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Quantifying the electron scattering by electrostatic fluctuations in the Earth's bow shock

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Collisionless shocks are known to be natural sources of suprathermal particles, but the mechanism resulting in acceleration of thermal electrons to suprathermal energies still remains elusive. The problem is, that the Diffusive Shock Acceleration (DSA) becomes efficient only for suprathermal electrons, which fluxes in the far upstream region are relatively low. Recent studies have shown that the so-called Stochastic Shock Drift Acceleration (SSDA) mechanism can potentially provide the necessary pre-acceleration of incoming thermal electrons to suprathermal energies. In this mechanism, electrons are temporarily kept trapped in the shock transition region due to magnetic mirror reflection by the magnetic ramp and pitch-angle scattering of electrons trying to escape upstream by wave turbulence. Spacecraft measurements showed that broadband electrostatic turbulence is always present in the Earth's bow shock, but its efficiency in scattering suprathermal electrons has not been estimated up to date. In this study we have quantified the electron scattering by the broadband electrostatic turbulence and, specifically, by electrostatic solitary waves (ion holes) substantially contributing to this turbulence in the Earth's bow shock. Adopting the solitary wave and turbulence parameters typical of the Earth's bow shock, we obtain quasi-linear scattering rates and compare these scattering rates to the results of test-particle simulations. This analysis showed that scattering of suprathermal electrons by the osberved electrostatic turbulence is relatively well estimated by the quasi-linear approach. We estimated the quasi-linear scattering rates at various energies and pitch-angles and demonstrated that the electrostatic turbulence in the Earth's bow shock can provide pre-acceleration of thermal electrons from a few tens of eV to a few hundred eV via the SSDA mechanism.

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