Abstract for an Invited Paper
for the DPP08 Meeting of
The American Physical Society

Magnetic Collimation of Fast Electrons in Laser-Solid Interactions and Fast Ignition

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In laser-solid experiments and in fast ignition electrons are accelerated from the critical surface into an overdense plasma. The basic physics of magnetic field generation by these fast electrons in the overdense plasma and the effect of this magnetic field on the fast electron transport are reviewed. A simple analytical model is developed that neatly describes both the magnetic field generation and its affect on the fast electron transport. The best known and most desirable of these effects is collimation (focusing or pinching). A simple and remarkably general criterion for collimation is derived, taking into account angular scattering, which is simpler, more accurate and more widely applicable than previous results [Phys. Rev. Lett. **93** 035003 (2003)]. It also shows that careful temporal shaping of the laser pulse could significantly increase collimation without increasing the laser energy; a refinement of the two-pulse collimation scheme [Phys. Rev. Lett. **100** 025002 (2008)]. It is shown that the magnetic field can also lead to beam hollowing, to an increase in beam divergence and to transport inhibition. The predictions of the analytical model are shown to compare favourably with hybrid code modelling. The implications for laser-solid experiments and for fast ignition are considered. The apparent lack of evidence for magnetic collimation in laser-solid experiments is discussed.