

The structure of quasi-perpendicular shocks is investigated by full particle simulations. An important parameter in such simulations is the ion to electron mass ratio, r . Because of computer limitations this ratio is usually artificially small. We have compared simulations with different values of r . While almost-perpendicular shocks periodically reform, the physical mechanism is different, depending on the mass ratio used.

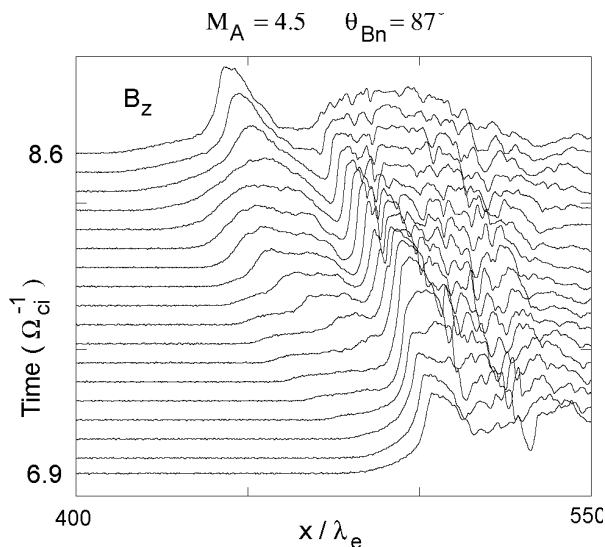


Fig. 1: Magnetic field profiles as a function of distance and time.

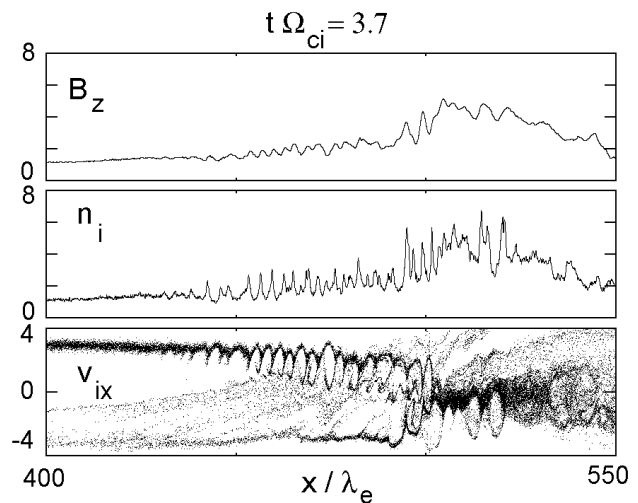


Fig. 2: B_z , n_i , and V_{ix} as a function of distance.

We have performed 3 one-dimensional full particle electromagnetic simulations of a quasi-perpendicular shock with the same Alfvén Mach number (4.5), shock normal - magnetic field angle 87 degrees, and ion and electron beta (particle to magnetic field pressure) of 0.05, but with different ion to electron mass ratios ($r = 80, 400, 1840$). It is known that at high ion beta the shock is steady. At low ion beta, as in the present simulations, the shock periodically reforms itself on the time scale of the inverse ion gyrofrequency. At unrealistically low mass ratios the reformation is due to accumulation of specularly reflected particles at the upstream edge of the foot. Figure 1 shows for a mass ratio 400 run stacked magnetic field profiles. The simulation is done in the downstream rest frame; thus the shock front moves to the left. One can see a growing upstream hump which develops into a new shock. The hump is due to specularly reflected ions accumulation at the upstream edge. At the realistic mass ratio the modified two-stream instability between the incoming solar wind ions and solar wind electrons is excited and leads to ion phase mixing and thermalization over the whole foot region. The reformation process is thereby considerably modified. Figure 2 shows at one particular time the magnetic field, the ion density, and ion phase space. The instability leads to vortices in incoming ion phase space and, by phase mixing, to thermalization. Eventually a new ramp appears at the upstream edge of the foot. At the lowest mass ratio the Buneman instability between the solar wind electrons and the reflected ions is excited, which is stabilized at higher mass ratios. Thus the occurrence of the Buneman instability in this parameter regime is purely artificial.

Scholer, M., I. Shinohara, I., and S. Matsukiyo, *J. Geophys. Res.*, 108, 1014, doi:10.1029/2002JA009515, 2003
 Scholer, M., and S. Matsukiyo, *Annales Geophysicae*, 22, 2345, 2004