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The fast acceleration of particles scattered by MHD wave in parallel shock

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The origin of the galactic cosmic ray is believed to be generated around the supernova remnant shocks (SNR), and the first-order Fermi acceleration is widely recognized as the standard theory of cosmic ray acceleration. Yet this acceleration mechanism is not always efficient enough to explain high energy cosmic ray particles extending to the knee. The maximum attainable energy expected by the first-order Fermi acceleration is less than the observations. To overcome this problem, additional acceleration and/or other efficient acceleration processes are needed.

Scattering process is important to investigate diffusive shock acceleration(DSA). In the previous numerical simulations, scattering is often treated as just numerical way like Monte-Carlo methods or electromagnetic perturbation. Among these researches, a special attention is paid to the particle acceleration for the particles scattered by magnetohydrodynamic (MHD) waves around the shock wave front. In the uniform system, when the wave phases are strongly correlated spatially localized traveling wave packets can efficiently large angle scatter charged particles (*Kuramitsu & Hada, 2000*). The scattering process through monochromatic large amplitude MHD waves around the parallel shock (*Sugiyama et al. 2001*) is regarded as a possible pre-acceleration process injecting the thermal particles into the Fermi acceleration process and the subsequent fast Fermi acceleration process.By extending the previous researches, we study a fast particle acceleration process for MHD turbulence around the parallel shock. By using the test particle simulation, we argue about the particle acceleration in the quasi-linear regime and also about the case of strongly coherent waves and large amplitude waves.

Keywords: acceleration of particles, cosmic ray, shock, Alfven wave, coherence, large amplitude