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Comparing Characteristic Gravitational Lensing Features in Black Hole Spacetimes of the Plebanski-Demianski Class

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Einstein's field equations allow various different black hole solutions. Among these solutions the most famous are most likely the Schwarzschild and the Kerr spacetimes, which are both special cases of the so-called Plebanski-Demianski spacetime. Besides the Schwarzschild and Kerr spacetimes the Plebanski-Demianski spacetime also includes other solutions as special cases, among them the C-metric and the NUT metric. They describe a linearly accelerating black hole and a black hole with gravitomagnetic charge, respectively. The question is now how we can determine if an astrophysical black hole can be described by one of these spacetimes.
We will address this question using gravitational lensing for the three spacetimes with the most salient lensing features, namely the C-metric, the NUT metric, and the Kerr metric. For this purpose we will first outline how to solve the equations of motion analytically using elementary and Jacobi's elliptic functions as well as Legendre's elliptic integrals. Then we will fix an observer in the domain of outer communication and relate the constants of motion of the lightlike geodesics to latitude-longitude coordinates on the observer's celestial sphere. We will use the analytic solutions to write down the lens equations, calculate the redshift, and the travel time. Finally, we will discuss and compare the results and comment on how we can use them to place constraints on the spin parameter, the acceleration parameter, and the gravitomagnetic charge of a black hole.

Primary author: FROST, Torben Christian (Kavli Institute for Astronomy and Astrophysics, Peking University)

Presenter: FROST, Torben Christian (Kavli Institute for Astronomy and Astrophysics, Peking University)

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