

Electron acceleration at rippled low-Mach-number shocks in high-beta cosmic plasmas: role of the pre-shock conditions

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Shock waves in cosmic plasmas are the places of the electromagnetic turbulence generation and acceleration of particles. They can be found in a big number of astrophysical objects on different scales, e.g. Earth's bow shock, solar flares, supernova remnant (SNR) shocks, merger shocks in galaxy clusters. In the latter case, X-ray and radio observations indicate the efficient electron acceleration. Merger shocks are found to have low Mach numbers ($M_s \ll 10$) and propagate in hot plasma with $\beta \gg 1$. The mechanisms of the particle acceleration at such conditions are poorly known yet, however recent studies indicate that electron energization can be provided by shock drift acceleration (SDA) accompanied by the particle-wave interaction. In the current work we investigate the role of the multi-scale wave structures, especially the ion-scale shock rippling modes, in the electron acceleration at low-Mach-number hi-beta shocks, using the large-scale 2D Particle-In-Cell (PIC) simulations. We showed that efficiency of the electron acceleration increases sufficiently after the appearance of rippling modes, and the main mechanism of the electron acceleration at such conditions is stochastic SDA (SSDA). The electrons gain energy from the motional electric field, being confined in the shock transition region by pitch-angle scattering off magnetic turbulence. Investigation of the multi-scale turbulence appearance at the different pre-shock conditions indicate the crucial role namely of the shock rippling modes in the electron generalization via SSDA.

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