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Studies of Non-Maxwellian ion-velocity distributions and their signatures in Fusion Product Spectra in Inertial Confinement Fusion plasmas

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There is a long-standing question about the impact of non-Maxwellian ion velocity distributions on experiments using the ICF platform to study astrophysics-relevant nuclear physics [1]. Neutron spectrum measurements from recent inertial confinement fusion (ICF) implosions suggest non-Maxwellian ion velocity distributions [2]. Kinetic ion-Fokker-Planck (iFP) simulations predict that a highly non-Maxwellian ion velocity distribution including a fast streaming ion population will form during the shock phase of an ICF implosion (kinetic beaming); discovery science experiments in the planning stages for the NIF also rely on this hitherto poorly understood mechanism for mixing of high-Z dopants into the hot core of shock-driven implosions. This presentation describes an ongoing program to address these themes by experimentally quantifying the impact of kinetic beaming and prevalence of non-Maxwellian ion velocity distributions in ICF-relevant conditions through a series of experiments at the OMEGA laser. This includes: (i) (T)^{3}He gas-filled buried CD layer implosions to study kinetic mixing [3] and (ii) a planar, diagnostically accessible ICF mock-up with opposing CD foils surrounding a D_2 gas jet, using 4ω Thomson scattering to study the ion velocity distributions. Experiments on both of these platforms are also being done with implanted ions of varying charge to study kinetic beaming as a function of Z. Results are being used to address impact of non-Maxwellian ion velocity distributions on ICF platform experiments and their signatures in fusion product spectra through a combination of measurements and iFP simulations, including in high-performing layered implosions and nuclear astrophysics-relevant experiments.

References

[1] A. J. Crilly et al., Front. Phys. 10:937972 (2022).

[2] E.P. Hartouni et al., Nat. Phys. 19, 72; O.M. Mannion et al., Phys. Rev. E 108, 035201 (2023).

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