Collision of two supercritical quasi-perpendicular collisionless shocks: full particle simulations

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Shock collisions are often invoked in the interaction of interplanetary shocks or during the impulsive phase of solar flares to explain the heating and particle acceleration arising from a large number of localized regions. Such collisions have been mainly analyzed with stationary shocks (Cargill, 1991). However, 1D and 2D numerous PIC (Particle in Cell) - and more recently hybrid- numerical simulations have clearly evidenced that the front of individual supercritical quasi-perpendicular shocks may be strongly nonstationary. Different source mechanisms have been identified as being responsible for this nonstationary behavior. One well recognized process is the so called "self-reformation" mainly driven by the accumulation of reflected ions over a foot distance from the ramp. In the present work, collisions between two supercritical quasi-perpendicular shocks are analyzed by using 1D full particle-in-cell simulations where space charge and induced effects, and nonstationary effects driven by this cyclic self-reformation are fully and self-consistently included. At the location of the shock fronts collision (in short SFC), strong local B fields build up associated to large magnetic pressure effects (accumulation of inter-penetrating ions). This accumulation is due to the local interaction (co-rotation) of individual ion vortices (signatures of individual self-reforming shock) whick takes place before ion phase mixing establishes. Then, local new shock fronts build up and separate each other. In order to cover a large number of collisional situations, different conditions of SFC have been performed covering high and low Mach number shock regimes. Key results show that (a) shocks cross each other (instead of being reflected) so that each incident shock keeps in propagating within the downstream region of the other one, (b) each well organized self-reforming shock (before the SFC) may be replaced by a very turbulent shock (after the SFC) where the self-reformation totally disappears, according to the concerned shock regime. Extensively, these results have been also analyzed with (i) symmetrical /asymmetrical SFC respectivley defined for incident shocks with identical and different Mach numbers, and (ii) synchronous / asynchronous shocks collisions.