Comparisons of Primary and Secondary Magnetic Island Evolution in 2D Reconnection

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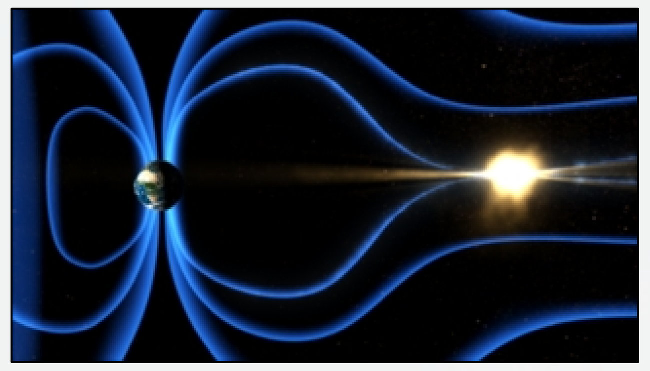

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INTRODUCTION

Motivation and Objectives:

◆ Extended thin current sheets are known to be unstable to the formation of magnetic islands (also called plasmoids or flux ropes) [1,2]. The main objective of this poster is to compare primary and secondary magnetic islands, and establish for the first time distinct features in electron velocity distributions for both types of islands.

◆ Magnetic islands observed during magnetotail reconnection are effective acceleration sites where electrons can attain suprathermal energies [3]. The island interior and exterior were identified based on the assumption that electron distributions in the island interior are similar to those in the exhaust [4]. The second objective of this poster is to validate this assumption by comparing electron distributions inside islands and those in the open exhaust.

Simulation Parameters:

Open boundary conditions: collisionless, undriven reconnection with no guide field.

Lobe appropriate beta: 0.0028, $m_i / m_e = 400$,

$T_i / T_e = 5$ (Harris Population), $\omega_{pe} / \Omega_{ce} = 2$, $L / d_i = .5$,

$N_b / N_o = .05$, $T_b / T_o = .333$

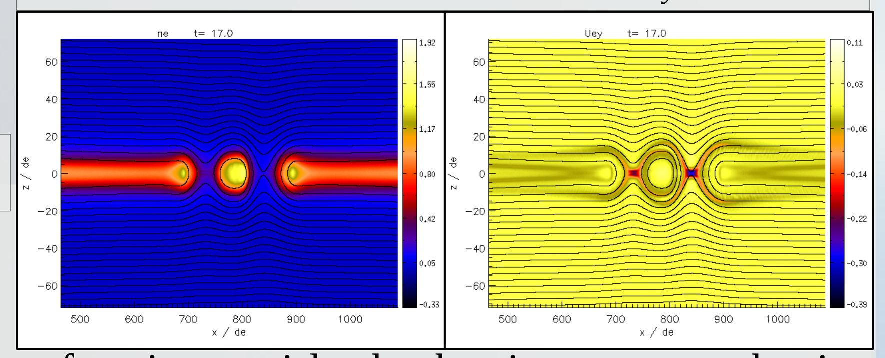
Particles per cell: 600, Number of cells: 1024 x 2560,

Total number of particles: ~ 1.5 x 10^9

Comparison of Island Evolution:

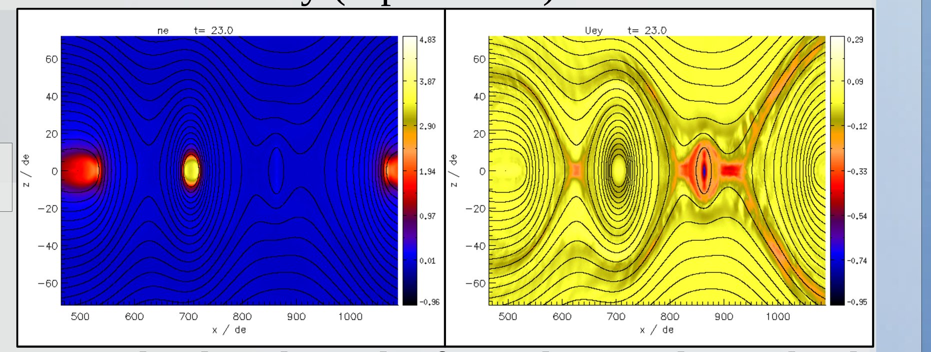
n_e | U_{ey}

$t\,\Omega_{ci} = 17.0$



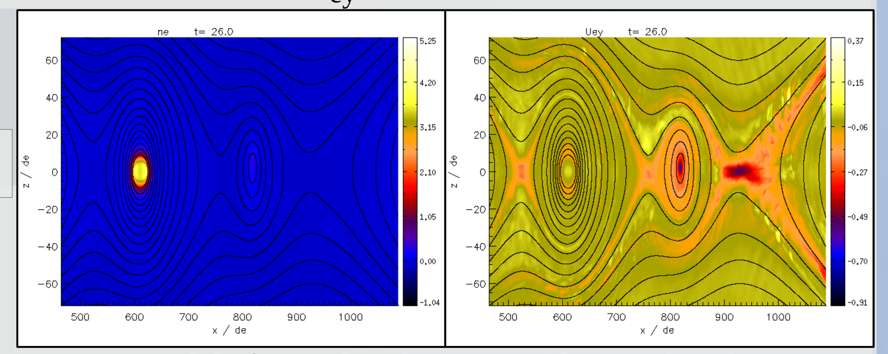
Early stage of primary island showing strong density compression (n_e) at the core and enhanced electron out-of-plane flow (U_{ey}) near island boundary (separatrices).

$t\,\Omega_{ci} = 23.0$



Growing primary island and newly formed secondary island showing that the secondary island's center has a pronounced U_{ey} peak, which it inherited from the electron current layer; the primary island shows no such U_{ey} peak.

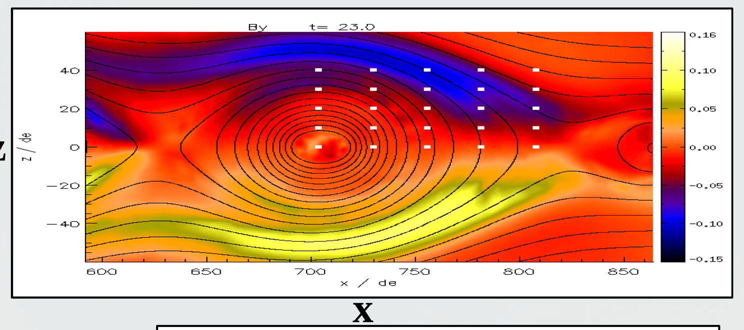
$t\,\Omega_{ci} = 26.0$



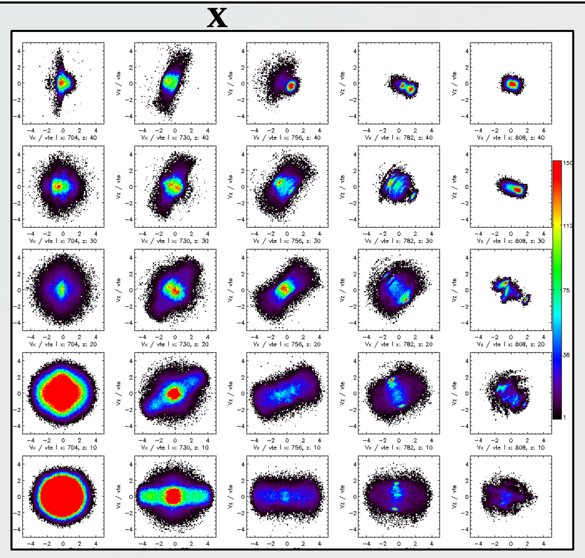
Both islands are ejected leftward. The secondary island retains its U_{ey} peak, while the primary island center is void of U_{ey} peak. A ring of enhanced U_{ey} develops in the primary island due to the large density gradient (∇P drift).

SIMULATION RESULTS

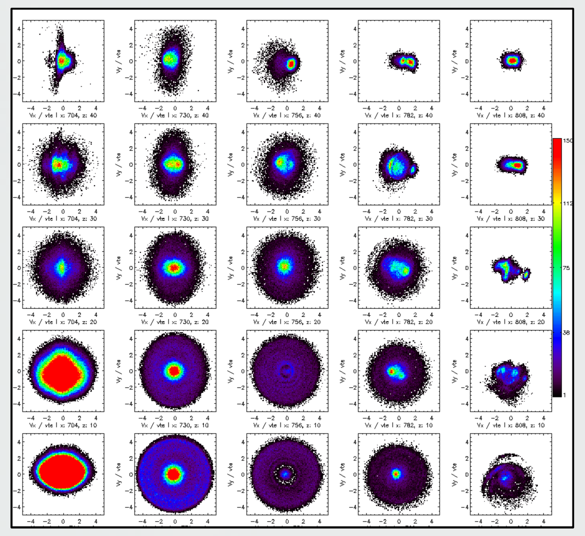
Primary Island: formed due to multiple X lines in unstable ion current sheet.



Vx-Vz



Vx-Vy

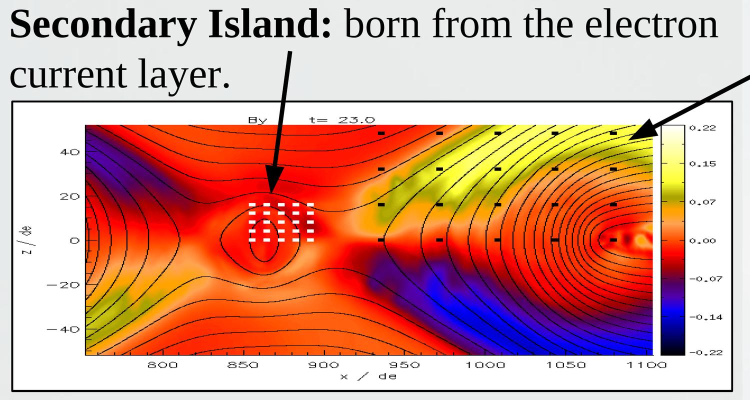


◆ Colder, dense island core.

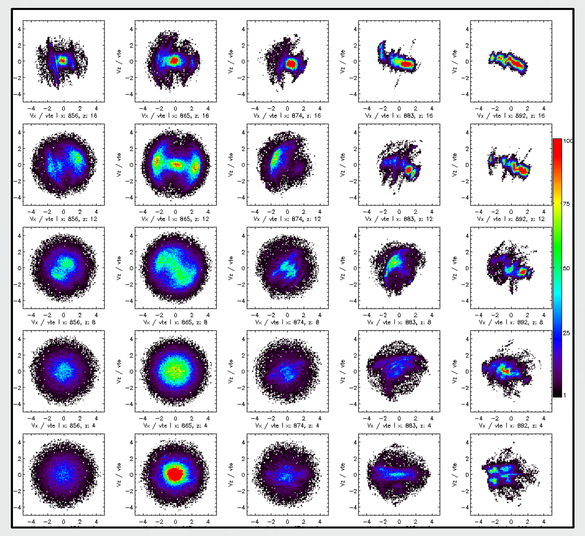
◆ Strong perpendicular heating in Vx-Vz space.

◆ Highly dynamic and very structured electron distributions as results of active reconnection.

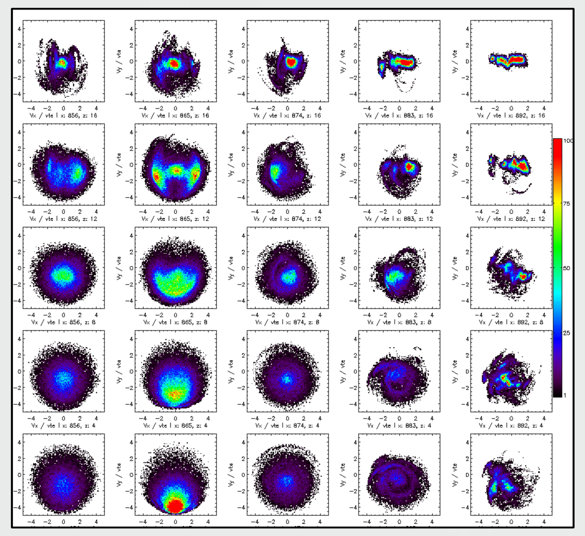
Secondary Island: born from the electron current layer.



Vx-Vz



Vx-Vy



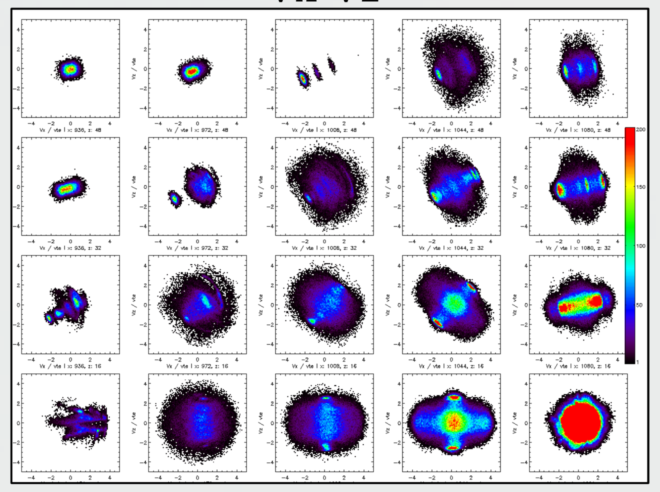
◆ Dense island core with strong peak in negative Vy direction.

◆ Perpendicularly heated populations.

◆ Multiple populations of electrons in both Vx-Vy and Vx-Vz distribution functions.

Open Exhaust: electron distribution functions from open exhaust region.

Vx-Vz

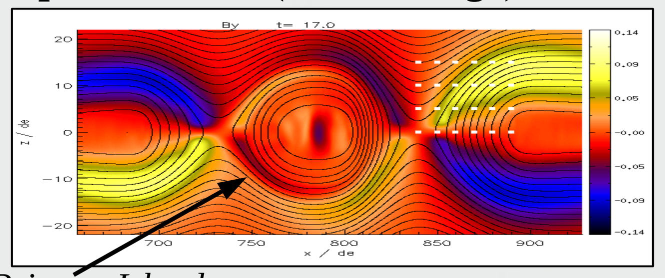


◆ Hotter, more structured distribution functions than at earlier stage (below).

◆ Isotropic distributions only in density pileup region

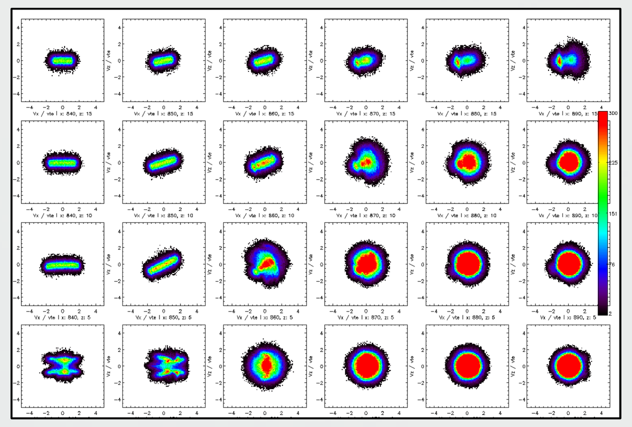
◆ Perpendicular heating at B pileup.

Open Exhaust (earlier stage):



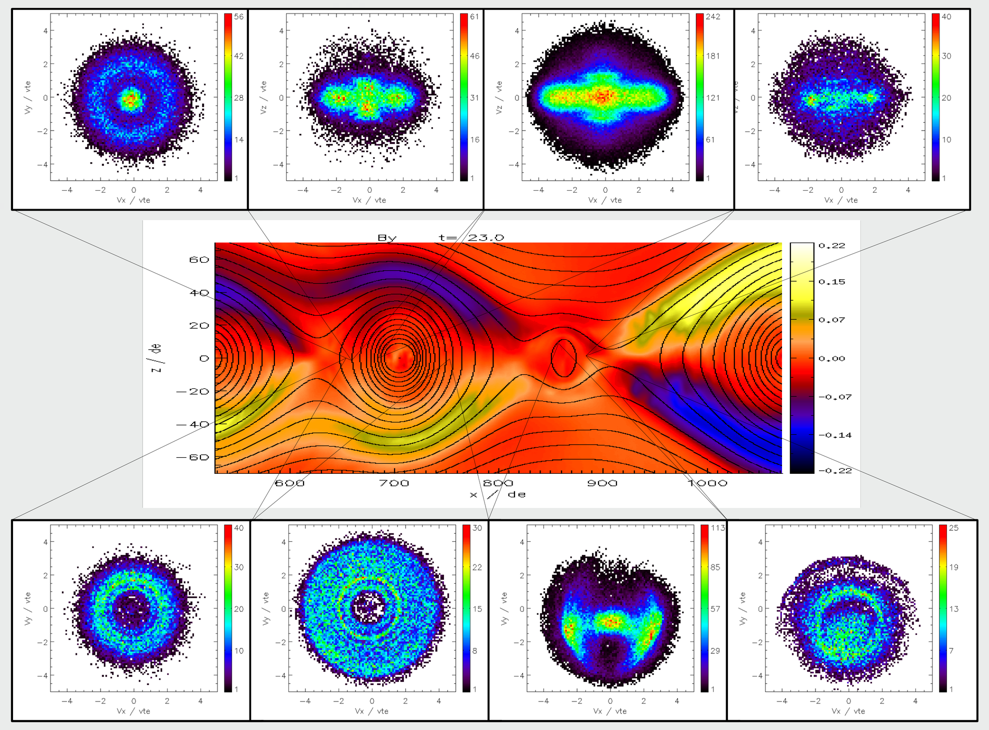
Primary Island

Vx-Vz



◆ Mostly hot and isotropic electrons, consistent with previous results [4].

Highlight of Unstable Electron Velocity Distributions: Vx-Vy and Vx-Vz velocity space distribution functions from both the primary and secondary island.



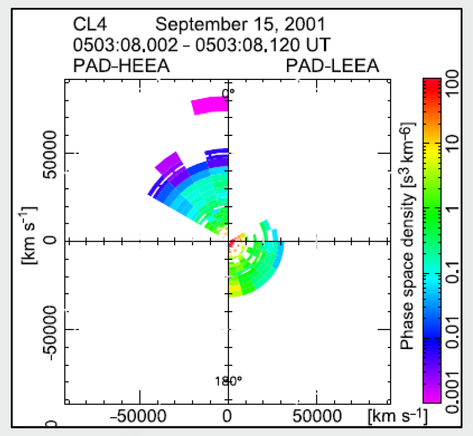
◆ Perpendicularly heated distributions, where $T_{perpendicular} > T_{parallel}$, are unstable to whistler wave generation [5].

◆ Multi-component electron distributions may lead to the generation of nonlinear electron waves, such as the electron holes observed in a magnetotail flux rope [6].

◆ New velocity-space-hole, or 'donut', structure found in Vx-Vy electron distribution functions.

CLUSTER Data:

A narrow beam moving toward X line [7], consistent with the separatrix electron distributions .



CONCLUSIONS

◆ Strong peak in the negative Vy direction in the secondary island core, but not in primary island.

◆ New velocity-space-hole structure in Vx-Vy that forms near boundary of closed field lines and semi-open field lines in primary island, but not in the secondary island.

◆ Highly structured electron distribution functions in both islands at all evolution stages.

◆ Colder, dense cores in both islands.

◆ The assumption that electron distributions within magnetic islands are similar to exhaust electrons is an oversimplification.

◆ Open exhaust regions are relatively isotropic at early stages, but anisotropies develop at later stages.

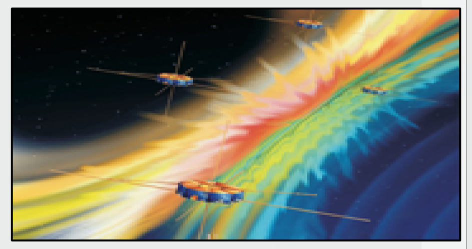
◆ Anisotropies in islands are different from anisotropies in exhaust.

◆ Distributions can be used to distinguish reconnection x-line from o-line.

Future Work:

◆ Comparison with CLUSTER electron measurements from within magnetic islands.

◆ Comparison with future electron data from Magnetospheric Multiscale (MMS), to launch in 2014, capable of resolving the types of structures revealed in the electrons of this simulation.



ACKNOWLEDGEMENTS:

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