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Quantum fluid model of coherent stimulated radiation by a dense relativistic cold electron beam

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ABSTRACT

Using a quantum fluid model, the linear dispersion relation for FEL pumped by a short wavelength laser wiggler is deduced. Subsequently, a new quantum corrected resonance condition is obtained. It is shown that, in the limit of low energy electron beam and low frequency pump, the quantum recoil effect can be neglected, recovering the classical FEL resonance condition, $k_s = 4k_w\gamma^2$. On the other hand, for short wavelength and high energy electron beam, the quantum recoil effect becomes strong and the resonance condition turns into $k_s = 2\sqrt{k_w/\lambda\!\!\!^{-}_c}\gamma^{3/2}$, with $\lambda\!\!\!^{-}_c$ being the reduced Compton wavelength. As a result, a set of nonlinear coupled equations, which describes the quantum FEL dynamics as a three-wave interaction, is obtained. Neglecting wave propagation effects, this set of equations is solved numerically and results are presented.

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