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Science of Collisionless Shock Explorer

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The characteristic length scale of typical dilute space plasmas is much shorter than binary collision mean free path. A pronounced feature unique to such a collisionless plasma is that efficient energy and momentum transfer is mediated by plasma waves. The plasma waves often reach to large amplitude, suggesting critical importance of nonlinear effects. In addition, it is often found that a small fraction of particles acquire extremely large energies and forms a nonthermal tail.

A collisionless shock is a magnetohydrodynamic shock wave forms in a collisionless plasma, involving all the above mentioned intriguing features of the collisionless system. In the shock transition region, a cold upstream plasma is violently heated via dissipation involving a lot of plasma waves excited simultaneously. The understanding of the dissipation process is extremely complicated due to its intrinsic strong nonlinearity and inhomogeneity. Although we know an ion-scale shock structure from early in-situ observations, recent measurements of plasma waves in and around the shock clearly indicate the importance of small-scale substructures and nonlinear wave-particle interactions. However, the temporal resolution of distribution function measurements with available satellites is not sufficient to understand the detailed shock dissipation processes.

In this talk, we discuss the scientific significance of collisionless shock physics that may be learned with high time resolution (1-10 msec) in-situ measurements of electron and ion distribution functions within the shock transition region along with recent theory, simulations, and observations.

Keywords: collisionless plasma, shock wave, wave-particle interaction, particle acceleration