Monte-Carlo study of shock acceleration with electrostatic potential

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High energy particles are observed in many astrophysical objects such as the Earth's magnetosphere, the solar corona, pulsar magnetospheres, supernovae and so on. It is believed that a part of these energetic particles is accelerated at shock waves. The research of shock acceleration is also related to the acceleration of cosmic rays to energies of 10**21 eV. In general, the acceleration mechanisms are categorized into two types: one is stochastic/diffusive acceleration, and the other is direct acceleration where the charged particles can continuously resonate with the electric fields. The former mechanism is known to produce a power law spectrum, which can predict the power law index close to the observed energy spectra in many astrophysical environments. However, there are some defects, that is, injection particles need very large energy, and it takes long time to accelerate particles. The standard theory may be difficult to explain in term of time scale. On the other hand, the latter can accelerate particles with shorter time than diffusive acceleration. It is suggested that this mechanism produces power law spectra but some questions have remained to be elusive. Then we simulated three processes all at once by adding shock potential. In this simulation, the magnetic field in plasma flame is composed by random number. We Lorentztransform this field into the shock rest flame and superpose the shock potential in neighborhood of shock wave. We follow particle trajectories in this field. We found that the efficiency of the acceleration can be greatly improved. In this presentation, we will discuss the behaviour of power law indices and acceleration time scale, and these dependences on shock angle, upstream flow velocity and the strength of the potential.