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Novel aspects of direct laser acceleration of relativistic electrons[1]

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Production of energetic electrons is a keystone aspect of ultraintense laser-plasma interactions that underpins a variety of topics and applications, including fast ignition inertial confinement fusion and compact particle and radiation sources. There is a wide range of electron acceleration regimes that depend on the duration of the laser pulse and the plasma density. This talk focuses on the regime in which the plasma is significantly underdense and the laser pulse duration is longer than the electron response time, so that, in contrast to the wakefield acceleration regime, the pulse creates a quasi-static channel in the electron density. Such a regime is of particular interest, since it can naturally arise in experiments with solid density targets where the pre-pulse of an ultraintense laser produces an extended sub-critical pre-plasma. This talk examines the impact of several key factors on electron acceleration by the laser pulse and the resulting electron energy gain. A detailed consideration is given to the role played by: (1) the static longitudinal electric field [1], (2) the static transverse electric field [2,3], (3) the electron injection into the laser pulse [4], (4) the electromagnetic dispersion, and (5) the static longitudinal magnetic field [4]. It is shown that all of these factors lead, under conditions outlined in the talk, to a considerable electron energy gain that greatly exceeds the ponderomotive limit. The static fields do not directly transfer substantial energy to electrons. Instead, they alter the longitudinal dephasing between the electrons and the laser pulse, which then allows the electrons to gain extra energy from the pulse. The talk will also outline a time-resolution criterion that must be satisfied in order to correctly reproduce these effects in particle-in-cell simulations [5].

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