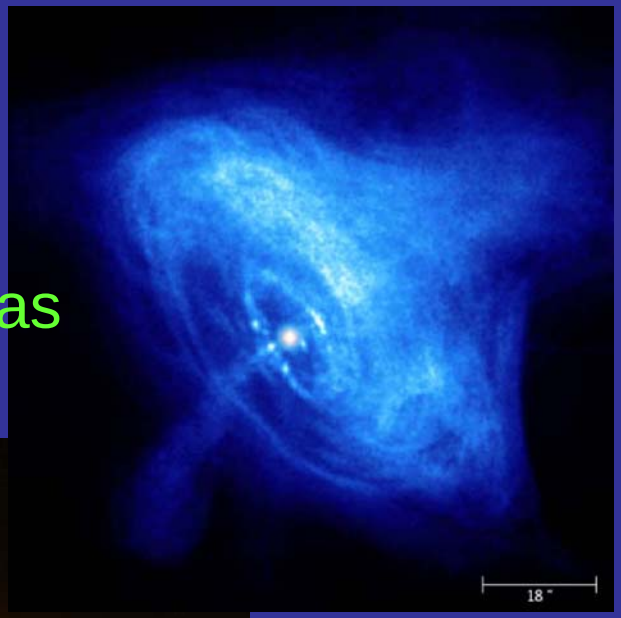
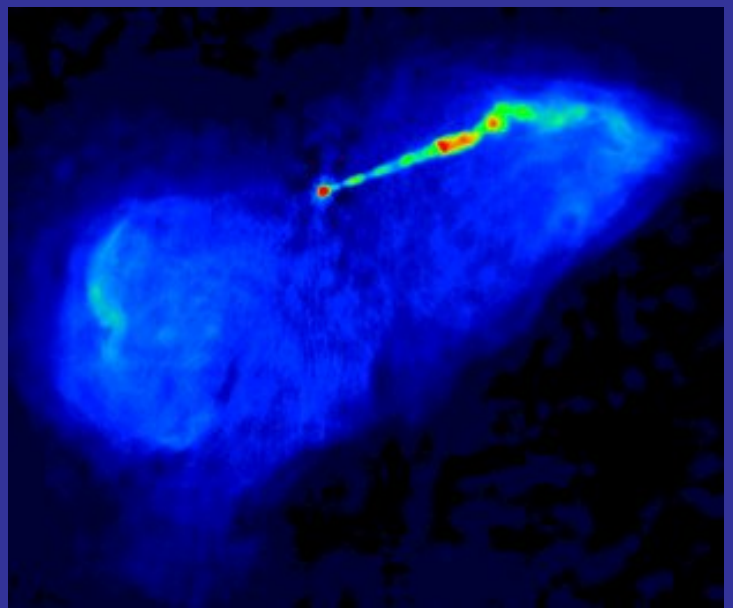
Magnetic Trapping Acceleration in Interplanetary Plasmas

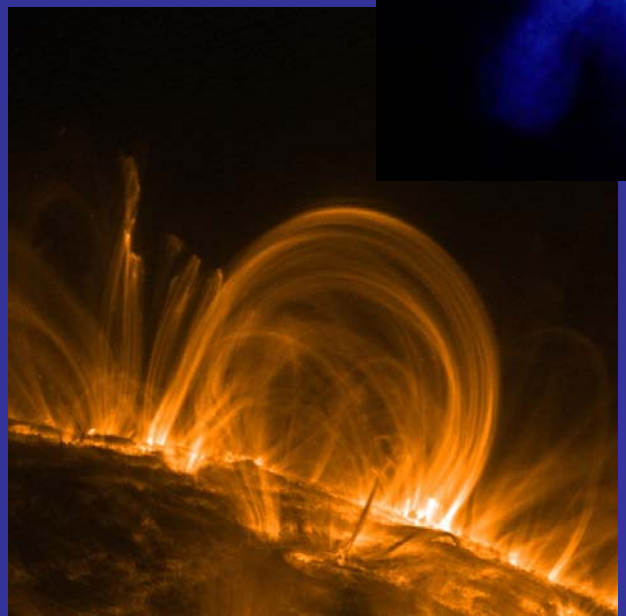
Satoshi TAKEUCHI
University of Yamanashi

Contents

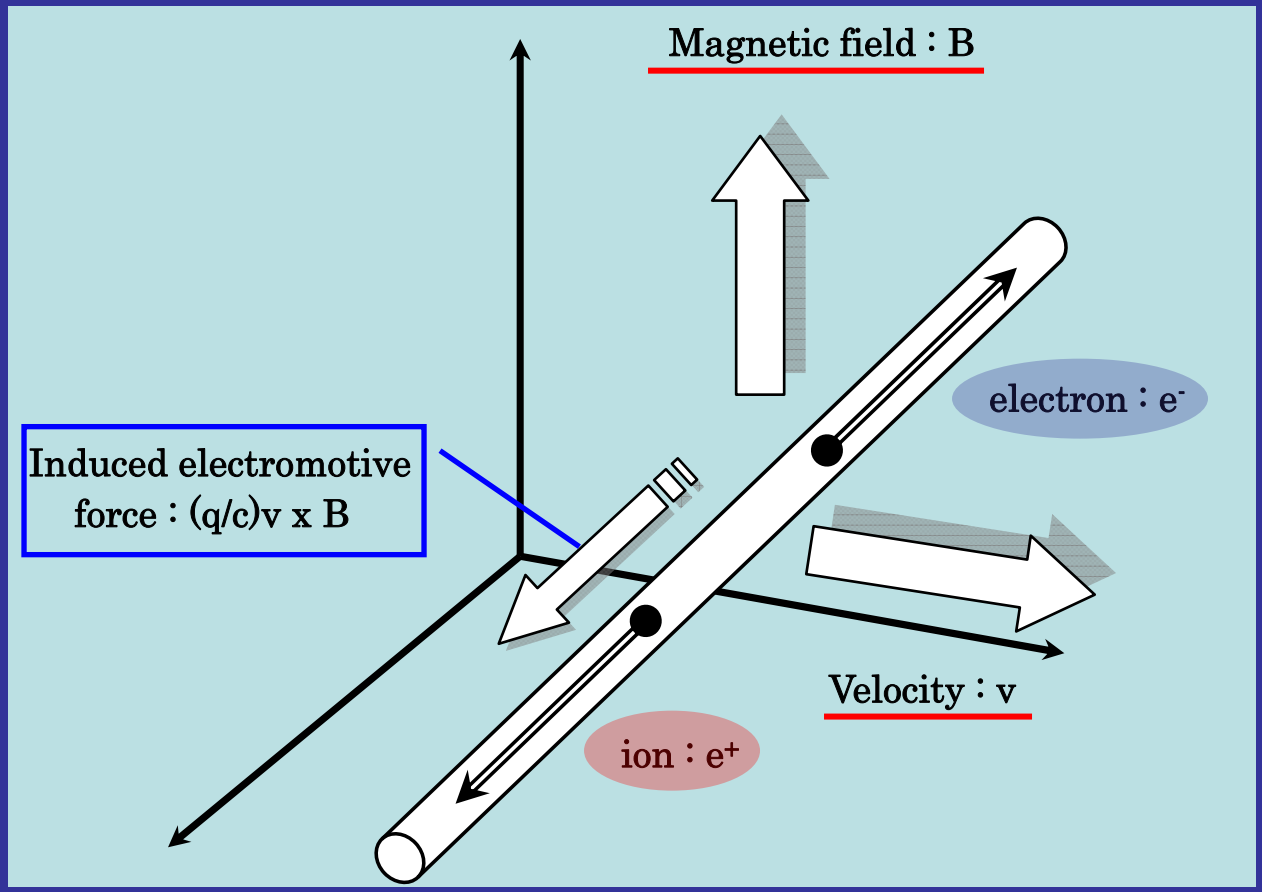
- Analogy of Magnetic Trapping Acceleration
  - ➔ magnetic neutral sheet
- Acceleration of two colliding plasmas
  - ➔ magnetic field reconnection
- Acceleration of electron-positron plasmas
  - ➔ unlimited acceleration





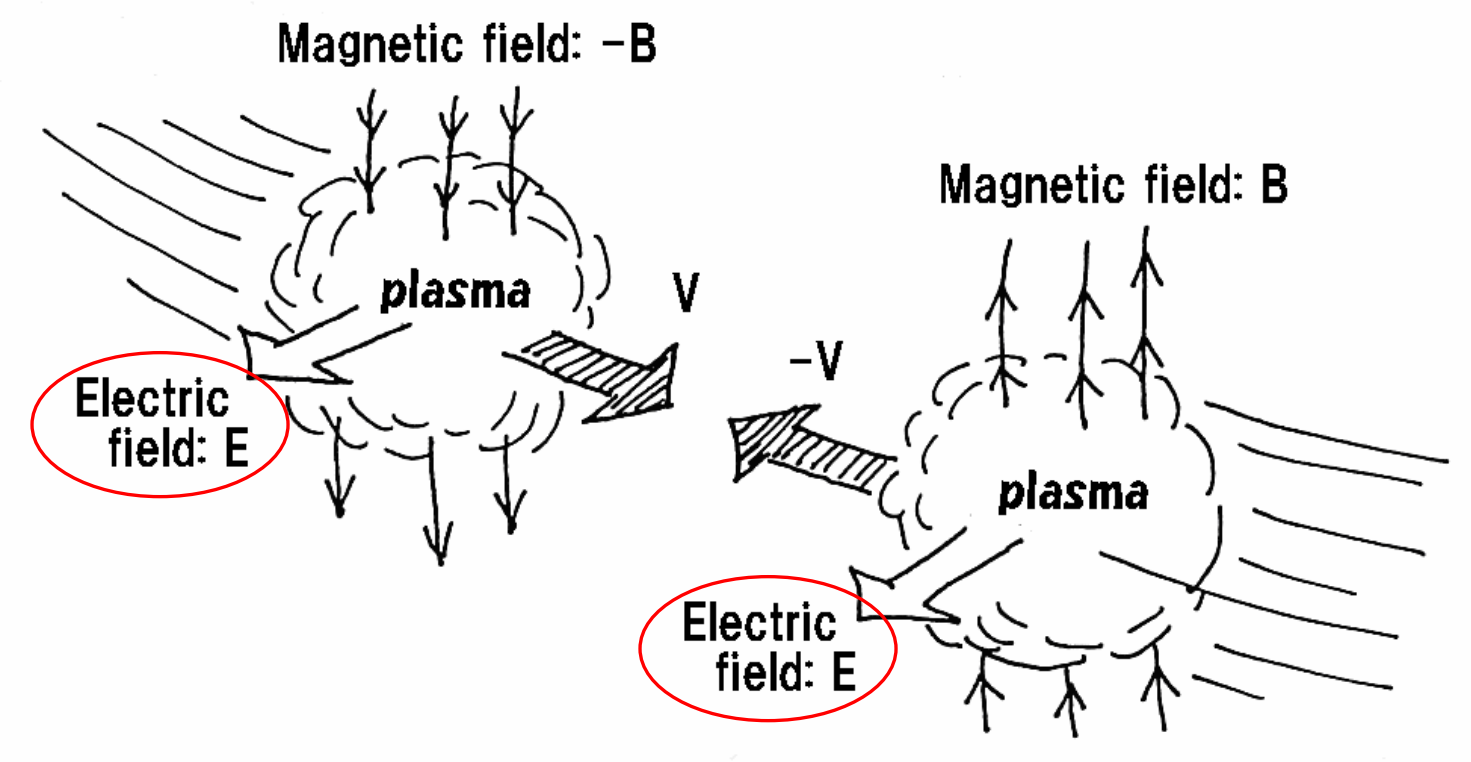


Analogy of MTA

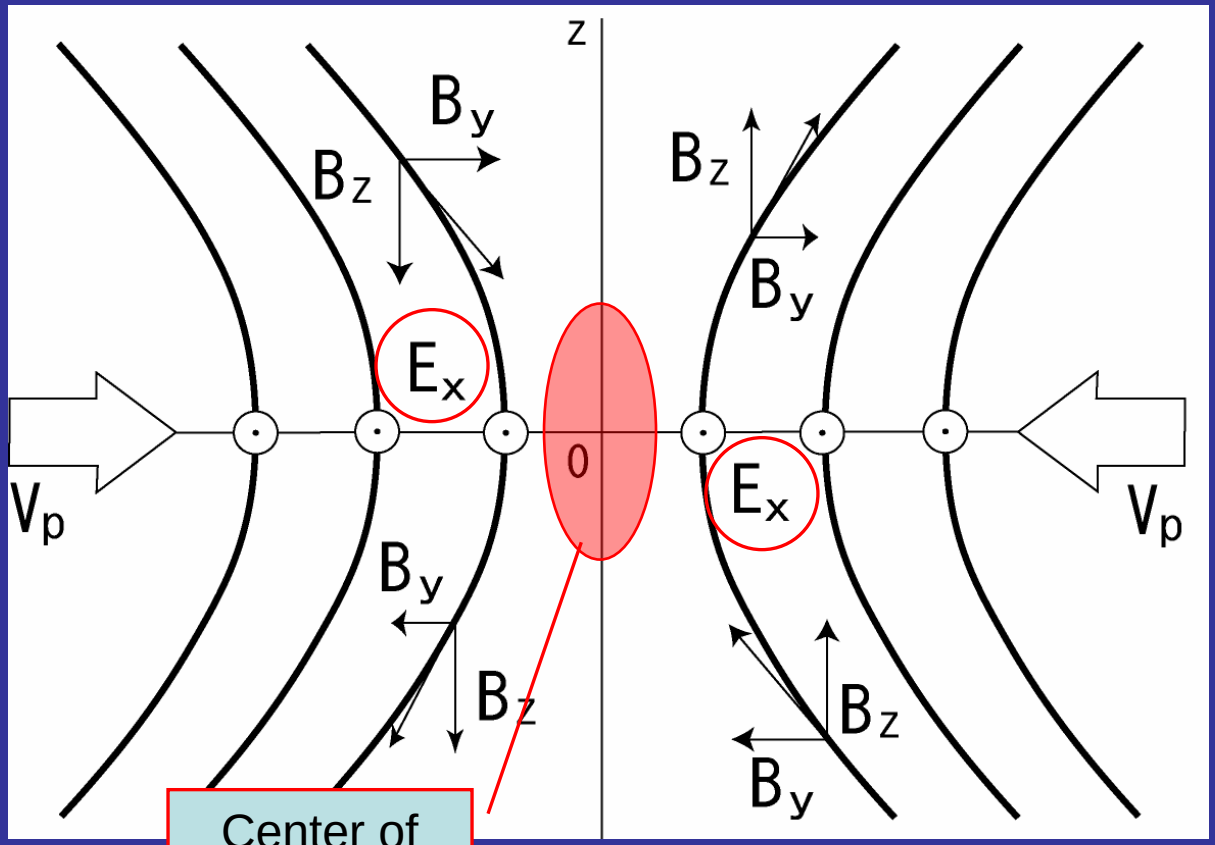


Electromagnetic induction

Colliding plasmas



Fields configuration



Basic equations

$$m\frac{d(\gamma\mathbf{v})}{dt} = q(\mathbf{E} + \frac{\mathbf{v}}{c} \times \mathbf{B}),$$

Relativistic Equation of motion

$$mc^2 \frac{d\gamma}{dt} = q\mathbf{E} \cdot \mathbf{v}$$

Energy equation

$$\nabla \times \mathbf{E} = -\frac{1}{c}\frac{\partial \mathbf{B}}{\partial t},$$

Faraday's law

$$\nabla \times \mathbf{B} = \frac{4\pi}{c}\mathbf{J}$$

Ampere's law

Numerical calculations

Magnetic field configuration

$$B_{zi} = (B_0 / 2)[\tanh \eta_i + (-1)^i]$$

parabolic

$$\eta_i \equiv k(y + v_{pi} t) + h_i (ky) + \phi_i$$

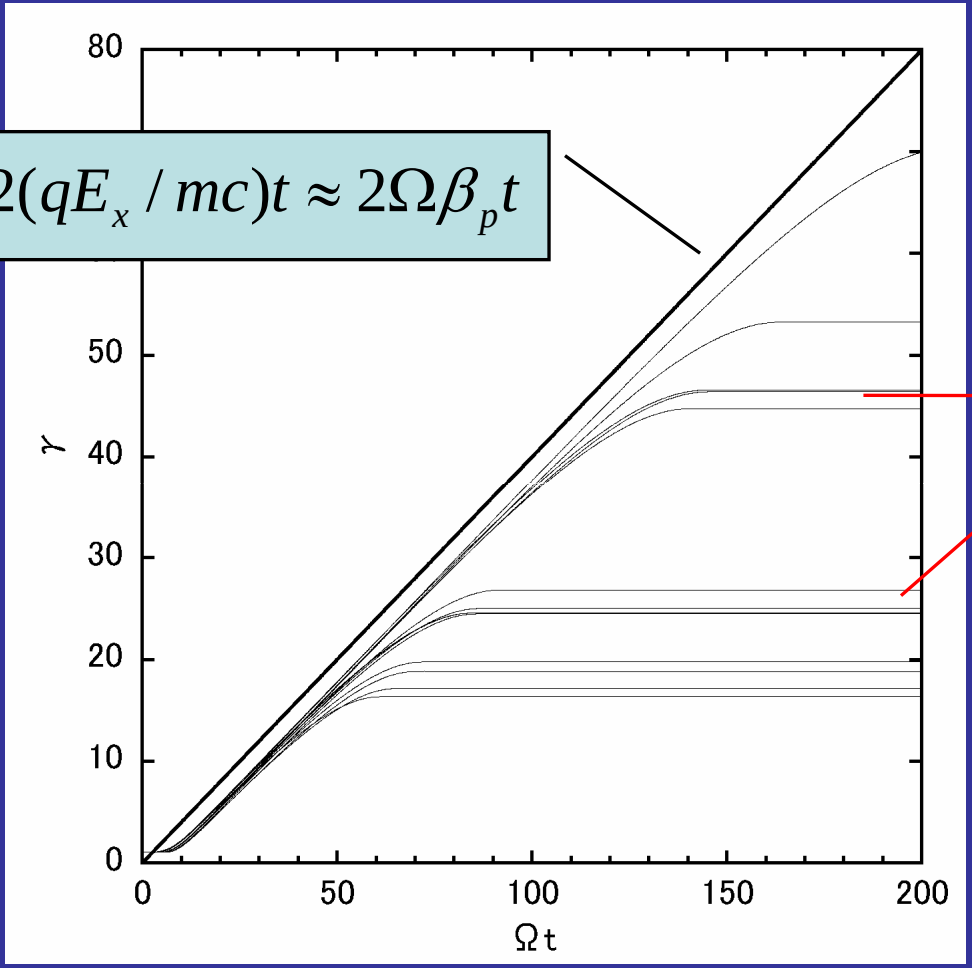
Phase parameters

Attainable gain of particle around the center of collision

$$\gamma \approx 2(qE_x / mc)t \approx 2\Omega \beta_p t$$

Attainable gains

$$\gamma \approx 2(qE_x / mc)t \approx 2\Omega\beta_p t$$



saturation

Attainable gain

Initial position of particle

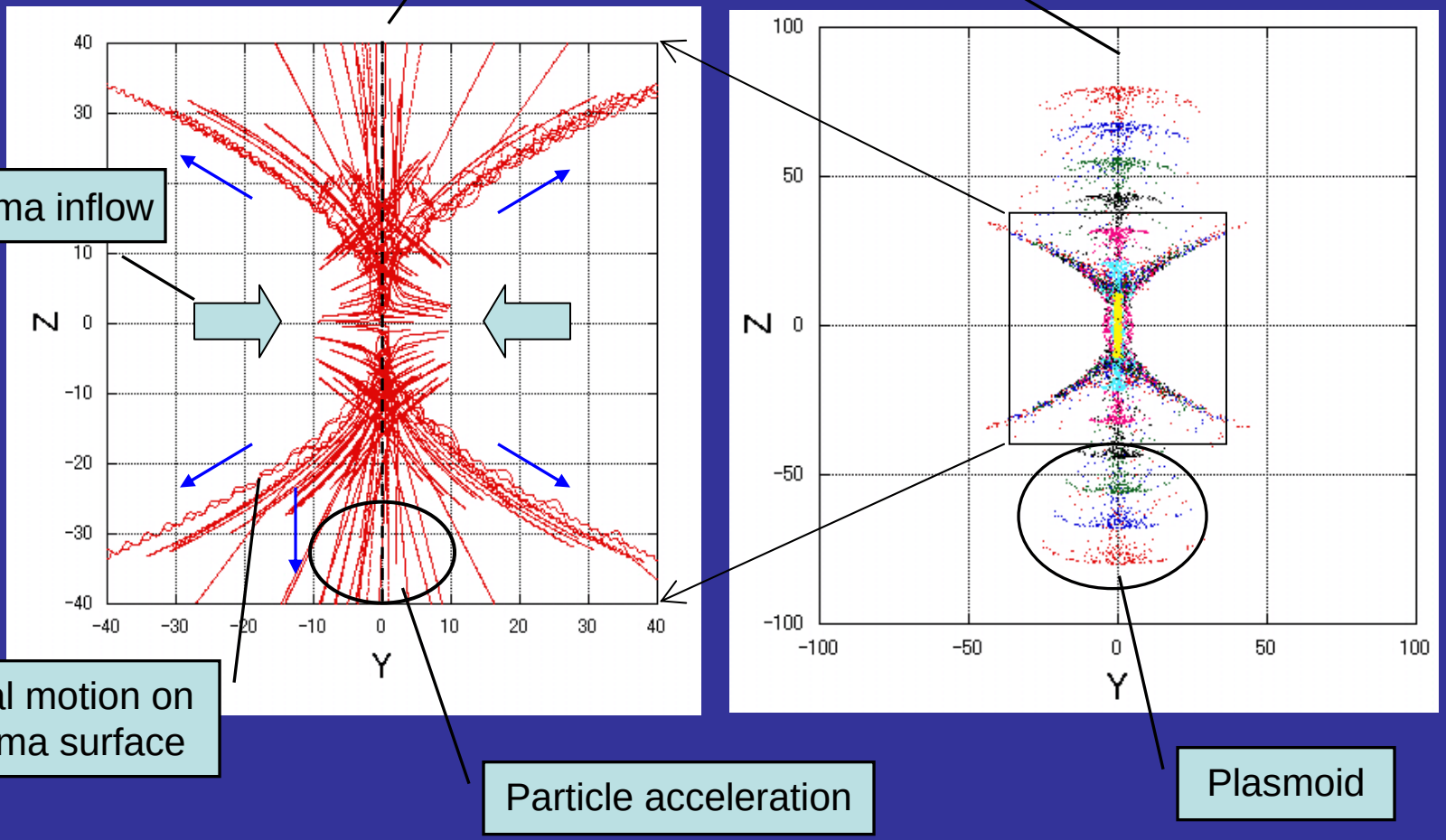
$$\gamma_a = C_1 \beta_p^3 / \alpha^2 \zeta_0$$ (theoretical)

Phase velocity

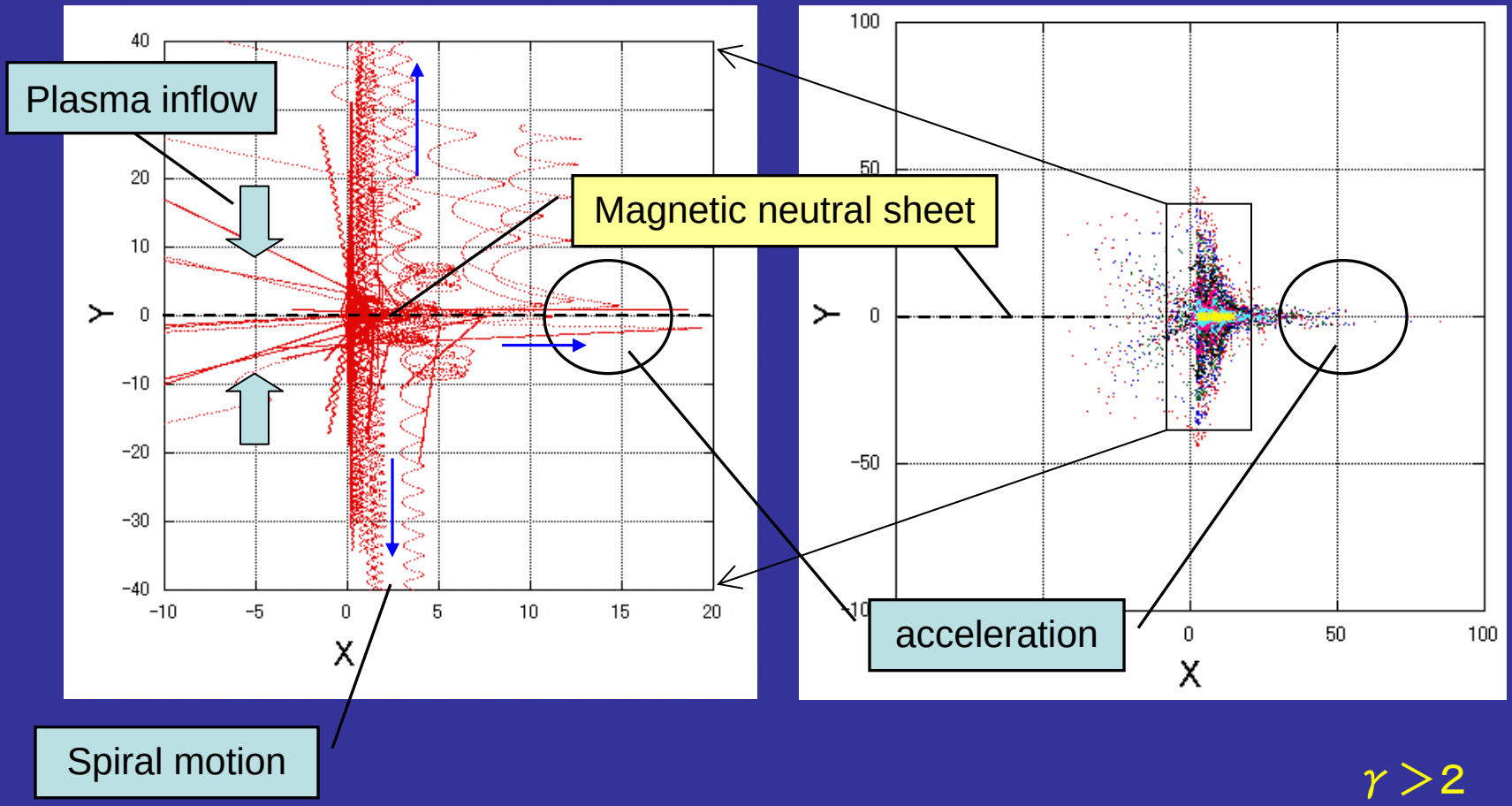
Radius of curvature of magnetic field

$$\gamma_a = C_2 \beta_p^{2.19} / \alpha^{1.22} \zeta_0^{0.28}$$ (numerical)

Particle trajectories & distributions（yz-plane）



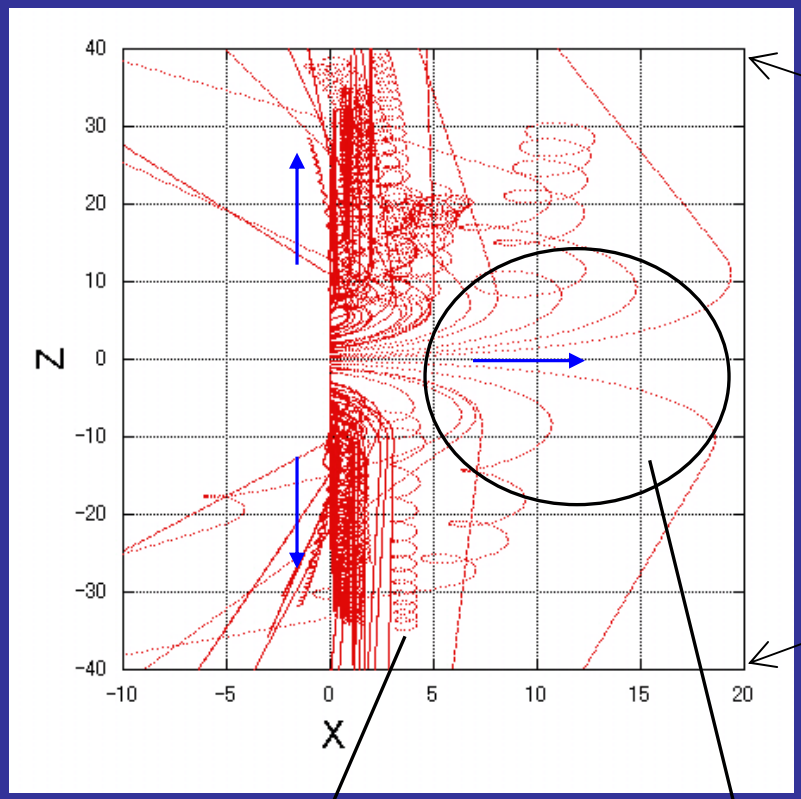
Particle trajectories & distributions（xy-plane）

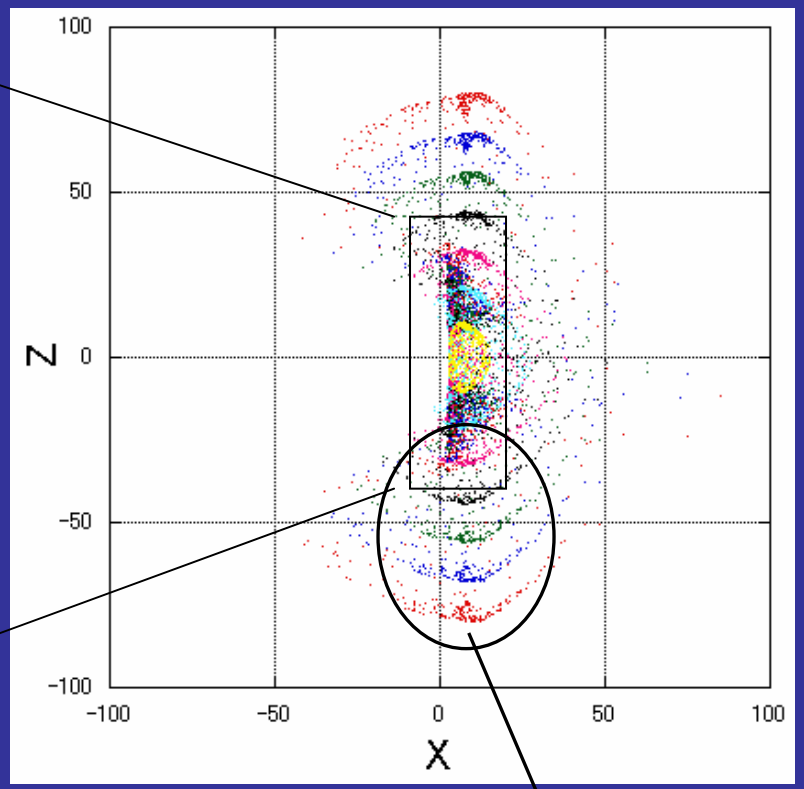


$\gamma > 2$

Particle trajectories & distributions（xz-plane）

$\gamma > 2$



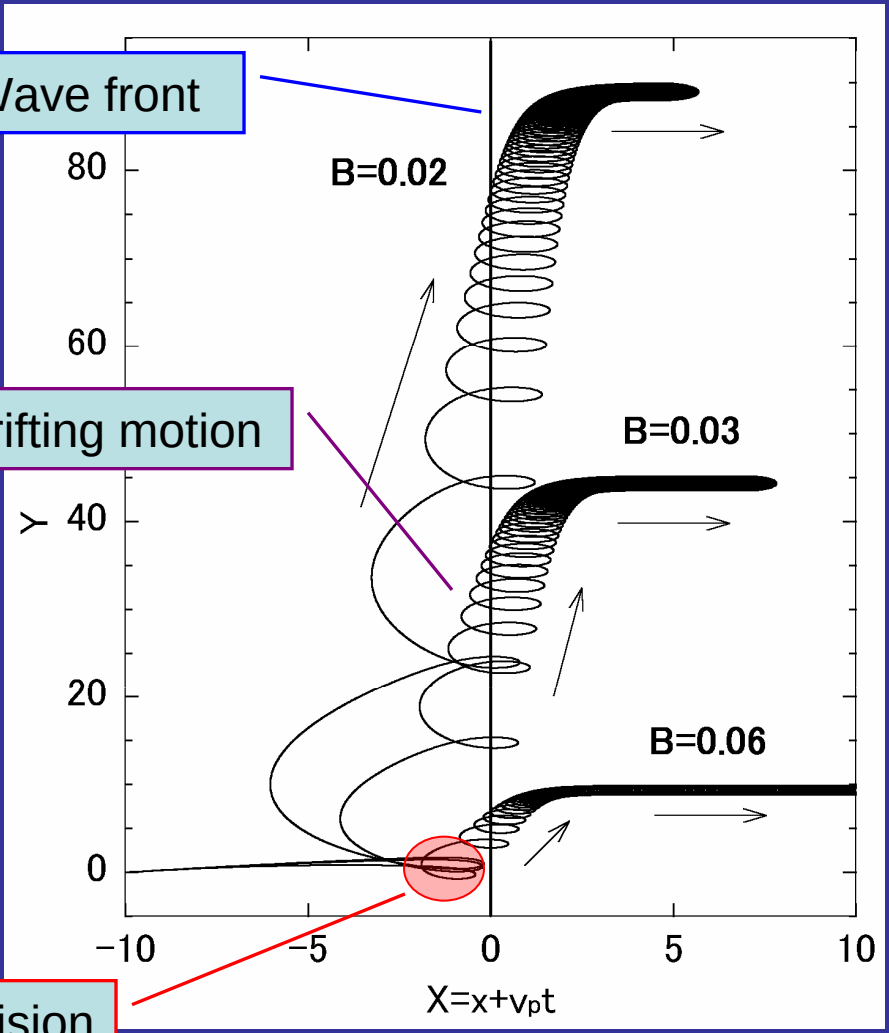


Spiral motion

Particle acceleration

Plasmoid

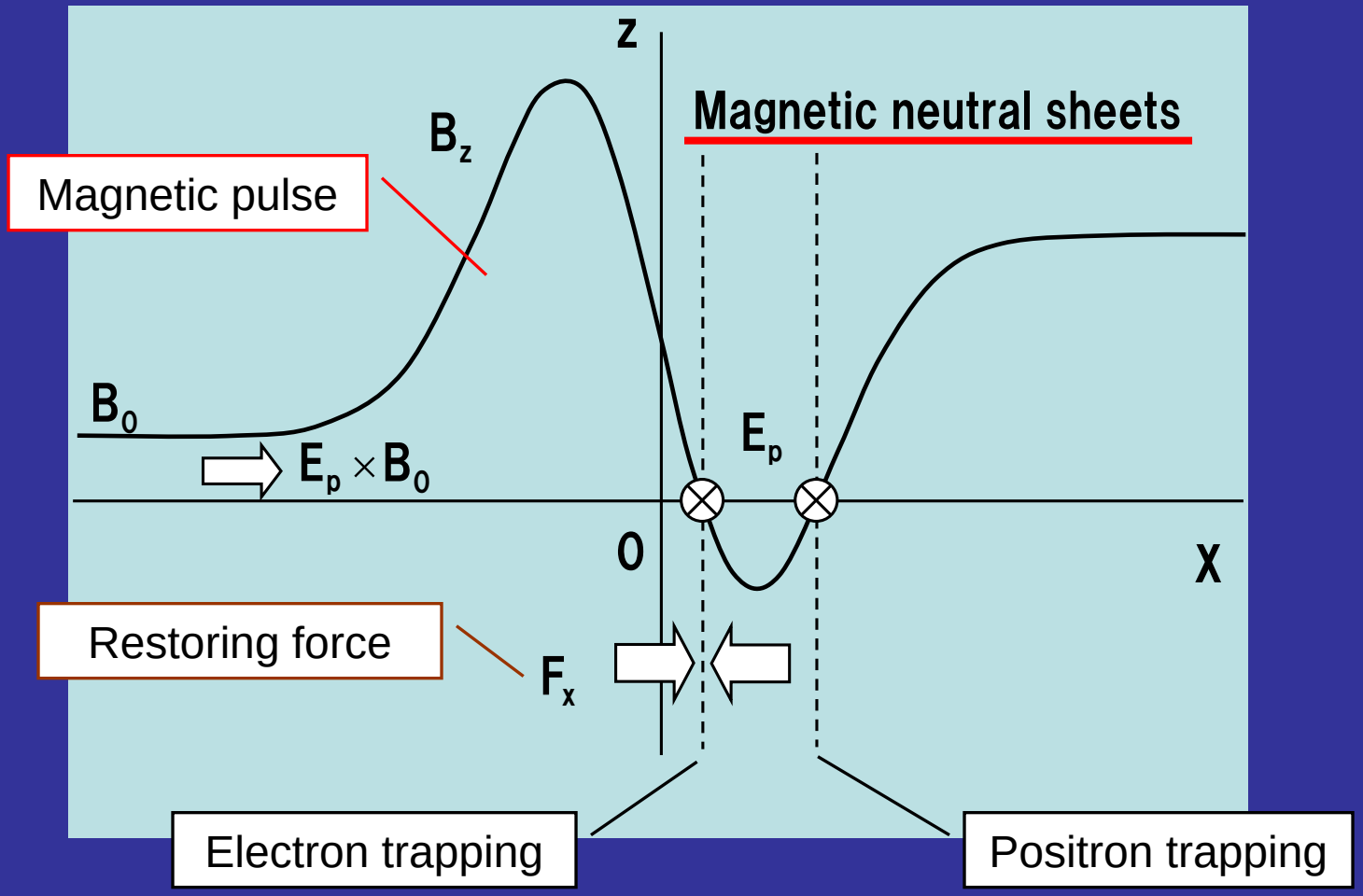
Current flow along wave front



Induced magnetic field

$$\nabla \times \mathbf{B} = \frac{4\pi}{c}\mathbf{J}$$

Electron-Positron Acceleration



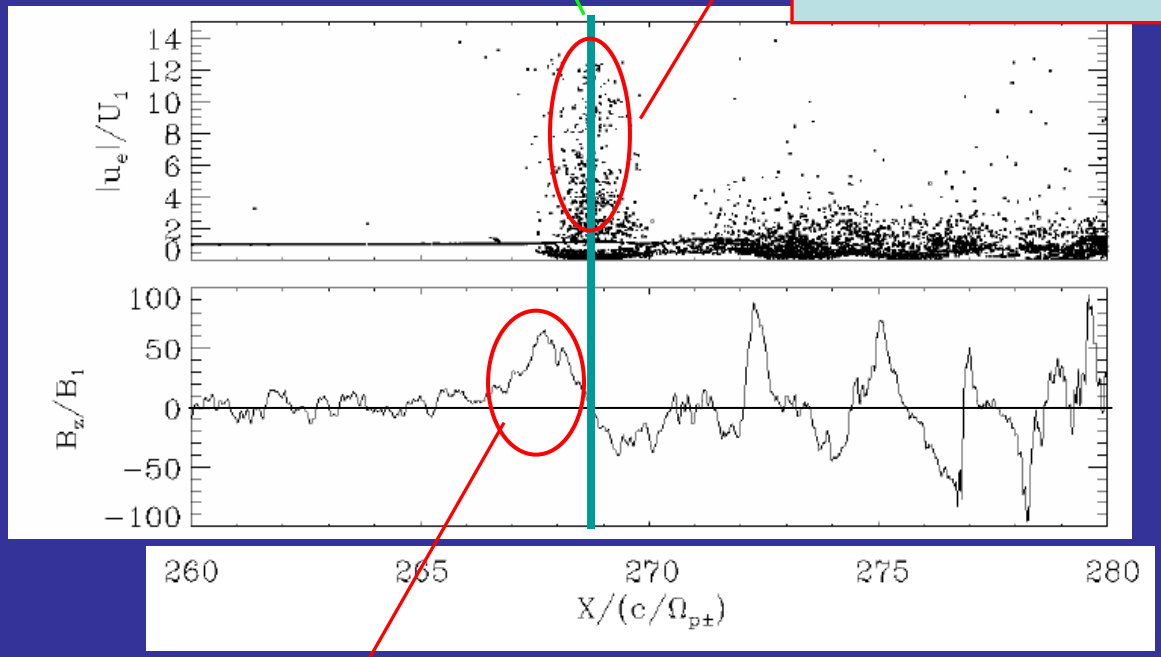
Particle simulation

"Current Sheet" Shock Surfing

Hoshino PTP 2001, Nagata 2005

Magnetic neutral sheet

High energy particles by MTA



Magnetic pulse

This can provide unlimited acceleration

Summary

Magnetic Trapping Acceleration

- magnetic neutral sheet
- magnetic field reconnection plasmoid
- electron-positron plasma

simultaneous acceleration of electron and positron, in principle, unlimited acceleration