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Geometry of trapped photon region in the phase space of Kerr-Newman and Kerr-Sen spacetime

In Einstein's general relativity, extremely strong gravity can trap light. In a spacetime admitting a singularity, we say that light (or a "photon") is trapped if it neither escapes to spatial infinity nor falls into the singularity. Null geodesics govern the trajectories of light. In the Schwarzschild spacetime with positive mass M, there exist (unstable) circular orbits of trapped photons at the Schwarzschild radius $r = 3M$, outside the black hole horizon at $r = 2M$. These orbits fill a three-dimensional submanifold of topology $S^2 \times \mathbb{R}$ called the photon sphere of the Schwarzschild spacetime. In general, a region in spacetime that is a union of all trapped null geodesics is called the Trapped Photon Region (TPR) of spacetime. In this talk, we will consider the Kerr-Newman and Kerr-Sen spacetime and see that, unlike the TPR of Schwarzschild spacetime, the TPR in such spacetimes is not a submanifold of the spacetime in general. However, the lift of TPR in the phase space is a five-dimensional submanifold. This result has applications in various problems in mathematical relativity (This work is an extension of a similar result but in Kerr spacetime by Cederbaum and Jahns- 2019).

Primary author: MOSANI, Karim (Ruhr University (Bochum), Germany)

Presenter: MOSANI, Karim (Ruhr University (Bochum), Germany)

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