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Electron acceleration parallel and perpendicular to overshoot magnetic field in quasi-perpendicular collisionless shock

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Energetic, non-thermal electrons are commonly observed both upstream and immediately downstream from the Earth's quasi-perpendicular bow shock (Gosling, 1989). Upstream the energetic electrons are generally field-aligned beams, whereas downstream the flux of them is generally most intense in the direction perpendicular to the magnetic field. However, the acceleration mechanism of these electrons remains unclear. Here, we show a new type of electron acceleration process at an overshoot downstream of a quasi-perpendicular collisionless shock, by performing a one-dimensional particle-in-cell (PIC) simulation. The shock parameters are as follows. The Alfven Mach number is 7.1, upstream plasma beta is 0.3, the shock angle is 70 degrees. The ion to electron mass ratio is 625, the ratio of electron plasma to cyclotron frequency is 10.

Kinetic energies of non-thermal electrons, averaged several gyrations, were divided into those of the guiding center motions parallel and perpendicular to the ambient field and that of the rotations of the guiding center. We then found the following electron acceleration process. Incoming electron is trapped in a thin structure of the time-varying, compressed overshoot magnetic field during a shock reformation process. Simultaneously, it gains a kinetic energy perpendicular to the magnetic field via betatron acceleration, followed by an additional energy increase along the field. The energy conversion from the perpendicular to parallel directions occurs due to a rapid decrease of the overshoot magnetic field; eventually, it is released upstream as a field-aligned beam. The result will be related to in-situ observations of the Earth's bow shock.

Keywords

electron acceleration; quasi-perpendicular shock; particle-in-cell simulation; earth's bow shock

Collaboration

other Collaboration

Subcategory

Theoretical Results

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