Summary

There are good opportunities in comparative studies of aurora and M-I coupling

Magnetosphere-Ionosphere Coupling in Aurora

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University of Alaska

M-I

- precipitating particles
- field aligned currents
- convection electric field
- momentum transfer by waves

I-M

- ionospheric conductivity
- upflowing heavy ions
- partial reflection of waves
- secondary electrons

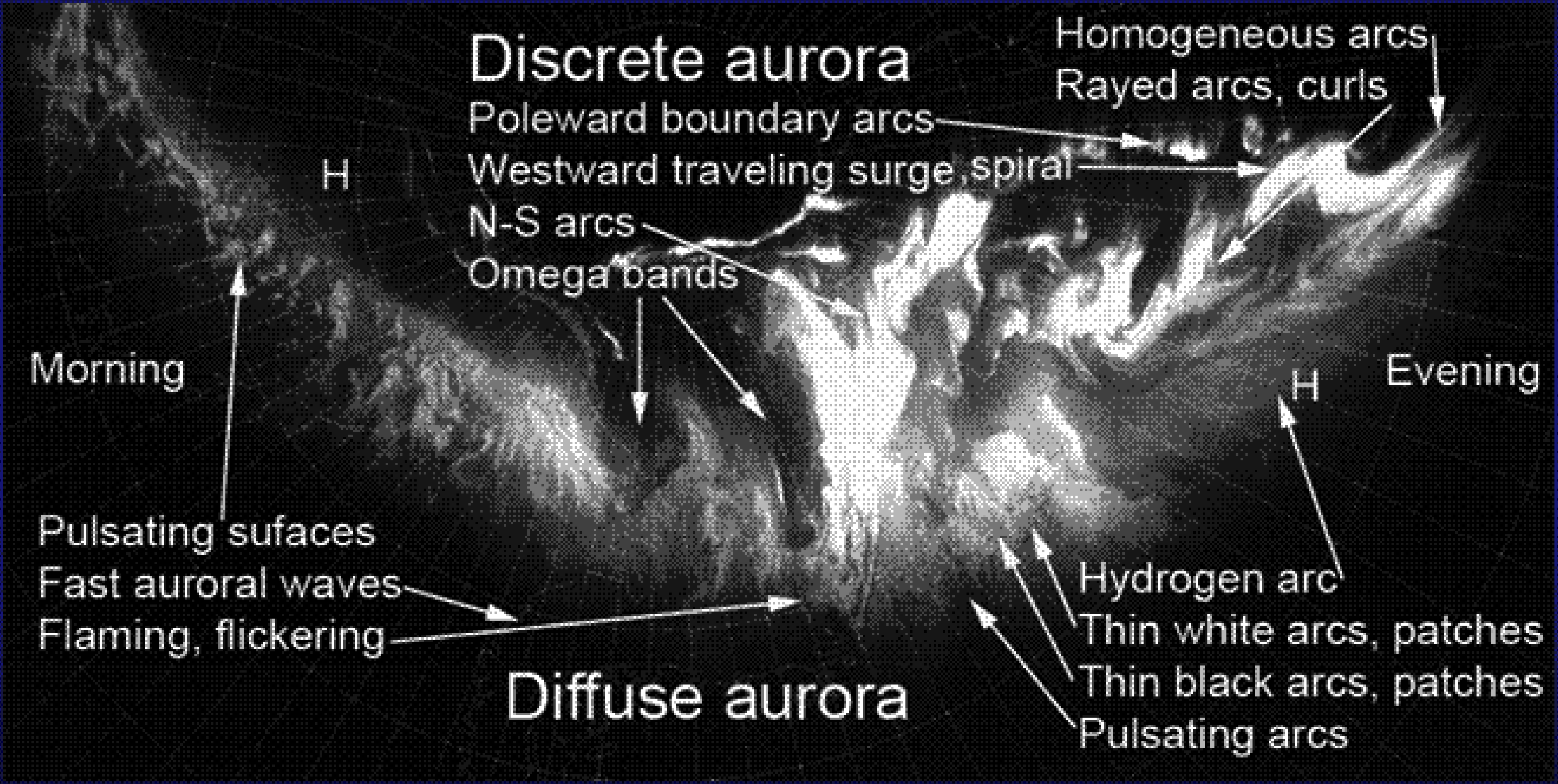
Aurora on Earth

- cusp and high latitude
- discrete arcs (auroral oval)
- diffuse aurora

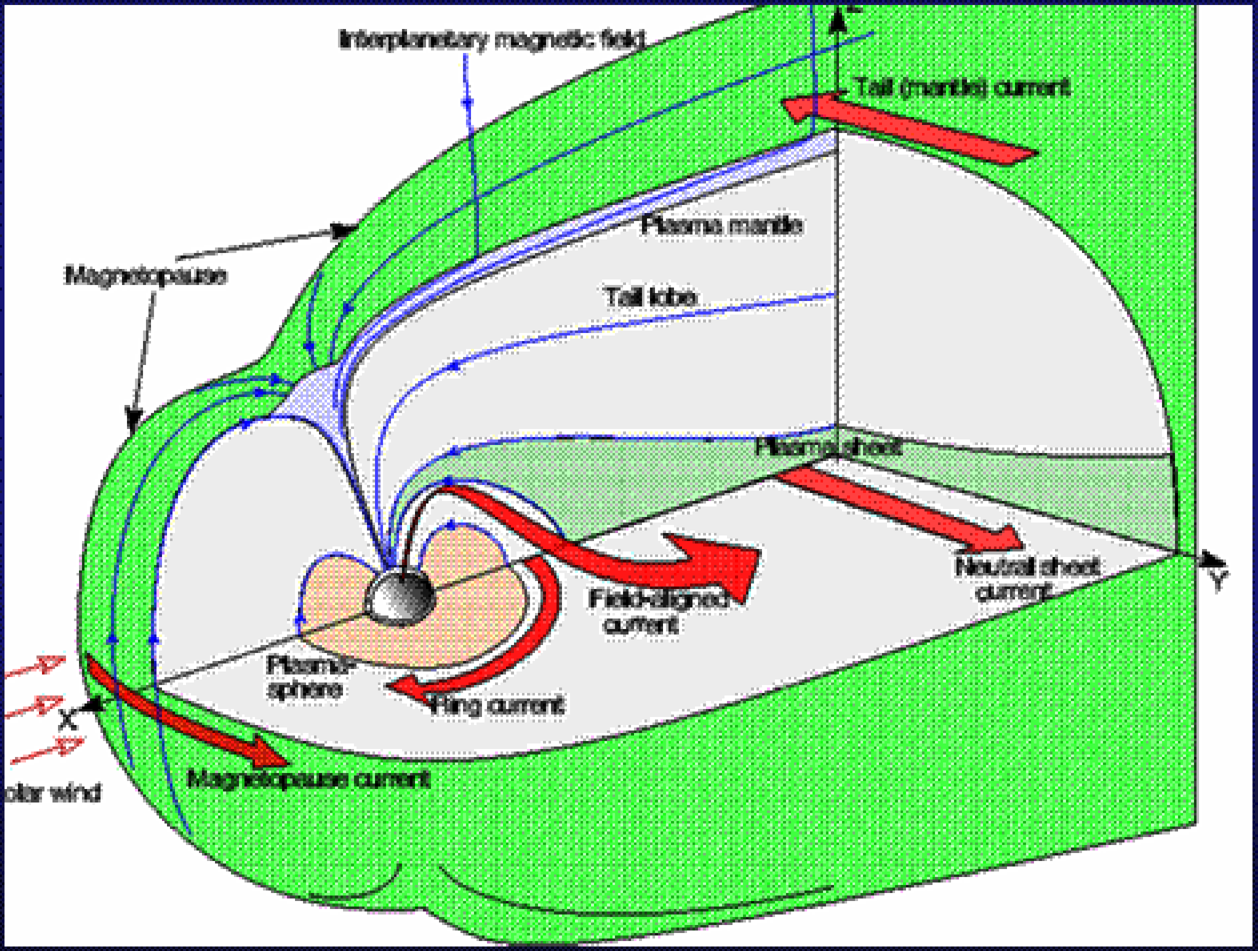
Aurora on Jupiter

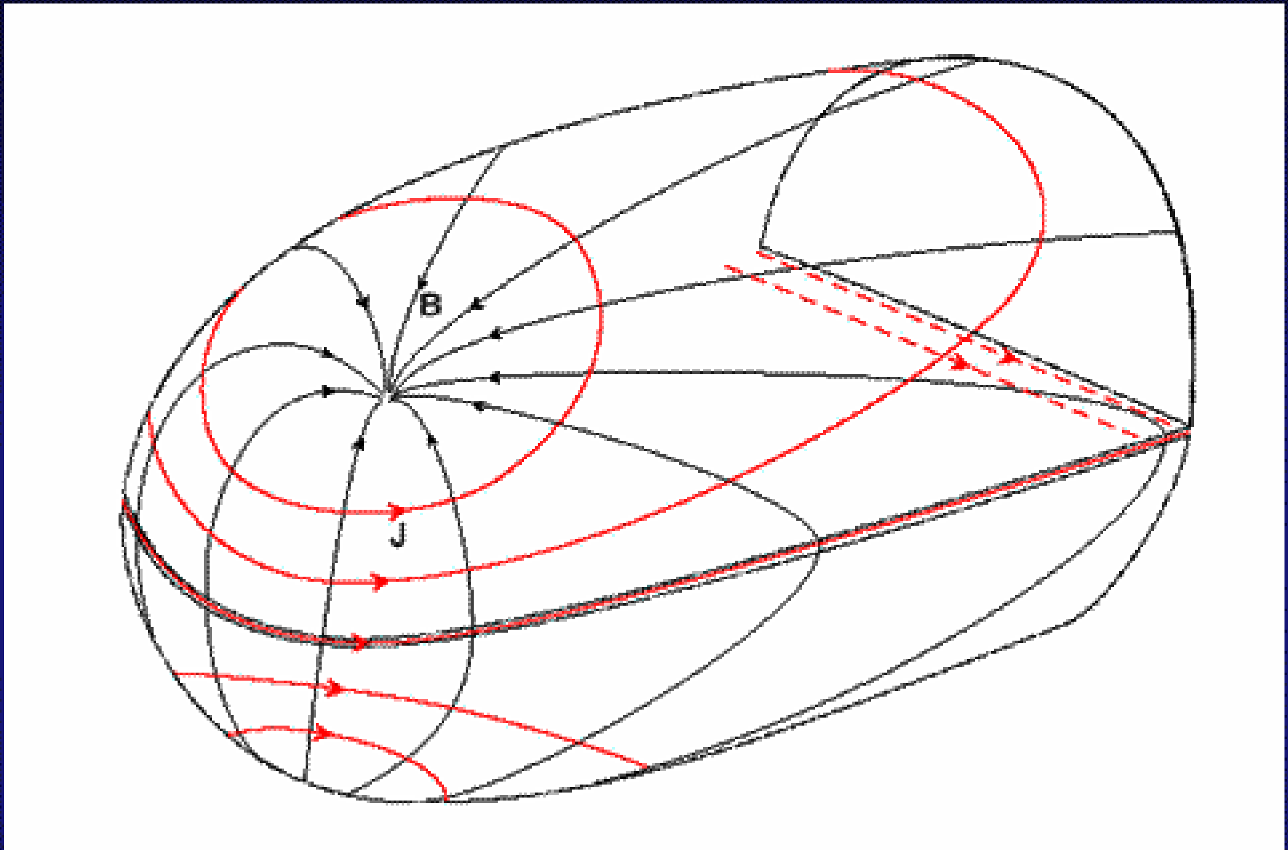
- footpoints of moons
- oval at co-rotation boundary
- high latitude Earth-like aurora?

Aurora on Earth



Cusp and High Latitude



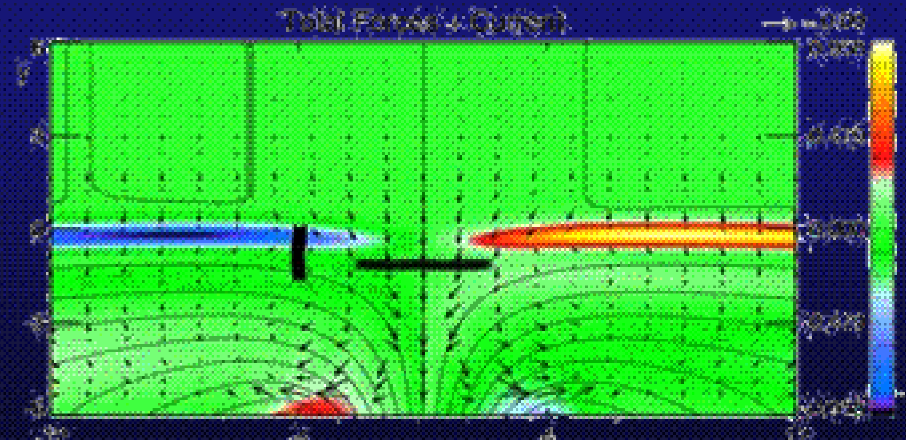


Any IMF magnetic field direction will meet antiparallel magnetospheric field at some place around the cusp.

3-D fluid simulations of solar wind-magnetosphere interaction at the cusp

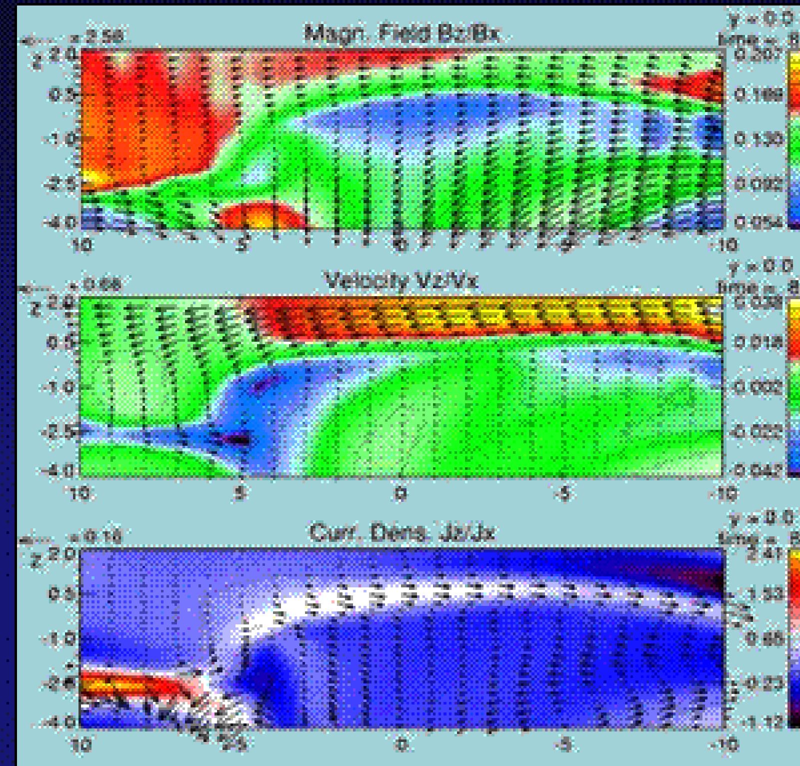
(Antonius Otto, Eric Adamson)

Initial conditions: dipole field, then introduce solar wind plasma and IMF

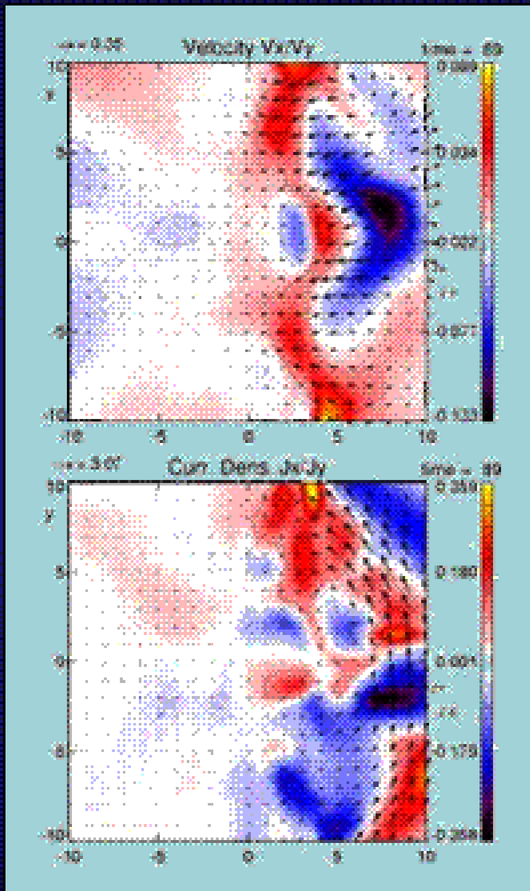


Almost northward IMF (10 degrees):

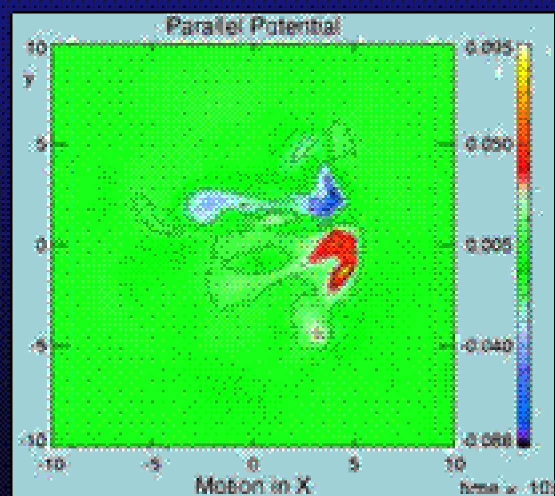
solar wind direction



Cut at const y=0

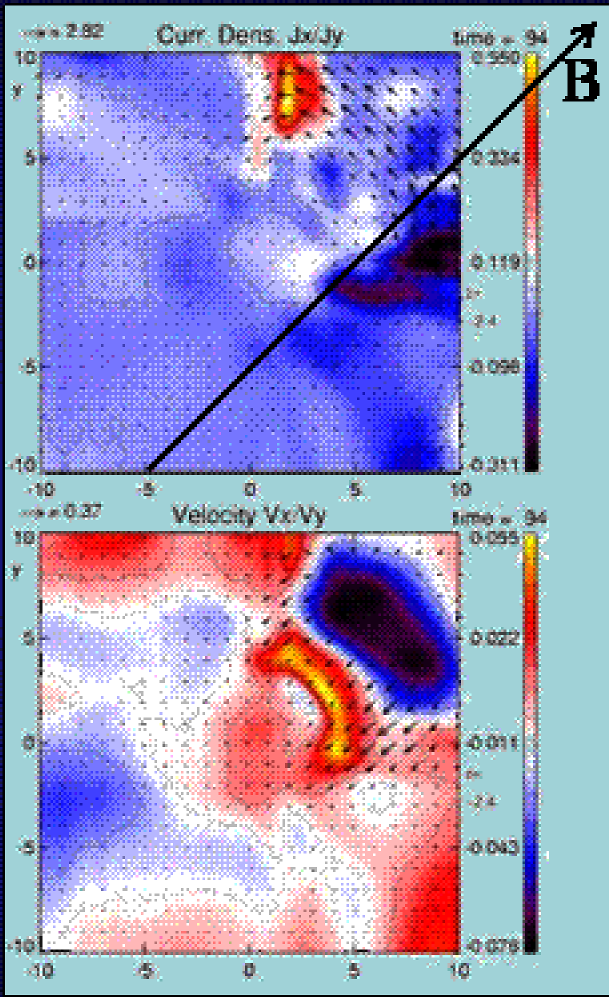


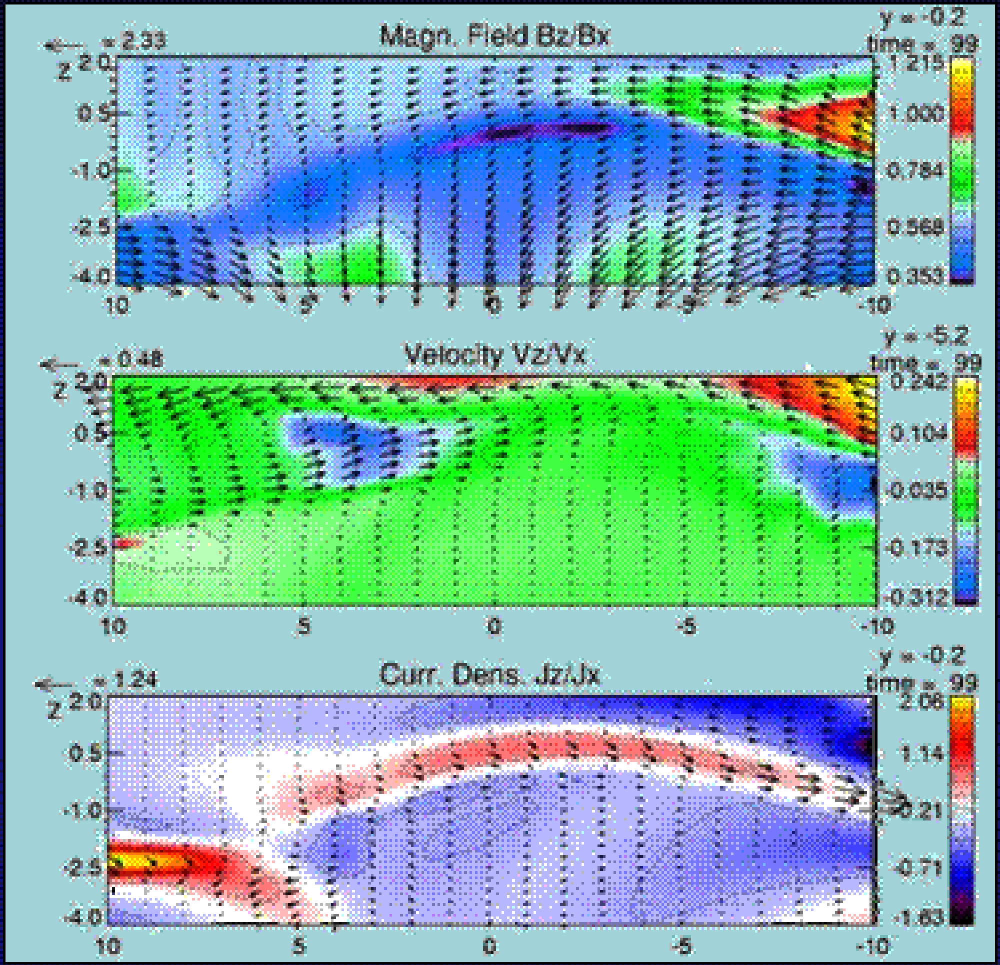
Cut at const z=-2.6



$$\Phi = \int_B \frac{\vec{E}\cdot\vec{B}ds}{B}$$

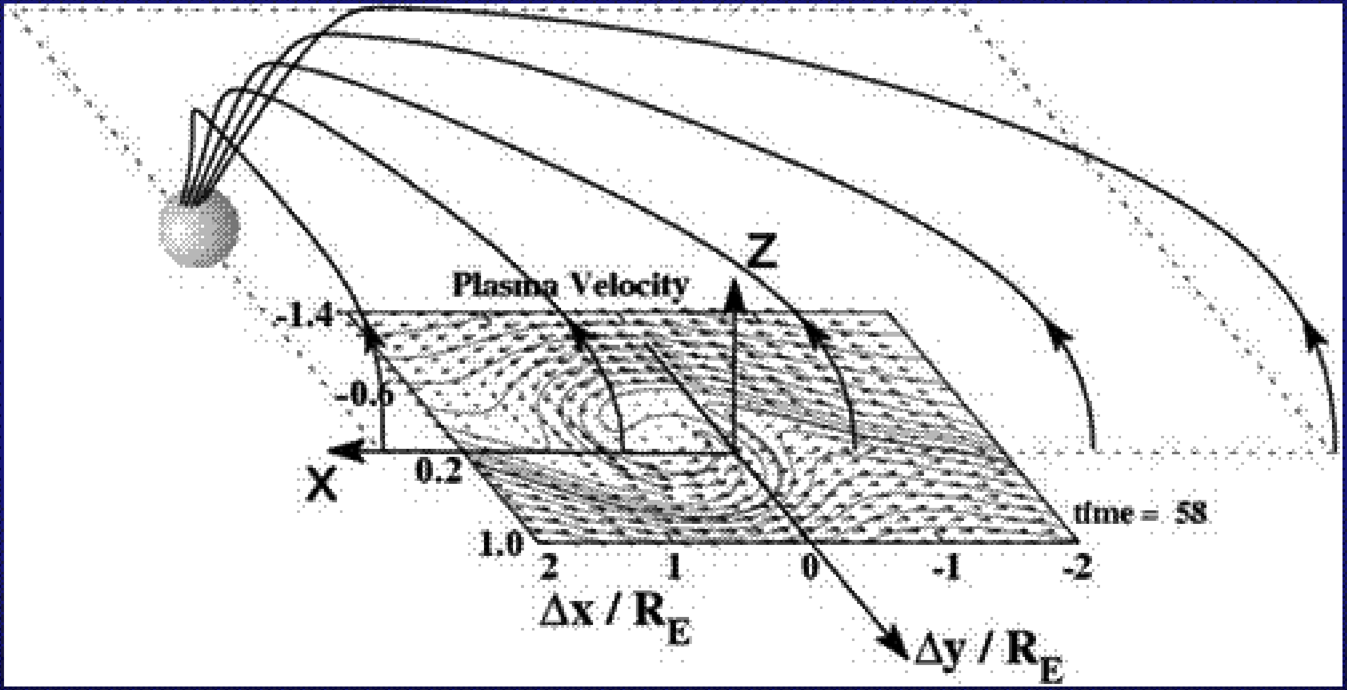
IMF 45 degrees north:



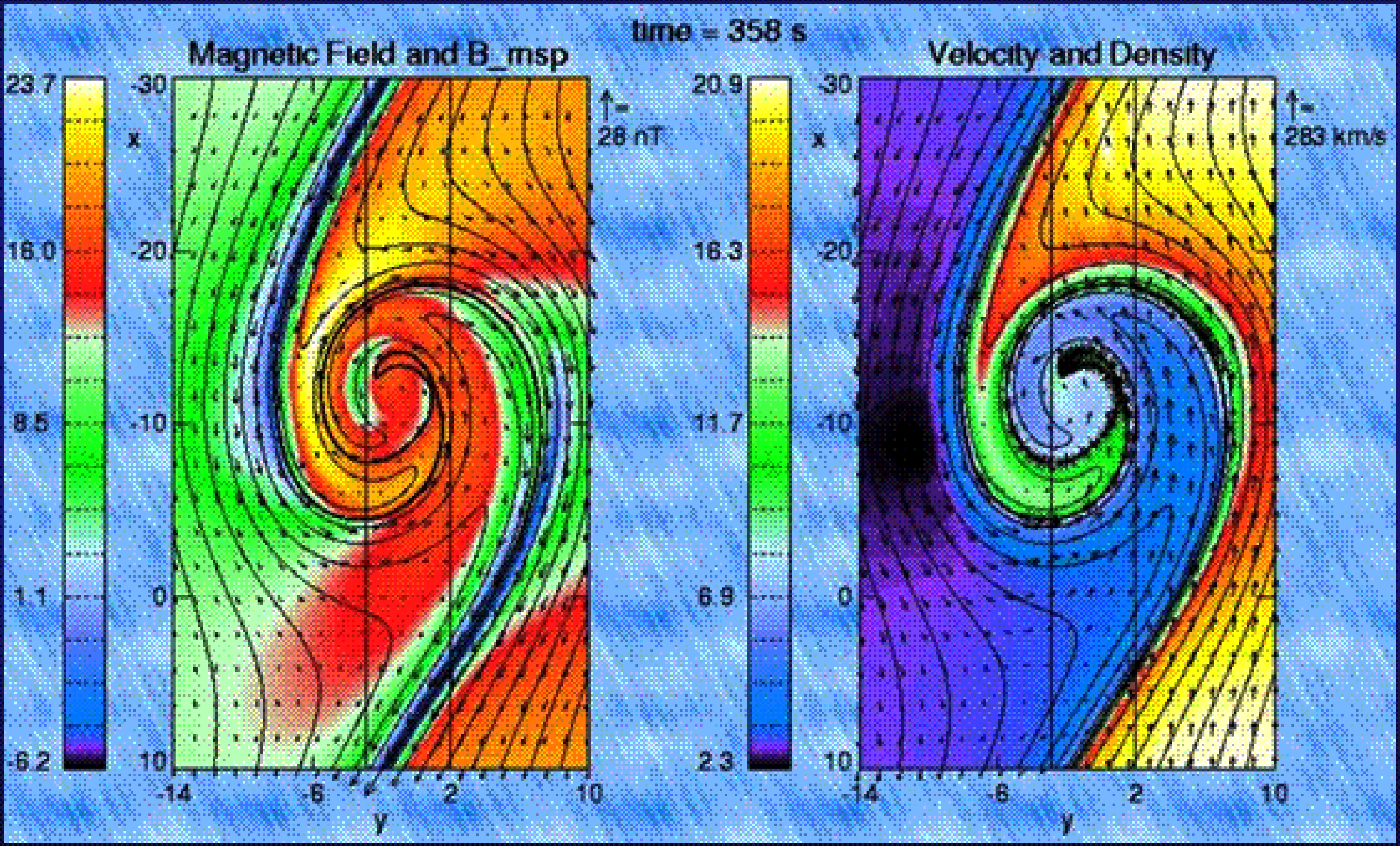


- Cusp bulge
- Reconnection on dawnside cusp
- Strong shear flows

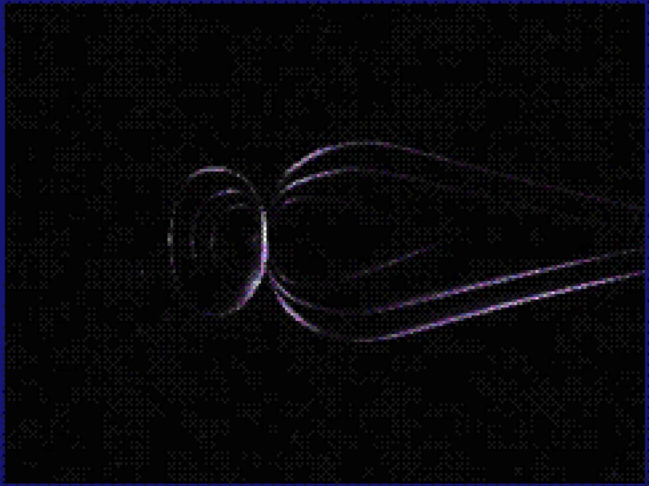
Solar wind – magnetosphere interaction on the flank of the magnetotail

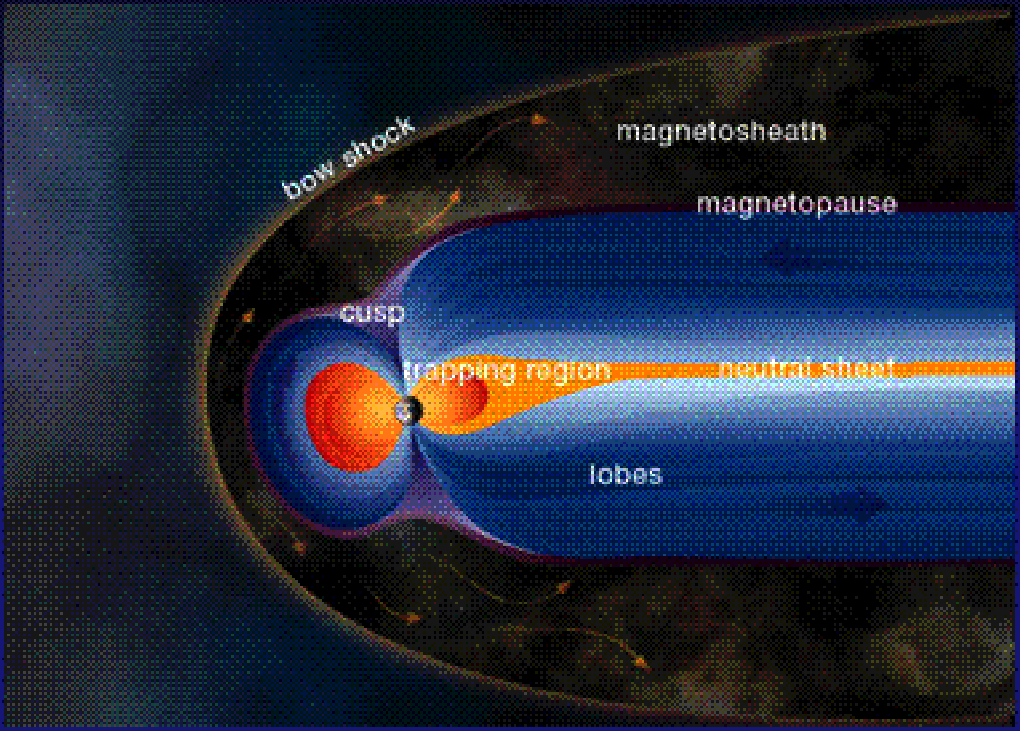


Forced reconnection in K-H vortex
(Otto and Nykyri)

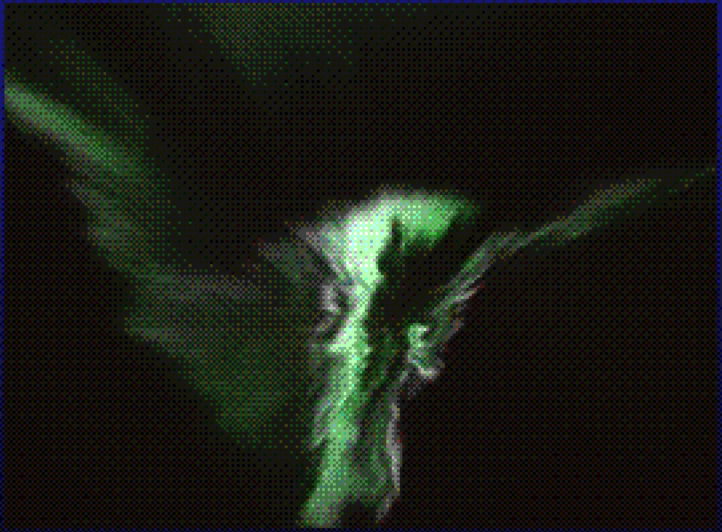


Discrete Arcs

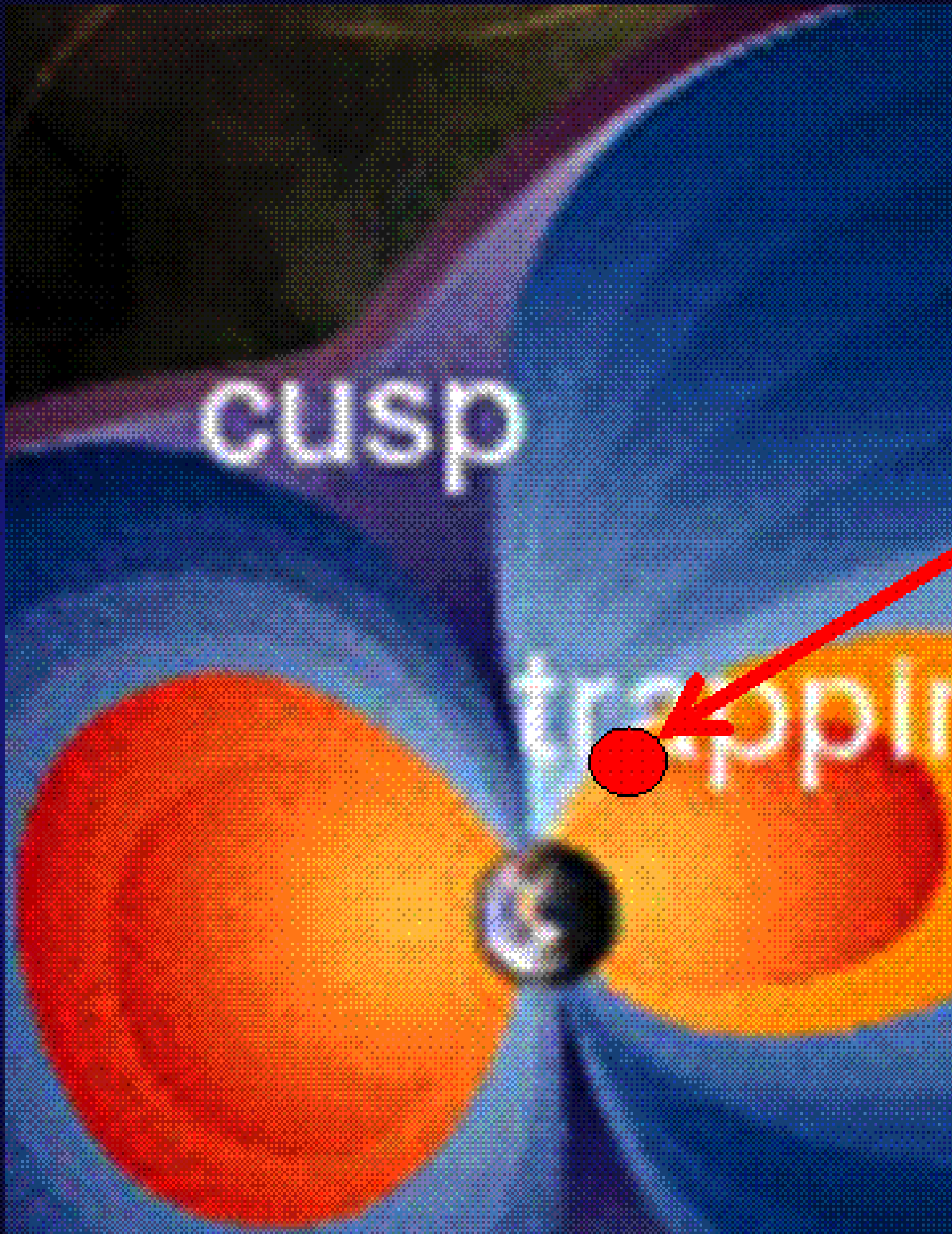




Tom Eklund



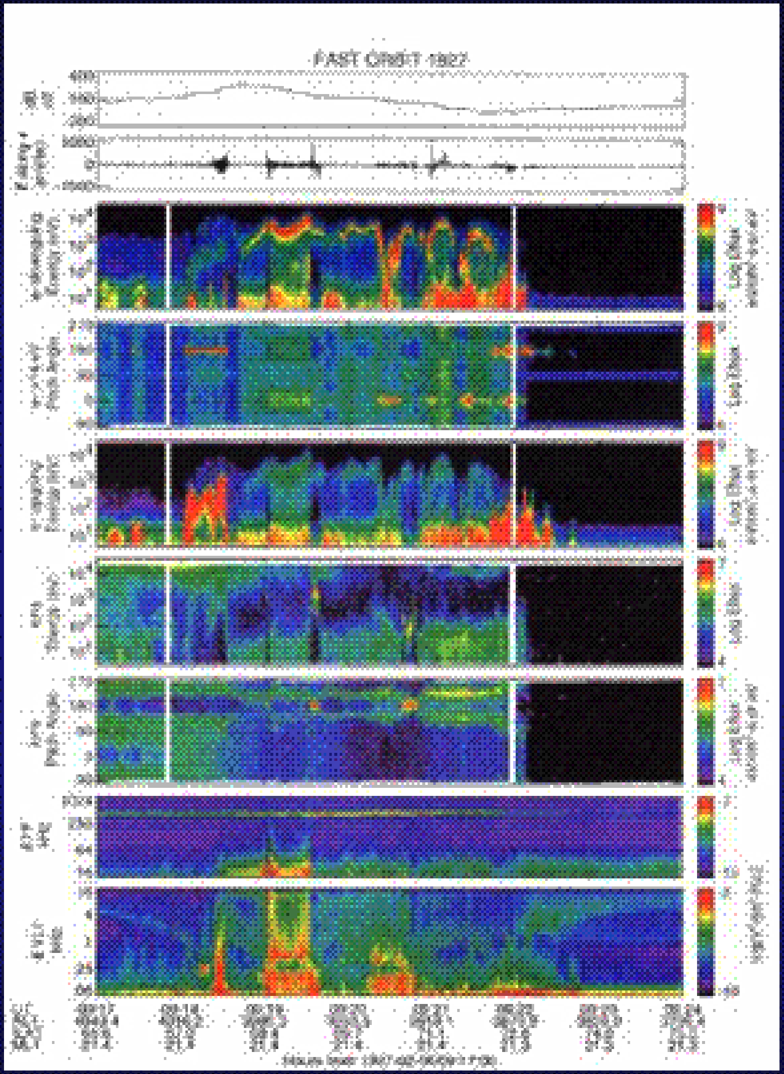
Jouni Jussila



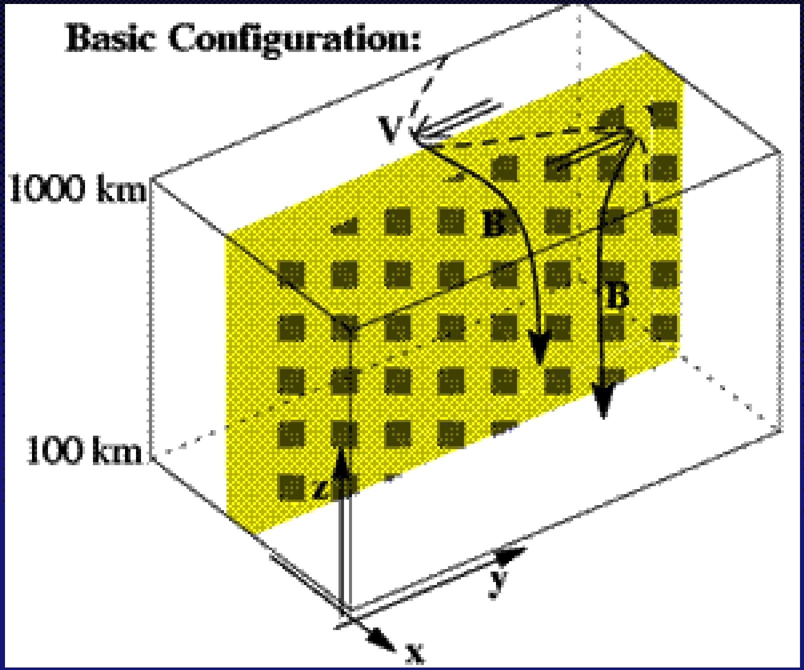
Auroral
acceleration region

Large scale
field-aligned
current sheet

structured aurora

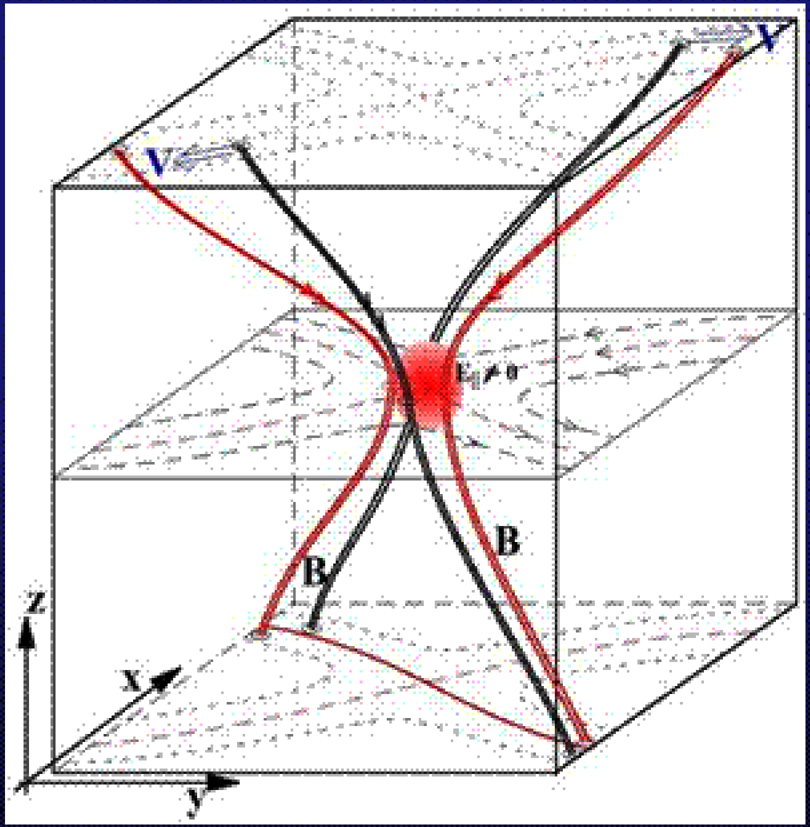


McFadden et al, 1999

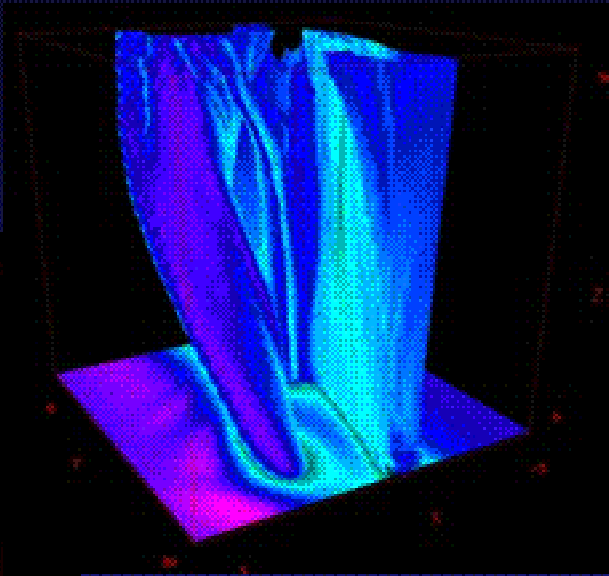


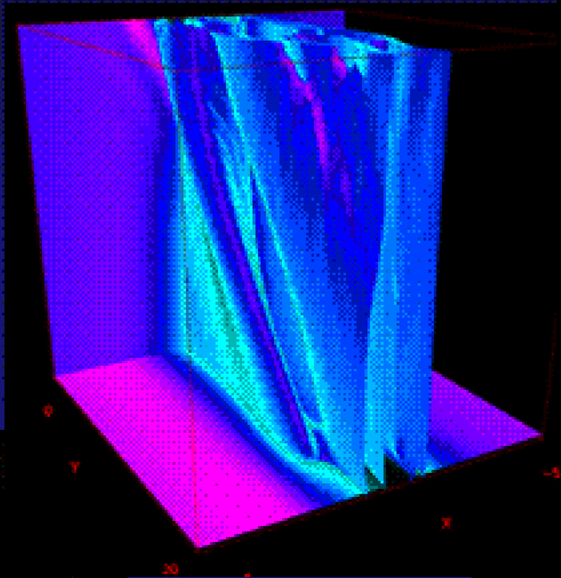
3-D fluid simulation of the acceleration region:

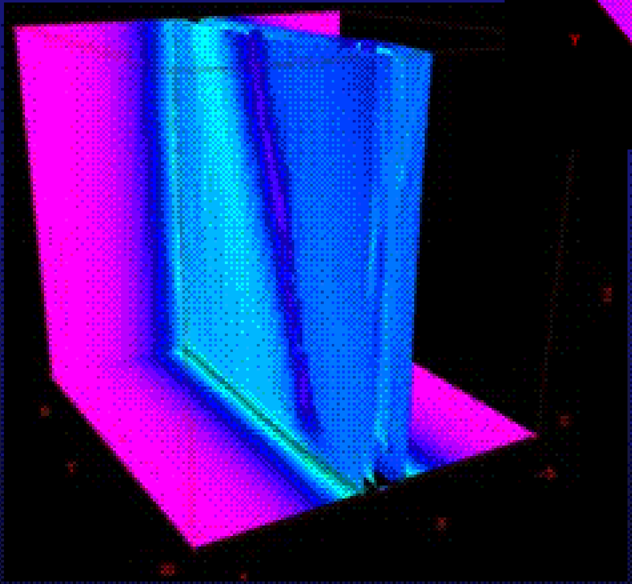
boundary condition at the top is an unstructured current sheet



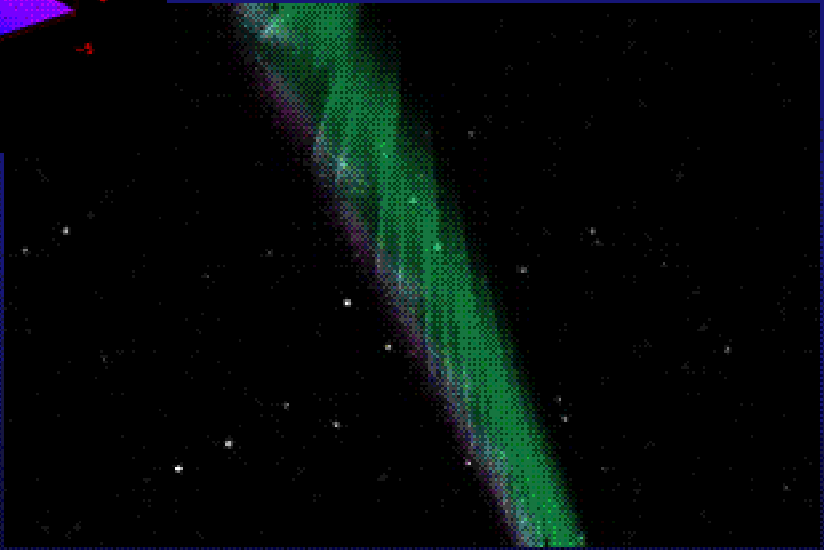
These plots show the temporal development of the auroral current sheet in the simulation.





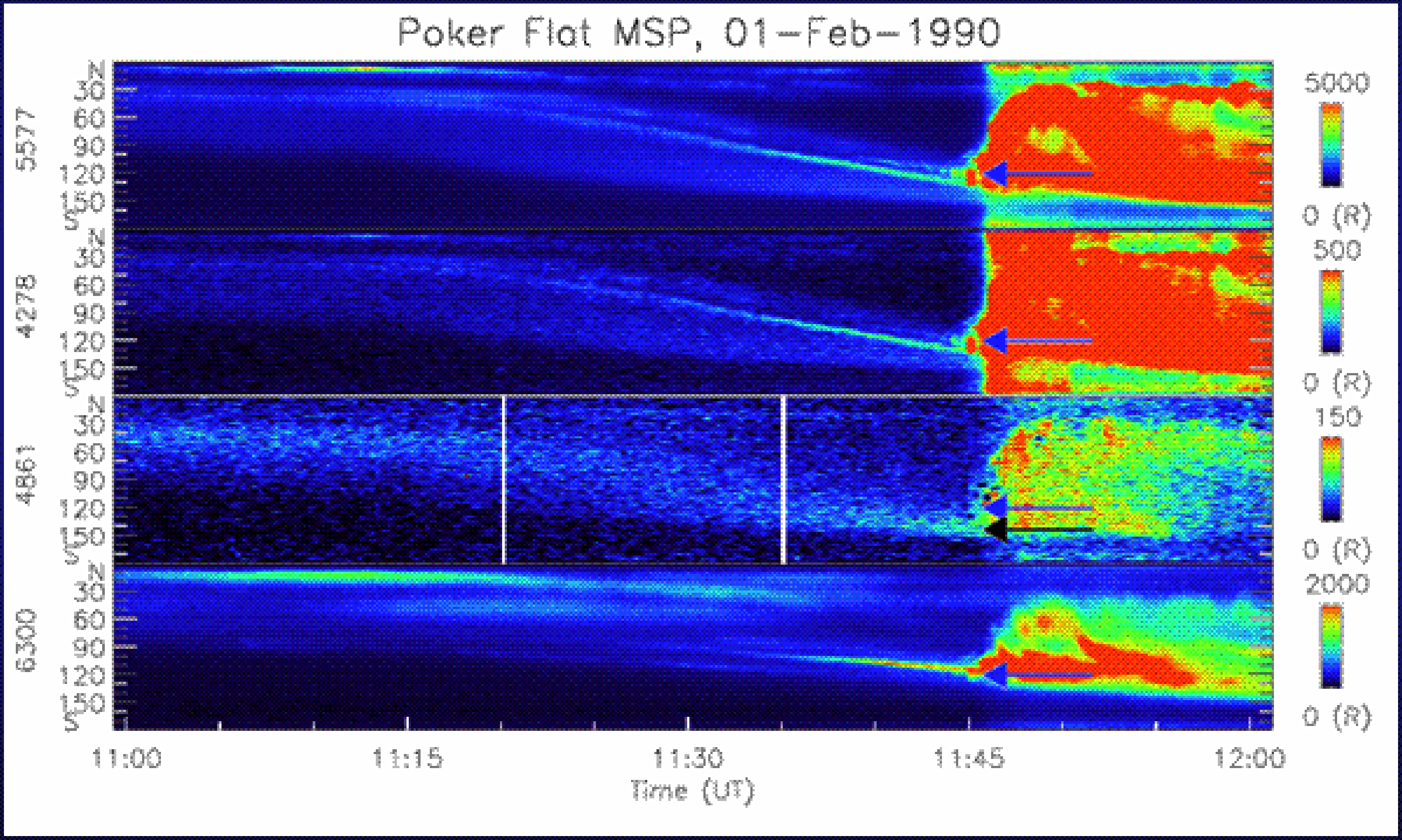


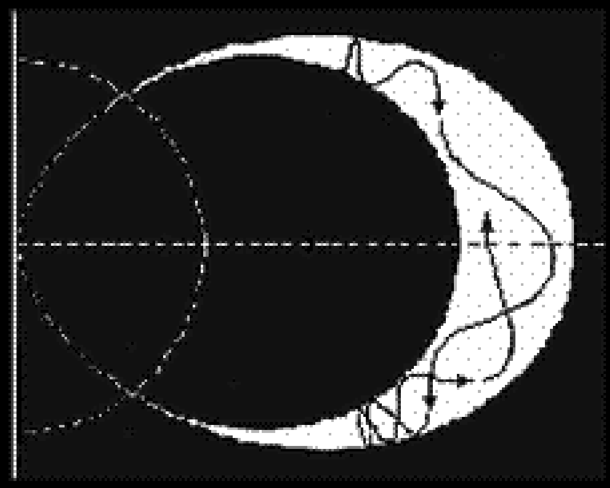
Otto et al

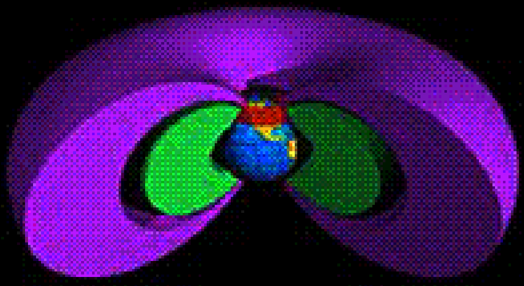


Visualization of aurora. This image is generated directly from simulation results.

Diffuse Aurora



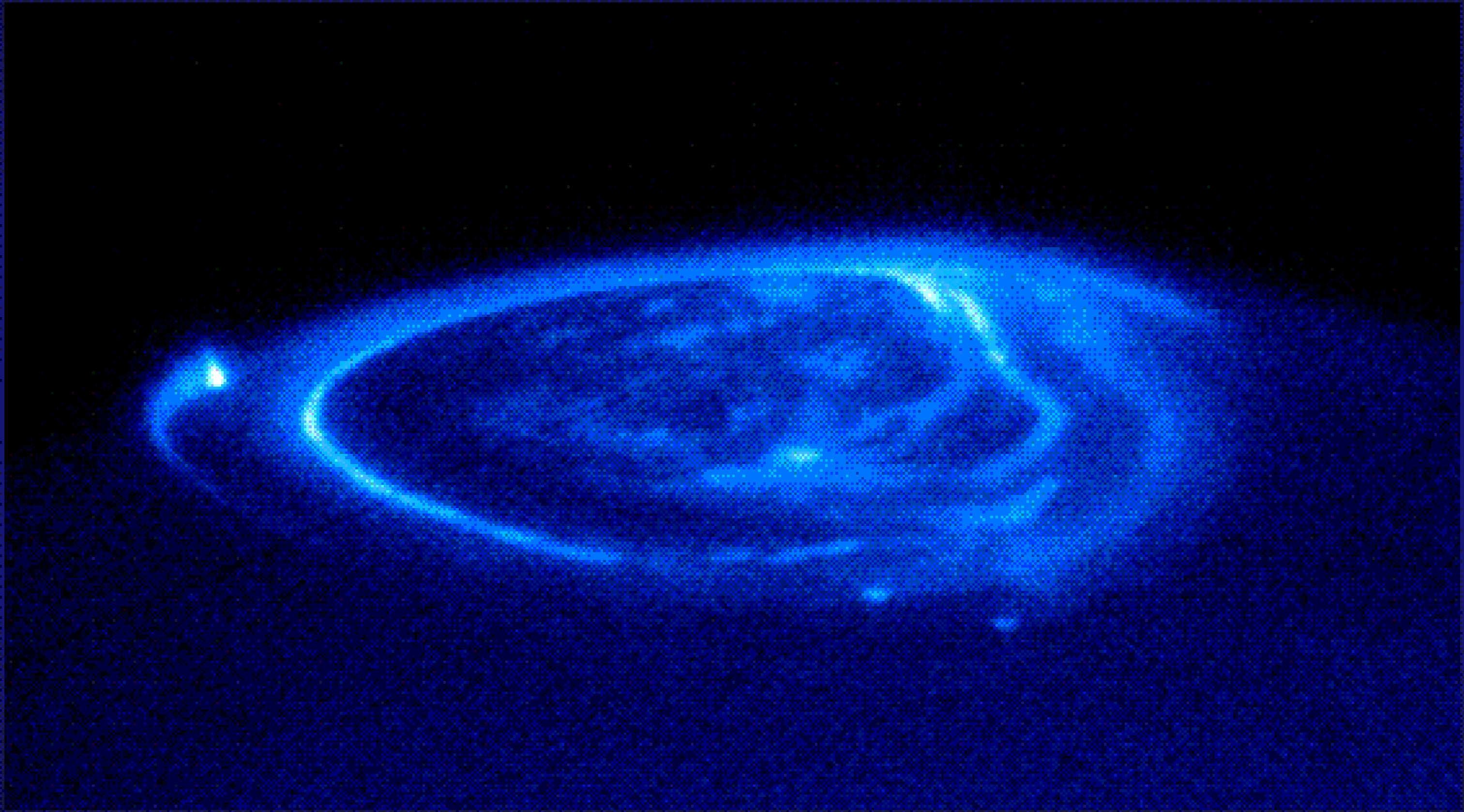




Diffuse Aurora:

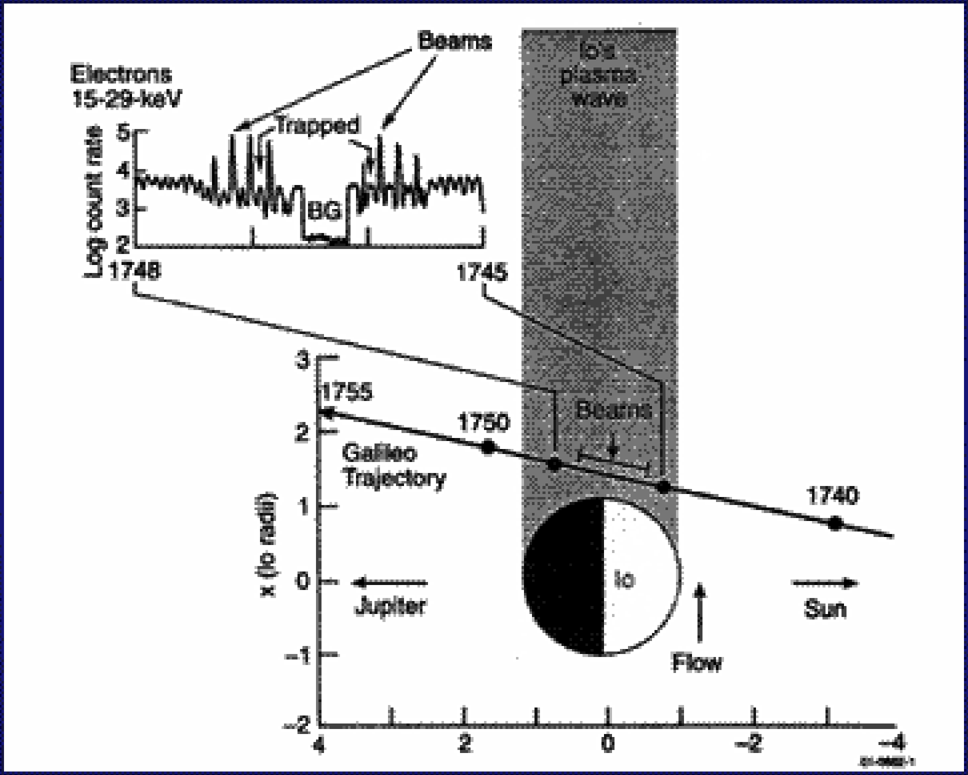
Pitch angle scattering of trapped particles causes precipitation into the upper atmosphere

Aurora on Jupiter

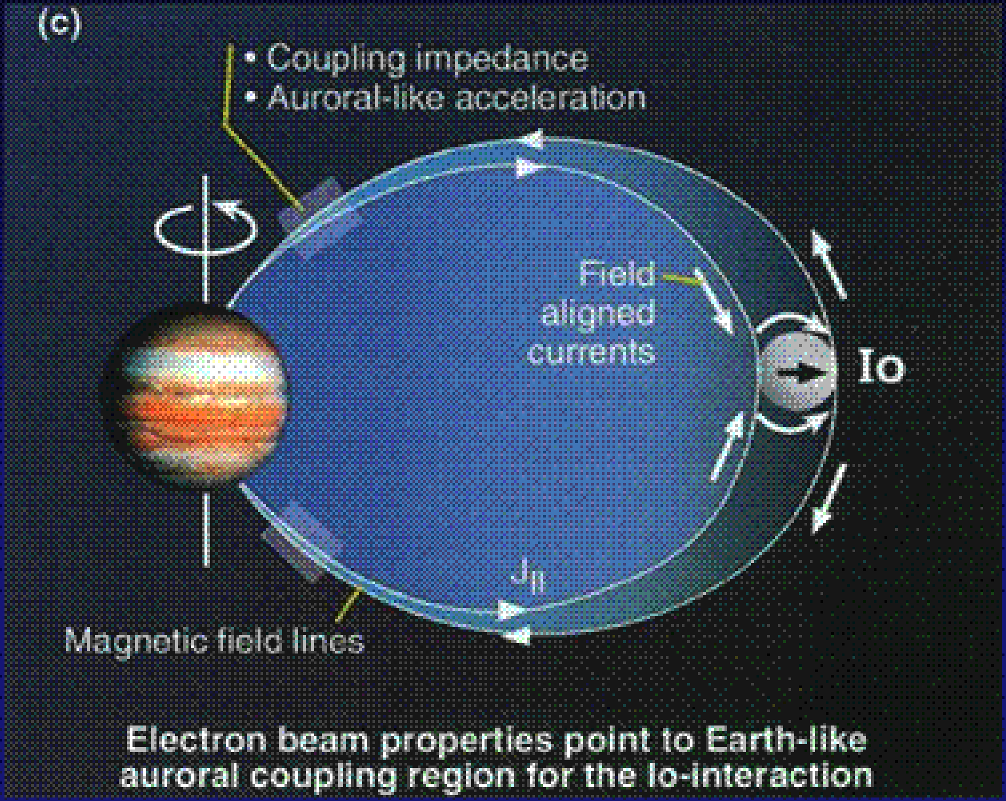


Hubble UV

Jupiter: Io Aurora



From Mauk et al, 2001



From Mauk et al, 2002

Similar process as we have them on Earth?

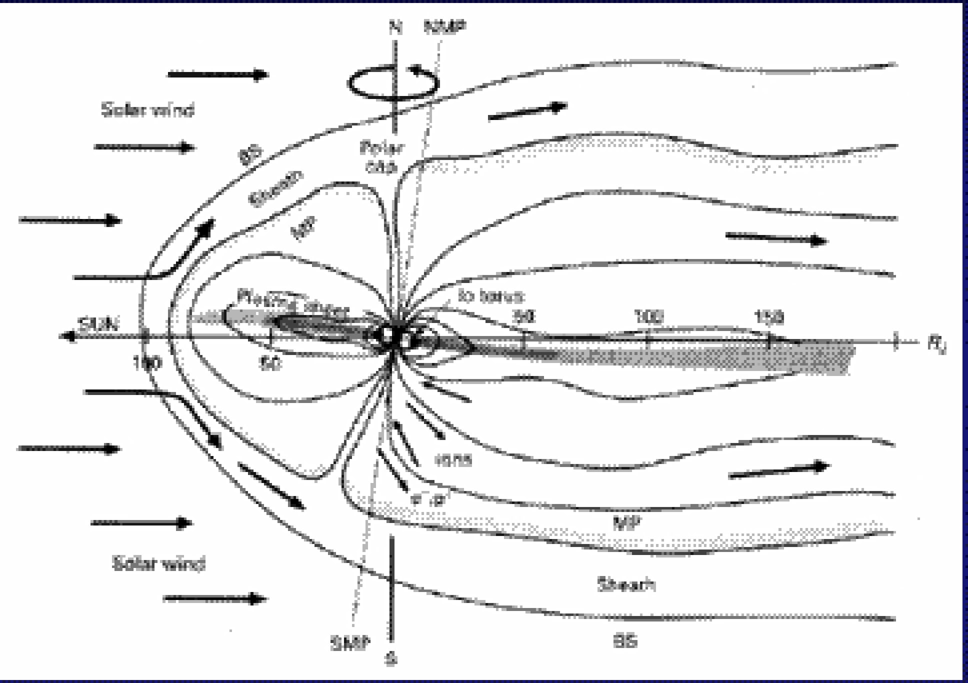
Question remains: what is the small scale structure of the Io aurora

Jupiter: Co-rotation

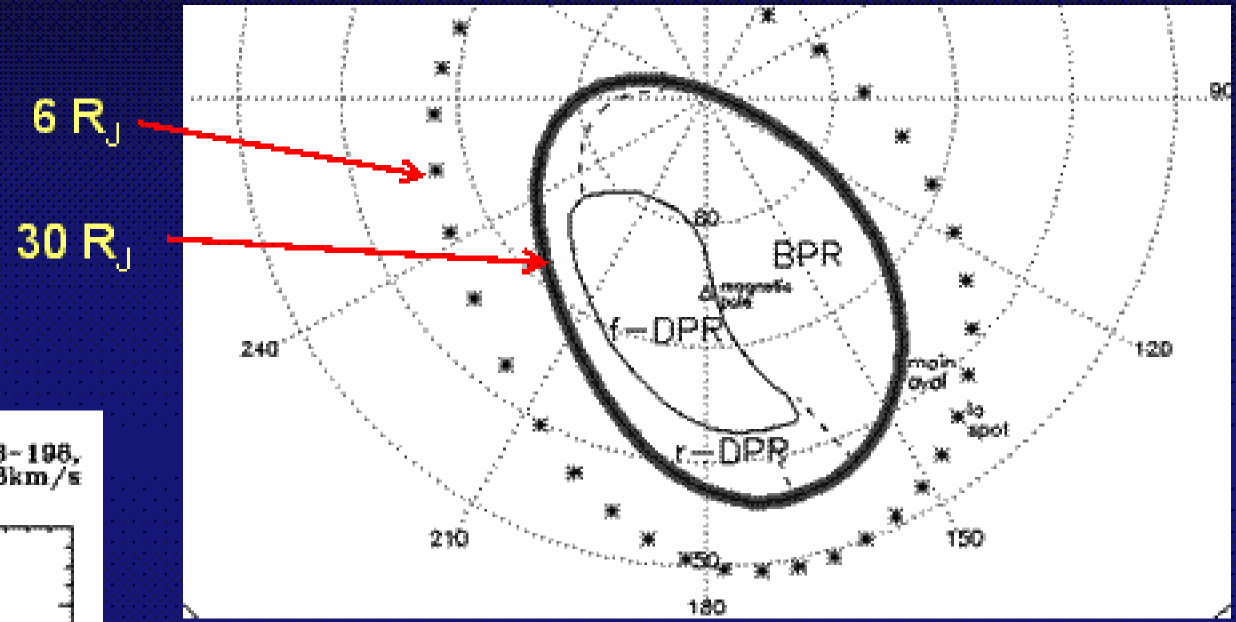
Inner magnetosphere: trapped relativistic electrons

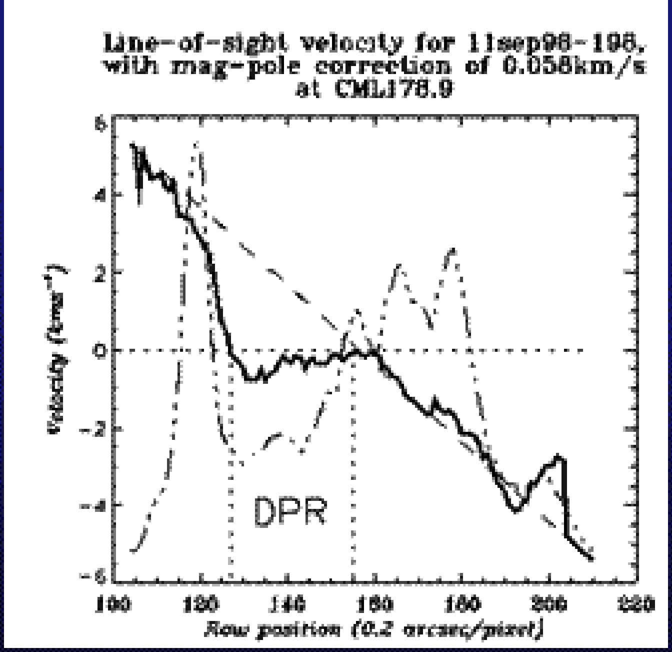
Middle magnetosphere: co-rotating plasma, heavy ion plasma torus, moons with their own magnetospheres

Outer magnetosphere: breakdown of co-rotation at 20 R_J, solar wind driven convection

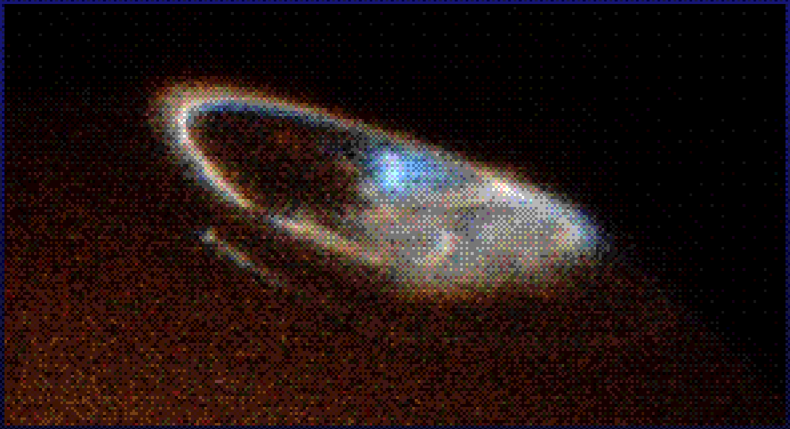


Co-rotating Ionosphere



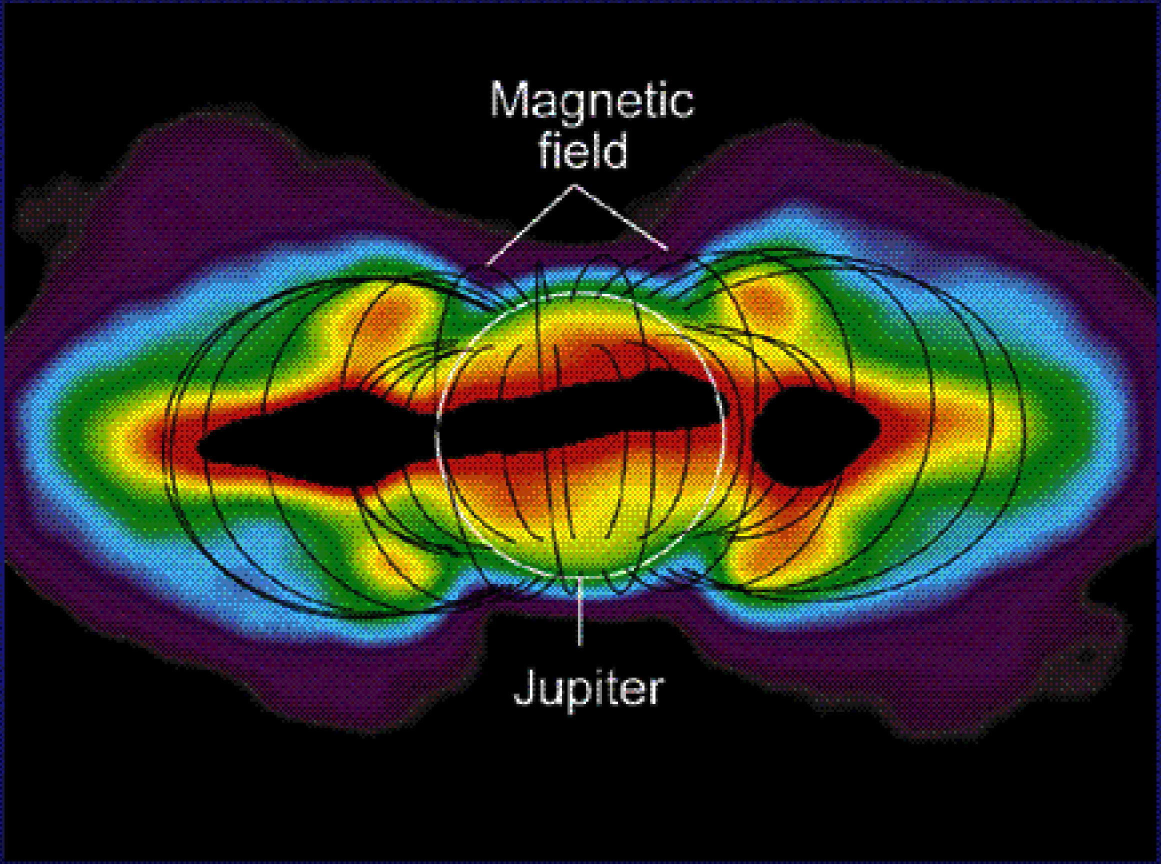


Stallard et al., 2002

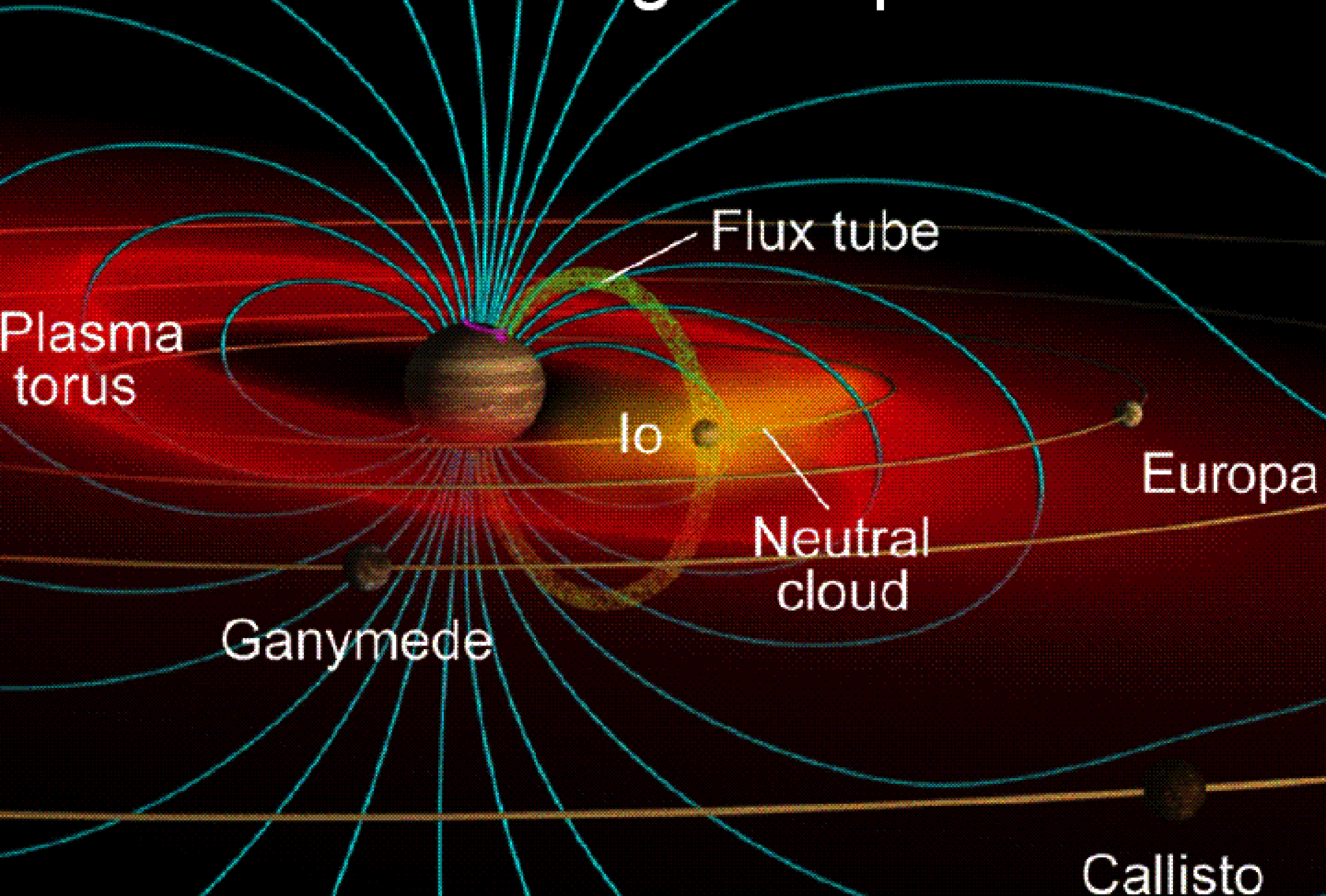


Inner Magnetosphere

Synchrotron radiation from relativistic electrons

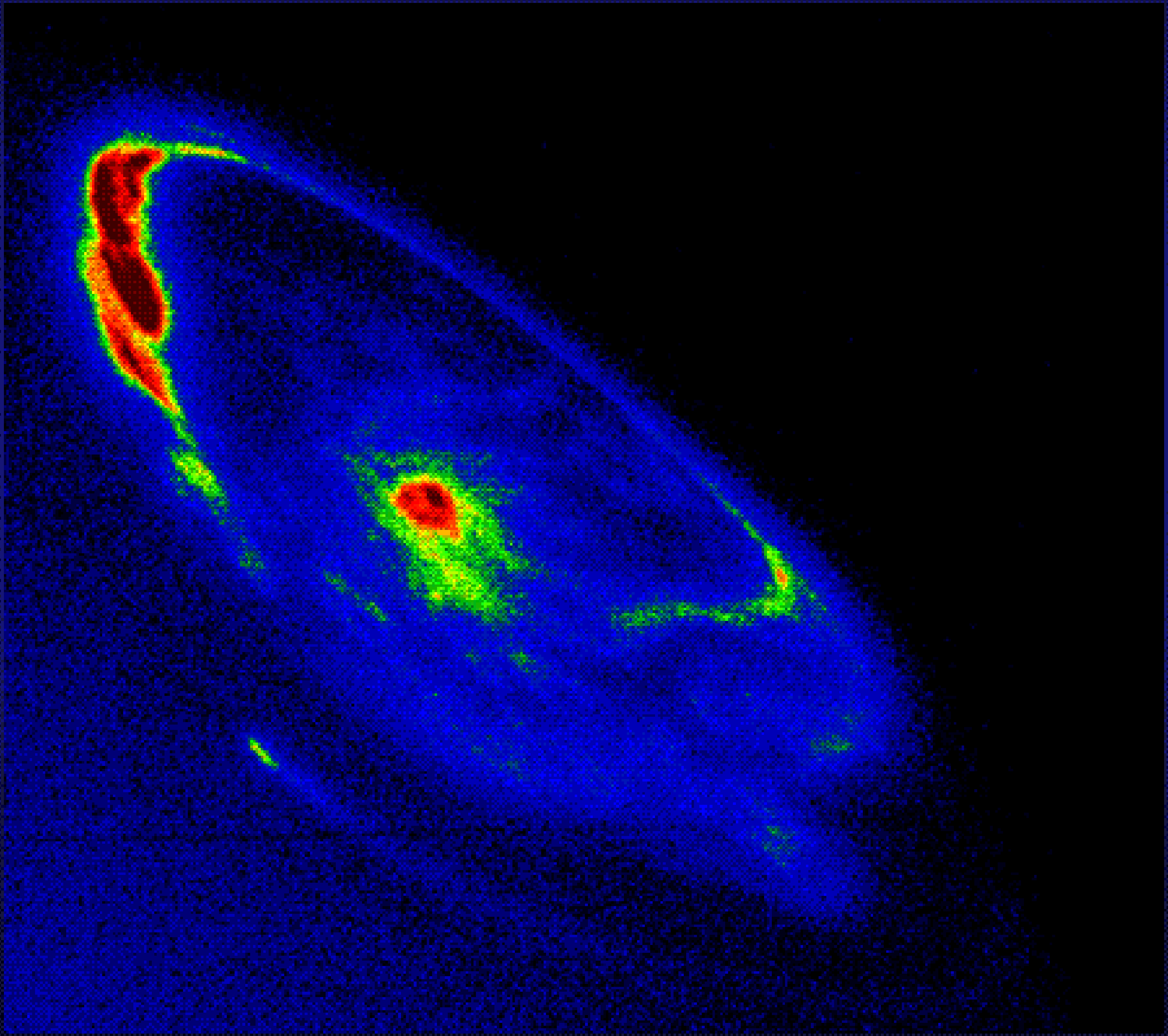


Middle Magnetosphere



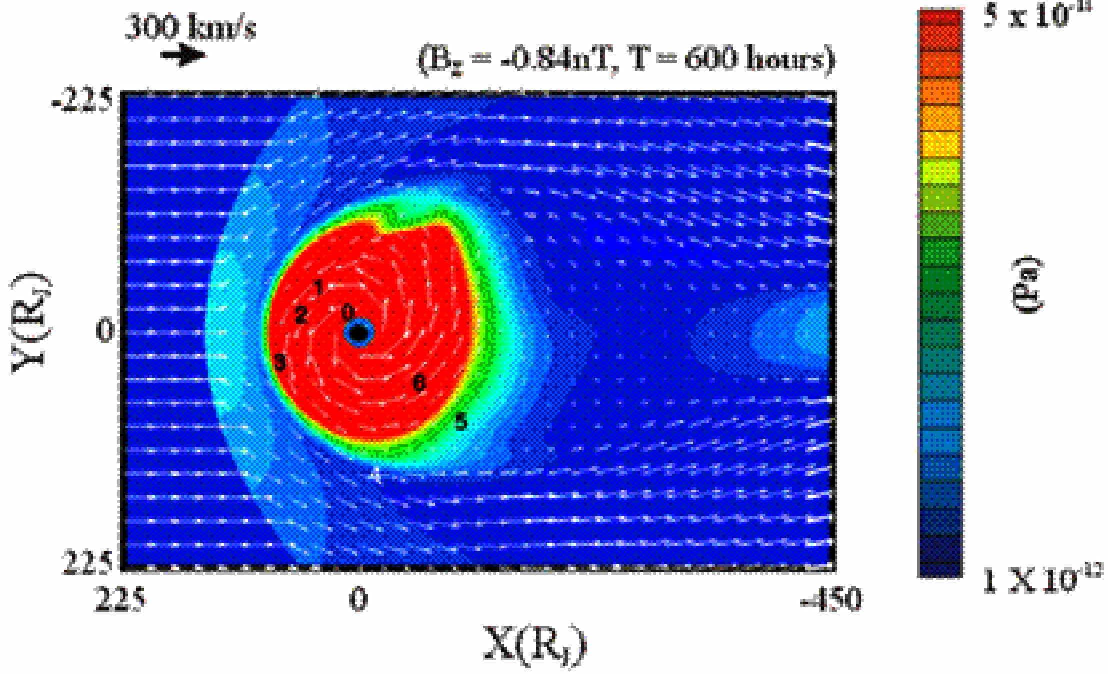
Outer Magnetosphere

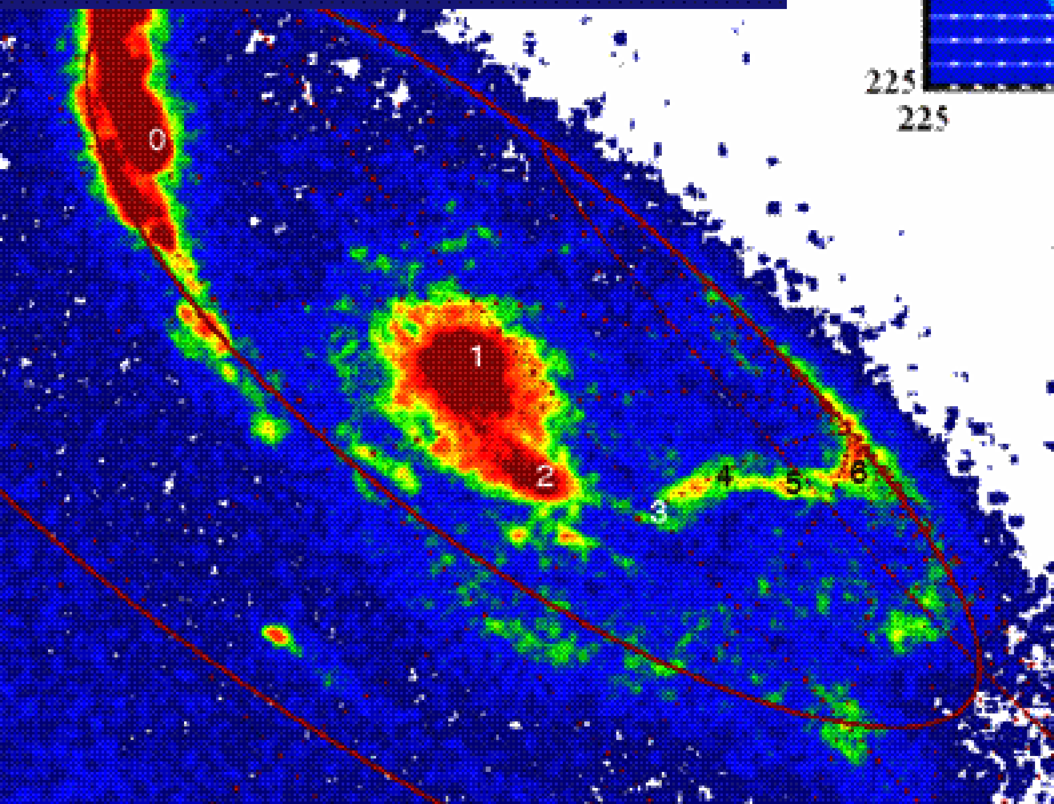
Solar wind driven Earth-like aurora?



Pressure and Flow Z = 0 Plane

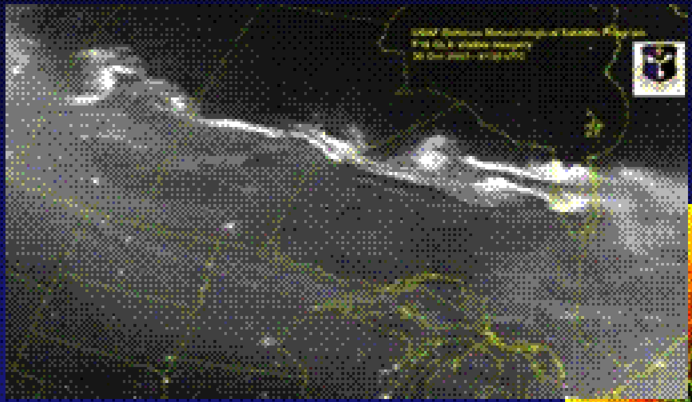
($\rho V^2 = 0.09$nPa)

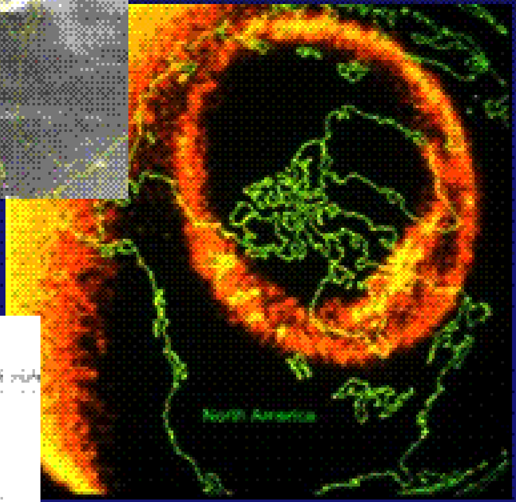


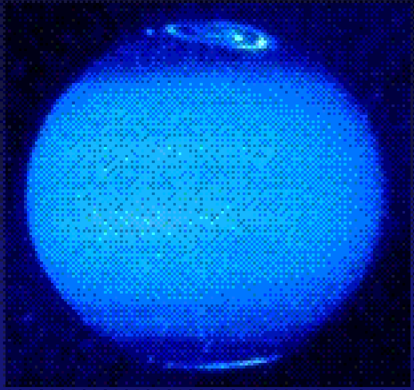


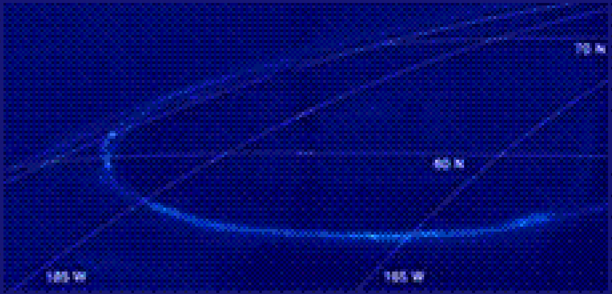
from R. Gladstone

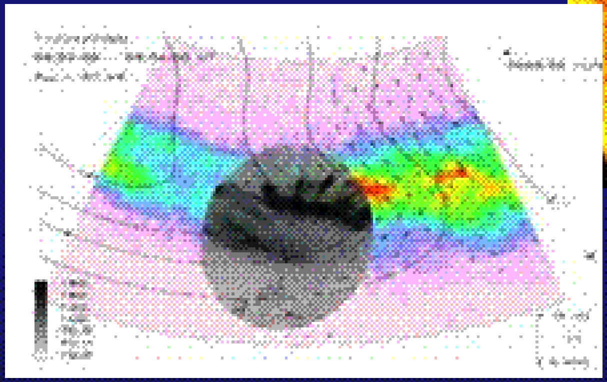
Earth – Jupiter Aurora

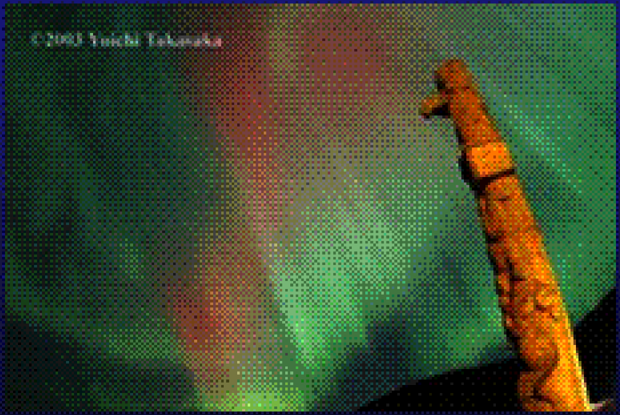


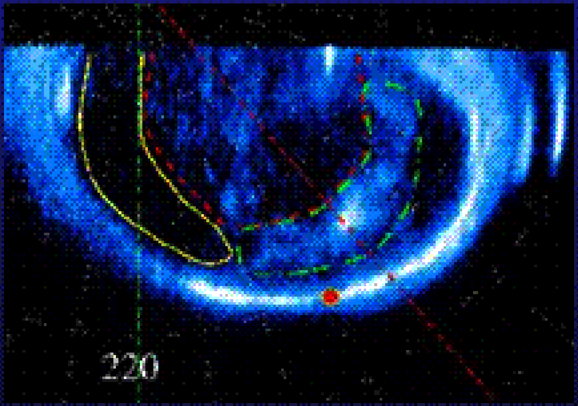






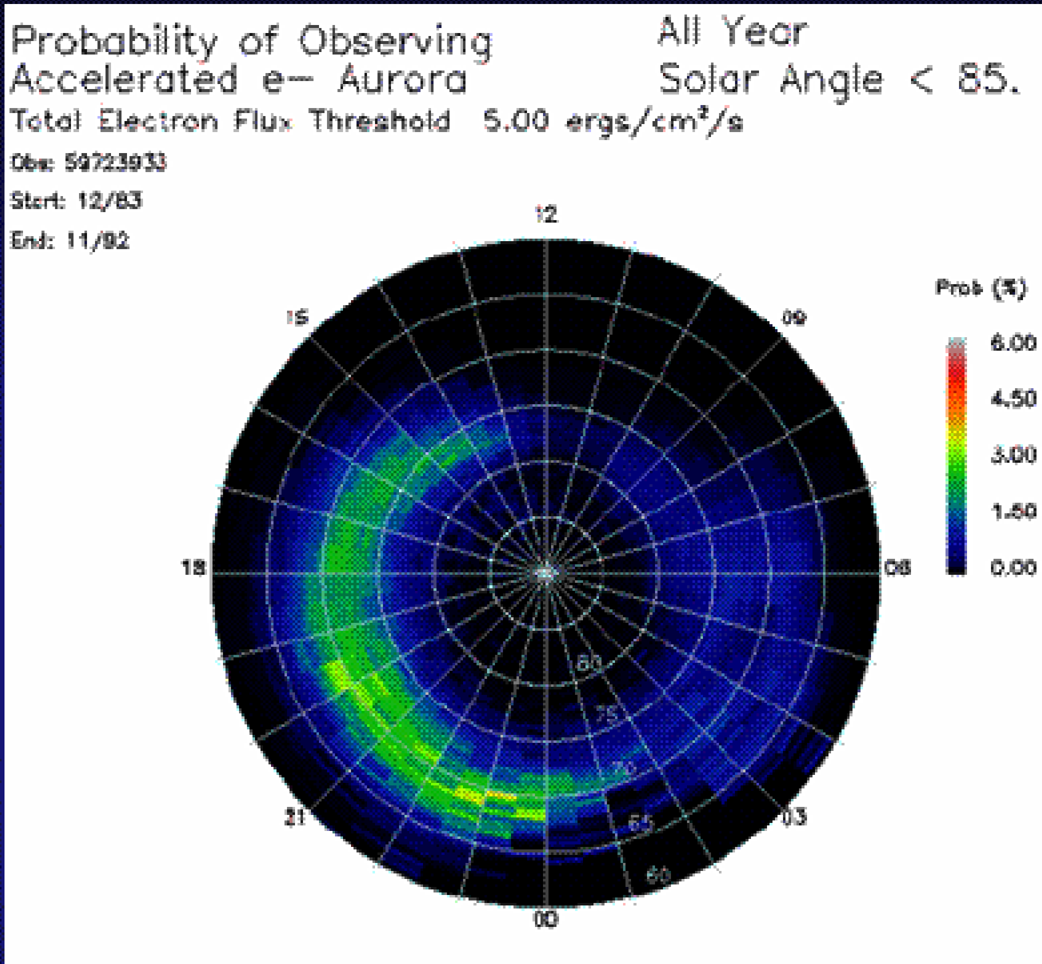






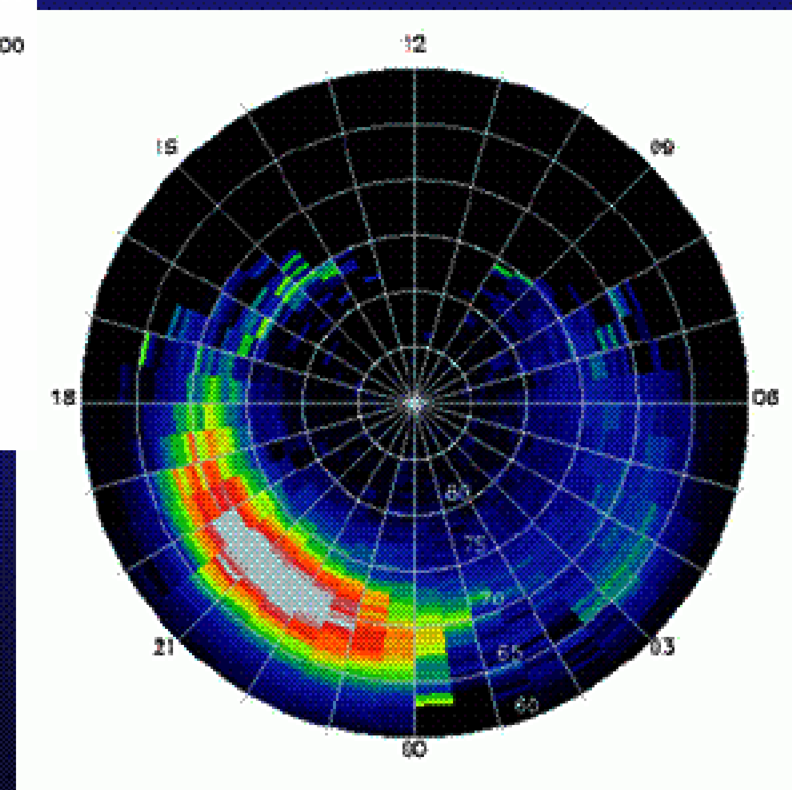
Commonalities and differences should help us understand magnetospheric processes that lead to aurora.

Does the ionosphere influence the auroral acceleration process?

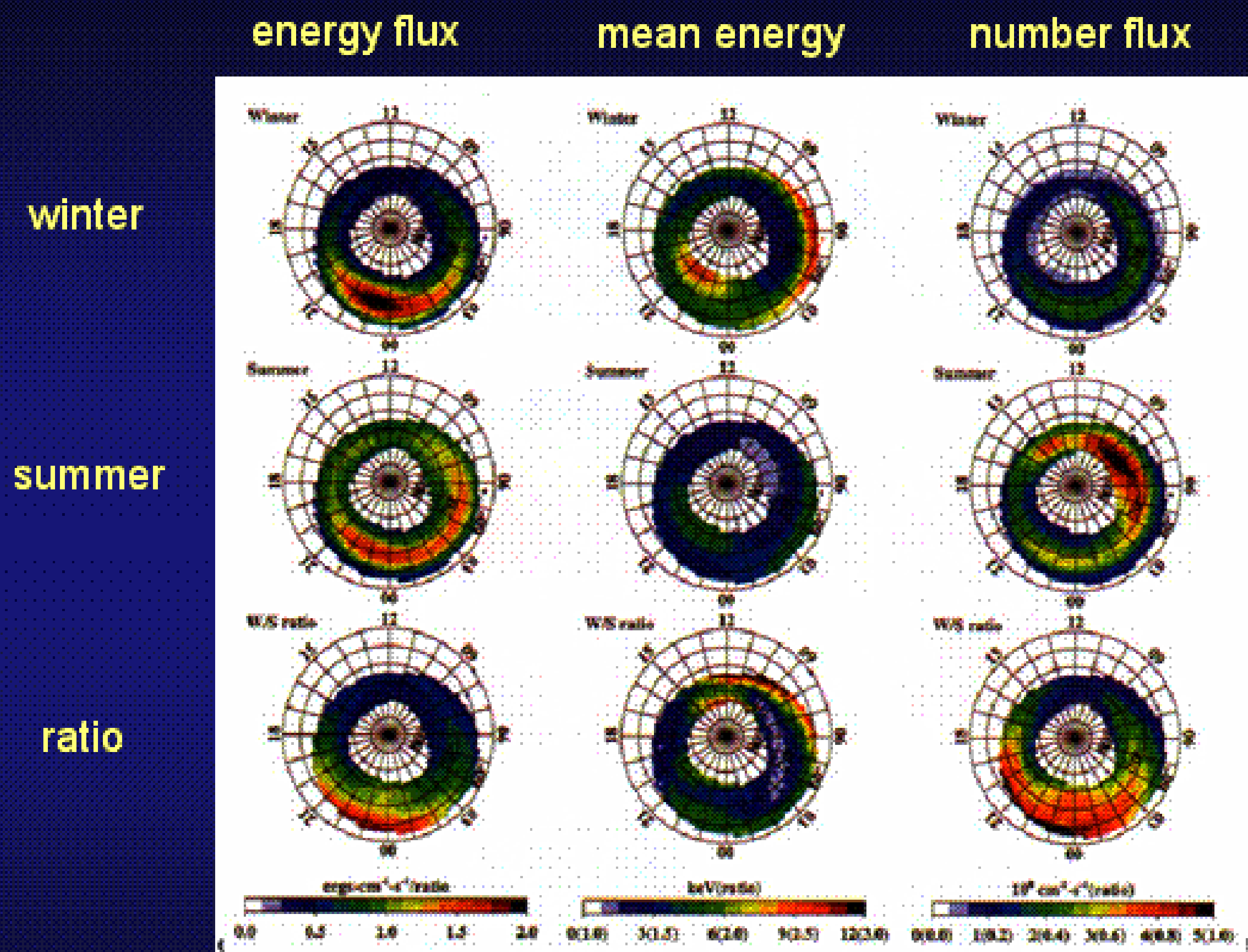


sunlit

night



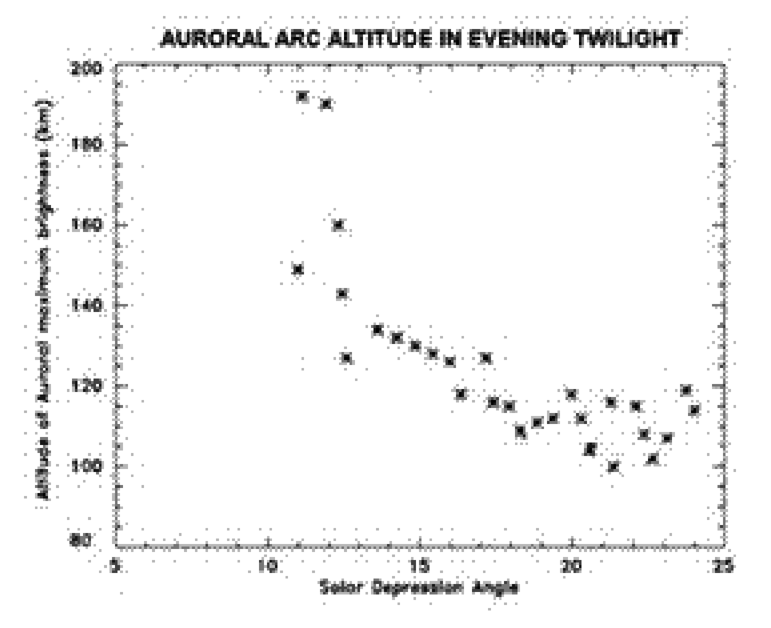
Pat Newell et al, 1996

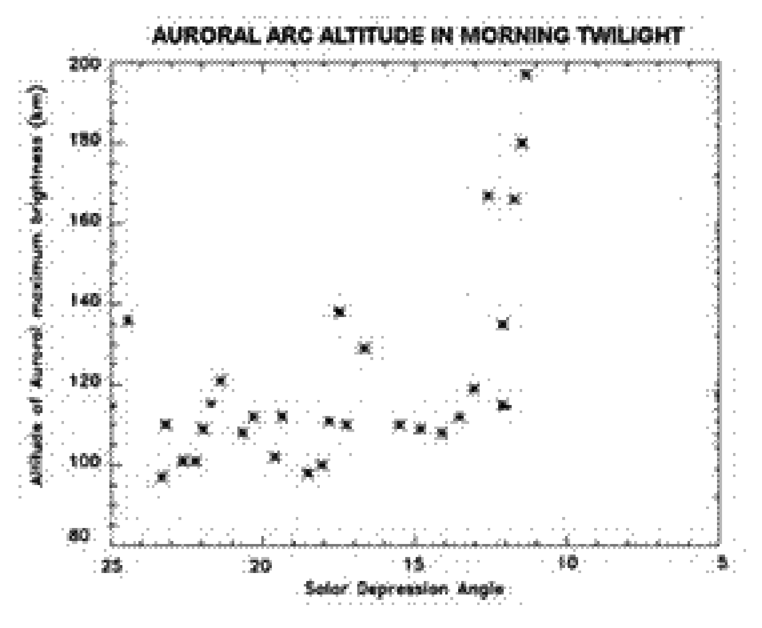


Kan Liou et al, 2001: UVI derived auroral precipitation

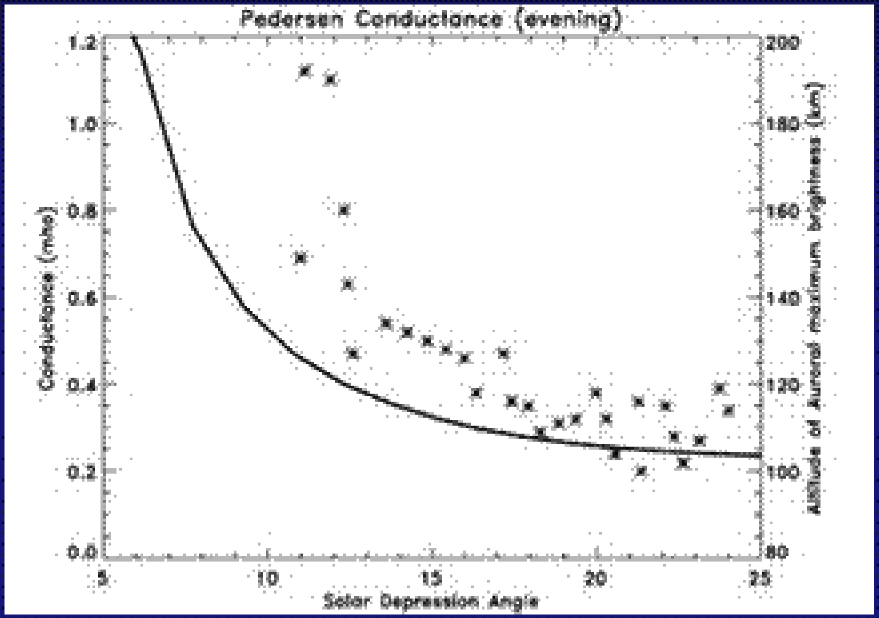
Six Days in March 1960

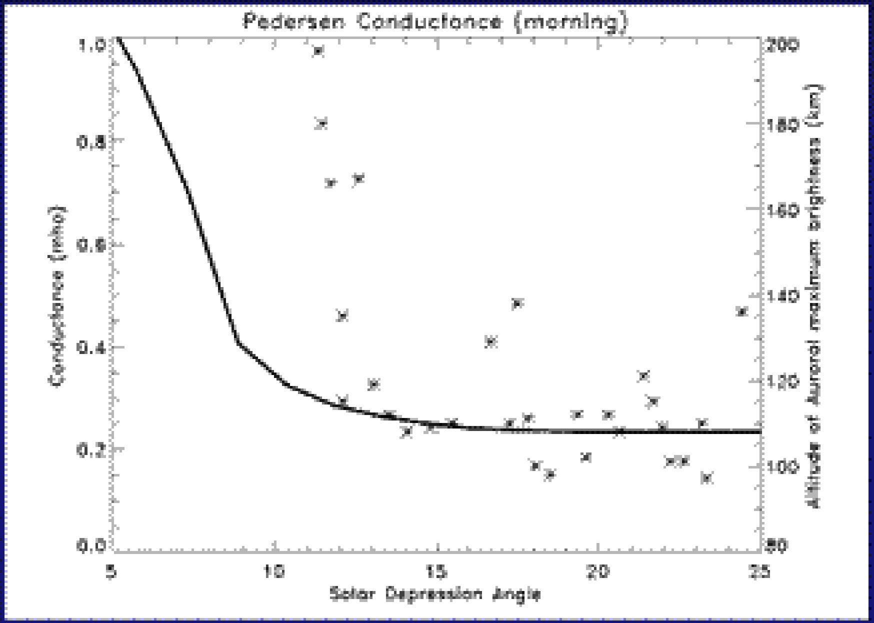
Deehr, Rees, Belon, Romick, and Lummerzheim, 2005





- Altitude drop in the evening & rise in the morning
- 5 to 15 observations averaged per data point.
- Effective electron energy change: 0.3 – 7 keV shown by altitude of max. energy deposition.

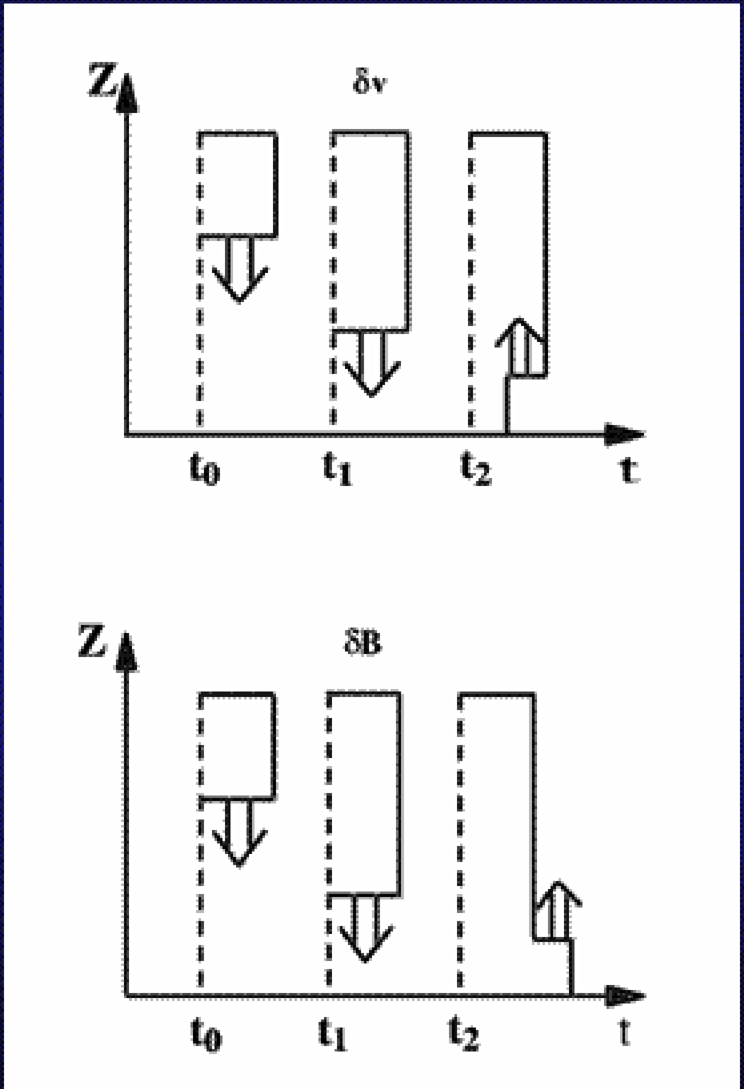




evening: auroral altitude and Pedersen conductance show a gradual change at sunset

morning: auroral altitude and Pedersen conductance show a sudden change at sunset

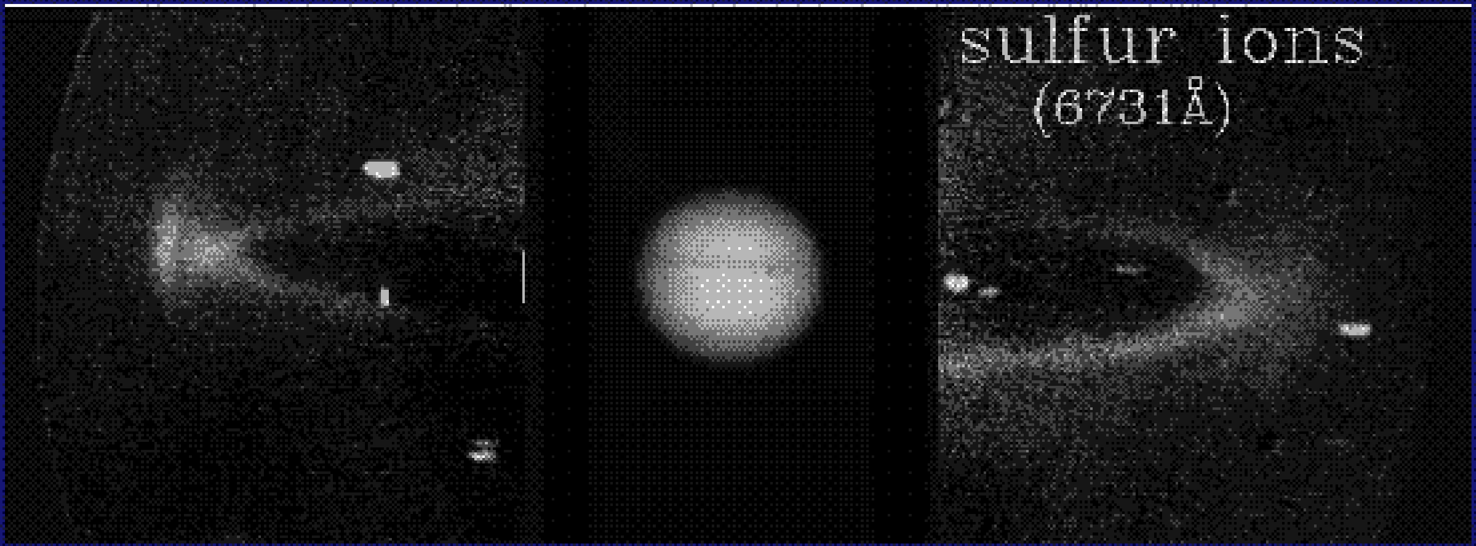
Alfvén Wave Reflection



Finite conductivity in the ionosphere (collisions between ions and neutrals) causes partial reflection

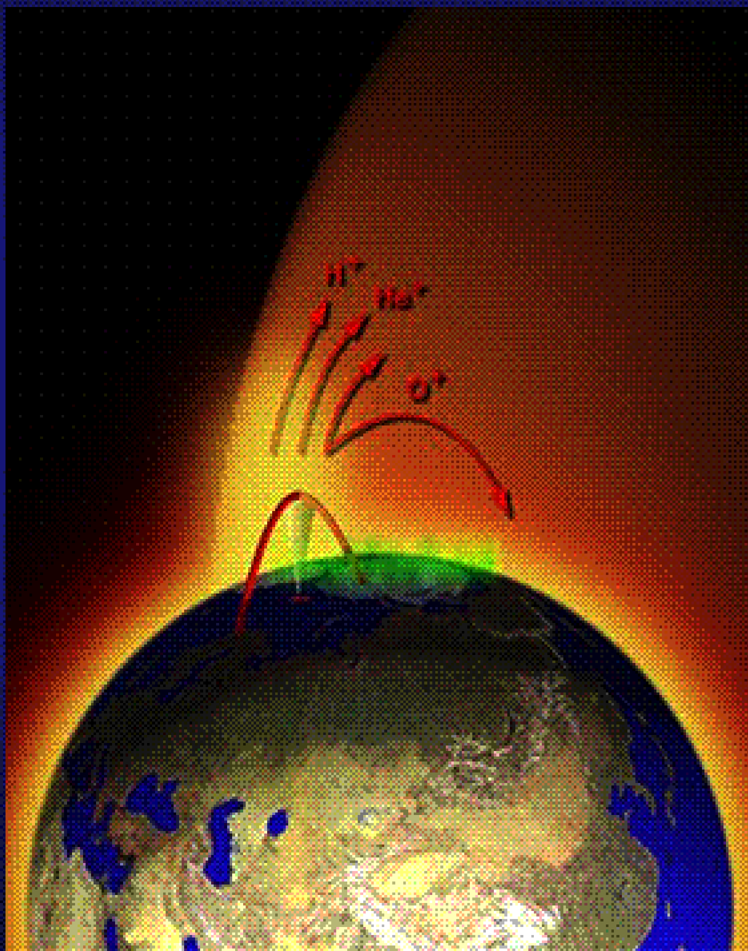
Ionospheric Ions in the Magnetosphere

Io Torus



Schneider and Trauger, Catalina Observatory

Cusp (Cleft) Ion Fountain



Multi-stage process:

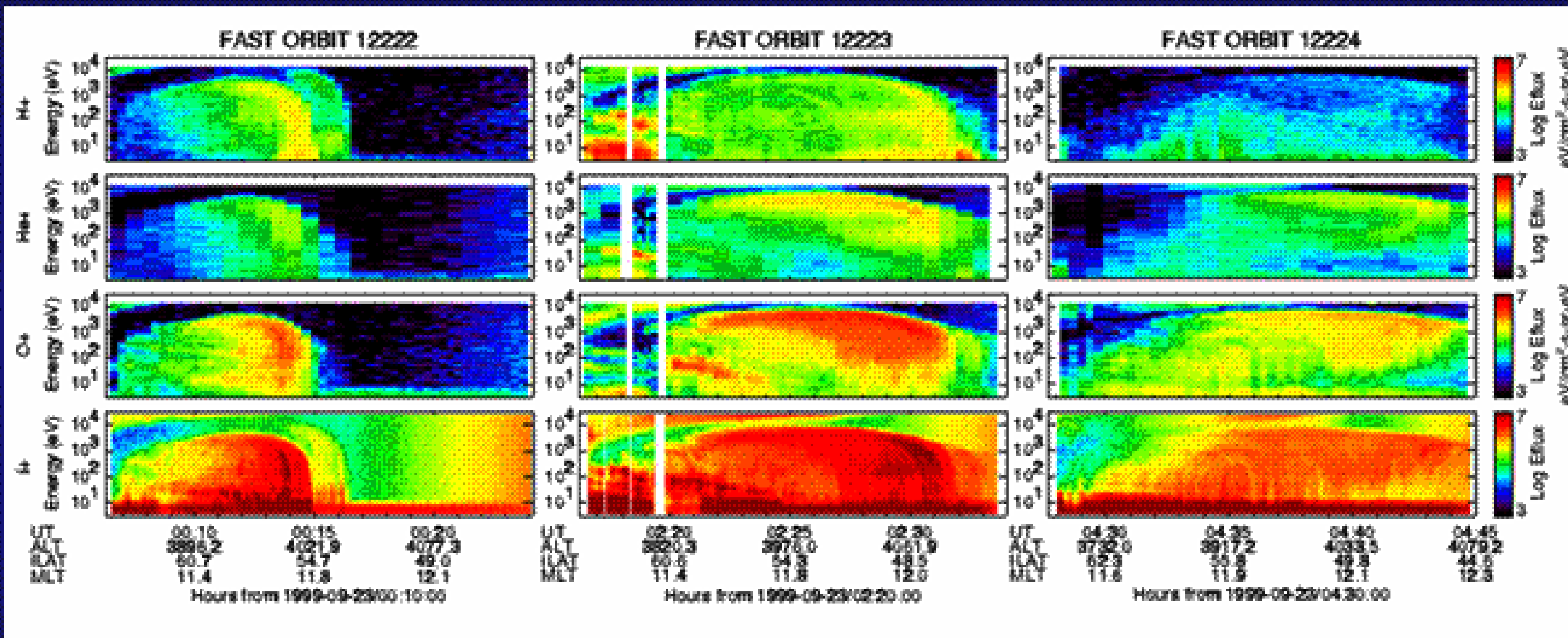
- lift ions out of the ionosphere
- accelerate ions to escape velocity

ISR radars see upflowing ions

satellites see ions above the ionosphere (FAST)

satellites see ions in the magnetosphere (POLAR)

FAST: Aurora and magnetic storms produce upflowing ions



McFadden et al, 2000

Post-Doc Opportunity

Are you interested in:

- M-I coupling?
- Numerical simulation?
- Small scale ionospheric processes?
- Aurora?

There will be an opportunity for a Post-Doctoral Fellow in the Space Physics Group at the Geophysical Institute at the University of Alaska. Contact Dirk Lummerzheim or Antonius Otto for more information, or apply to the generic post-doctoral position announcement (see on the web at: `http://www.gi.alaska.edu/admin/human_resources/jobs/GIpostdoc.html`).