Kinetic Structure of the Reconnection Layer

Manfred Scholer

Max-Planck-Institut für extraterrestrische Physik
Garching, Germany

Due to the breakdown of particle adiabaticity in the current sheet of the magnetopause and the magnetotail the application of the MHD approximation in order to study the reconnection process in these regions is questionable. Test particle calculations in magnetic field configurations with a neutral line have actually resulted in structural features of the ion distributions depending on the distance from a neutral line and have emphasized the nonlocal character of particle motion in reconnection configurations. The non-gyrotropic distributions in the center of the reconnection layer and the distributions with backstreaming ions on reconnected field lines within the separatrices contain free energy which can excite various instabilities. These instabilities largely determine the structure of the reconnection layer. We will review results from large-scale hybrid simulations of magnetotail reconnection where the ion kinetic effects have been studied in the self-consistently evolving electric and magnetic fields. Although such simulations should eventually result in slow mode shocks, it turns out that such shocks develop rather far from the neutral line. The dissipation processes in shocks bounding the reconnection layer can, in principle, also be analyzed by solving an equivalent Riemann problem of the decay of a current sheet with a normal magnetic field component. It will be shown that since instabilities excite waves with wave vectors parallel to the magnetic field a two-dimensional treatment of the Riemann problem is necessary. These simulations have shown that ion beams in the boundary layer excite the electromagnetic ion/ion cyclotron instability with obliquely propagating waves. These waves heat the beam ions within the layer as well as the plasma outside of the separatices perpendicular to the magnetic field. The resulting temperature anisotropy excites parallel propagating Alfven ion cyclotron waves. As the layer expands with increasing distance from the reconnection site the compressed waves thermalize the plasma within the layer.