The Electron Cyclotron Drift Instability in space plasmas.

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Abstract:

When the solar wind (in supersonic regime) hits a magnetized obstacle such as a planetary magnetized environment (so called magnetosphere), a permanent shock wave forms upstream of the magnetosphere, allowing a transition of the flow from super- to sub-sonic regime. Such shocks are frequently observed around different planets (Uranus, Earth, Mercury, Jupiter etc..). This shock is called 'collisionless' since its characteristic spatial scale is much lower than the free mean path which is of the order of the 1 Astronomical Unit (1 AU= 146 x 10 **6 kms). Collisionless shocks are also frequently met in solar physics, interplanetary physics, heliospheric physics (interaction of the insterstellar wind with the obstacle formed by the heliosphere) etc..In a first approach, collisionless shocks can be classified into 2 main groups : (i) the quasi-perpendicular and quasi-parallel shocks when the angle between the shock normal and the upstream magnetostatic field is varying between (90°, 45°) and (45°, 0°) respectively, and (ii) the subcritical and supercritical shocks.

Super/sub-critical quasi-perpendicular shocks are characterized by a noticable/poor fraction of the incoming ions which is reflected at the steep front, stream across the magnetic field and form a foot upstream of the ramp. While gyrating, reflected ions accumulate within the foot and have several impacts : (i) these carry a significant amount of energy and play a key role in transforming the directed bulk energy (upstream) into thermal energy (downstream) and (ii) are source of microturbulence within the shock front itself. Indeed, the relative drift between the reflected ion beam and the incoming electrons within the foot can easily destabilize waves (electron cyclotron drift instability or ECDI) in the electron cyclotron frequency range. By means of linear analysis, several Bernstein harmonics are shown to be unstable, their number being proportional to the drift, yet limited by the ion beam’s temperature. Separate electromagnetic PIC simulations restricted to all ions and electrons populations present in the foot region have been performed in order to investigate the nonlinear characteristics of these waves with a high spatial resolution and a high statistics, which will be presented.