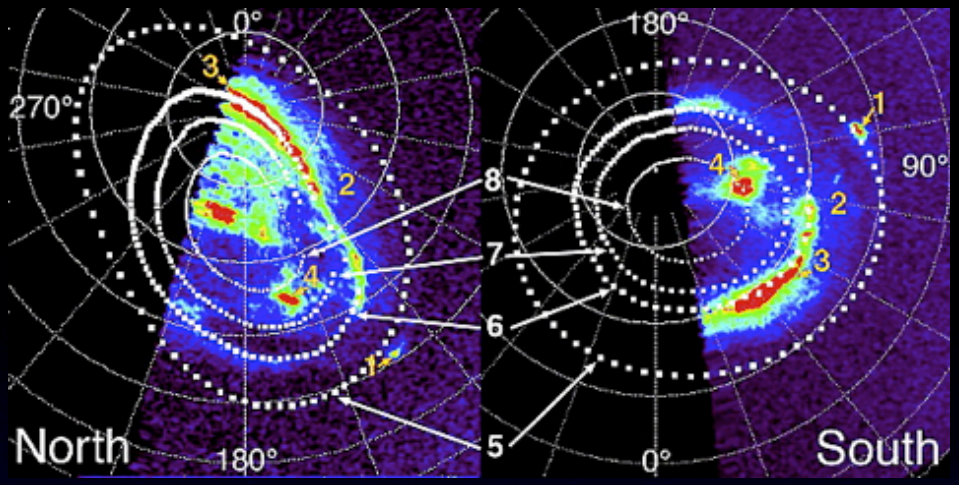
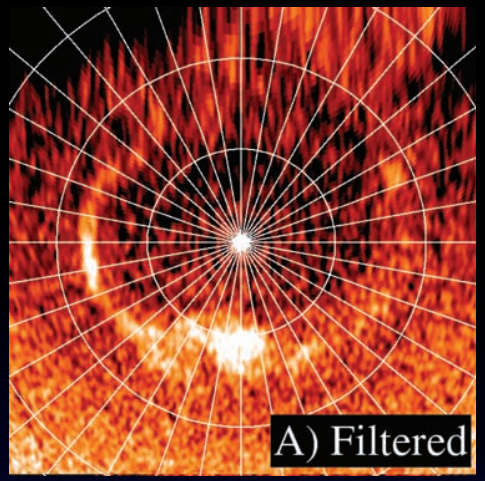
Jupiter: Pallier & Prangé, GRL, 2004



Saturn: Gérard et al., JGR, 2005



Comparative Cusp Processes

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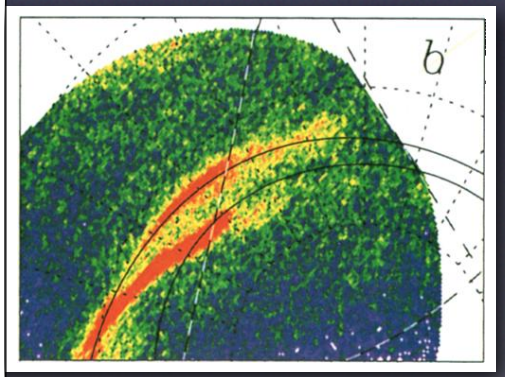
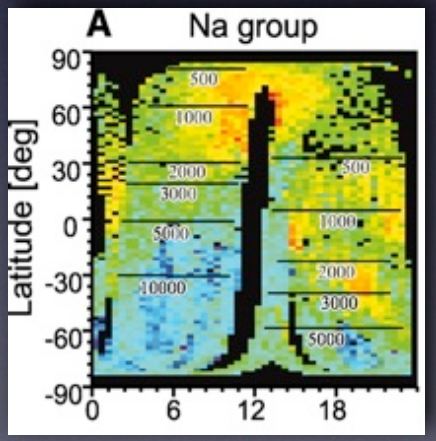
AOGS ST14-A016



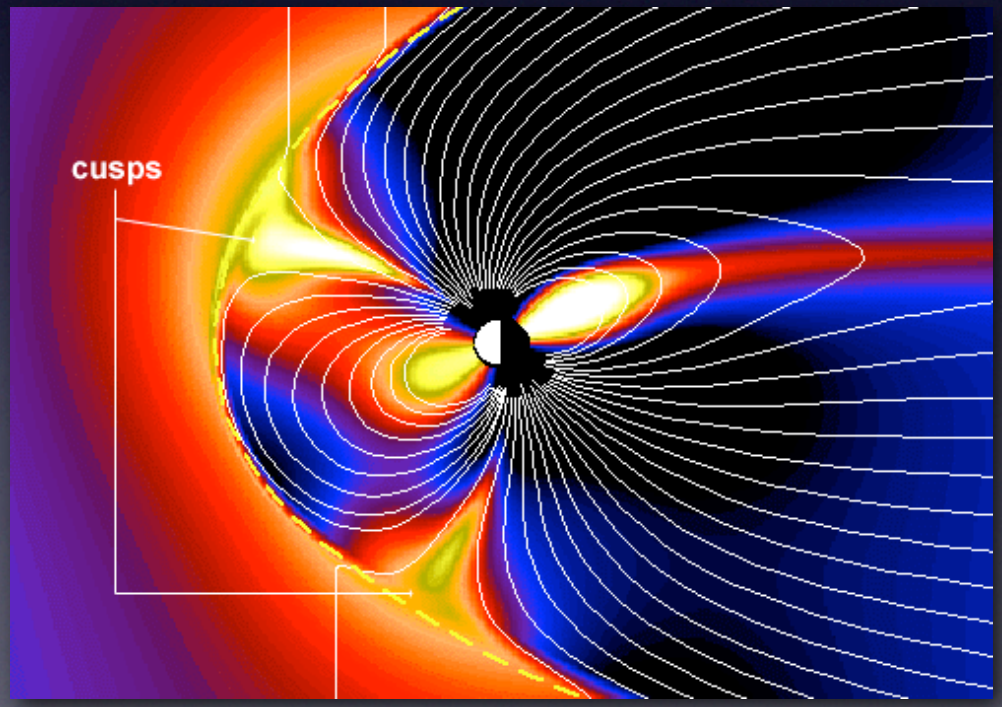
Earth: Milan et al., JGR, 2000



Mercury: Zurbuchen et al., Science, 2011

Magnetospheric Cusps

- Minima in magnetic field - between sunward and anti-sunward field lines
- Magnetosheath plasma can penetrate to the planetary ionosphere or surface
- Exists for northward and southward IMF



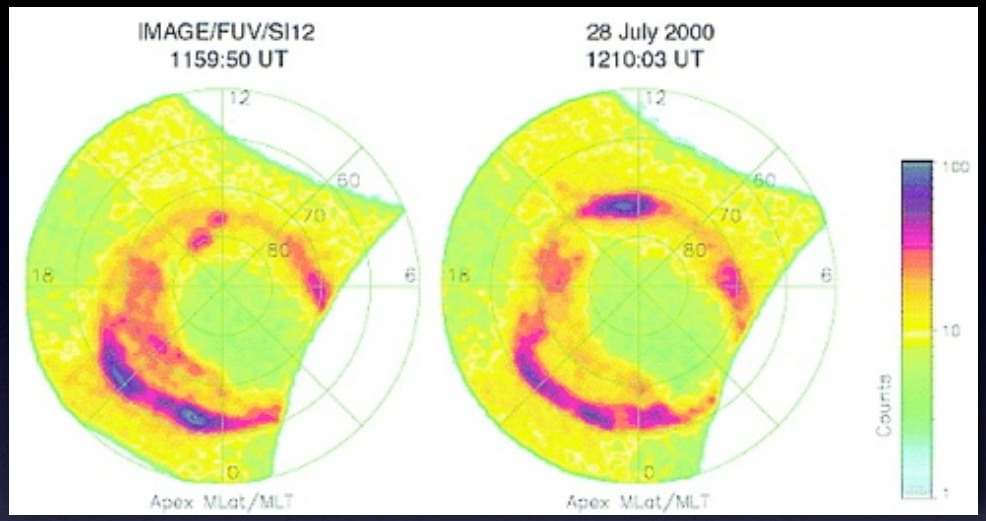
Tsyganenko & Russell, JGR, 1999

- Dynamics are driven by reconnection
- Location and spectrum of precipitating particles depends on IMF orientation

Terrestrial cusp spots

- Proton aurora cusp spot seen when solar wind dynamic pressure is high

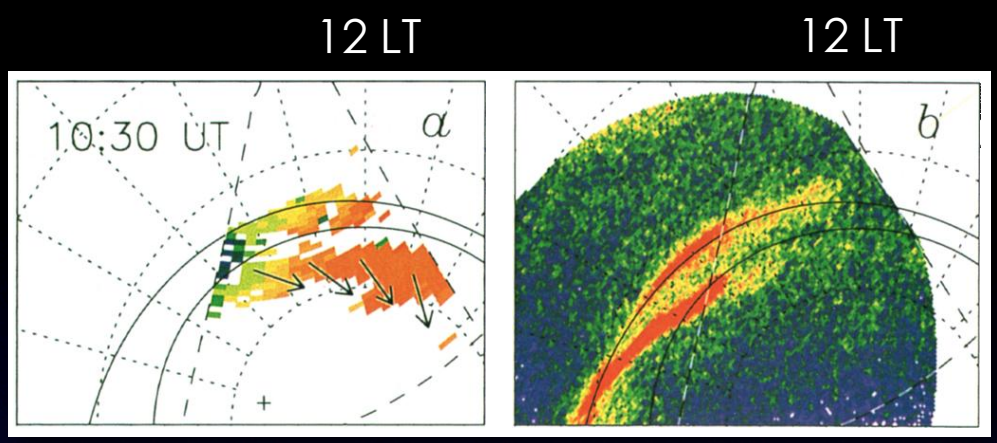
Fuselier et al., JGR, 2002



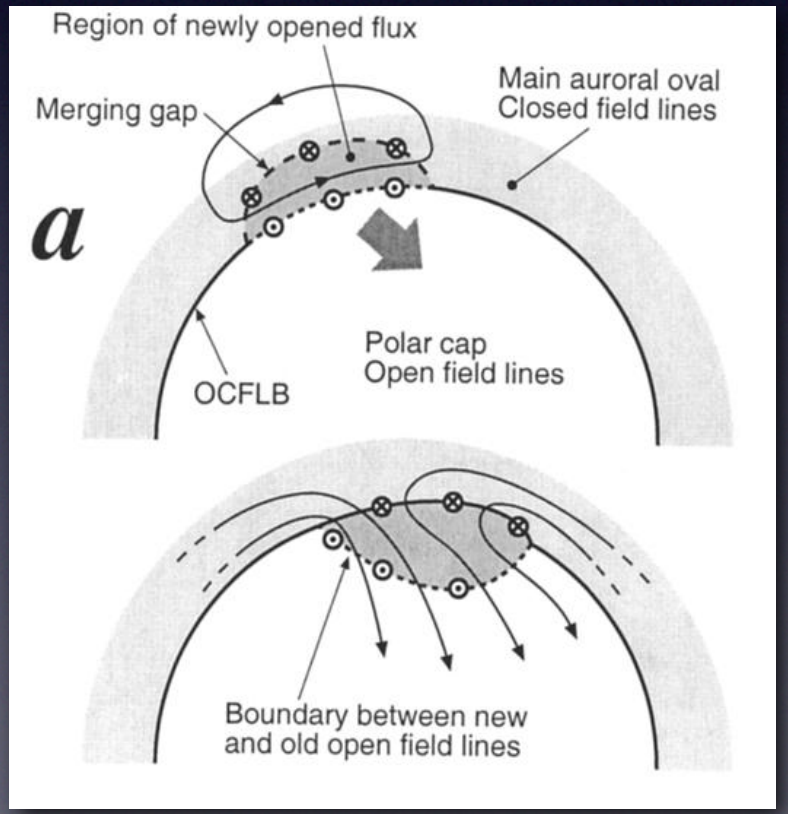
- Northward IMF:
  - Proton cusp spot poleward of noon auroral oval
  - Anti-parallel reconnection occurring at high latitude (lobe)
- Southward IMF:
  - Cusp spot merges into intense noon auroral oval
  - Component reconnection occurring across broad region of low-latitude magnetopause

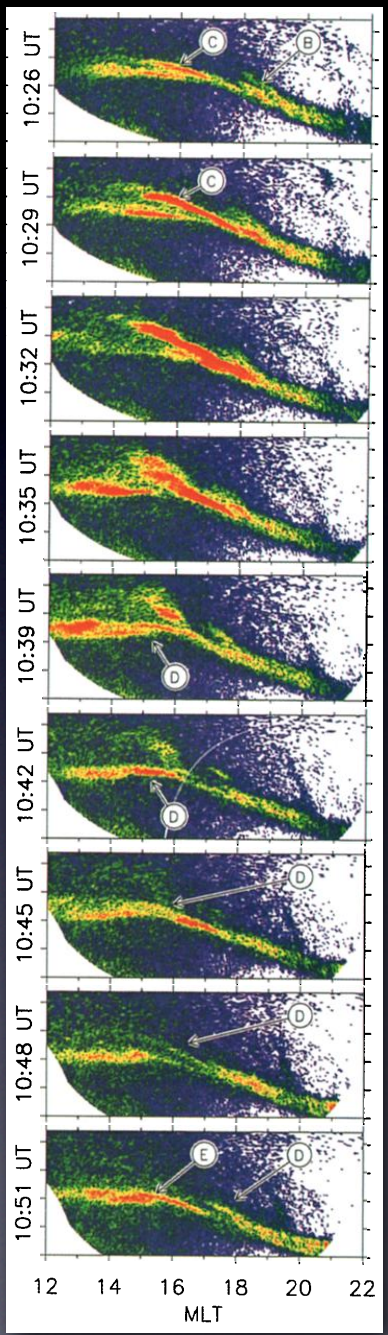
Ionospheric signatures of reconnection

a. Radar data showing poleward flow
b. Auroral image showing splitting of arc



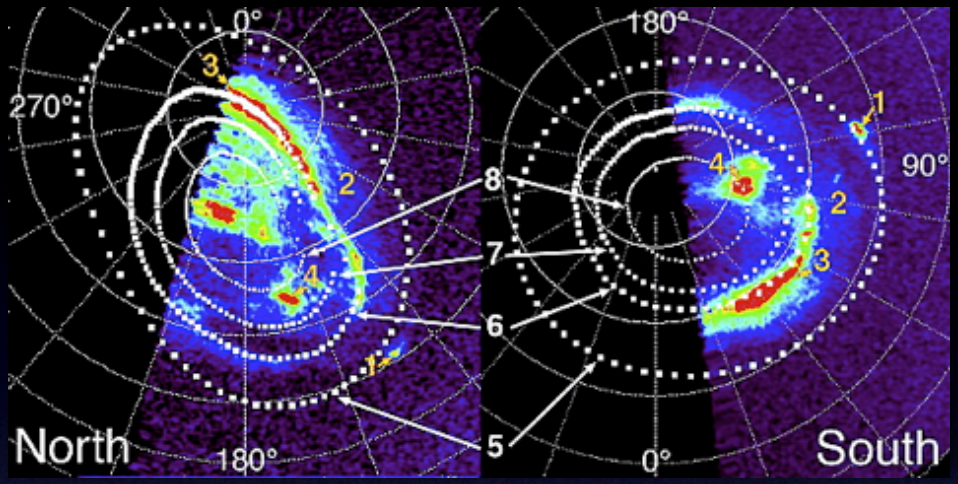
- Poleward moving auroral forms (dayside arc bifurcations) are signatures of transient reconnection at the magnetopause
[Milan et al., JGR, 2000]





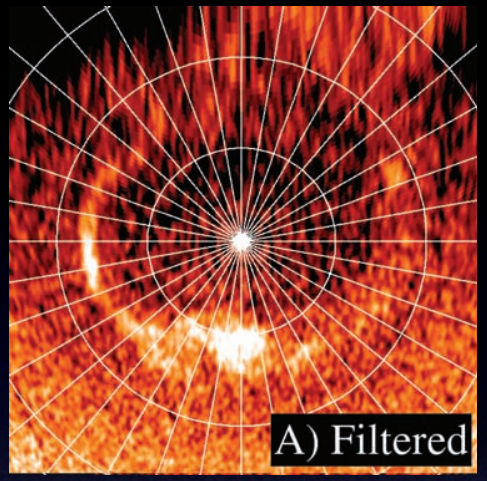
Cusp aurora at other planets?

Jupiter (HST/STIS)

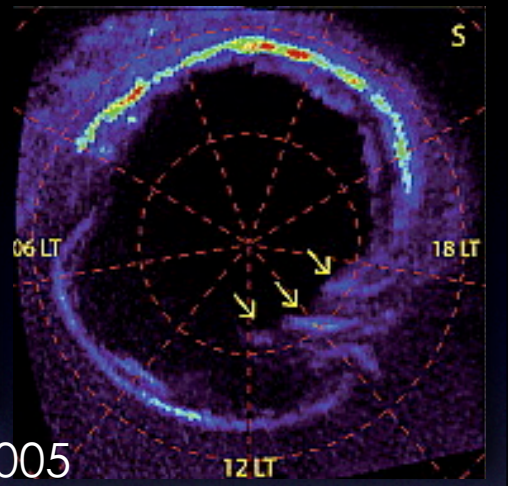


Pallier & Prangé, GRL, 2004

Saturn (HST/STIS, Cassini/UVIS)



Gérard et al., JGR, 2005

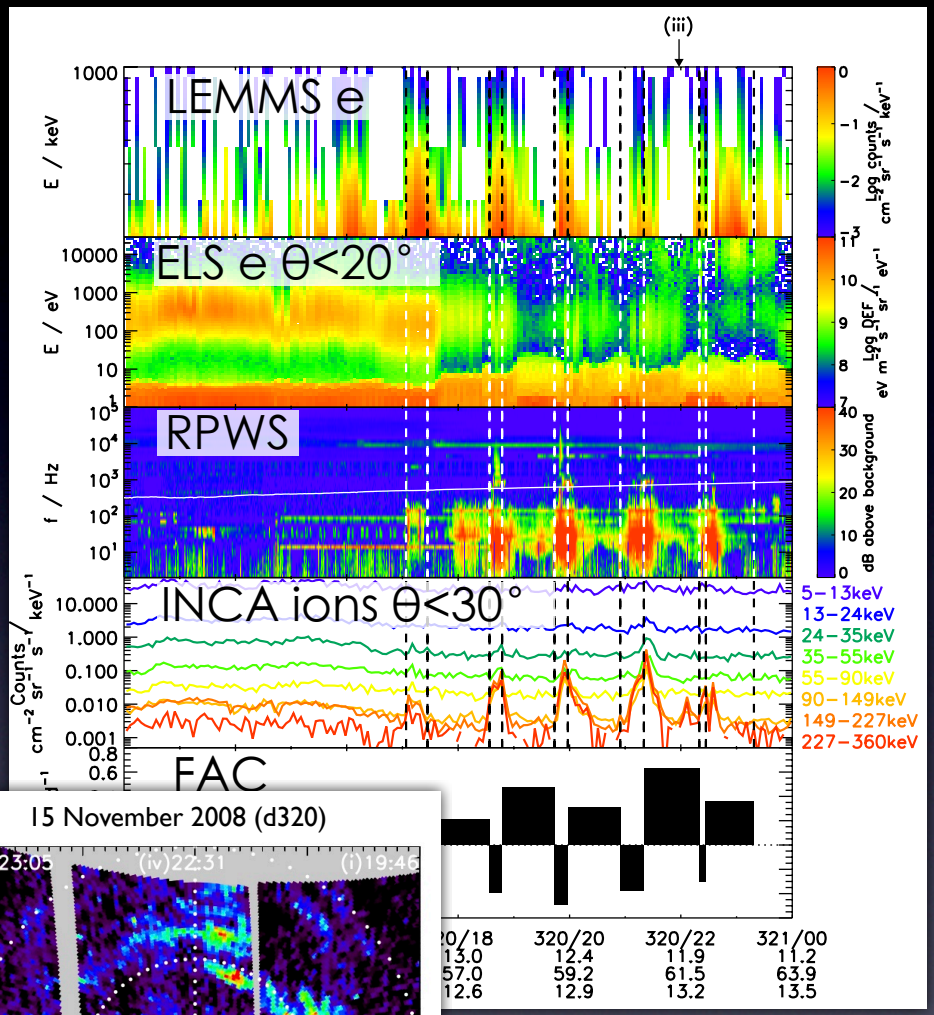


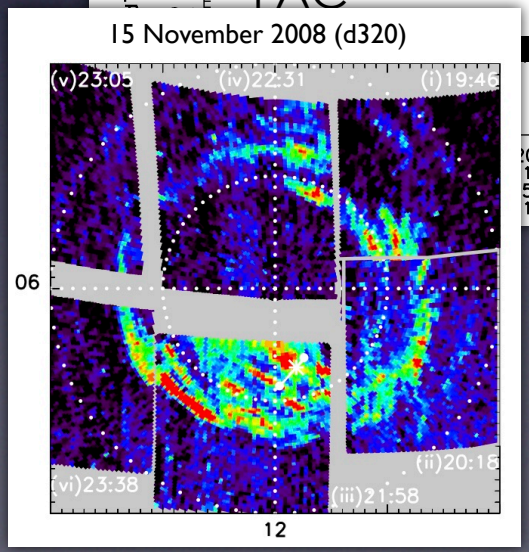
Radioti et al., JGR, 2011

- Magnetosheath plasma density and temperature are not sufficient to produce the auroral intensities observed: ~MR (J), ~10s kR (S)
- Field-aligned potential drops are required to accelerate plasma and sufficiently increase the precipitating energy flux [Bunce et al., JGR, 2004(J), 2005(S)].
- Driven by pulses of reconnection?

In situ observations and images of Saturn's cusp

Badman et al., JGR, 2012

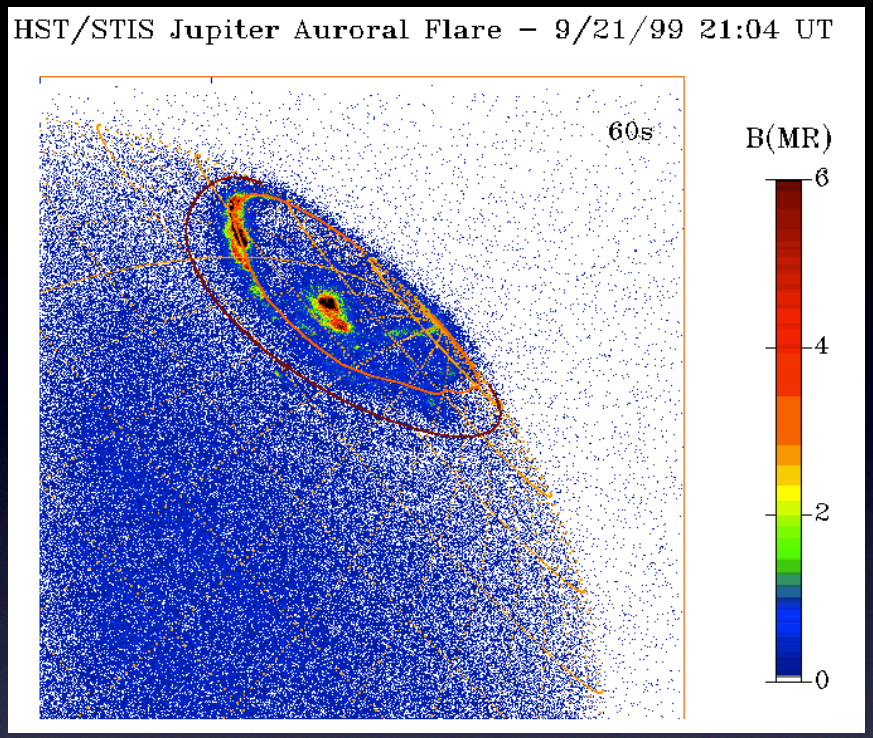




- Cassini observed remote and in situ signatures of repeated, transient reconnection events.
- Layers of currents & poleward auroral arcs.
- Some plasma-depleted field lines
- Bursts of
  - electrons (keV - MeV)
  - upward ion conics (⩾300 keV H and ~600 keV O)
  - whistler waves (1-100 Hz)

- Both high latitude (lobe) and low latitude (flux opening) transient reconnection are possible [Bunce et al., JGR, 2005].

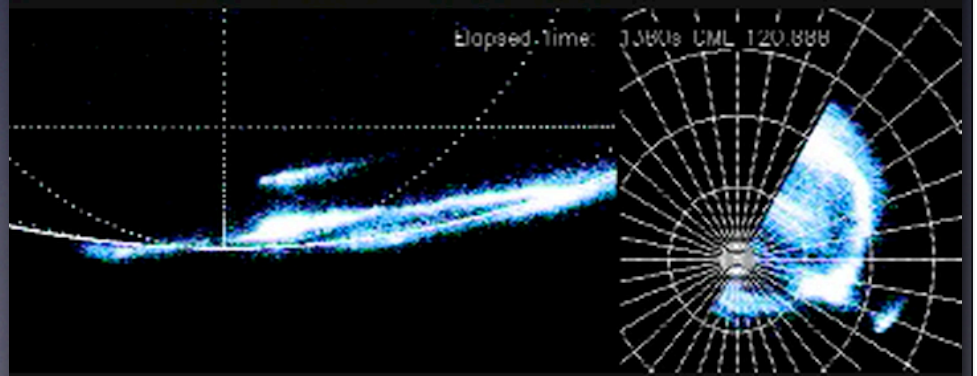
Jupiter's cusp emissions



Waite et al., Nature, 2001

- UV auroral flares
- 2 min periodicity in intensity, similar to FTE occurrence
- ~100 keV electron precipitation

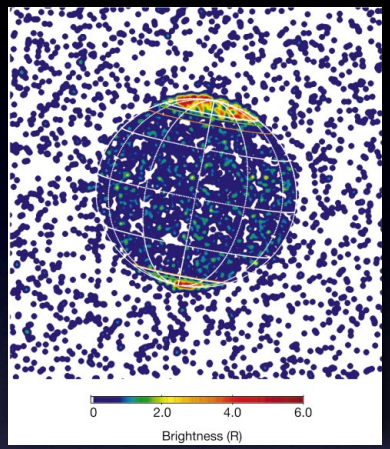
- Main oval driven by corotation-enforcement currents mapping to the middle magnetosphere
- Cusp emissions are high latitude

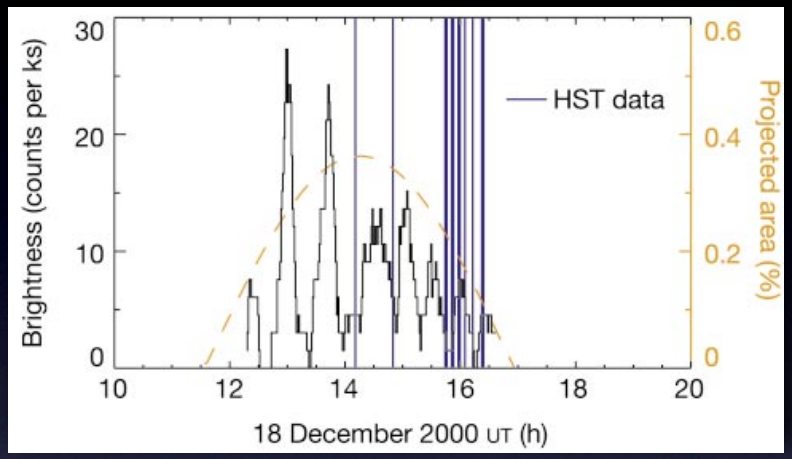


Bonfond et al., GRL, 2011

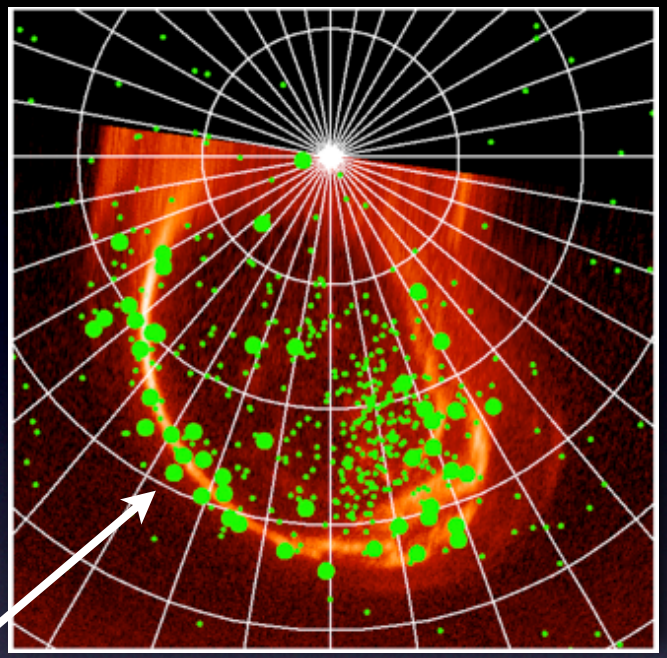
Jovian X-ray emissions

- 40 min periodicity in X-ray counts
  [Gladstone et al., Nature, 2002]





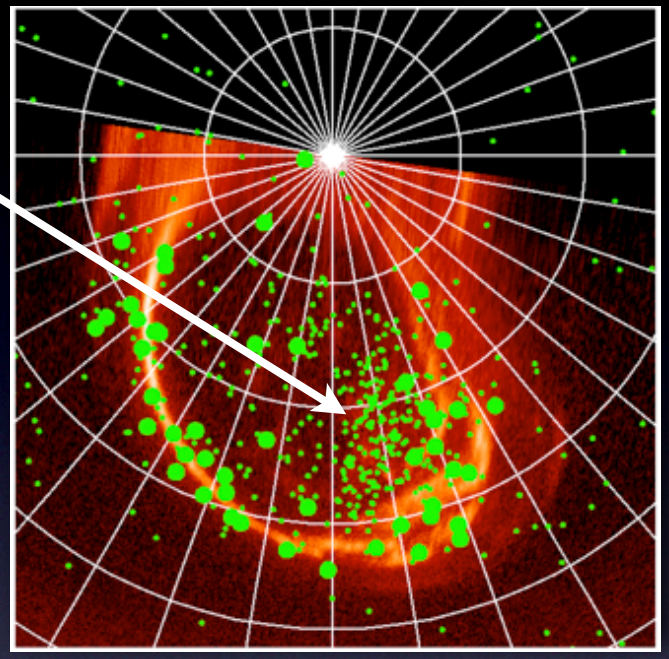
Branduardi-Raymont et al., JGR, 2008



- Large dots: >2 keV photons
- Electron bremsstrahlung
- Co-located with main UV emission: same accelerated magnetospheric electron population (~100 keV)

Jovian X-ray emissions

Branduardi-Raymont et al., JGR, 2008

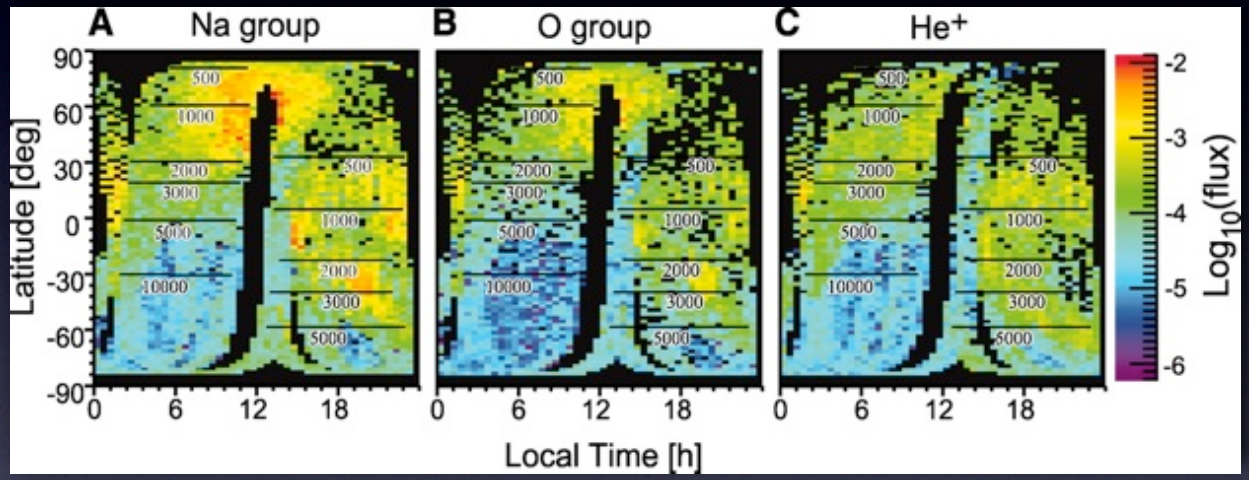


- Small dots: <2 keV photons
- Heavy ion charge exchange (highly stripped O and S) [Elsner et al., JGR, 2005]
- Outer magnetosphere source, accelerated to ~16 MeV by low-altitude field-aligned potential
- Consistent with Ulysses observations of 16 MeV electron bursts streaming away from Jupiter [McKibben et al., PSS, 1993]. These were sometimes pulsed with ~40 min periodicity
- Location, periodicity, downward current are explained by pulsed reconnection model with outer magnetosphere plasma source [Bunce et al., JGR, 2004]

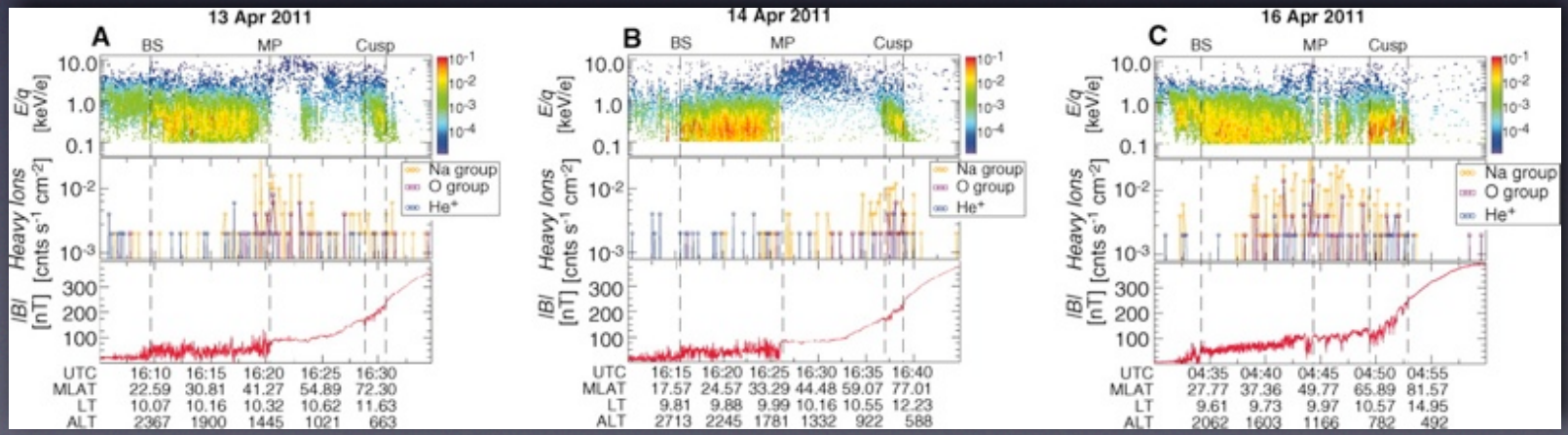
Mercury cusps

- The lack of atmosphere means the solar wind plasma impacts on the planet's surface: source of exosphere
- Neutral exosphere is ionized by precipitating particles

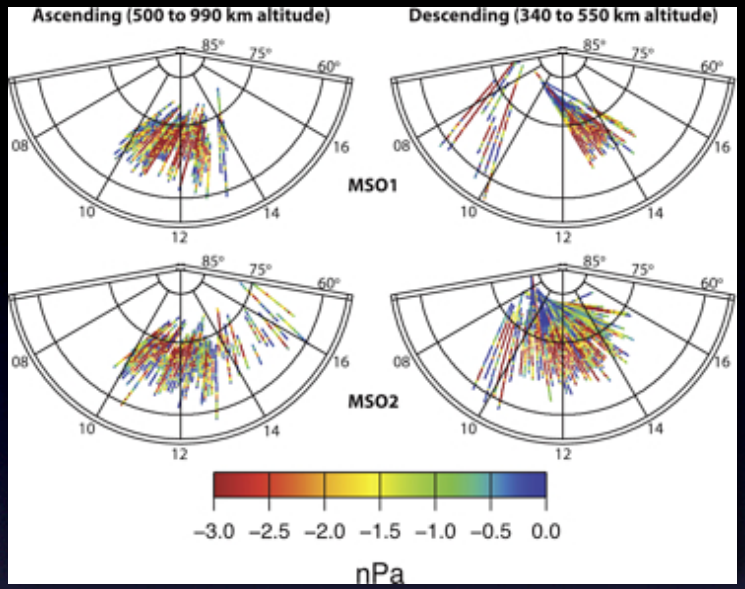
Zurbuchen et al., Science, 2011



- Na and O ion fluxes enhanced over northern cusp
- Ion fluxes reflect variability in solar wind conditions

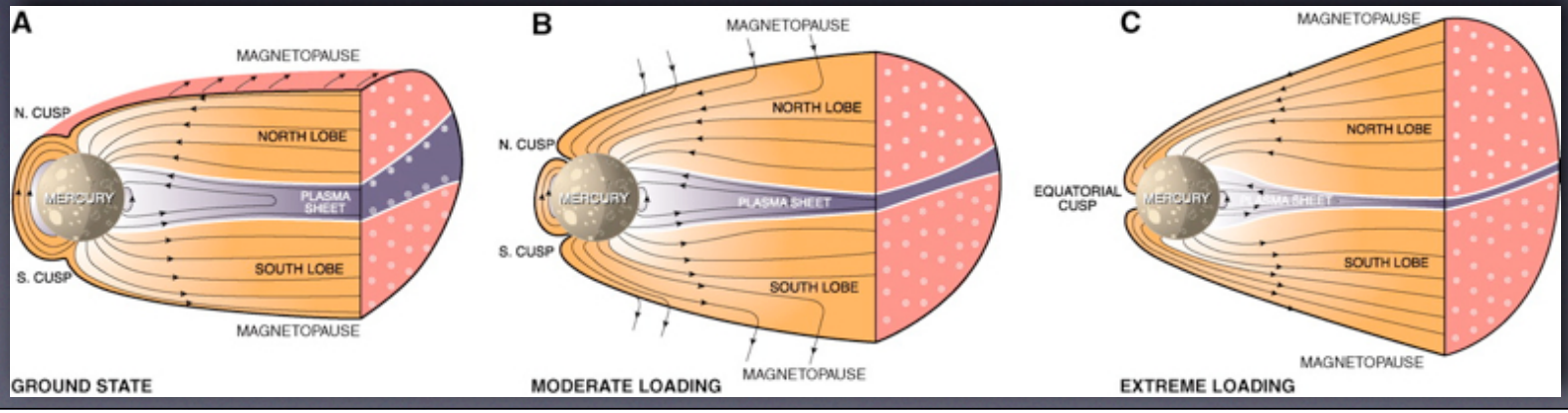


Mercury cusps



Winslow et al., GRL, 2012

- Northern cusp region is persistently present
- Spatial extent depends on magnetospheric dynamics
- Magnetic depression is stronger for high solar wind dynamic pressure intervals and anti-sunward IMF orientation (B_X<0)
- Southern cusp expected to be larger, with more sputtering & contribution to the exosphere

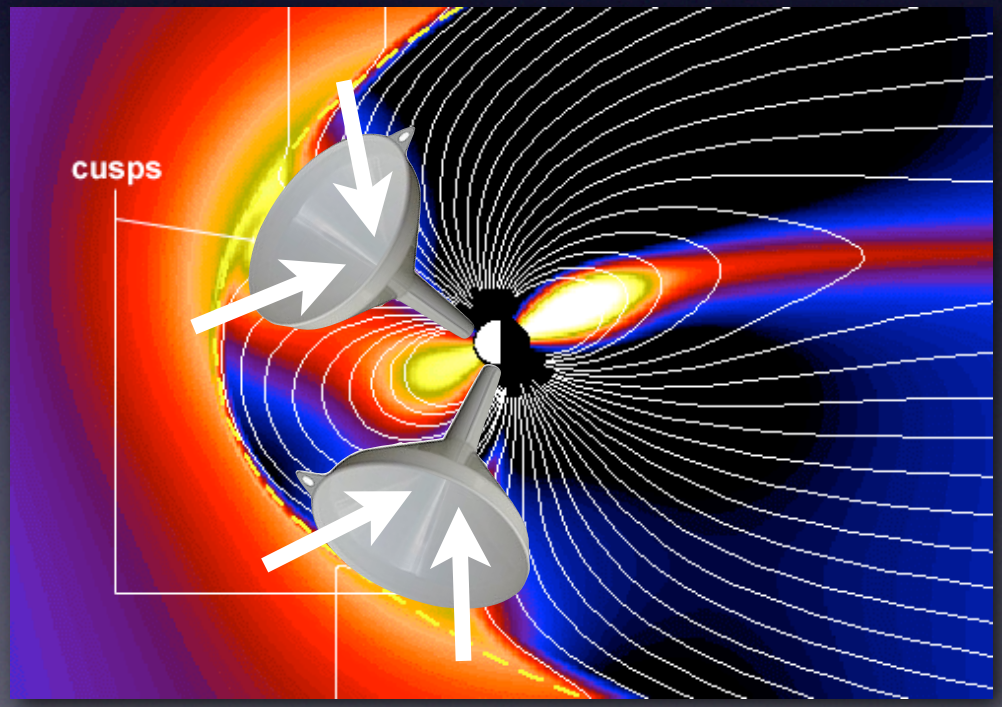


Slavin et al., Science, 2010

?

Summary

- Magnetospheric cusps funnel plasma down to the planet's atmosphere or surface.
- Ionization, excitation, and sputtering occur.
- Cusp auroral features can be used to diagnose the location and type of reconnection occurring.



Tsyganenko & Russell, JGR, 1999

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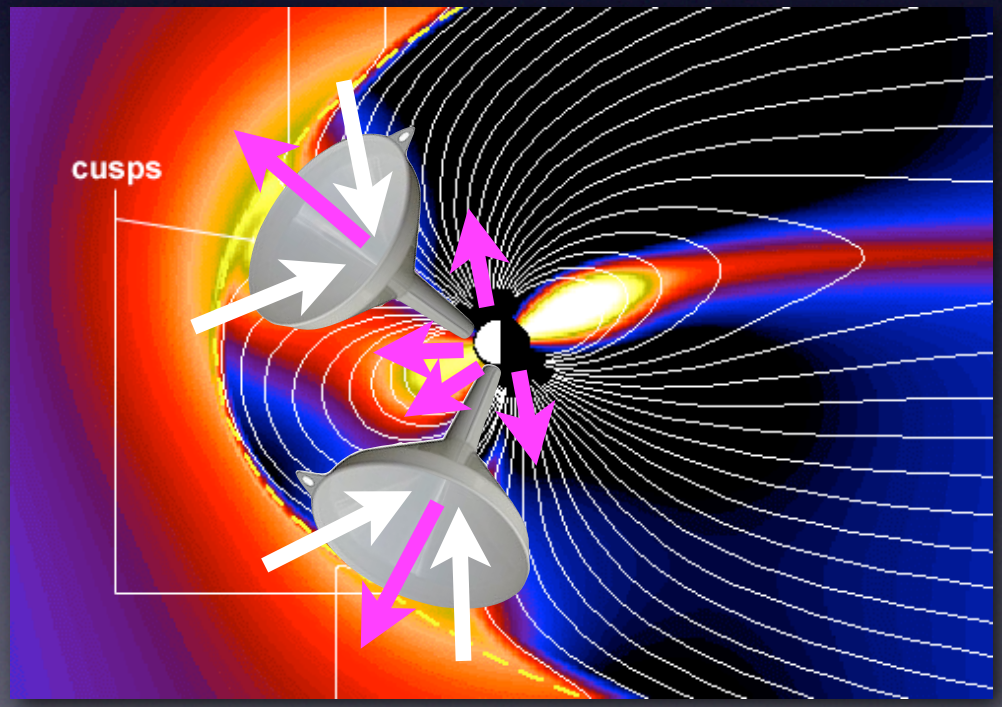

Tsyganenko & Russell, JGR, 1999

- Not just funneling down:
- Saturn: 600 keV O ion conics
- Jupiter: X-ray aurora & relativistic electrons
- Mercury: heavy ion exosphere