FROM EXPONENTAIL TO POWER-LAW: TEMPORAL DEVELOPMENT OF ENERGETIC ION SPECTRA AT QUASI-PARALLEL SHOCKS

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Diffusive shock acceleration theories predict ion energy spectra of power-law forms. On the other hand, the energy spectra obtained around terrestrial bow shocks and in hybrid simulations show exponential forms over a wide energy range (from several keV up to a few hundreds keV). Loss of ions from the acceleration region (by, e.g., cross-field diffusion) is supposed to cause this difference. However, even in one-dimensional quasi-parallel shock simulations where cross-field diffusion is inhibited, the spectra are still exponential. Here, we propose another point of view, that is, the spectrum develops from an exponential to power-law form in time. We have performed test-particle calculations in which we set non-physical walls in both the upstream and the downstream region. These walls elastically reflect ions in the local fluid frame. First we obtain an exponential spectrum which is produced by the injection process from the thermal to the non-thermal ions at the shock front. Later, the effect of the reflections at the walls dominates and the spectrum develops from the exponential to a power-law form. The results show that considerable time is required to form a power-law spectrum unless the distance to the walls is very short.