EXACT CALCULATION OF EIGENMODES FOR THREE-DIMENSIONAL FREE ELECTRON LASER INTERACTION WITH A WARM ELECTRON BEAM

Ming Xie
Center for Beam Physics
Lawrence Berkeley Laboratory
Berkeley, CA 94720, USA.

ABSTRACT

We present an exact calculation of free-electron-laser (FEL) eigenmodes (fundamental as well as higher order modes) in the exponential-gain regime. These eigenmodes are solutions of the coupled Maxwell-Vlasov equations describing the FEL interaction taking into account the effects of energy spread, emittance and betatron oscillations of the electron beam, and diffraction and guiding of the radiation field. The unperturbed electron distribution is assumed to be of Gaussian shape in four dimensional transverse phase space and in the energy variable, but uniform in longitudinal coordinate. Our approach permits an exact calculation of the exponential growth rate, transverse mode profile of the guided radiation mode, the perturbed electron distribution, the FEL gain spectrum, and the effect of non-equal transverse focusing and emittance. We also present a handy formula, obtained from interpolating the exact solution, for a quick calculation of FEL exponential growth rate.

* This work was supported by the Director, Office of Energy Research, Office of Basic Energy Sciences, Materials Sciences Division, of the U.S. Department of Energy under contract No.DE-AC03-76SF00098.