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Semiclassical lensing and Radiative Lense Equations

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We present phenomenological analysis of photon lensing in an external gravitational background in the case of photons and neutrinos, and propose a method to incorporate radiative effects in the classical lens equations. The study is performed for a Schwarzschild metric, generated by a point-like source, and expanded in the Newtonian potential at first order. We use a semiclassical approach, where the perturbative corrections to scattering, evaluated at one-loop in the Standard Model, are compared with the Einstein formula for the deflection using an impact parameter formulation. For this purpose, we use the renormalized expression of the graviton/fermion/fermion vertex presented in previous studies. We show the agreement between the classical and the semiclassical formulations, for values of the impact parameter bh of the neutrinos of the order of bh~20, measured in units of the Schwarzschild radius. The analysis is then extended with the inclusion of the post Newtonian corrections in the external gravity field, showing that this extension finds application in the case of the scattering of a neutrino/photon off a primordial black hole. The energy dependence of the deflection, generated by the quantum corrections, is then combined with the standard formulation of the classical lens equations. We illustrate our approach by detailed numerical studies, using as a reference both the thin lens and the nonlinear Virbhadra-Ellis lens.

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