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Exploring axions through the photon ring of a spherically symmetric black hole

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Abstract: Axion is a pseudo-Nambu-Goldstone boson of U(1) Peccei-Quinn symmetry breaking introduced to solve the strong CP problem in Quantum Chromodynamics. Axion and axion-like particles possess certain properties that allow these particles to convert into photons when traversing through a magnetic field, making it feasible to probe them both in laboratory settings and in astrophysical environments. In this talk, I will discuss the phenomenon of photon-axion conversion occurring in the spacetime surrounding a black hole. Observations of the black hole in the center of the M87 galaxy (M87) through the Event Horizon Telescope imaged polarized synchrotron emission at 230 GHz on event horizon scales. Specifically, the potential existence of a magnetic field around M87 could facilitate the conversion of photons into axions in close proximity to the black hole photon sphere. The unstable photon orbits around the photon sphere will generate a bright ring-like structure. The conversion of photons to axions reduces the number of photons escaping the photon sphere, resulting in a dimming effect on the bright ring. We propose the possibility of detecting these axions through high-resolution telescopes. This study focuses on the mechanism considering the black hole to be non-rotating and spherically symmetric. We also investigate the photon ring luminosities if the black hole possesses a charge parameter. Apart from U(1) electric charge, the presence of an extra dimension may induce a tidal charge with a characteristic signature. The modified luminosity of the black hole's photon ring offers a valuable means of constraining the axion's coupling and mass parameter. Thus, our findings contribute to a better understanding of photon-axion conversion in the environment of a black hole spacetime and help us explore the possible existence of extra spatial dimensions.

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