Chaos bound and its violation for charged particles around electrically charged distorted black holes

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Abstract

We investigate the chaos bound for charged test particles around a electrically charged distorted black hole. We analyze the Lyapunov exponents of equatorial and polar equilibrium orbits, accounting for the regularity of the spacetime and the admissibility of the electromagnetic field. For static particles, we derive an analytical expression for the Lyapunov exponent and examine its radial dependence. For particles with arbitrary angular momentum, we investigate the near horizon behavior and show that the Lyapunov exponent approaches that of the unstable equatorial photon orbit in the large angular momentum limit. Our results demonstrate that sufficiently strong external distortion can violate the chaos bound at finite distances from the horizon. We also find that near horizon polar equilibrium are stable, whereas a distortion induced field null point exhibits saddle type instability, with its Lyapunov exponent increasing with the particle's specific charge. These findings reveal how external gravitational distortion and electromagnetic interactions influence the stability of charged particle orbits and the validity of the chaos bound in non-asymptotically flat black hole spacetimes.

Keywords: General Relativity, Black Holes, Lyapunov exponent, Chaos