

# Analytical Studies of Photon Rings in Black Hole Imaging

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**Abstract:** Future observations are expected to reveal the so-called photon rings in detailed images of black holes. These rings are lensed higher-order images of luminous matter surrounding the black hole, formed by photons that loop around it before reaching the observer. In this talk, we present analytical studies of photon rings in the images of spherically symmetric black holes. We start with a discussion of the concept of higher-order images in black hole lensing and a brief historical perspective. We then derive an explicit equation in polar coordinates that describes the shape of higher-order photon rings. This formula characterizes the apparent shape of the higher-order images of an equatorial emission ring of a given radius around the black hole, as seen by a distant observer at an arbitrary inclination. Finally, we discuss how the black hole metric can be constrained by measuring the relative separation between neighboring photon rings, even without knowing the details of the emission.



**16:30**  
**November 19, 2025**  
**Seminario B118, Fac. Ciencias**



**Financiado por**  
**la Unión Europea**  
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