BLACK HOLES WITH SURROUNDING MATTER AND RAINBOW SCATTERING

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The scattering of light by water droplets can produce one of the most beautiful phenomena in nature: the rainbow. This optical phenomenon has analogues in molecular, atomic, and nuclear physics. Recently, rainbow scattering has been shown to arise from the gravitational interaction of a scalar field with a compact horizonless object. We show that rainbow scattering can also occur in the background of a black hole with surrounding matter. We study the scattering of null geodesics and planar massless scalar waves by Schwarzschild black holes surrounded by a thin spherical shell of matter. We explore various configurations of this system, analyzing changes in mass fraction and radius of the shell. We show that the deflection function can present stationary points, which leads to rainbow scattering. We analyze the large-angle scattered amplitude as a function of the shell's parameters, showing that it presents a nonmonotonic behavior.