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ψ -diagrams for spherically symmetric spacetimes

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We propose and discuss a ψ -diagram a novel kind of a plot representing light-like geodesics. We consider spherically symmetric, static spacetimes. The general construction is illustrated with diagrams for light rays in the proximity of the Schwarzschild, Reissner–Nordstrom (charged) and Kerr (rotating) types of black holes.

The idea is developed from the phase portraits illustrating the null geodesics in Schwarzschild spacetime [1]. But our proposal puts greater emphasis on the role of observer and his/her perception of light. We consider various types of observers including local static and freely falling. The construction for freely falling one is of particular interest, since it allows analysis of an interior of the black holes.

The diagrams can improve our understanding of the peculiarities of communication outside and inside horizon of black holes [2] and issues like self-focusing or dimensional reduction [3]. What is more significant light rays of infinite angular momentum observed inside horizon seems to be pictured clearly in this picture. The diagrams can also serve as a suitable illustration of a well-known problem of a Doppler shift near the event horizon [4,5,6] and can be useful in determination of a size of a black hole (problem of black hole shadow) [7].

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