ANALYSIS OF GYROTROPIC/NON GYROTROPIC ION POPULATIONS IN THE EARTH'S QUASI-PERPENDICULAR ION FORESHOCK: FULL-PARTICLE 2D SIMULATION OF A CURVED SHOCK

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The ion foreshock located upstream of the Earth's bow shock is populated with ions reflected back by the shock front with an high energy gain. In-situ spacecraft measurements have clearly established the existence of two distinct populations in the foreshock upstream of the quasi-perpendicular shock region (i.e. for $45° \leq \theta Bn \leq 90°$, where θ_{Bn} is the angle between the shock normal and the upstream magnetostatic field): (i) field-aligned ion beams (or FAB) characterized by a gyrotropic distribution, and (ii) gyrophase bunched ions (or GPB) characterized by a NON gyrotropic distribution, which exhibits a non-vanishing perpendicular bulk velocity. Present 2D PIC simulations of a curved shock, where full curvature effects, time of flight effects and both electrons and ions dynamics are fully described, have evidenced that the shock front itself can be the possible source of the different backstreaming ions. Our analysis shows that both populations can be discriminated in terms of interaction time (Δ_{inter}) and distance of penetration within the shock front, in particular that "GPB" and FAB populations are characterized by a short ($\Delta_{inter} = 1$ to $2\ t_{ci}$) and much larger ($\Delta_{inter} = 1$ to $10\ t_{ci}$) interaction time respectively, where t_{ci} is the ion upstream gyroperiod. This discrimination allows a deeper statistical analysis which evidences that: (i) backstreaming ions are splitted into both "FAB" and "GPB populations" depending on their injection angle when hitting the shock front (i.e. defined between the local normal to the shock front and the gyration velocity vector at the time ions hit the front). (ii) As a consequence, ion trajectories strongly differ between the "FAB" and "GPB" populations at the shock front. In particular,FAB ions suffer multi-bounces along the curved front whereas GPB ions make only one bounce. Such differences can explain why the FAB population loses their gyro-phase coherency and become gyrotropic which is not the case for the "GPB". As also evidenced by these simulations, the origin of both populations can be associated directly to their interaction with the shock front itself and do not require any upstream instability which can be another source for such backstreaming ions.