Electron Characteristics in Inflow Regions during Magnetotail Reconnection

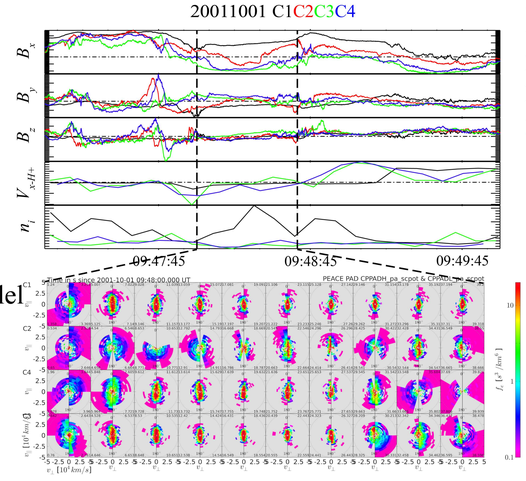
Guanlai Li[1] (gpw6@wildcats.unh.edu), Li-Jen Chen[1], Jason R Shuster[1], William S Daughton[2], Roy B Torbert[1]

[1] Space Science Center, University of New Hampshire, Durham, NH 03824, U.S.A.

[2] Los Alamos National Laboratory, Los Alamos, NM 87545, U.S.A.

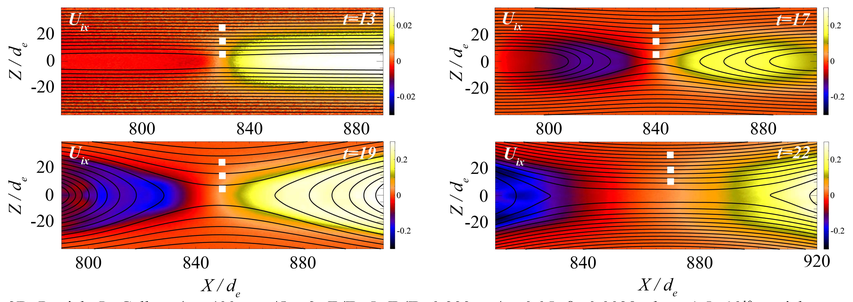
Introduction

- Characteristics of electrons in reconnection inflow region can serve as observables to identify diffusion regions.
- In *situ* observation of one magnetotail reconnection event (at right) has shown that electrons in the inflow region of reconnection exhibit a temperature anisotropy with $T_{e//}>T_{e\perp}$[1];
- Theoretical and simulation work shows that the parallel electric field and magnetic moment conservation can account for the inflow anisotropy [2][3];
- Here we examine 12 magnetotail reconnection events observed by Cluster spacecraft to further establish inflow electron characteristics.

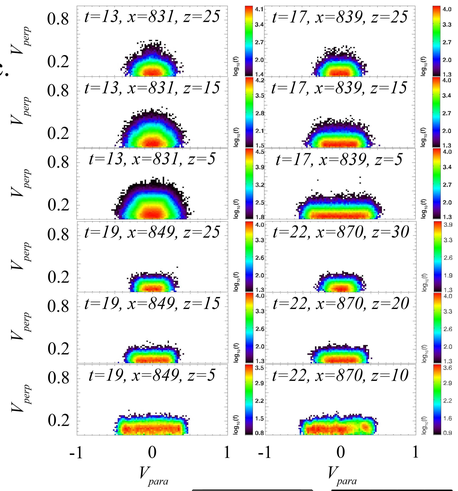


Evolution of inflow electron distribution in a simulation

- $4/\omega_{ci}$ before the peak reconn. rate, the electron distributions are cold and isotropic.
- As time advances, $T_{e//}/T_{e\perp}$, V_{iout}, and the size of diffusion region become larger;
- $T_{e//}/T_{e\perp}$ is larger at positions closer to X-point;

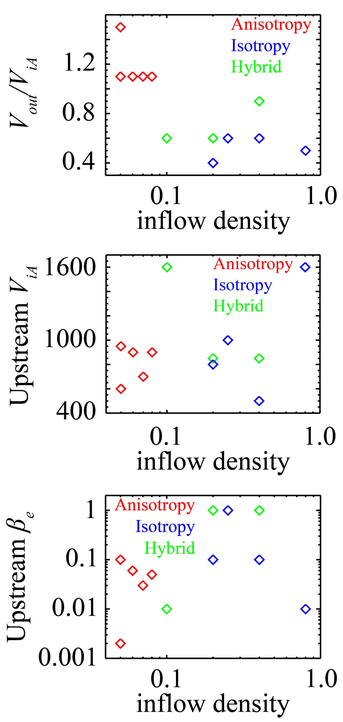


2D, Particle-In-Cell, m_i/m_e=400, ω_{pe}/Ω_{ce}=2, T_i/T_e=5, T_b/T_0=0.333, n_b/n_0=0.05, β_e=0.0028, about 1.5×10^{10} particles



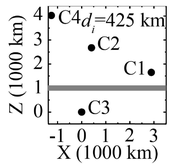
Observation results

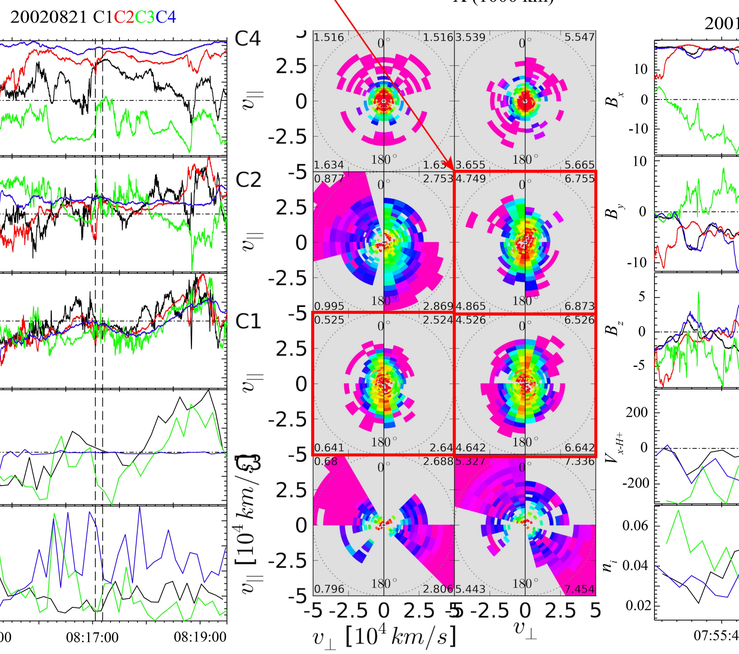
- 3 distinct types of inflow distributions;
- With higher degree of anisotropy, the inflow density is smaller; V_{iout}/V_{iA} is larger.
- Degree of anisotropy does not show dependence on upstream V_{iA} and β_e;



Anisotropy (5/12 events)

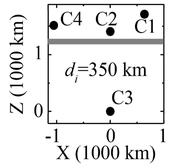
single population with $T_{e//}>T_{e\perp}$

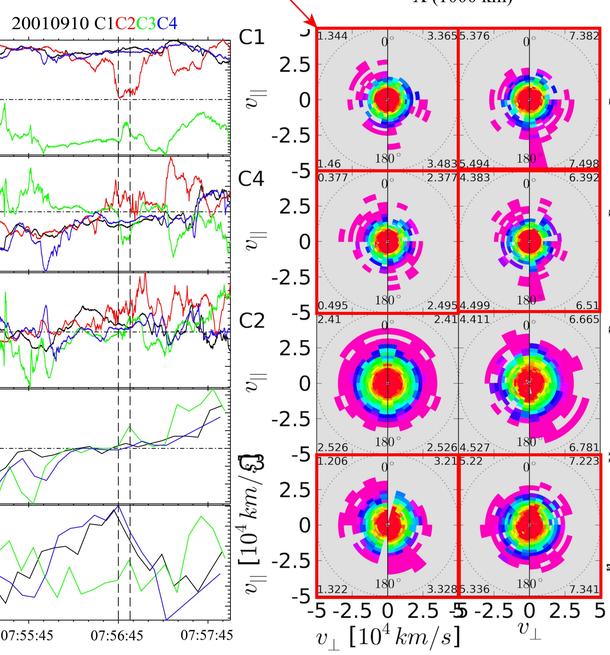




Isotropy (4/12 events)

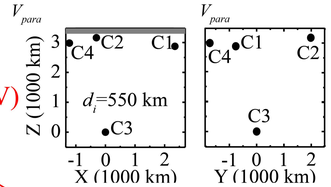
Isotropic and cold population





Hybrid (3/12 events)

Isotropic high energy (up to 10 keV) and anisotropic low energy population with $T_{e//}>T_{e\perp}$



Criteria of identifying inflow region:

- B_y and B_z reverse sign;
- Electric field smaller and less fluctuating than separatrix region;
- V_{ix} reverses sign;

Summary

- Three distinct types of electron distributions are observed.
- Isotropic inflow electrons are consistent with those in the early stage of reconnection in simulation;
- Hybrid distributions have not been reported before and cannot be explained by the simulation.
- Inflow electron distributions can be used to infer the evolution stage of observed reconnection. Cold and isotropic inflow electrons indicates early stage, while anisotropic inflow electrons indicates matured stage.

Acknowledgement

Rearch at UNH is supported in part by NSF grants PHY-0903923 and NASA.

Reference

[1] Chen et al., *J. Geophys. Res.*, 2008
[2] Egedal, et al., *J. Geophys., Res.*, 2009
[3] Egedal, et al, *J. Geophys. Res.*2010