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Efficiency of Electron Shock Drift Acceleration in the Presence of Ion-scale Rippling

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It is known that a number of plasma instabilities are excited in and around collisionless shocks and are believed to play the role for the dissipation at the shocks. Among them, the electromagnetic ion cyclotron (EMIC) instability can be excited by the temperature anisotropy of ions at the quasi-perpendicular shock transition region. Particle-in-cell (PIC) and hybrid simulations have demonstrated that the shock surface is strongly modulated most likely due to this instability. The spatiotemporal scale of the resulting ripple structure is determined by Larmor radius and frequency of ions. The rippling can, however, also affect the dynamics of electrons.

We have investigated the trajectories of electrons within the shock in the presence of the rippling. The electromagnetic field in the time-dependent (i.e., rippled) shock structure is given by an analytical form. Test-particle trajectories in the assumed field are then followed numerically. We have found that some electrons are "trapped" in the transverse direction due to the compression of the magnetic field. These trapped electrons are eventually transmitted to the downstream even when the initial pitch angles (in the de Hoffmann Teller frame) are out of the loss cone. The resulting energy gain of these electrons are larger than those expected from simple adiabatic theory. We will also present a more detailed analysis of the acceleration mechanism. The efficiency, and the consequence of this study are discussed in a quantitative fashion.

Keywords: collisionless shock, particle acceleration