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Pushing the hard thermal loop theory with effective field theory methods

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We show that effective field theory techniques can be applied in the high temperature T regime of plasmas to improve the accuracy of the physics of the hard scales (or scales of order T), and as a by-product, also that of the soft scales (or scales of order gT). At leading order in the coupling constant the hard scales of the plasma can be viewed as on-shell classical particles. Based on this observation, and without any reference to the state of the system, we derive an effective field theory describing the quantum fluctuations around an on-shell fermion with energy p, described as a set of high dimension operators over the on-shell energy p. When applied to systems close to thermal equilibrium, where for most on-shell particles p ~T, we show that the on-shell effective field theory (OSEFT) properly describes the HTL photon polarization tensor of QED, and its power corrections. We also present compact expressions for the power corrections to the HTL Lagrangian of QED in d space dimensions. The OSEFT is also used to derive corrections beyond the classical approximation of transports equations valid for QED.

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