Laboratory Study of Cosmically-Relevant Collisionless Shocks via the Head-on Collision of Two High Velocity Plasma Jets

S. C. Hsu[1], A. L. Moser[1,2], J. P. Dunn[1], C. Thoma[3], C. S. Adams[4], M. A. Gilmore[4], and A. G. Lynn[4]

[1]LANL
[2]Caltech
[3]Voss Scientific
[4]University of New Mexico

March 22, 2012

Abstract

We describe a recently initiated laboratory experiment to form and study cosmically-relevant collisionless shocks via the head-on collision of two high velocity (100–150 km/s) hydrogen plasma jets (initial $n_i \sim 10^{16}$ cm^{-3}, $T_e \sim T_i \sim 5$ eV) launched by pulsed power driven plasma railguns. The experiments will be conducted on the Plasma Liner Experiment (PLX) located at LANL. Although collisionless shocks in plasmas were first predicted in the 1950s and discovered in the 1960s, many research questions relating to the microscopic physics of collisionless shock formation, evolution, and shock acceleration of particles to very high energies remain unanswered. The proposed experiments will emphasize the ability to (1) control and scan physics parameters over a range of values and across physics regimes in order to validate physics models, and (2) obtain far more measurements in both space and time compared to either in situ space satellite measurements or astronomical observations. A magnetic field will be

applied via coils at the jet interaction region to access magnetized regimes which are essential for cosmic relevance. In contrast to other much smaller collisionless shock experiments, scale sizes of the jet diameter and shock thickness in our experiments will be $\sim$ 30–50 cm and $\sim$ 1 cm, respectively, enabling detailed characterization of shock structure and evolution via relatively simple diagnostics. Key dimensionless parameters in the experiments will satisfy quantitative physics criteria for the collisionless shocks to be of cosmic relevance. The objectives of this work are to develop insights into collisionless shocks not obtainable via satellite measurements or astronomical observations alone, and to unfold the specific physics mechanisms underlying collisionless shock formation and shock-particle interactions.