Electron acceleration at quasi-perpendicular shocks: comparison between simulation results and observations

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We have studied an electron acceleration process at quasi-perpendicular shocks by using 3D full particle simulations. We have shown that the trapping by the large-amplitude electromagnetic wave excited in the most front region of the shock foot is essential for the acceleration. During the trapping electrons get more energy from the motional electric field of the flow. In contrast to the standard Fermi acceleration at quasi-parallel shocks, the electron acceleration process at quasi-perpendicular shocks is much quicker (order of the ion cyclotron period); however, electrons cannot experience effective acceleration again so that there would be a limitation of the acceleration.

A study using Geotail bow shock crossings shows (Oka et al., GRL, 2006) that electron acceleration up to 100 keV occurs at quasi-perpendicular bow shocks. They concluded that electron energy spectrum index becomes harder at higher Alfven Mach number and in the cases those shock angles is closer to 90 deg. Assuming that the acceleration is due to the electron drift motion during the trapping by the large amplitude electromagnetic wave in the foot region toward the motional electric field direction of plasma flow within a few reformation cycles, the energy increase is approximately proportional to u/c. Comparing with our simulation results with the Geotail observations, these results of electron energy gain are almost consistent with above approximation.

However, the electron acceleration at quasi-perpendicular bow shocks is not always observed. In order to address what are the control parameters of electron acceleration, we revisited the bow shock crossing events used by Oka et al. (2006). In particular, our analysis is focused on the existence of the magnetic fluctuations in the foot region. Our initial result shows that no electron acceleration is observed when no magnetic fluctuation in the foot region. We will report the comparison between our 3D simulation results and observation results in detail.