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Particle acceleration and foreshock evolution in heliospheric shocks from self-consistent Monte Carlo simulations

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Self–consistent Monte Carlo simulations have been a fruitful approach to model particle acceleration dynamically coupled with the foreshock development in quasi-parallel shocks. Our group has developed the global Coronal Shock Acceleration (CSA) Monte Carlo simulation capable of modeling self-consistent shock acceleration from the inner corona to the solar wind. However, in the currently used CSA model, the resonant interactions of particles with the foreshock Alfvénic turbulence are not modeled using the full resonance condition. The applied simplification leads to isotropic pitch-angle scattering of particles off the turbulence. In contrast, the exact (within quasi-linear theory) treatment implies anisotropic pitch-angle scattering with reduced scattering efficiency at large pitch-angles. This changes the modeled acceleration efficiency of the shock. We have developed a new Monte Carlo model of particle acceleration at shock, in which we overcome the previous simplification. We present energy spectra of accelerated protons and Alfvén wave distributions in the foreshock, resulting from the new model and compare them with those resulting from the CSA model and from the analytical steady-state theory. The simulations are done for a parallel coronal shock and for the Earth's magnetospheric bow shock. In the latter case, we compare our results on foreshock evolution with those of hybrid-Vlasov simulations (kinetic ions, fluid electrons) to probe the range of applicability of quasi-linear theory.

Collaboration

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