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Gravitational Lensing in the Kerr Spacetime: The Standard Observer

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The Kerr spacetime is one of the most relevant spacetimes in contemporary astrophysics and describes the spacetime of a rotating black hole. When light rays pass by or are emitted in the close vicinity of a Kerr black hole they are gravitationally lensed and this leads to characteristic lensing features on the sky of a distant observer. While it is a common assumption that the observer is located at a large distance from the black hole and therefore static, in real astrophysical settings this is not necessarily the case. However, when the observer is located at a finite distance from the black hole he is commonly dragged along by the black hole which also impacts the observable lensing features.
In this talk, we will now analyse what such an observer will see. For this purpose, we will assume that we have a standard observer (sometimes also called Carter observer) in the domain of outer communication outside the photon region. First, we will introduce an orthonormal tetrad and reparameterise the constants of motion of the lightlike geodesics using latitude-longitude coordinates on the observer's celestial sphere. Then we will derive and discuss the angular radius of the shadow of the black hole in dependence on the celestial longitude. In the next step, we will then characterise the different types of motion and analytically solve the equations of motion using elementary and Jacobi's elliptic functions as well as Legendre's elliptic integrals. Finally, we will use the analytic solutions to write down a lens equation and to derive the redshift and the travel time, and discuss the results. We will also discuss the implications for the observation of different types of light sources.

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