Investigating the growth of Weibel filaments using optical Thomson Scatering

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Collisions of high Mach number flows are ubiquitous in astrophysics, and the resulting shock waves are responsible for the properties of a variety of phenomena, such as supernova remnants, Gamma Ray Bursts and structures formed by jets launched from Active Galactic Nuclei. Because of the low density of astrophysical plasmas, the mean free path due to Coulomb collisions is typically very large. As a result, most shock waves in astrophysics are "collisionless", i.e. they form due to localisation of the ions by electro-magnetic fields which are typically self-generated via plasma instabilities. Scaled laboratory experiments at large scale laser facilities[1,2] are able to approach the conditions necessary to initiate the process of collisionless shock formation, and therefore provide an avenue to study this complex nonlinear physics in a controllable and diagnosable enviroment.

A series of experiments have been conducted at the National Ignition Facility and the Omega and Omega-EP lasers, with the goal of generating collisionless shock conditions by the counter-streaming of two high-speed plasma flows resulting from laser ablation of solid targets using ˜10^{16} W/cm2 laser irradiation. These experiments aim to answer questions of relevance to collisionless shock physics: the importance of electromagnetic filamentation (Weibel) instabilities in shock formation, the self-generation of magnetic fields in shocks, the influence of external magnetic fields on shock formation, and the signatures of particle acceleration in shocks. This presentation focuses on discussing new measurements of these experiments using optical Thomson scattering. These data show direct evidence of the development and growth of Weibel filaments, based on observations of modulations in the observed intensity of the Tho`mson scattering ion feature peaks corresponding to two interpenetrating ion populations; this effectively corresponds to a direct measurement of the modulation of the ion current. The development of Weibel filaments is the first step in the formation of the collisionless shock.

References

[1] C. M. Huntington *et al.*, Nat. Phys. **11**, 173 (2015)

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