Nonstationarity of two-dimensional perpendicular shocks: competing mechanims

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Two-dimensional (2-D) full particle electromagnetic simulations are used for analysing in detail different nonstationary behaviors of perpendicular supercritical shocks. A recent study (Hellinger et al., 2007) has evidenced that the shock front is dominated by the emission of coherent large amplitude whistler waves for some plasma conditions and shock regimes. These whistler waves are emitted in two-dimensional perpendicular shocks and inhibit the self-reformation driven by the accumulation of reflected ions: then, the shock front appears almost "quasi-stationary", a result which could seem in apparent contradiction with previous results. The present study allows to clarify the situation by bringing new complementary results:(i) there exists a transition regime around a critical Mach number threshold Mwwe, within which both self-reformation and whistler waves emission can co-exist. (ii) Below (above) this threshold regime, the self-reformation (whistler waves emission) is fully retrieved and becomes dominant. (iii) As MA is larger than Mwwe , this shock front looks "quasi-stationary" in 1-D y-averaged fields profiles, but in fact is nonstationary in full 2-D profiles and over a smaller time scale (lower than one ion gyroperiod). This nonstationarity is characterized by a quasi-periodic reinforcement of nonlinear waves emission from the ramp. This effect results from the fact that the emission of nonlinear whistler waves varies in time according to the local need for balancing the nonlinear effects at the shock ramp (steepening). (iv) Whistler waves are observed for a strictly perpendicular shock, as B0 is within the simulation plane; in contrast, as B0 is perpendicular to the simulation plane, no whistler waves emission is evidenced even for large Mach number and only self-reformation is observed. Present results, even if unexpected, are shown to be not in disagreement with previous 2D PIC and 2D hybrid simulations these are compared with.