Cosmic ray acceleration and magnetic field amplification in the vicinity of a collisionless shock

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Self-generation of magnetic field fluctuations in the vicinity of a collisionless shock and associated cosmic ray acceleration are investigated by utilizing one-dimensional relativistic full particle (PIC) code.

The power law spectrum of cosmic ray energy has the 'knee' at ˜10ˆ15 eV which has thought to be the maximum energy of cosmic rays produced by a supernova shock in our galaxy. According to the standard theory of the diffusive shock acceleration (DSA) this maximum energy depends on amplitude of upstream magnetic field fluctuations, although the standard theory gives the maximum cosmic ray energy about one order smaller than the observed value. To overcome this contradiction, Lucek and Bell [2000] proposed the model that magnetic field fluctuations are amplified by cosmic rays themselves.

We reinvestigate the above model by using 1D PIC code with periodic boundary conditions, and give detailed discussions on parameter dependence of amplitude of magnetic field fluctuations. Wave-particle interactions between cosmic rays and amplified magnetic fields are further studied by performing simulation with nonperiodic boundary conditions, i.e., the system contains a self-consistently produced shock wave and cosmic rays continuously injected from the upstream boundary.