Vlasov simulation of the wakefield acceleration

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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 ~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

[1] T. Tajima & J. M. Dawson, Phys. Rev. Lett,, 43, 267, 1979
[2] P. Chen, T. Tajima, & Y. Takahashi, Phys. Rev. Lett., 89, 161101, 2002
[3] Y. Lyubarsky, ApJ, 652, 1297, 2006
[4] M. Hoshino, ApJ, 672, 940, 2008
[5] Y. Kuramitsu, Y. Sakawa, T. Kato, H. Takabe, & M. Hoshino, ApJ, 682, L113, 2008
[6] A. Suzuki & T. Shigeyama, JCoPh, 229, 1643, 2010

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