Energy exchange via multi-species streaming in laser-driven ion acceleration

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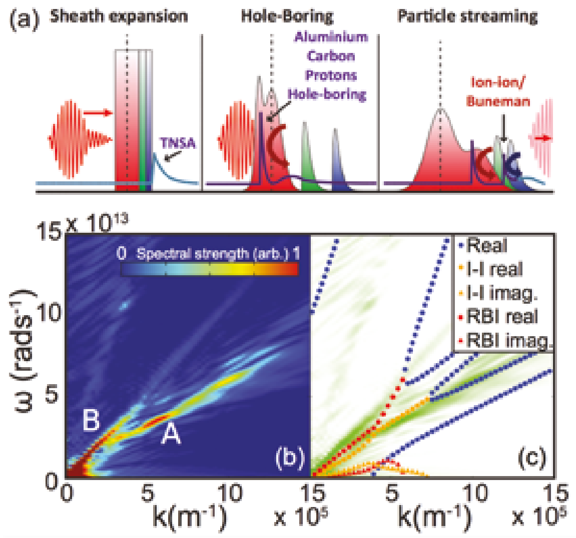
Throughout the interaction of an ultra-intense laser pulse with a thin foil, a variety of complex collective electron dynamics and multiple ion acceleration mechanisms can occur. This can lead to a multitude of charged particle populations overlapping spatially with differing momentum distributions. For certain scenarios, it is possible for this behaviour to induce streaming instabilities such as the relativistic Buneman instability and the ion-ion acoustic instability. Through the use of particle-in-cell simulations, the potential for these instabilities to grow and evolve is demonstrated. Energy-exchange via the ion-ion acoustic instability can occur between ion species if a population of ions can be accelerated to achieve sufficient momentum such that it can propagate through other more slowly expanding ion populations.



(a) Schematic illustrating the three-stages of the forward-directed ions of a 1D laser-acceleration simulation. (b) Spectral power from the 1D simulation as a function of frequency and wavenumber during the particle streaming stage (c) Analytic solutions to the combined dispersion relation for the ion-ion acoustic instability (I-I) and relativistic Buneman instability (RBI) for the averaged electron and ion densities and momentum over the same period as (b).

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The complex ion structure of warm dense carbon measured by spectrally resolved x-ray scattering

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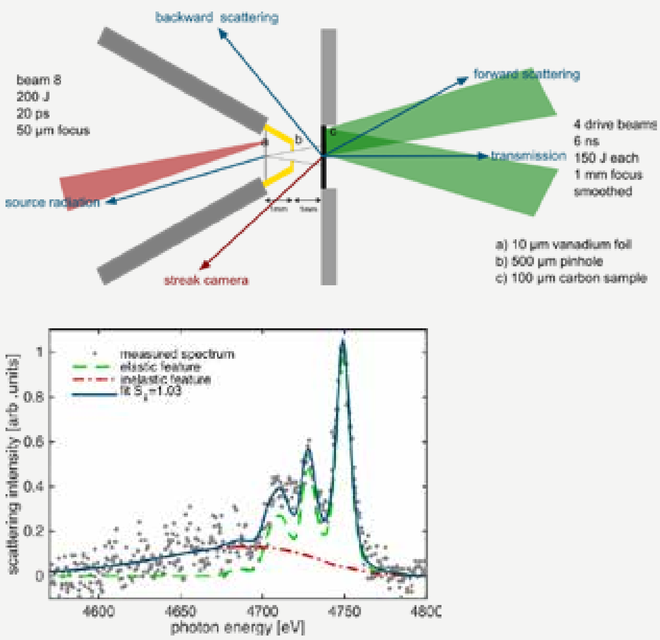
An improved understanding of carbon in the warm dense matter (WDM) regime has motivated an increasing number of experimental and theoretical studies, mainly driven by particular problems in planetary physics and inertial confinement fusion.

At CLF, we have performed measurements of the complex ion structure of warm dense carbon close to the melting line at pressures around 100 GPa. High-pressure samples were created by laser-driven shock-compression of graphite and probed by intense laser-generated x-ray sources with photon energies of 4.75 keV and 4.95 keV. High-efficiency crystal spectrometers allow for spectrally resolving the scattered radiation. Comparing the ratio of elastically and inelastically scattered radiation, we find evidence for a complex bonded liquid that is predicted by ab initio quantum simulations showing the influence of chemical bonds under these conditions. Using graphite samples of different initial densities, we demonstrate the capability of spectrally resolved x-ray scattering to monitor the carbon solid-liquid transition at relatively constant pressure of 150 GPa.



Top: Schematic of the experimental setup at Target Area West. Bottom: Spectrally resolved x-ray scattering from a carbon sample that was driven to a liquid state.

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