Numerical simulation of electron dynamics in collisionless quasiperpendicular shocks

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Electron dynamics is important to collisonless shock physics because it redistributes energy, provides information on shock fine structure, and leads to shock-heated and accelerated electrons responsible for various plasma waves and emissions. Here, test particle simulations are performed to investigate the electron dynamics and electron distributions upstream and downstream of collisionless quasiperpendicular shocks. The main results are: (1) The electron dynamics inside the shock layer is strongly dependent on the angle θ_{bn} between upstream magnetic field and shock normal. (2) The development of magnetic overshoot significantly distorts upstream and downstream electron distributions by preventing more electrons from crossing the shock than the asymptotic fields can. (3) The demagnetized motion of electrons inside the thin shock layer depends on the scale lengths of the shock potential and magnetic field and also on θ_{bn}. Demagnetized electrons are mainly those that cross the shock and most of them increase their magnetic moments. Reflected electrons conserve their magnetic moments on average. (4) Incorporating the overshoot into both the cross-shock potential and magnetic field profile increases the number of electrons convecting downstream by changing the ratio of parallel to perpendicular speeds. The cross-shock potential extracted from the distribution contours using adiabatic theory corresponds to the maximum potential inside the thin shock layer, which is larger than the total cross-shock potential jump. (5) The calculations suggest that temporal modifications of the shock front will lead to major changes in electron distributions and associated plasma waves upstream and downstream. Nonstationarity and shock ripples could thus be quantitatively important for wave/radio phenomena near shocks, perhaps also mimicing a second electron acceleration process and requiring modification to the steady state shock model used for predicting foreshock radio emission.