Decoherence in a Chirped-Pulse Free-Electron Maser

F.V. Hartemann, E.C. Landahl, A.L. Troha,

J.P. Heritage, H.A. Baldis, and N.C. Luhmann, Jr.

Institute for Laser Science and Applications, LLNL

Department of Applied Science, UC Davis

Theoretical studies [1-3] have shown that the relativistic subpicosecond electron bunches produced by high-brightness rf photoinjectors can be used to generate coherent synchrotron radiation in a free-electron maser (FEM). Furthermore, in a waveguide structure, the group velocity of the radiation can be matched to the axial bunch velocity in the helical wiggler, thus minimizing slippage in the device and yielding extremely short pulse of coherent millimeter-wave radiation, with instantaneous bandwidths exceeding 50%. Because of group velocity dispersion, the output pulses are chirped. The transition from coherent to incoherent synchrotron radiation in the FEM has first been studied within the context of a relativistic fluid model [2-3] ; we will discuss the limitations of such a model, and propose a new hybrid model capable of describing the electron bunch behavior both in the electron fluid and stochastic gas limits. In particular, there is a continuous transition from the exponential coherence factor of the fluid model, $N_e^2 \exp\left[-\left(\frac{\omega \Delta z}{2\beta_{//} c}\right)^2\right]$, to the incoherent radiation scaling, N_e. Here, N_e is the number of electrons in the bunch, ω is the Doppler-shifted radiation frequency, Δz is the bunch duration, and $\beta_{//}$ is its axial velocity. This will be discussed both in the context of fast-wave FEMs, and for short wavelength, laser-driven Compton scattering sources.

[1] A. Gover *et al.*, Phys. Rev. Lett. **72**, 1192 (1994).

[2] F.V. Hartemann, *et al.*, Phys. Plasmas **1**, 1306 (1994).

[3] F.V. Hartemann, *et al.*, Phys. Plasmas **3**, 2446 (1996).

This work was partially supported under the auspices of the US DoE by LLNL under contract No. W-7405-ENG-48 through ILSA, and by DoD/AFOSR (MURI) F49620-95-1-0253, AFOSR (ATRI) F30602-94-2-001, and ARO DAAHO4-95-1-0336.