

Ion reflection at quasi-perpendicular shocks: 2D simulations

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We have performed one- and two-dimensional hybrid simulations of quasi-perpendicular shocks to investigate how many non-thermal particles are produced from incoming upstream thermal ions. In the present simulations, neither cross-field diffusion term nor additional upstream waves are artificially included. Particle motions and wave excitation processes are all self-consistently solved in the system. Simulation results show that non-thermal particles are not extracted from the incoming thermal ions in the one-dimensional case but are extracted in the two-dimensional case. They are reflected and injected into the upstream region. In the one-dimensional case, no remarkable wave is observed in the upstream and at the shock surface. By the contrast, in the two-dimensional case, waves are excited not only in the upstream region by ion beam instability but also at the shock surface by Alfvén ion cyclotron instability or mirror-mode instability. Therefore, these waves are strongly related with the reflection processes at the shock surface.