164. Analytic investigation of the imprints of charge on Reissner Nordström black hole photon ring

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Abstract

Exquisite precision has been demonstrated in testing General Relativity (GR) in weak-field regimes; however, substantial absence of precise tests persists in strong-field regimes. Black holes serve as laboratories to scrutinize GR in strong-gravity regimes. Observations from a variety of cosmological probes consistently point to the existence of dark energy which is responsible for the universe's accelerating expansion. The cosmological constant provides an elegant explanation for this observed acceleration. Furthermore, it is possible to assume that black holes have charge making it vital to investigate how this affects their observational properties. The Reissner–Nordström black holes solution is the black hole metric that incorporates both charge and the cosmological constant. This research is dedicated to probing the nature of strong gravity for black holes in Reissner–Nordström space time through the photon ring and other observables. The foundational part of our study begins with an exploration of the fundamental concept of photon orbits, serving as the basis for constructing the photon ring. Precise computations of time delays, Lyapunov exponents, and changes in azimuthal angle parameters will follow, providing insight into how they shape the structure of the photon ring. The expected outcomes point out that an increase in charge will have influence on the photon ring structure and the critical parameters. Astrophysically relevant values of the cosmological constant will have no noticeable effect as compared to the Schwarzschild black hole. The findings of this work will aid in imposing constraints on the amount of charge that can exist in Reissner–Nordström spacetime. Additionally, they will contribute significantly to the validation or exclusion of this solution, particularly in the context of future Event Horizon Telescope observations.

Keywords: *general relativity, charge, black holes, time delays, Lyapunov exponents,changes in azimuthal angle*