A SMITH-PURCELL FREE ELECTRON LASER BASED ON AN X-BAND PHOTOINJECTOR

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A Smith-Purcell free electron laser (SPFEL) involves the interaction of an electromagnetic (EM) wave, a periodic grating structure, an electron beam propagating parallel to the plane of the grating and normal to the grating rulings, and an optical cavity. The scattering of the EM wave from the grating leads to a number of diffracted waves, both propagating and evanescent. For effective coupling with the beam, one of these evanescent modes should have a longitudinal propagation velocity along the grating direction approximately equal to the beam velocity. SPFEL's have clear antecedents in classical traveling wave tubes (TWT's) and millimeter (mm) wave devices such as orotrons. A major difference is in the unconfined nature of the EM mode in which external feedback is required in order to have stimulated emission. In contrast, the EM mode in a TWT propagates in a bounded slow wave structure (SWS). This SWS provides feedback of the radiation into the beam and hence, results in stimulated emission. Similarly, in planar orotrons, the EM mode propagates in a waveguide structure in a direction parallel to the beam, which provides the feedback process. Orotrons have also been operated in open geometries analogous to the SPFEL's. Most of this work has focused on relatively long wavelengths. We are interested in the extension of these technologies into the mm, sub-mm, and then ultimately into the infrared where tunable coherent radiation sources would be of particular interest.

In this presentation we describe plans for a detailed experimental and theoretical study of a SPFEL The source of the electron beam will be the X-band photoinjector under development at LLNL [1]. This source was originally designed for the optimum production of coherent radiation at frequencies up to 1 THz; the device produces relativistic (5 MeV) electron bunches with sub-ps duration. Therefore, the X-band rf gun would be ideally suited to generate high power (MW) pulses of coherent mm-wave radiation, via the coherent SPFEL interaction mechanism. Details of both the experimental hardware and theoretical motivations will be provided.

[1] E.C. Landahl, F.V. Hartemann, G.P. Le Sage, W.E. White, H.A. Baldis, C.V. Bennett, J.P. Heritage, N.C. Luhmann, Jr., and C.H. Ho, IEEE Trans. Plasma Sci., vol. 26, pp. 814-824 (1998).

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