

On the reformation at a quasi-perpendicular shock: Full particle-in-cell simulation

Yoshitaka Kidani[1]; Takayuki Umeda[1]; Tatsuki Ogino[2]; Shuichi Matsukiyo[3]

[1] STEL, Nagoya Univ.; [2] STEL, Nagoya Univ.; [3] ESST Kyushu Univ.

A full particle-in-cell (PIC) simulation study is carried out on the reformation at a quasi-perpendicular collisionless shock with a relatively low Alfvén Mach number ($M_A=5$) at a shock-normal angle of 80 degrees. Previous self-consistent one-dimensional (1-D) hybrid and full PIC simulations have demonstrated that ion kinetics is essential for the non-stationarity of perpendicular collisionless shocks. These results have shown that reflection of ions at the shock front is responsible for the periodic collapse and redevelopment of a new shock front on a timescale of the ion cyclotron period, which is called the shock reformation. Recent 2-D hybrid and full PIC simulations, however, suggested that the shock reformation does not take place in exactly-perpendicular shocks with $M_A \sim 5$. By contrast, another 2-D hybrid PIC simulation showed that the shock reformation persists in quasi-perpendicular shocks with $M_A \sim 5$. Although these recent two works seem to be inconsistent with each other, this reason is not well understood because of several differences in simulation conditions. In the present study, we performed a 2-D full PIC simulation of a quasi-perpendicular shock to make a direct comparison between quasi- and exactly-perpendicular shocks with almost the same condition. It is found that the time development of the shock magnetic field averaged over the shock-tangential direction shows the transition from the reformation to no-reformation phase, which is consistent with the recent full PIC simulation results of exactly-perpendicular shocks. On the other hand, local shock magnetic field shows the evident shock reformation, and the period of the reformation is changed in the no-reformation phase.