PIC Simulation of Electron Acceleration during Reconnection via Magnetic Islands Coalescence

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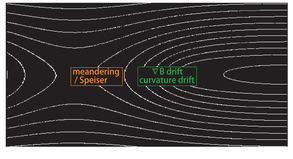
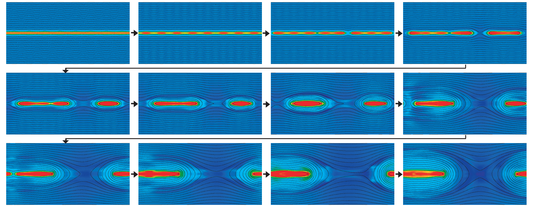
Introduction

Production of high energy electrons is one of the most interesting topics in space plasma physics. In the Earth's magnetosphere, magnetotail reconnection has been thought to be a generation mechanism of the observed energetic electrons. However, the detailed electron acceleration mechanism in magnetic reconnection still remains an open question.

In earlier studies, it is sugestted that high energy electrons are produced from meandering/Speiser motion near X-line and ∇B/curvature drift at pileup region. In our study, we notice an effect of magnetic islands coalescence.



Magnetic islands coalescence is induced by tearing instability. Intensive variation of magnetic field during coalescence yields strong Ey which accelerates electrons. Process of coalescence is shown in below snapshots of plasma density.



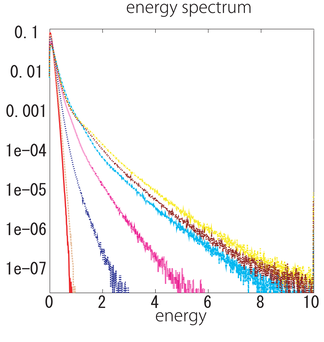
Result

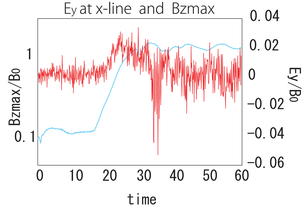
We carried out 2D PIC simulation of magnetic reconnection via magnetic islands coalescence.

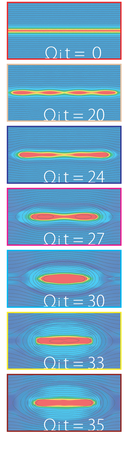
Energizing electron during coalescence is shown in below figures. A color of each spectra corresponds one of snapshot frame. It is shown that An islands coalescence yeilds strong Ey at X-line and accelerates electrons.

In right column, a color in glaphs corresponds each run. The upper right figures are contours of electron density at neautral sheet - axes are Time-X, so we call them "X-T diagram" , and they show time evolution of reconnection.

Electron Acceleration Associated with Coalescence

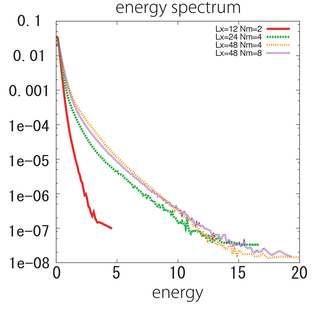


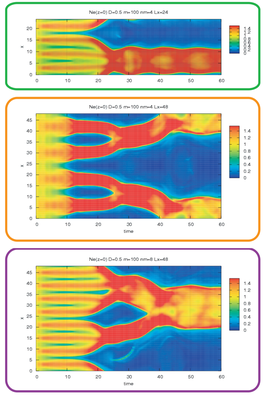




Comparison of Initial Setup

run A	run B	run C
Lx = 24 λi	Lx = 48 λi	Lx = 48 λi
nm = 4	nm = 4	nm = 8

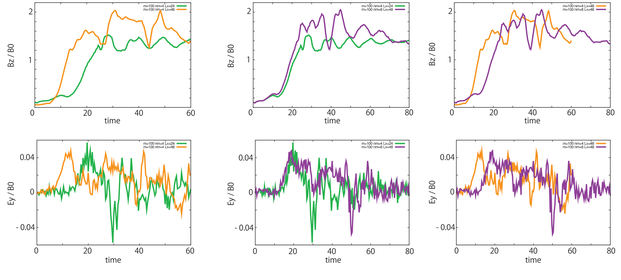




run A vs run B
System Size Dependence
(constant islands number)

run A vs run C
System Size Dependence
(constant island size)

run B vs run C
Islands Dependence
(constant system size)



Summary

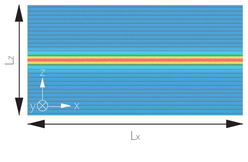
- We indicated process of electron accelerateion during coalescence with 2D PIC simulation.
- Ey near X-line during coalescence is important for electron acceleration.
- Production of high energy electrons depends on system size.
- System size has much effect not on intensity of but on duration time of reconnection electric field.
- Initial condition of islands seems not to have distinct relation with high energy electrons.

Simulation Setup

initial condition : Harris Current Sheet + Perturbation in Magnetic Flux

$$B_x(z) = B_0 \tanh(z/D) \qquad n_{cs}(z) = n_0/\cosh^2(z/D)$$

Mass Ratio = 100
D (Current sheet half thickness) = 0.5 λi
Tcs / Tlobe = 8
Ti / Te (at current sheet) = 8
Lx / Lz = 3/2



Normarization Parameters

Time : 1 / Ωi Length : λi (ion inertia length)