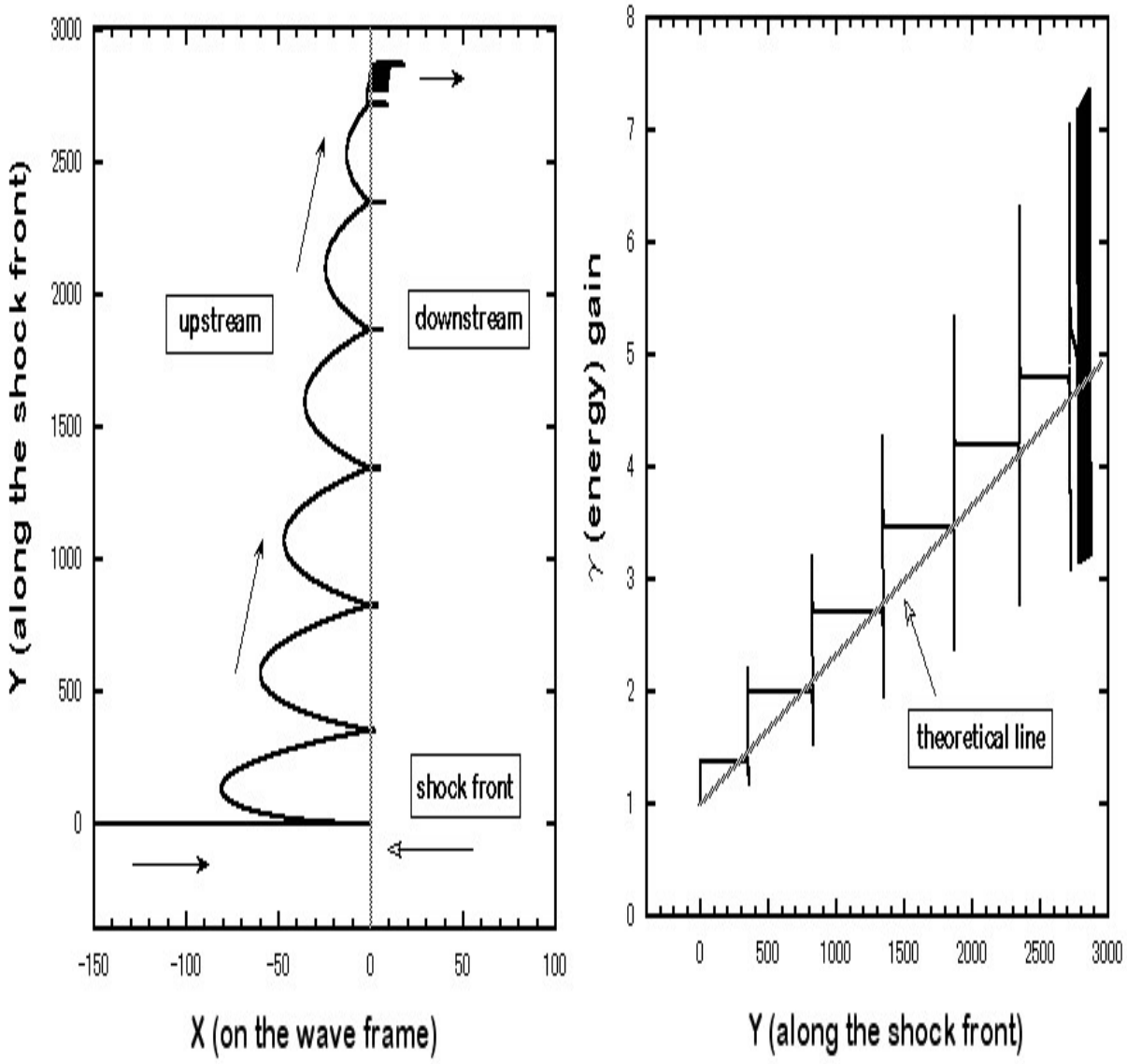
Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

PEM031-02 Room: Exibition hall 7 subroom 1 Time: May 24 09:13-09:26

Particle accelerations by shock waves in electron-positron plasmas

Satoshi Takeuchi[1*]

[1]University of Yamanashi



A plausible candidate of ultra-high energy sources may be an shock wave in an active galactic nuclei. Under this motivation an acceleration mechanism of the particle interacting with the shock wave propagating in the electron-positron plasmas is investigated.
In the electron-ion plasmas the space charge is generated by the difference of the mass inertia between the electron and ion, thus the electrons trapped by the electrostatic potential near the shock front are accelerated effectively[1]. On the other hand in the electron-positron plasmas (pair plasma) the space charge effect is so small to accelerate particles because the mass of electron is

equal to the mass of positron. Therefore, to account for the particle acceleration in the pair plasma another mechanism is needed[2,3].
We assume that the magnetic field in the background plasma is uniform and thus the particles gyrate with the cyclotron motion in this region. Furthermore the plasma shock wave with electromagnetic fields is assumed to be propagates perpendicularly to the uniform magnetic field. The relativistic equation of motion can be analyzed theoretically on the wave frame. By the Lorentz transformation the electric field of the shock wave disappears and on the other hand the motional electric field appears from the uniform magnetic field in the background plasma. The energy equation derived from the equations of motion shows that the particle can be accelerated by the motional electric field and gains net energy.
Numerical calculations of the particle trajectories are carried out on the laboratory frame. In the upstream region the particle locating far from the shock wave comes closer and collides with the shock front. The particle reflected by the shock front returns to the upstream region again and gyrates in the uniform background field. In an instant of the reflection the particle gains a momentum from the shock wave. Repeating such the collision and reflection many times, the particle is accelerated along the shock front and gains a net energy .
The typical trajectory of the particle colliding with the shock front and the (energy) gain of the particle along the wave front are shown in the figure.

[1] Ucer & Shapiro: Phys. Rev. Lett. 87,075001 (2001)
[2] Hoshino: Prog. Theore. Phys. 143, 149 (2001)
[3] Takeuchi: Phys. Plasmas, 12, 102901 (2005)

Keywords: particle acceleration, shock wave, electron-positron plasmas, relativistic equations of motion