HEDLA 2022
13th International Conference on High Energy Density Laboratory Astrophysics
hedla@tecnico.ulisboa.pt

Early-time Linear-saturation of the Ion-Weibel Instability in Counter-streaming Plasmas of CH, Al, and Cu

M. J.-E. Manuel[1,†], S. Ghosh[2], M. B. P. Adams[3], F. N. Beg[2], S. Bolaños[2], C. M. Huntington[4], R. Jonnalagadda[2], D. Kawahito[2], B. B. Pollock[4], B. A. Remington[4], J. S. Ross[4], D. D. Ryutov[4], H. Sio[4], G. F. Swadling[4], P. Tzeferacos[3], H.-S. Park[4]

[1] *General Atomics, San Diego, CA 92121 USA*
[2] *University of California San Diego, San Diego, California, 92093, USA*
[3] *University of Rochester, Rochester, New York, 14627, USA*
[4] *Lawrence Livermore National Laboratory, Livermore, California 94450, USA*

[†] manuelm@fusion.gat.com

The ion-Weibel instability is a leading candidate mechanism for the formation of collisionless shocks observed in many astrophysical systems. Experimental and computational studies have shown that the ion-Weibel instability drives current filamentation in interpenetrating plasma flows [1,2] with the capability to mediate collisionless shock formation and subsequent particle acceleration [3] in the lab. The present work focuses on the experimental study of nonlinear ion-Weibel evolution under various plasma conditions through utilization of different ion species and experimental geometries. Laser driven foils of CH, Al, or Cu were driven by high-intensity lasers ($I > 10^{15}$ W/cm^2) to produce counter-streaming, high-velocity ($V > 1500$ km/s) plasma flows. This technique intrinsically produces varying plasma conditions at the mid-plane of the two-flow interaction where Weibel-driven B-fields are generated and studied. Experiments discussed in this talk demonstrate robust formation of Weibel-driven B-fields in all cases. Radiation-hydrodynamic simulations from FLASH were benchmarked with Thomson scattering measurements and used to perform a linear-saturation analysis at the mid-plane through the evolving plasma conditions. These results are compared with a Fourier analysis of path-integrated B-field distributions derived from 15-MeV proton images. The new analyses presented here indicate that the low-density, high-velocity plasma conditions present during the first linear-growth time ($\sim$300-500ps) sets the spectral evolution of the Weibel filaments during the entire evolution. Application of linear theory to plasma conditions further into the evolution are inconsistent with the data that show dominant filament scale sizes of $\sim 300 \mu$m and B-field amplitudes of order $\sim$2T.

References

[1] C. M. Huntington *et al.*, Physics of Plasmas **24** (2017)
[2] G. F. Swadling *et al.*, Physical Review Letters **124** (2020)
[3] F. Fiuza *et al.*, Nature Physics **16** (2020)