Basic scalings for collisionless shock experiments

D.D. Ryutov[1], N.L. Kugland[1], H.-S. Park[1], C. Plechaty[1], B.A. Remington[1], and J.S. Ross[1]

[1]Lawrence Livermore National Laboratory

March 22, 2012

Abstract

Issues that one has to face when designing and performing the collisionless shock experiments include the scalability from a plasma with predominantly hydrogen ions (as is the case in most of astrophysical systems) to the plasmas of heavier elements, like beryllium or carbon, which are more readily usable in the laboratory. Sometimes, one has to work with a plasma of mixed composition, e.g. CH2 plasma. The change of the ion species leads to a change of the characteristic scales and growth rates of collisionless instabilities and eventually affects measurable parameters like the width of the shock transition. In this paper, a set of general scaling constraints is provided that allows for a scaled substitution of one element by the other. Reduced versions suitable for electrostatically-mediated and magnetically-mediated models of the shocks are described. The presence of these scaling relations can serve as a basis for making comparisons between models and selecting the most plausible models. One more phenomenon that may affect the shock properties are intra-jet collisions, whose frequency may be non-negligible even if the collisions between the particles of two jets are very rare. We discuss the role of this phenomenon in the shock formation.

Work performed for U.S. DoE by LLNL under Contract DE-AC52-07NA27344.