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Invited Session

Experimental Discrimination between Thermal and Hydrodynamic Motions in High-Energy-Density Plasmas

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Distinguishing between energy stored in the hydrodynamic motion of plasma and the thermal energy of ions is of fundamental significance for laboratory plasma physics, astrophysics, and hydrodynamics, including high-energy-density (HED) plasmas, where energy stored in the hydrodynamic motion contributes neither to radiation nor to fusion reactivity, whereas thermal energy does.

Yet, to the best of our knowledge, experimentally distinguishing ion temperature from hydromotion in HED plasmas had never been made prior to the studies described here.

Two novel spectroscopic methods have been developed and implemented.

The first method is based on determining the rate of heat transfer from ions to electrons by measuring the total ion kinetic energy, its dissipation rate, the total radiation from the plasma, and the electron density and temperature [1]. The second method [2] is based on the effect of the ion-ion coupling on the Stark line shapes [3].

The experiments were performed in z-pinch plasmas, investigated during both the implosion and stagnation stages. Required were observations with high resolution in spectrum, space, and time, augmented by detailed line shape and time-dependent plasma-kinetics modeling. Remarkably, the ion temperature in both stages was found to be significantly lower than the total ion kinetic energy. The dissipation time of the hydromotion was determined. The data also allowed for assessing reliably the pressure and energy balance in the stagnation stage of the imploding plasma [4]. Implications to various HED plasmas in large systems will be discussed.

[1] E. Kroupp *et al.*, PRL 98, 115001 (2007), PRL 107, 105001 (2011).

[2] D. Alumot *et al.*, ICOPS 2012, ICOPS 2013.

[3] E. Stambulchik and Y. Maron, JQSRT 99, 730 (2006).

[4] Y. Maron *et al.*, PRL 111, 035001 (2013).