Deflection of Light in Equatorial Plane of Kerr-Sen Black Hole

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Abstract

We study the gravitational lensing by a Kerr-Sen black hole spacetime which arises a solution to the low-energy effective field theory for four-dimensional heterotic string theory. A closed form expression of the deflection angle of light rays lensed by the Kerr-Sen black hole is derived as a function of impact parameter, spin and charge in the equatorial plane of the black hole. It is observed that charge parameter behaves differently from the spin parameter for the photons in direct and retrograde orbits around the black hole. The deflection angle becomes larger in strong field limit with an increment in the value of charge parameter and it is observed that this effect is more perceptible in case of the direct orbits as compared to the retro orbits. The results obtained are also compared with the corresponding cases of well known Kerr black hole in General Relativity.

Key Results and Future Directions

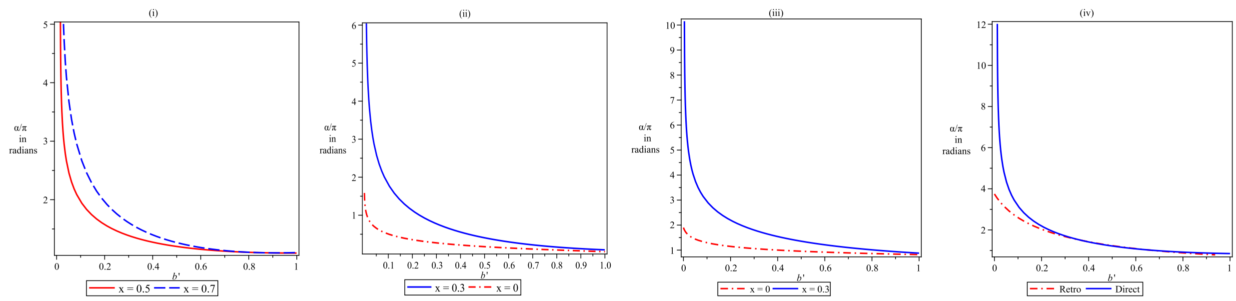

Figure 1: Exact deflection angle as a function of normalised impact parameter with spin parameter value $a = 0.5$. Left section of the above plots where $b' \to 0$ corresponds to the strong deflection limit while the right section where $b' \to 1$ corresponds to weak deflection limit.

The main objective of the present work is to study the Gravitational Lensing by a Kerr-Sen BH (KSBH) in equatorial plane to have exact closed-form solutions for the deflection angle of light such that both the strong and weak field limits are satisfied [15, 16, 17, 18, 19]. In the present work we have followed the approach used in [13]. The main difference between our approach and the work done in [20, 21] is that we have obtained an explicit expression for the bending angle for both the cases i.e. direct and retrograde motion. The final expression for bending angle depends on BH mass and spin (i.e. angular momentum per unit mass of the BH) parameters.
The effect of frame-dragging on the bending angle of photons in such cases has previously been discussed for Kerr BH [13]. The additional charge parameter behaves similar to the spin parameter for direct orbiting photons but oppositely for retrograde orbiting photons as the bending angle increases in either case on increasing the numerical value of the charge parameter. Though this increment is still much larger for direct orbiting photons. This difference in the bending angle can clearly be visible through the shifts of the corresponding relativistic images. In order to study this shift in relativistic images, one needs to study the series expansion of the bending angle in weak as well as strong deflection limits. Hence, as a further work we will derive the series expansion of the above obtained bending angle formulas in both the strong and weak field limits. This will allow an easier comparison with similar results obtained for other BH types. We intend to report these results in near future.

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