Effects of resistive fields and stopping power modelling on ion beam-plasma interaction

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The study of ion beam-plasma interaction is a growing field of research as the beams are appealing for their potential applications in a broad range of research fields. Targets can be strongly heated in picosecond time scales by using laser-driven high-energy ions, enabling fundamental studies on high energy density matter [1], ion fast ignition (IFI) [2] and others. Most of the ion beam-plasma interaction models used so far rely on strong assumptions such as perfectly focused beams that interact with the plasma via Coulomb collisions only. Even for the simplest acceleration scheme, ions emerge with a relatively high divergence angle (≈10-15 º) and the beam intensities may be high enough to generate resistive fields. Only recently, anomalous interactions between the beam and the target due to those fields have been reported [3]. In addition, there are substantial differences between the stopping power models available, particularly at low energies. Therefore, it is interesting to study the interaction of ions with plasma including:

i. Beam divergence. It is motivated by the important divergences found in PIC simulations even for converging geometries such as the cones typically used for IFI. Its effects in proton FI applications are presented in [4].

ii. Self-generated fields. Hybrid simulations have shown that resistive fields affect ion beam propagation and energy deposition. For instance, the ignition energies reported for IFI [4] should be increased moderately (≈ 10 %) when resistive fields are included.

iii. Experimentally validated stopping power. Recent experiments [5] of proton stopping in plasmas have shown a good agreement with the BPS stopping power model [6] while there are substantial differences with the standard stopping models. As the ranges predicted by the BPS model are 20-30% higher, the optimal ion kinetic energies will be affected substantially in many ion beam applications.

Results about the importance of resistive fields and beam divergence on ion beam transport in plasmas will be presented for both generation of high energy density matter and IFI. In addition, the sensitivity of the ion energy deposition to the stopping power model will be addressed as well.

References

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