



Contribution ID: 301

Type: **Talk in a parallel session**

## Shape of higher-order photon rings in image of Schwarzschild black hole

*Monday, 8 July 2024 17:00 (25 minutes)*

Higher-order photon rings can be expected to be detected in a more detailed image of the black hole found in future observations. These rings are lensed images of the luminous matter surrounding the black hole and are formed by photons that loop around it. We have succeeded to derive an analytical expression for the shape of the higher-order rings in the form that is most convenient for application: the explicit equation of the curve in polar coordinates. The formula describes the apparent shape of the higher-order image of the circular ring with the given radius around Schwarzschild black hole as viewed by distant observer with an arbitrary inclination. For the derivation, the strong deflection limit of the gravitational deflection is used. Our formula is a simple and efficient alternative to the numerical calculation of ray trajectories, with the main application to studying the shape of  $n = 2$  and  $n = 3$  photon rings.

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**Session Classification:** Gravitational lensing, shadows and photon rings

**Track Classification:** Experimental Gravitation (EG): Gravitational lensing, shadows and photon rings