U.G.C. Minor Research Project

The Strong field Gravitational Lensing in Black Hole space time Pierced by a cosmic String

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Gravitational lensing is a phenomenon that comes straight from Einstein's theory of general relativity. A massive object - like a black hole, or an entire galaxy - will have a powerful gravitational influence over the surrounding space-time, warping it. Anything, including light, will therefore be influenced by the curvature of space-time surrounding the massive object. It was first observed by Arthur Eddington and Frank Watson Dyson in 1919 during a solar eclipse. _As predicted by General Relativity, photons passing near a black hole suffer deviations from their original trajectory. If the minimum distance between photon and black hole is much larger than the gravitational radius, a weak field approximation of the metric tensor is sufficient to describe the light deflection. Two images of the original source are then detected by the observer. On the other hand, photons passing very close to the black hole may suffer very large deviations without falling into the black hole. These photons may perform one or more loops around the black hole before emerging in the observer direction, thus generating two infinite sets of relativistic images very close to the black hole shadow. It can be easily shown that these relativistic images represent a unique probe to gain information on the very strong gravitational fields surrounding the black holes. Through their study it would be possible to learn the properties of black holes and get new insight on General Relativity in a strong field regime.

We have discussed gravitational lensing and the image formation by various black holes (RN extremal, Schwarzschild anti de sitter and BTZ black hole) in the weak field limit. In particular, calculations are done for a super massive black hole with mass 2.8X10 ^{6} times the mass of the sun, which may be an ideal model for the type of black hole in the center of our galaxy. The geometry of the lensing is studied using thin lens approximation, which leads to the possibility of images depending mass and distance parameters. Then derived the expression for magnification and found the magnification of each images. We found that the magnification of one image falls extremely and the other image rise as the source position increases from the perfect alignment for RN extremal black hole. Whereas for Schwarzschild anti de sitter black hole the magnification of two images are found to be decreasing when the source position deviate from perfect alignment, where as for the third image the magnification is increasing. For BTZ black hole, magnification of all three images falls as source position increases from the perfect alignment.

Using strong field gravitational lensing and cosmic string effect we can study the behavior of different kinds of black holes. Here Schwarzschild and Schwarzschild Anti-de Sitter black hole having cosmic string are taken in to consideration. In both cases when the cosmic string effect is decreasing the strong field parameter is found decreasing. Therefore as a conclusion we can say that if there is a cosmic string it is easy to differentiate from the one which does not have a cosmic string if we are studying the field coefficients. For both Schwarzschild and Schwarzschild Anti-de Sitter black hole case, we found different images at different source positions, only with strong cosmic string value. When the cosmic string effect is low, we cannot distinguish the image formed by different source positions.

In Schwarzschild and Schwarzschild Anti-de Sitter black hole magnification was found to be decreasing as the angle of source position was increased. Also the magnification of the image is found increased in the presence of cosmic string.

We also studied the variation of strong field coefficients a and b with cosmic string parameter k for a black hole having electric charge. For high charged black hole, a and b decreases as k increase. That means effect of cosmic string is suppressed by the presence of high charge. The images formed by an RN black hole having less charge with high cosmic string and the black hole having high charge with less cosmic string with different source positions are distinguishable. In other words if the source position are different the images formed by a black hole having less charge with less cosmic string and images formed by a black hole having high charge with high cosmic string are indistinguishable. The magnification produced by the images for various source positions are compared. And it is clear that as the source position increases the magnification decreases for black hole having less charges. But in the case of highly charged black hole for a fixed source position, magnification of the image increases as cosmic string effect decreases (k value increases). Cosmic string effect will be prominent only if the charge of RN black is less.

The aim of this project was to review the theoretical aspects of gravitational lensing by various black holes. And from our studies the result of gravitational lensing in strong and weak limit depends up on the black hole metric and we believe that the present work will help to reveal many unknown truth about the universe.