Runaway electron production during intense electron beam penetration in dense plasma

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Abstract

Relativistic electrons are efficiently generated when multiterawatt lasers focused to ultrahigh intensities $\gtrsim 10^{19}\ \mathrm{W/cm^2}$ illuminate the surface of dense plasma targets. A new theoretical study finds that during typical pico-second pulse widths, significant amounts of Dreicer produced runaway electrons can build up due to the high axial electric field driving the neutralizing return current. An important consequence is that there will be a conversion of plasma current to runaway electron current, which is maximized at some optimum value of the beam-to-plasma density ratio $N_b = n_b / n_e$, depending on the plasma collisionality. At collisionalities representative of solid target experiments, complete conversion to runaway electrons can only take place over a certain range of N_b values. At higher collisionalities and pulse widths, applicable to the fast ignition concept for inertial confinement fusion, it was found that conversion to runaways has a peak at $\sim 90\%$ around $N_b \sim 0.06$. Significant lessening of target material heating by Joule current dissipation is also possible, since part of the beam energy loss is transferred through the electric field directly to the formation of energetic runaways. Implications for beam transport inhibition by the electric field are also discussed.

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