Geophysical Research Abstracts, Vol. 7, 06195, 2005
SRef-ID: 1607-7962/gra/EGU05-A-06195

Quasi-perpendicular shock structure: full particle electromagnetic simulations

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We review recent full particles electromagnetic simulations of quasi-perpendicular shocks. The structure of these shocks depends considerably on Mach number, shock normal - magnetic field angle Θ_{Bn} and ion and electron beta (particle to magnetic field pressure). Large Θ_{Bn} shocks are nondispersive, i.e., whistler waves can not phase stand in front of the shock. At high ion beta (~ 1) the shock is steady. It is shown that the cross-shock potential is not a good proxy for the density: specularly reflected ions contribute due to their gyration in the foot largely to the potential. At low ion beta (< 0.05) the shock periodically reforms itself. However, whereas at exactly $\Theta_{Bn} = 90°$ reformation is due to accumulation of specularly reflected particles at the upstream edge of the foot, at oblique shocks the modified two-stream instability between the incoming solar wind ions and solar wind electrons leads to ion phase mixing and thermalization. This results eventually in shock reformation on the time scale of the inverse ion gyrofrequency. At low betas and very high Mach number the Buneman instability occurs between solar wind electrons and reflected ions, which can lead to electron holes and acceleration.