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X-ray correlations due to extreme lensing by black holes

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Constraining the mass and spin of black holes is among the holy grails of contemporary research into accreting sources. Any image of a sufficiently optically thin source near a black hole exhibits contributions of extremely lensed light rays, which orbit the black hole due to its inexorable pull before travelling to the observer. In interferometric images like those produced by the Event Horizon Telescope, these source-independent, universal effects are expected to give rise to the (yet unresolved) photon ring. Here we provide a proof-of-concept demonstrating that the signature of the photon ring may be detected as spectro-temporal correlations in the X-ray band of active black holes, potentially allowing to probe their fundamental properties in numerous sources. To substantiate our claim, we perform ray tracing calculations and map the energy and arrival time of photons that reach the observer based on the number of half-orbits they experienced around the black hole due to extreme lensing. We will show results for the monochromatic emission from a hot spot orbiting the black hole at the innermost stable circular orbit. The resulting spectro-temporal correlations show a clear dependence on the black-hole spin and inclination. Analogous results will be shown for a different class of emission models that emulate a stochastic accretion disc. Future perspectives on deciphering photon-ring signals using X-ray observations of Active Galactic Nuclei and X-ray binaries using upcoming missions like New Athena will be discussed.

Author: Dr HARIKESH, Sreehari (University of Haifa, Israel)

Co-authors: Prof. CHELOUCHE, Doron (University of Haifa, Israel); Dr HADAR, Shahar (University of Haifa, Israel)

Presenter: Dr HARIKESH, Sreehari (University of Haifa, Israel)

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