A study of non-stationary shock front at a Q-perpendicular shock: A Comparison of PIC simulation results with Cluster observation

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It is well known from ISEE observations that ion reflection is the primary process for high Mach number shocks and the backstreaming ions produced low frequency waves in upstream region of oblique shocks. Additionally, non-stationary behavior of an oblique shock has been investigated using one/two-dimensional hybrid simulation. Results of recent numerical simulation studies indicate that non-stationary behavior of the shock transition layer can strongly affect dissipation mechanisms of the collision-less shock. However, detailed dissipation mechanisms in the shock transition region are still uncertain. In this paper, based on the in-situ observational data, relationship between the electron dynamics and shock structure in the quasi-perpendicular shock is discussed. We study three shock crossing events at quasi-parallel/perpendicular shocks observed by Cluster. In these events Alfven Mach numbers are 5-6 and shock angle between upstream magnetic field and shock normal are 50-60 degrees. Non-stationary shock front was observed in these events. In addition we can observe the low frequency waves due to backstreaming ions in the upstream region as well. However there are limitations in studying shock structure from observational data only. In order to interpret the event, we carried out two 2D simulation runs using PIC with parameters (shock angle: 50 deg, Ma: 5, ion beta: 1.3 and 0.13) determined from the observations and the results are compared with the observations. For simulation result with high beta, upstream waves are apparent but reflected ions were not seen. On the other hand, for low beta event upstream waves were clearly seen and shock front was unstable. Based on the comparison of simulation results with observational data, we discuss the relationship between the shock structure and electron dynamics in shock transition region.