STEPS Students Report

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Before modeling the structure of shock in 1D PiC (particle in cell) code, the solution of Rankine-Hugoniot equations has been gotten [1]. For steady one-dimensional flow, equations relating initial and final conditions are readily derived. A useful way to visualize the various solutions of the RH relations is to plot the square of upstream modified intermediate Mach number versus downstream value. Here intermediate Mach number refers to the flow speed in shock rest frame divided by the modified intermediate speed ($V_{I0}\sqrt{1-(\beta_{\parallel}-\beta_{\perp})/2}$) where V_{I0} is the intermediate speed in an isotropic plasma, and $\beta_{\parallel}, \beta_{\perp}$ are plasma parameters in the direction parallel and perpendicular to the magnetic field.

In this work, we investigated the effect of anisotropy and shock angle on the shock structure by using PIC simulation. The dynamics of slow shocks are examined using PIC which uses a conventional adiabatic fluid model for the massless electrons, so the shock dissipation is provided by the ion dynamics alone. The PIC method treats both electrons and ions kinetically using the same techniques. The simulations are 1D in space (x) but have three components of velocities and two components of fields. The upstream magnetic field is in the x- z plane at an angle with respect to the x axis. The simulations are carried out in the normal incidence frame and the shock is formed using the piston method by injecting the upstream plasma from the right simulation boundary and reflecting it off the piston at the left boundary. The shock forms through the interaction of the incident and reflected ion streams via ion inertial Length waves on the Alfvén branch that propagate at large angles with respect to the magnetic field. These waves are generated by the electromagnetic ion-ion cyclotron instability. These waves also interact with the electrons through Landau resonance, which results in electron parallel heating by the parallel electric field.

Different aspects of slow mode shock study started during internship. But in order to understand the real mechanism behind MR, slow shock and particle acceleration further theoretical and experimental studies need. In this work, 1D and 2D simulations have been studied, but the nearest goal is study of 3D simulation to check the validity of results by using observational data. Parallel work should be analyzing MMS satellite data, which may give us the correct understanding of real structure of slow mode shock.