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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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