Vlasov simulation of the wakefield acceleration

Akihiro Suzuki¹, Toshikazu Shigeyama¹

¹Research Center for the Early Universe, University of Tokyo, Hongo 7-3-1, Bunkyo-ku, Tokyo, Japan, 113-0033, suzuki@resceu.s.u-tokyo.ac.jp

Power-law energy spectra of particles are ubiquitous structure seen in high-energy astrophysical phenomena. Various acceleration processes are proposed in order to reproduce power-law energy spectrum of particles. Wakefield acceleration [1] is one of the processes. The mechanism of the process is as follows:
1) an intense light pulse propagates in a stationary plasma composed of ions and electrons, 2) radiation pressure of the pulse modifies the spatial distribution of electrons, 3) the displacement of the spatial distribution of electrons excites a longitudinal electric field, 4) the thus excited electric field accelerates electrons.

Astrophysical applications of the wakefield process have been proposed recently. Ref. [2] claimed that the wakefield excited by some magnetowaves could procudes ultra high-energy cosmic rays (UHECRs). Ref. [3] argued that the wakefield acceleration can occur in the upstream of a relativistic collisionless shocks. Ref. [4] showed that the wakefield acceleration actually occur in the upstream of a relativistic collisionless shock by using a particle simulation. Recently, it is found that electrons accelerated by the wakefield have power-law energy spectrum with an index $\sim 2$ [5].

We have developed a code to solve the relativistic Vlasov-Maxwell system, the equations governing the kinetic evolution of relativistic collisionless plasmas. [6] In this presentation, some results of simulations of the wakefield acceleration are shown. Then, we discuss the mechanism of the formation of the power-law energy spectrum of electrons accelerated by the wakefield.

References