SELF-REFORMATION OF QUASI-PARALLEL SHOCK IN FULL PARTICLE SIMULATIONS

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ABSTRACT

Self-reformation mechanisms of quasi-parallel shock (θ_{Bn}=30°) propagating in supercritical regime are analyzed with the help of 1D full particle simulations. In contrast with previous hybrid simulations, accessibility to processes occurring over scales (much) less than ion inertia length and ion cyclotron frequency scales is allowed. Different features associated to the shock front self-reformation are fully retrieved and are found to be in good agreement with previous works of Scholer (1993) [1]: (i) upstream ions are reflected by the shock front, (ii) emission of upstream waves with long wavelength (excited by reflected ion beams interacting with upstream plasma), (iii) emission of whistler from the front, (iv) shrinking (with associated wave steepening) of the long wavelength upstream waves spatial scales when penetrating progressively within the downstream region until these form a new shock front, and (v) relatively stable wave patterns far within the downstream region. These features are characteristics of the main reformation cycle (with a large cyclic time period of the order of 17-20 inverse ion gyrofrequency), where the steepening of long wavelength magnetosonic waves plays a key role.

However, present numerical results show that, for higher Mach regime (keeping all other parameters unchanged), a few sub-cyclic features can be identified within such one large reformation cycle. The reason is that whistler wave train emitted from the shock front has enough time to reach an amplitude large enough so that strong steepening (nonlinear effects) can take place. These sub-cycles features are characterized as follows: (i) upstream whistler wave train suffers some steepening and initiate a new shock front, (ii) large, spiky, and short-lifetime electrostatic field occur related to this steepening, and (iii) this steepening initiates a local ion reflection. Within one sub-cycle, the whistler steepening tends to disappear progressively as local ion reflection succeeded to dissipate local accumulated energy at the front; meanwhile, a new front forms progressively upstream by local steepening effects. One key point is that upstream magnetosonic waves do not contribute to this (small period) sub-cyclic self-reformation, since these did not reach a large growing amplitude yet. This sub-cycle is repeatedly recognized until the long wavelength upstream wave starts nonlinearly growing and succeeds to control the main (long time period) cyclic reformation. A quasi-parallel shock intrinsically possesses both "local" (whistler steepening) and "global" (upstream wave steepening) dissipation processes over different time scales which are identified and will be presented.

Relationship with other structures (as SLAMS [2]), as well as shock parametric (M_A and θ_{Bn}) investigation will be also presented. Each wave structure is analyzed in details in order to determine their local interaction of both ions and electrons, and to propose a global scenario of the quasi-parallel shock dynamics for different Mach regimes.

REFERENCES

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