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Experimental discrimination between ion temperature and hydromotion in turbulent plasmas.

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Distinguishing between energy placed in hydrodynamic motion of plasma from thermalization of the ions is of fundamental significance for laboratory plasma physics, astrophysics, and hydrodynamics, including high energy density (HED) plasmas, where energy placed in hydrodynamic motion contributes neither to radiation nor to fusion reactivity, whereas ion temperature does. Yet distinguishing ion temperature from hydromotion in HED plasmas has been regarded to be very difficult, since Doppler-broadened line shapes of emission lines can be due to either effect. However, 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 is based on the effect of the ion-ion coupling on the shape of Stark-broadened lines [2]. This method requires an independent determination of the electron density, and the Doppler broadening of the emission line should be small. The experiments were performed using neon z-pinch plasmas. Required were observations with high-resolution in spectrum, space, and time, augmented by line-shape and time-dependent CR and radiation-transport modeling. The ion temperature 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 phase of the imploding plasma [3]. Implications on various HED plasmas in large systems will be discussed.

[1] E. Kroupp et at., PRL 98 (2007), PRL 107 (2011).
[2] D. Alumot et al., ICOPS 2012, ICOPS 2013.
[3] Y. Maron et al., PRL 2013.