Importance of Richtmyer-Meshkov Instability on measurements of Cosmic-Ray acceleration efficiency at Supernova Remnants

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Abstract

Using three-dimensional (3D) magnetohydrodynamics (MHD) simulations, we show that the efficiency of cosmic-ray (CR) acceleration in supernova remnants (SNRs) is over-predicted if it could be estimated based on proper motion measurements of Balmer filaments in combination with shock-jump conditions.

The CR acceleration efficiency at the SNR has been widely discussed, which seems to be ubiquitously so high that back reaction of CRs onto background shock structure is significant, with assuming that SNRs shock is plane parallel.

The role of the Richtmyer-Meshkov Instability (RMI) has recently been studied using MHD simulations that have shown that the forward shock of SNRs is rippled due to the interaction with interstellar medium, which has Kolmogorov-like density power spectrum. The kinetic energy of the shock wave is transferred into that of downstream turbulence as well as thermal energy that is related to the shock velocity component normal to the shock surface.

Our synthetic observation shows that the CR acceleration efficiency is overestimated by 10-40% despite of no CR acceleration. Furthermore, our simple analytical argument gives upper and lower bounds of apparent CR production efficiency, which is roughly consistent with our numerical results.