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Electron Beam Conditioning by High-Intensity Lasers and the Role of Off-Polarization Field Components[1]

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Recent experimental results demonstrating the role of the longitudinal laser field components in direct laser-electron scattering at relativistic intensity are reported[1]. Electrons with E$\sim$100 keV obliquely incident on a relativistic intensity laser have been experimentally deflected by three degrees along the laser. This result is corroborated by simulations only with the longitudinal fields included. As this deflection is strongly dependent on the particle energy and laser intensity, this technique can be used to generate the shortest electron bunches ever produced with tunable energy and a small energy spread. Among the applications of these beams are ultrafast electron diffraction, laser-driven X-ray generation, and fast ignitor fusion. The requirements for the generation of a conditioned 1 MeV electron beam for fast ignitor fusion are derived. As the small off-polarization field components play a dominant role in ponderomotive scattering, all field components must be known accurately. An exact theoretical formalism is developed for arbitrary laser fields reflected from both on- and off-axis parabolas for all F/#'s. Solutions are presented for Gaussian and super-Gaussian incident beams and compared to the standard TEM_{00} mode. Large F/# are in good agreement, but small F/# off-axis parabolas produce significant deviations. Such high accuracy fields are required not only for beam conditioning but also for characterization of ultra-relativistic intensity lasers ($I \sim 10^{23}$ W/cm^2), direct laser acceleration of electrons, and laser machining of sub-micron features.

[1] S. Banerjee, S. Sepke *et al.*, Phys. Rev. Lett. **95**, 035004 (2005)

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