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Unveiling the elusive traces of extra dimensions through the dimiming of the photon ring of black holes via axion-photon conversion mechanism

Axions are hypothetical pseudoscalar, originally proposed as a resolution to the strong CP problem in quantum chromodynamics. These particles are considered to be potential candidate for dark matter. Hence probing axions and determining its mass is of great interest, especially near supermassive black holes like M87∗. We have examined the phenomenon of photon axion conversion occuring in the spacetime surrounding a black hole. Specifically, we focus on the potential existence of a magnetic field around the supermassive black hole M87∗, which could facilitate the conversion of photons into axions in close proximity to the photon sphere. As photons travel across curved spacetime due to gravity, they spend time near the photon sphere, where they are further converted into axions. As a result, the intensity of the photon ring around the black hole decreases. We suggest monitoring the photon sphere with better resolution telescopes to investigate the possibility of discovering these hypothetical axion particles. This allows us to obtain vital insights into the conversion mechanism that occurs within a generic spherically symmetric black hole. Furthermore, we study how photon ring luminosities are affected if the black hole is considered in presence of extra-dimension.It is vital to note that the conversion mechanism's success is dependent on the axion-photon coupling and mass. As a result, studying the modified luminosity of the black hole's photon ring provides a useful way of restricting the axion's mass and coupling parameters within a given range. We predicted frequency range upon which the luminosity of the photon sphere may be effected due photon-axion conversion phenomenon. We find that the dimming rate of photon sphere changes not only with frequency of photons but also with the change in extra-dimensional parameter. This study helps to understand the dimming phenomena of photon sphere due to axion-photon coversion in presence of extra dimension.

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