Predicting maximum ion energies in Target Normal Sheath Acceleration using a sheath theory for arbitrary electron distributions

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Target Normal Sheath Acceleration (TNSA) is a method for accelerating ions using high intensity laser pulses hitting solid density targets. Relativistic electrons travel through the target forming a space charge sheath at the rear surface. The electric field in this sheath accelerates ions to high energies. For pulse durations shorter than the electron traversal time the fast electrons forming the sheath will have a non-equilibrium distribution with a beam like component. For longer times the electrons can reach equilibrium in the form of the Maxwell-Jüttner distribution.

Most previous theories invoke a Boltzmann factor to model the electron density. This implies that the fast electrons have reached an equilibrium distribution. In this presentation I present a kinetic theory of a planar rear sheath for arbitrary electron distribution function. It is found that the far field is determined by the high energy tail of the distribution.

When accounting for electrons escaping the sheath region a finite potential drop over the sheath is found. This finite potential drop implies a maximum energy for ions being accelerated in the sheath field. The results are generalised to spherical sheaths. For a realistic electron distribution for short laser pulses, maximum ion energies of around 66MeV are predicted.