Electron Heating via Multiple Instabilities in the Foot of a Quasi-Perpendicular Shock

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Electron heating in the foot of a high Mach number quasi-perpendicular shock is investigated. A two-dimensional PIC (particle-in-cell) code with periodic boundary conditions is utilized to simulate a part of the foot region. By assuming the system composed of incoming electrons, incoming ions, and reflected ions, various types of instabilities get excited through interactions between electrons and incoming or reflected ions.

For high Mach number ($M_A \sim 10$) and low beta (β=0.1) case, modified two-stream instability (MTSI) and electron cyclotron drift instability are linearly unstable. These instabilities energize electrons not only directly but also indirectly via successive two-step instabilities. Especially, electron acoustic instability following the MTSI based on electron-reflected ion interactions leads to strong electron heating. Efficiency of electron heating notably depends on the angle between incident magnetic field and shock normal (or incident ion flow) direction, Θ_{Bn}. Electron heating processes at different Θ_{Bn} are discussed in detail.