Scalar waves absorption by a Schwarzschild black hole surrounded by a thin spherical shell

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We consider planar massless scalar waves impinging upon a Schwarzschild black hole surrounded by a thin spherical shell, which we call dirty black holes. We compute the absorption cross section numerically, and present a sample of results for different values of the black hole mass and the spherical shell position. In the low-frequency regime, we show that the absorption cross section coincides with the event horizon area. For high frequencies, we show that the absorption cross section approaches the null geodesic capture cross section in an oscillatory way. Moreover, when considering null geodesics, we show that there are two light rings for some values of the black hole mass and the position of the spherical shell.