Particle acceleration in collisionless shock with large scale magnetic field variation

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Collisionless shocks are thought to be the main accelerators for most energetic particles in and out of the solar system. The diffusive shock acceleration, originated from the idea that the particles can gain a large amount of energy by bouncing back and forth upstream and downstream of shocks multiple times, has been proposed for more than 30 years and naturally explained the cosmic ray observations. However, recent in-situ Voyager observation in termination shock and heliosheath has shown the one-dimensional model could be oversimplified and needs expansions. A lot of works have been devoted on this, concerning different effects. On the other hand, the physics of the shock and particle acceleration in shocks are strongly associated with magnetic field fluctuations and irregularities in different scales. In this study we use stochastic integration to solve 2-D Parker transport equation, which contains the physics of diffusive shock acceleration, for a planar shock with large scale magnetic field sinusoidal variation. The results show the simple 1-D picture can be significantly altered as a result of particle transport in large scale meandering field lines. The particles will be trapped and accelerated along the shock in the region that the foot points of magnetic field on the shock surface approaching each other, form 'hot spot' of accelerated particles. For the regions where the foot points are separating from each other, the acceleration will be suppressed. This result is fundamental and has potential importance in understanding, for instance, anomalous component in termination shock, and galactic cosmic rays accelerated in supernova shocks.