Nonlinear propagation of light in Dirac matter

Bengt Eliasson, Padma K. Shukla

(Submitted on 18 Jul 2011)

The nonlinear interaction between intense laser light and a quantum plasma is modeled by a collective Dirac equation coupled with the Maxwell equations. The model is used to study the nonlinear propagation of relativistically intense laser light in a quantum plasma including the electron spin-1/2 effect. The relativistic effects due to the high-intensity laser light lead, in general, to a downshift of the laser frequency, similar to a classical plasma where the relativistic mass increase leads to self-induced transparency of laser light and other associated effects. The electron spin-1/2 effects lead to a frequency up- or downshift of the electromagnetic (EM) wave, depending on the spin state of the plasma and the polarization of the EM wave. For laboratory solid density plasmas, the spin-1/2 effects on the propagation of light are small, but they may be significant in super-dense plasma in the core of white dwarf stars. We also discuss extensions of the model to include kinetic effects of a distribution of the electrons on the nonlinear propagation of EM waves in a quantum plasma.

Comments:	9 pages, 2 figures
Subjects:	**Plasma Physics (physics.plasm-ph)**
Cite as:	**arXiv:1107.3596 [physics.plasm-ph]**
	(or **arXiv:1107.3596v1 [physics.plasm-ph]** for this version)

Submission history

From: Bengt Eliasson [view email]
[v1] Mon, 18 Jul 2011 23:36:03 GMT (31kb)

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