Proton Stopping Power Measurements near Bragg Peak in Warm Dense Matter

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Warm dense matter (WDM) is a fascinating state of matter that lies at the intersection of condensed matter and plasma, in which neither a quantum nor classical treatment alone properly model the dynamics. As such, the study of ion stopping power in WDM is not only of interest to basic science research, but also has applications in inertial confinement fusion and isochoric heating. Although various theoretical models show agreement for ion stopping power in WDM, much of the experimental data is limited to ion projectile speeds v_p much greater than thermal electron speeds (v_p / v_{th} >> 1). The Bragg peak regime v_p / v_{th} ~ 1 is largely unexplored experimentally, and models' predictions of stopping power may vary by as much as 30-40%. Recent efforts on the VEGA2 laser have yielded the first proton stopping power measurements with low velocity ratio v_p / v_{th} ~ 3-10 in the WDM regime [Malko (2022)]. Here, we report on advancements made at the CSU ALEPH laser since these first measurements. For the first time, 500 keV protons with an ultra-narrow energy bandwidth of 20 keV and short bunch duration (< 200 ps) were selected from a laser-driven proton source [Apiñaniz (2021)] and directed toward a laser-heated WDM sample. We present a preliminary analysis of proton energy loss at various delays from WDM heater beam, along with WDM characterization through plasma spectroscopy.

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