FIRST MEASUREMENTS OF CHARGED-PARTICLE STOPPING AROUND THE BRAGG PEAK AND ITS DEPENDENCE ON TEMPERATURE AND DENSITY IN HIGH-ENERGY-DENSITY PLASMAS

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Over the last few decades, charged-particle stopping in weakly- to strongly-coupled plasmas has been subject to extensive analytical and numerical studies [1-8], but a theoretical treatment of the stopping power especially around the Bragg peak remains a very difficult problem. The consensus is that the charged-particle stopping at projectile velocities (v_i) much larger than the average thermal velocity (v_{th}) of the target particles (here, electrons) is treated well by the Born approximation, while at small projectile velocities ($v_i < v_{th}$), the charged-particle stopping is harder to characterize but generally understood in terms of the T-matrix model. At projectile velocities near v_{th}, i.e. around the Bragg peak, both these approximations break down. The Born approximation breaks down because scattering is no longer weak and the T-matrix models break down because collective screening effects are dynamic. Convergent kinetic theories try to rectify these problems by taking advantage of the strengths of both types of models, but it is not clear how best to combine them. Accurate measurements of plasma stopping power around the Bragg peak are therefore needed. The work described in this paper represents the first experimental effort to address this issue. In these experiments, the energy loss of DD-tritons, DD-protons, D^{3}He-alphas and D^{3}He-protons have been measured in D^{3}He gas-filled filled implosions. As the DD and D^{3}He fusion products span a large range of velocities, these measurements represent the first detailed experimental study of charged-particle stopping, ranging from linear low-velocity stopping, through the Bragg peak, to high-velocity stopping. The results are used to validate and differentiate commonly used theories, including the Brown–Preston–Singleton, Li–Petrasso and T-matrix formalisms in addition to a parameterization of Molecular Dynamics simulations. This work was supported in part by the US DOE, NLUF, LLE and GA.

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