cosmological constant, i.e. de Sitter space. We classify the horizons, which evidently reveal themselves in the static coordinates, and derive the Gibbons-Hawking temperatures. An example 2 of quintessence with the state parameter $w = 2/3$ is discussed in detail.

As it is observed that the existence of magnetic charge$g$ of BH and spin causes a decrease of the radius of ISCO of the test particles. Because of similar behaviors of the ISCO it is challenging to differentiate in the measurements of the ISCO radius in the astronomical observations. The degeneracy values of BKBH parameters c and the spin of Kerr BH which provide the same radius of ISCO are explored in this section and we show how to categorize the BHs through (direct or indirect) measurements of ISCO radius. The ISCO radius of test particles moving around rotating Kerr BHs for prograde and retrograde orbits has the following form.

Now one may consider the conditions for the circular motion i.e. no radial motion ($\dot{r} = 0$) and no forces act in the radial direction ($\ddot{r} = 0$) and obtain the radial profiles of the specific angular momentum and a specific energy for circular orbits at the equatorial plane ($\theta = \pi/2$) in the following form.

$$\frac{2\left(c\left(r^3 + 2M\epsilon^2\right) - r^{1+3\omega}\left(r^3 + 2M\left(-r^2 + \epsilon^2\right)\right)\right)^2}{2r^{2+6\omega}\left(-3Mr^5 + r^6 + 4Mr^3\epsilon^2 + 4M^2\epsilon^4\right) - 3cr^{1+3\omega}\left(r^3 + 2M\epsilon^2\right)^2(1+\omega)} = E^2$$

$$\frac{2Mr^{5+3\omega}\left(r^3 - 4M\epsilon^2\right) + c\left(r^4 + 2Mr\epsilon^2\right)^2(1+3\omega)}{2r^{1+3\omega}\left(-3Mr^5 + r^6 + 4Mr^3\epsilon^2 + 4M^2\epsilon^4\right) - 3c\left(r^3 + 2M\epsilon^2\right)^2(1+\omega)} = \mathcal{L}^2$$

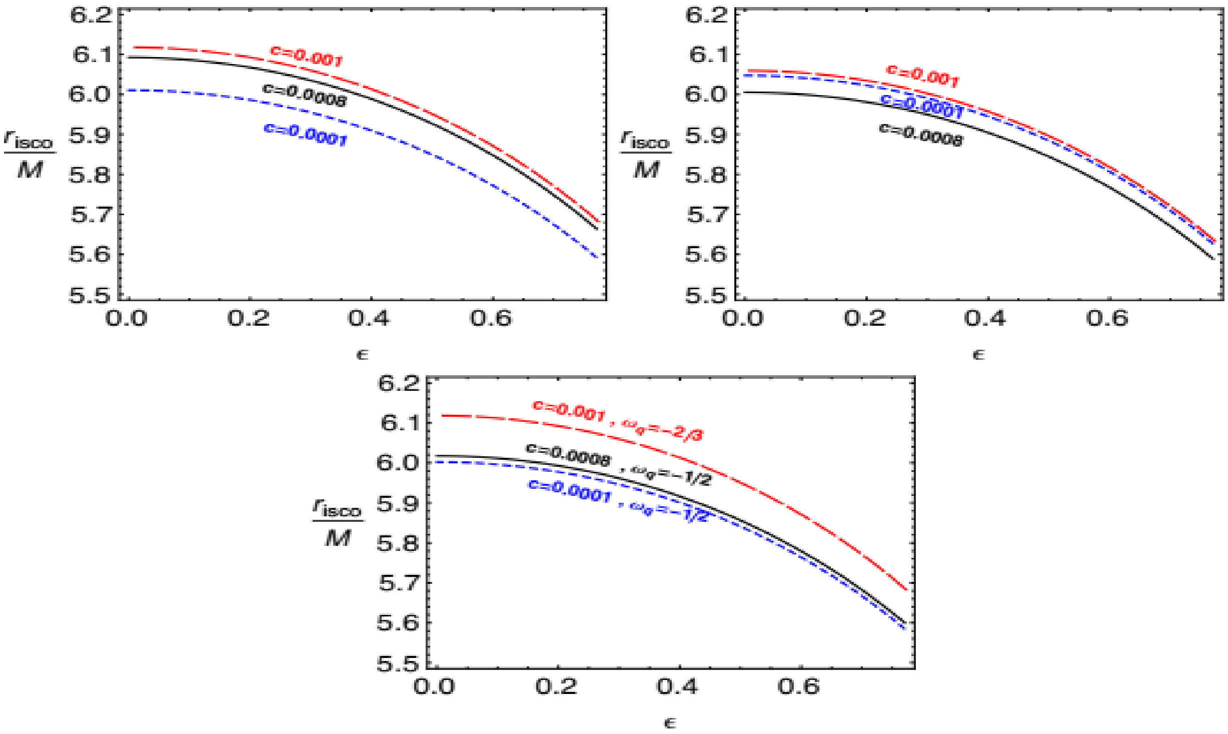

FIG. 1: Dependence of ISCO radius of test particles on the charge for the different values of the parameters c and ω

That the frequency of the radial oscillations of test particles moving around the Schwarzchild BH gets its maximum value at $r = 2M$ and in case of Kerr BH it gets a greater value as compared to Schwarzchild and its maximum value is at $r = M$. In both cases frequencies are always increasing. But for BKBH frequency of the particle's oscillation is first increasing to its maximum value and then starts decreasing. As value of c increases the frequency of the particle decreases.In Fig. (1) dependence of ISCO of a neutral particle moving around HKBH on the parameters ε, c and ω is studied graphically. It is observed that as the value of c increases (decreases) the minimum value of radius of ISCO also increases (decreases). Also, for smaller (larger) value of ω the value of minimum radius for ISCO is larger (smaller).

Conclusions

In this research article we have studied the dynamics of neutral particle moving around Hayward-Kiselev BH (HKBH). This research work is devoted to focus on the effects of the normalization parameter c of the Bardeen BH and equation of state parameter ω on the dynamics of particle. It is observed that all these scalars are defined at the centre of BH so there is no curvature singularity and as values of c increases the scalar invarients at the origin of the BH also increase in values. Then we discussed the horizon structure of the BH, the horizon of the BH becomes larger in radius as the values of normalization parameter c increase

References

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