MAR05-2004-003921

Abstract for an Invited Paper
for the MAR05 Meeting of
the American Physical Society

Characteristics and Applications of High Intensity Coherent THz Pulses from Linear Accelerators[1]

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Fifteen years have passed since coherent synchrotron radiation (CSR) from relativistic electrons was first observed[1,2]. Since then, CSR has served as a tool for characterizing electron bunch shapes[3] and has been proposed as a new type of millimeter wave source[4]. But until recently, the source characteristics (spectral range reaching 1 THz, waveform shape, energy per pulse, etc.) have not shown significant advantages over THz generators based on ultra-fast lasers. The present generation of photo-injected linear accelerators are now capable of producing sub-picosecond bunches with approximately 1nC of charge (or more), and the coherent radiation they emit has qualities that readily surpass what is available from other source types[5]. This presentation will describe characteristics of the coherent THz pulses produced as transition radiation from the Source Development Lab linac[6] at the National Synchrotron Light Source. Consistent with calculations, pulses can now be produced with energy approaching 100 microjoules (which is 2 orders of magnitude higher than from non-accelerator methods) and with spectral content reaching 2 THz. Other facilities (e.g., at Jefferson Lab) operate at multi-MHz repetition rates such that the average power is also very high. The E-field of a propagating THz pulse can be coherently detected and imaged using the electro-optic effect in ZnTe[7]. When focused, the transient E-field for such a pulse can exceed 1 MV/cm and should be sufficient for studying non-linear effects in solids, critical currents in superconductors, and ultra-fast magnetization in thin films. [1] T. Nakazato et al., *Phys. Rev. Lett.* **63**, 1245 (1989). [2] H. Happek et al., *Phys. Rev. Lett.* **67**, 2962 (1991). [3] R. Lai et al., *Phys. Rev.* E**50**, R4294 (1994). [4] T. Takahashi et al., *Rev. Sci. Instrum.*, **69**, 3770 (1998). [5] G.L. Carr et al, *Nature* **420**, 153 (2002). [6] X.J. Wang and X.Y. Chang, *Nucl. Instr. & Meth.* A **507**, 310 (2003). [7] Q. Wu et al., *Appl. Phys. Lett.* **68**, 3224 (1996).

[1]In collaboration with H. Loos, B. Sheehy, D. Arena, J.B. Murphy, & X.-J. Wang. Work supported by the U.S. Dept. of Energy under contract DE-AC02-98CH10886.