VALIDITY OF PLANE-WAVE APPROACH FOR COSMIC RAY ACCELERATION BY SUPERNOVA SHOCKS

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Abstract

We describe a direct comparison between a plane-wave,steady-state approach and a kinetic model for cosmic ray (CR) acceleration by an expanding, spherical shock. We show that the plane-wave approximation adequately describes the nonlinear shock modification and the spectrum of accelerated CRs particularly during the free expansion phase of a supernova remnant. The essential point is that the dilution of energy density as energetic particles fill an ever increasing volume in an expanding, spherical shock (which determines the cutoff energy of accelerated particles), produces qualitatively the same nonlinear effect as energetic particles escaping from the shock, as is parameterized in the plane-wave approximation. Thus, the shock evolution during this phase can be accurately represented as a sequence of quasi-stationary states.