A challenge of numerical modeling of SEP originated in a CME driven shock

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Prediction of the flux of solar energetic particles (SEP) is the most significant part of the space weather forecast. Observationally, the SEP events are roughly categorized into two groups of impulsive and gradual. In impulsive events, flux of SEP increases in a short timescale after a large flare and then decay until shock arrival, in which the particles are thought to be originated from the flare site. In gradual events, oppositely, SEP increases gradually until a shock arrival, which is thought to be accelerated in a shock in front of a coronal mass ejection (CME).

Recently, Sugiyama & Kusano performed a self-consistent shock acceleration simulation using a newly developed plasma simulation code in which Hybrid simulation and energetic particle Hall MHD one are interlocked. They revealed that thermal protons are successfully energized when they repeat pass through a shock. The simulation code enable us to simulate with a huge numerical domain, i.e., to include the return of higher energy particles.

CMEs associated with SEP are usually erupted from active regions and accelerated through the solar corona, and then propagate in the interplanetary interacting with the solar wind. Between the CME path, plasma parameters such as magnetic field strength, velocity, pressure, and density in front of CME driven shock varies and the position of the SEP source region connected to the Earth also varies.

In this study, we have developed a technique to extract such a time dependent shock parameters from the results of data-driven MHD simulation of CME propagation through the solar wind (Kataoka et al. 2009). The extracted shock parameters such as field angle to the shock normal, Alfven Mach number, and plasma beta are imported to upstream of the interlocked simulation of shock acceleration. As the result of the simulation it is found that thermal plasma in the solar wind successfully accelerated at least to ˜10MeV until the CME arrival.