

## Solar wind interaction at Jupiter

$$v \text{ constant} \Rightarrow v \sim 400 \text{ km s}^{-1}$$

$$nvr^2 = \text{constant} \Rightarrow n \sim 0.2 \text{ cm}^{-3}$$

$$B_{\text{mag}} r^2 = \text{constant} \Rightarrow B_{\text{mag}} \sim 0.2 \text{ nT}$$

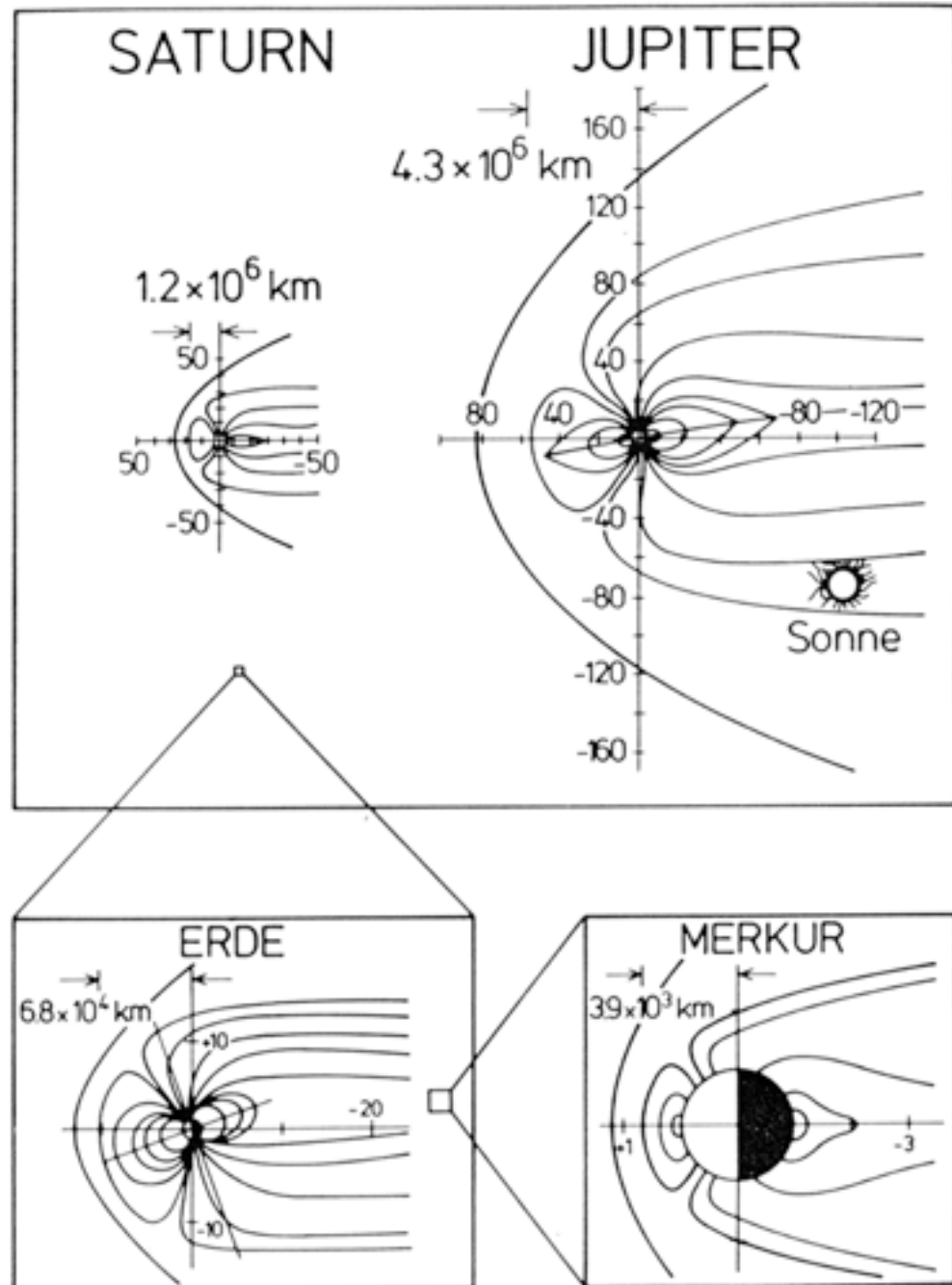
$$B_x \sim 0.2 B_y$$

Jovian dipole moment the opposite direction as Earth  
 $\Rightarrow$  Northward IMF leads to increased dynamics

Northward IMF : MP  $\sim 63 R_J$

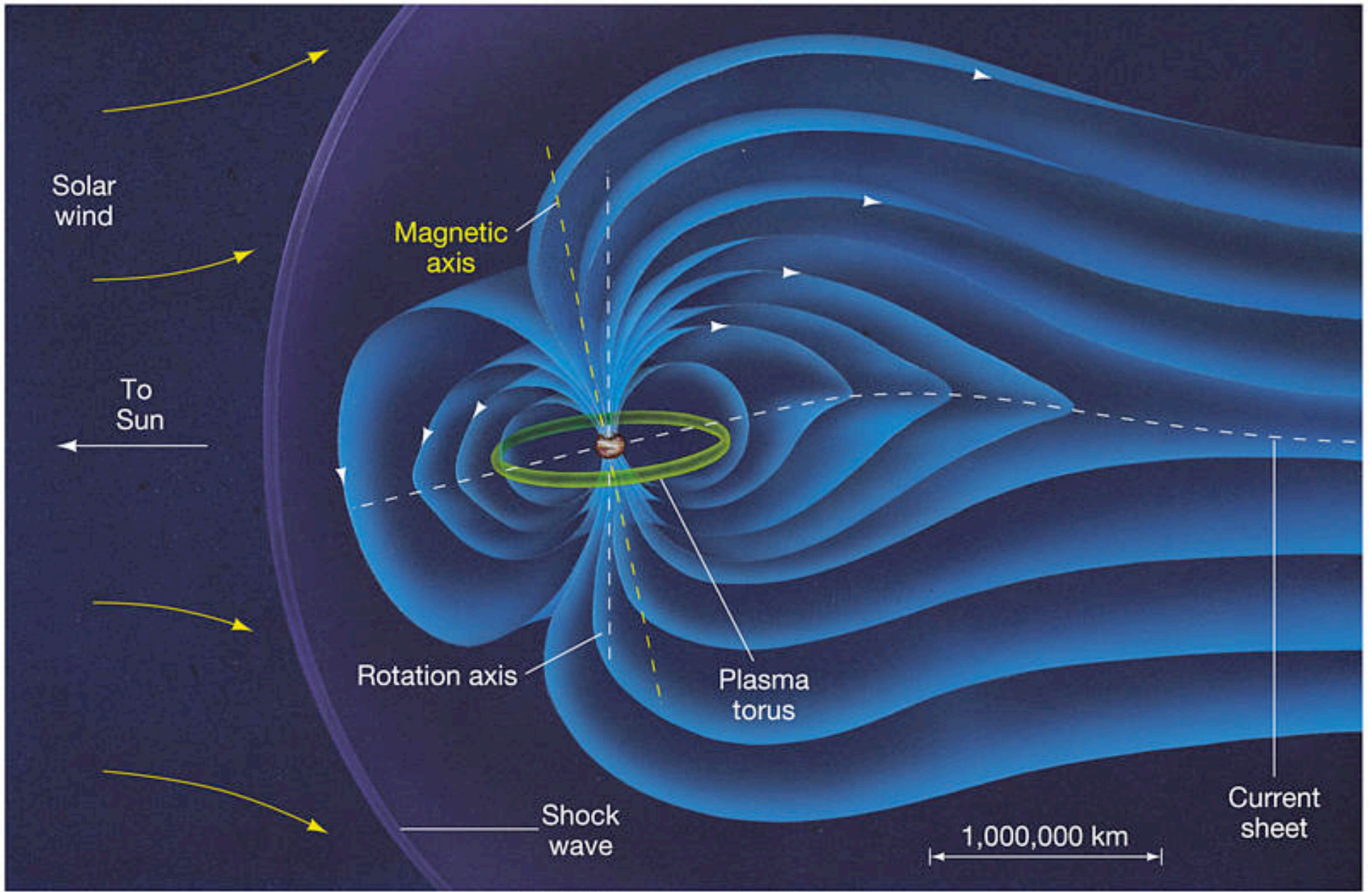
Southward IMF : MP  $\sim 92 R_J$

The Jovian magnetosphere is the largest object inside the solar system

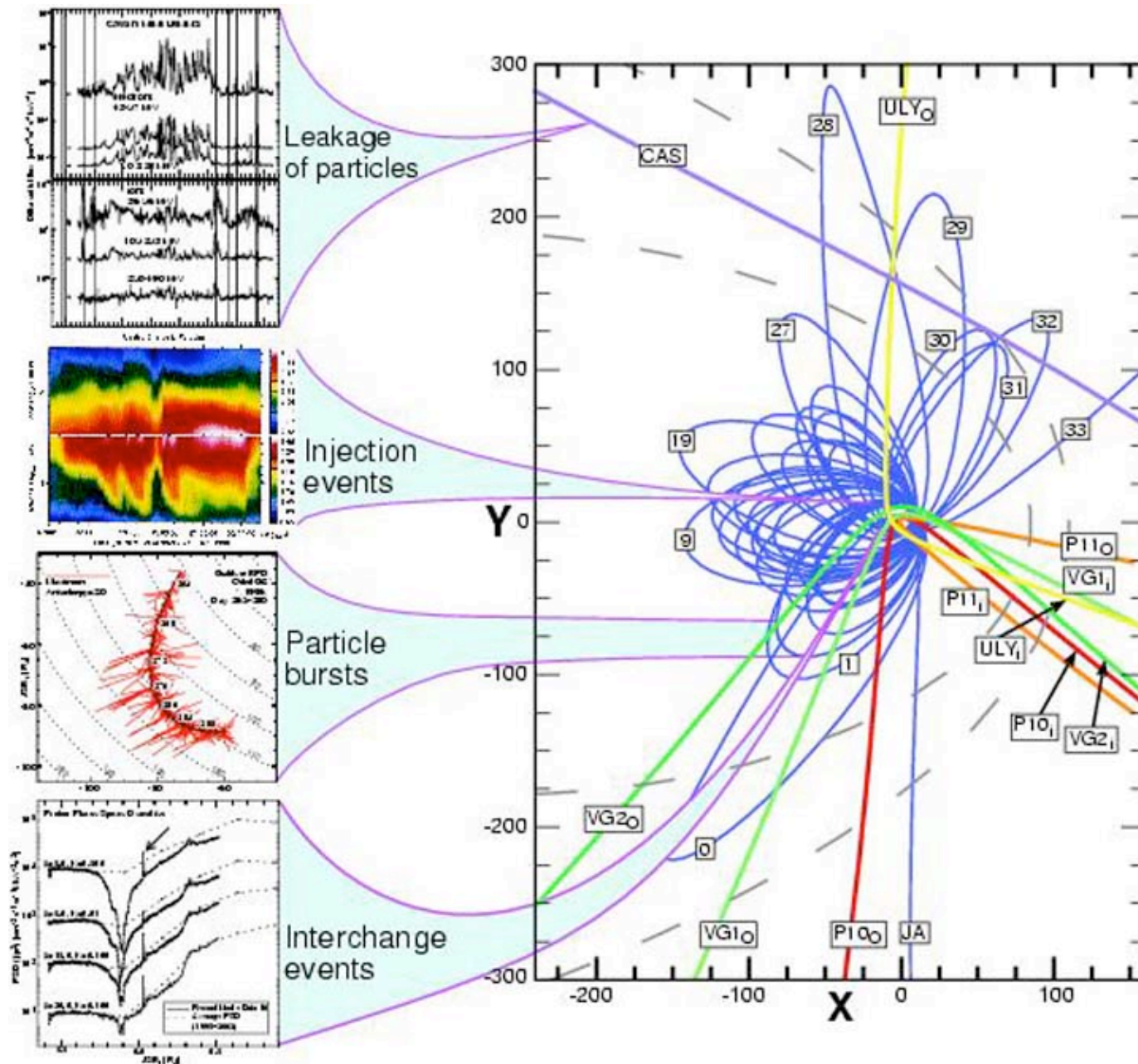




Tail can reach past the orbit of Saturn - 5 AU or over  $1000 R_J$  away



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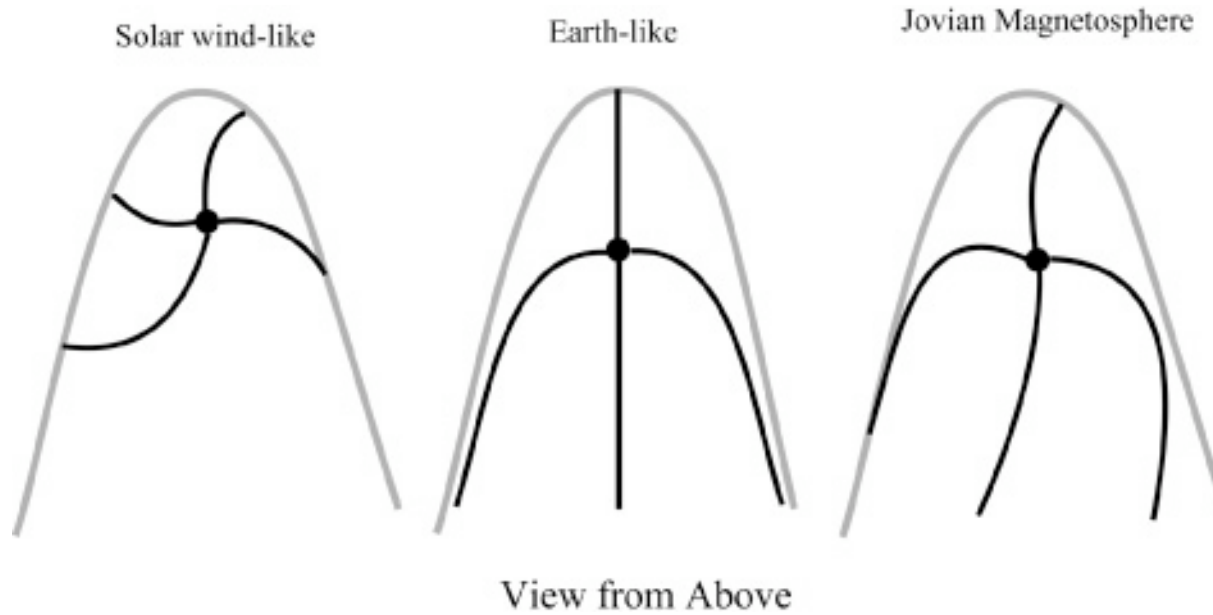
# Processes controlling Jovian magnetosphere

Jupiter magnetic field strength -  
“surface” equatorial field = 700,000 nT

Jupiter corotation rate - 9.6 hours

Internal plasma source - 1 ton s<sup>-1</sup> lost from Io

# Corotation

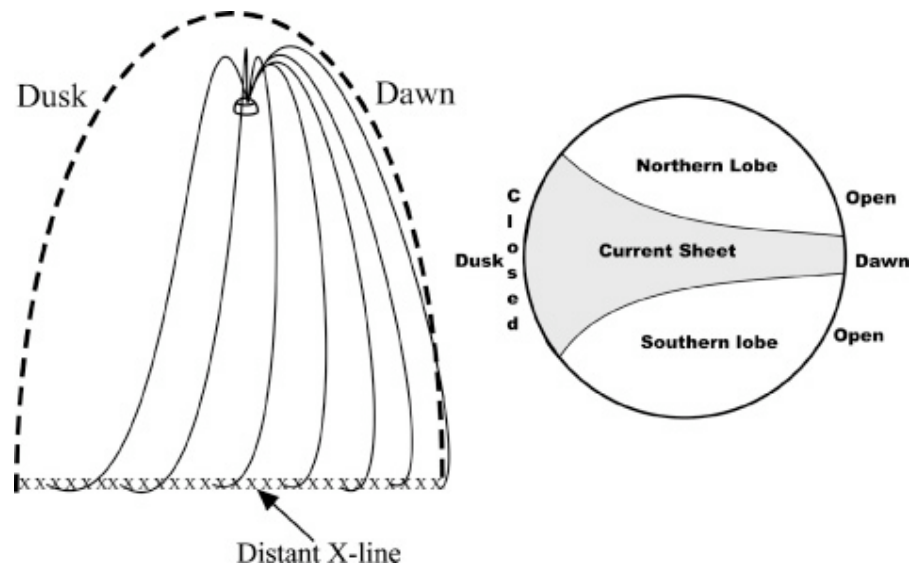


Moons travel into their own wake  
Io's orbital velocity =  $17 \text{ km s}^{-1}$   
Plasma flow velocity =  $74 \text{ km s}^{-1}$

# Magnetotail

Corotation (in addition to other processes) leads to significant dawn - dusk asymmetry

Bi-directional streaming plasma observed by Ulysses  
⇒ closed fieldlines



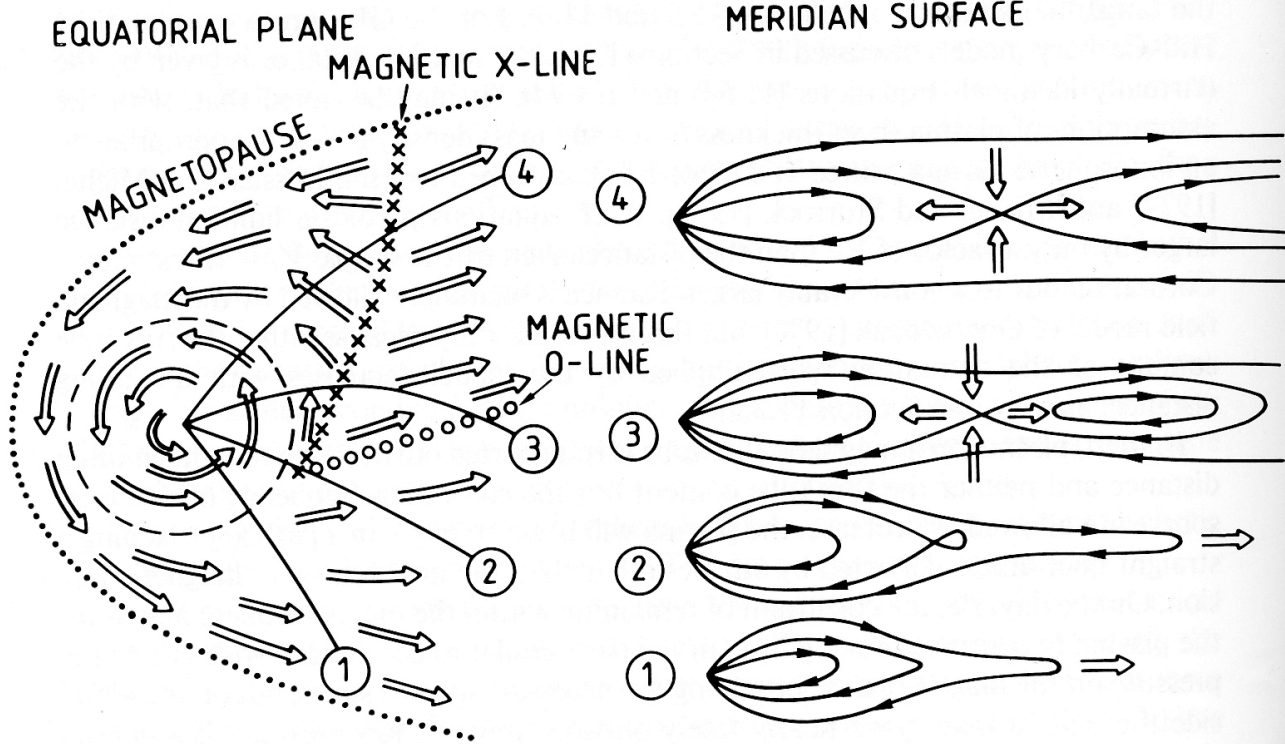




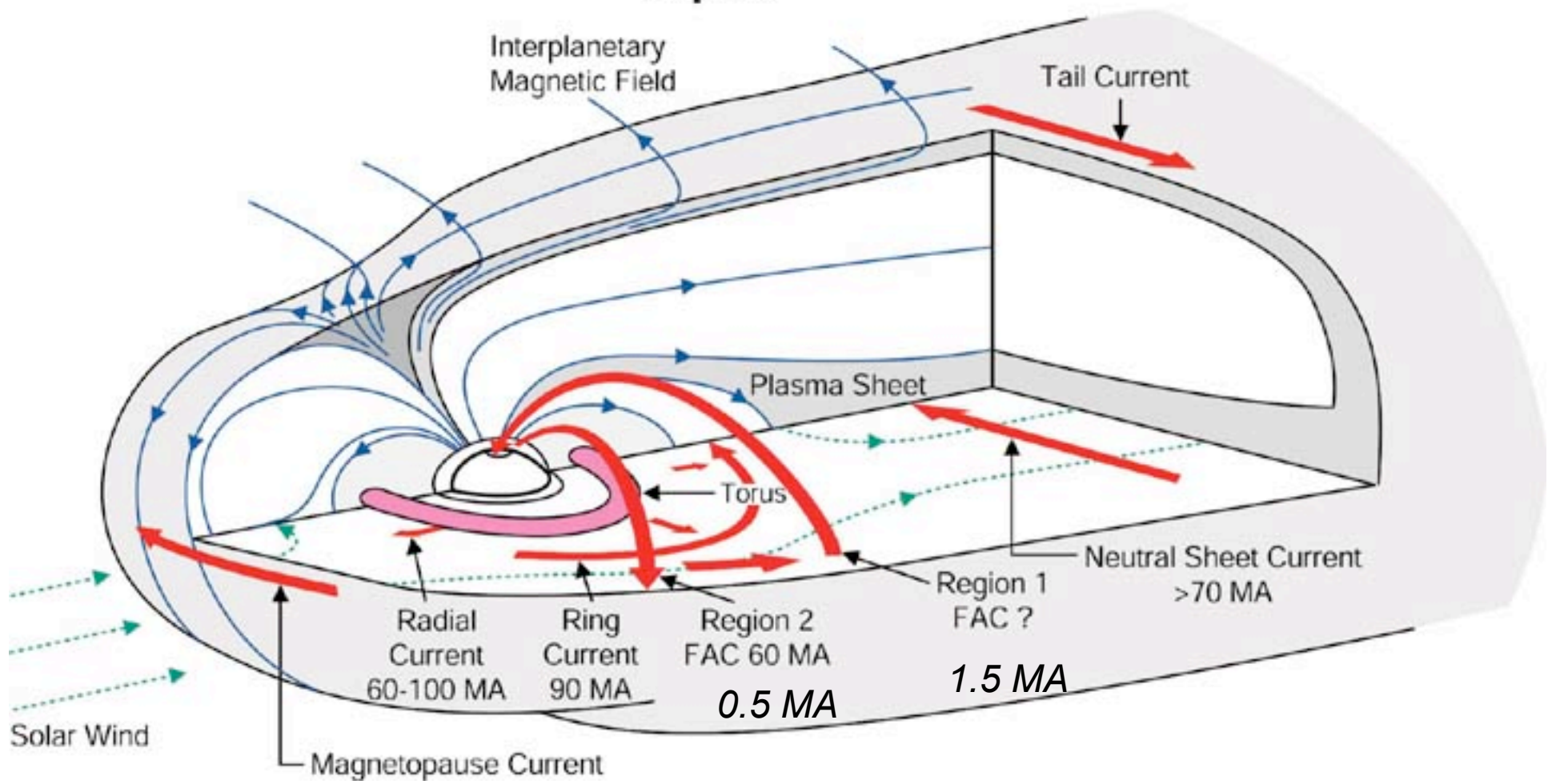
# Reconnection - Vasyliunas model

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*Physics of the Jovian magnetosphere*



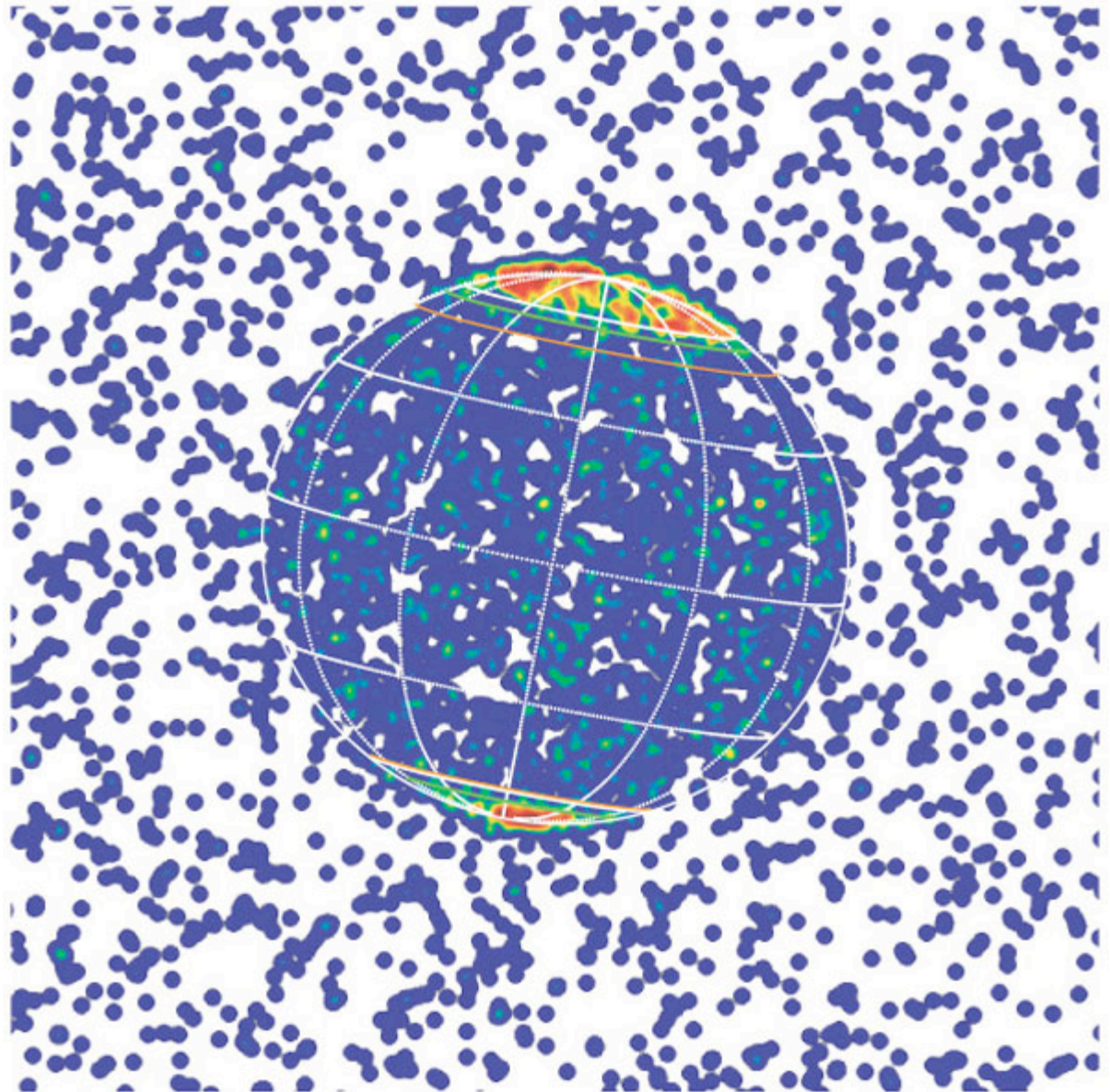
# Jupiter



Pulsating X-ray spot  
– 45 minute period

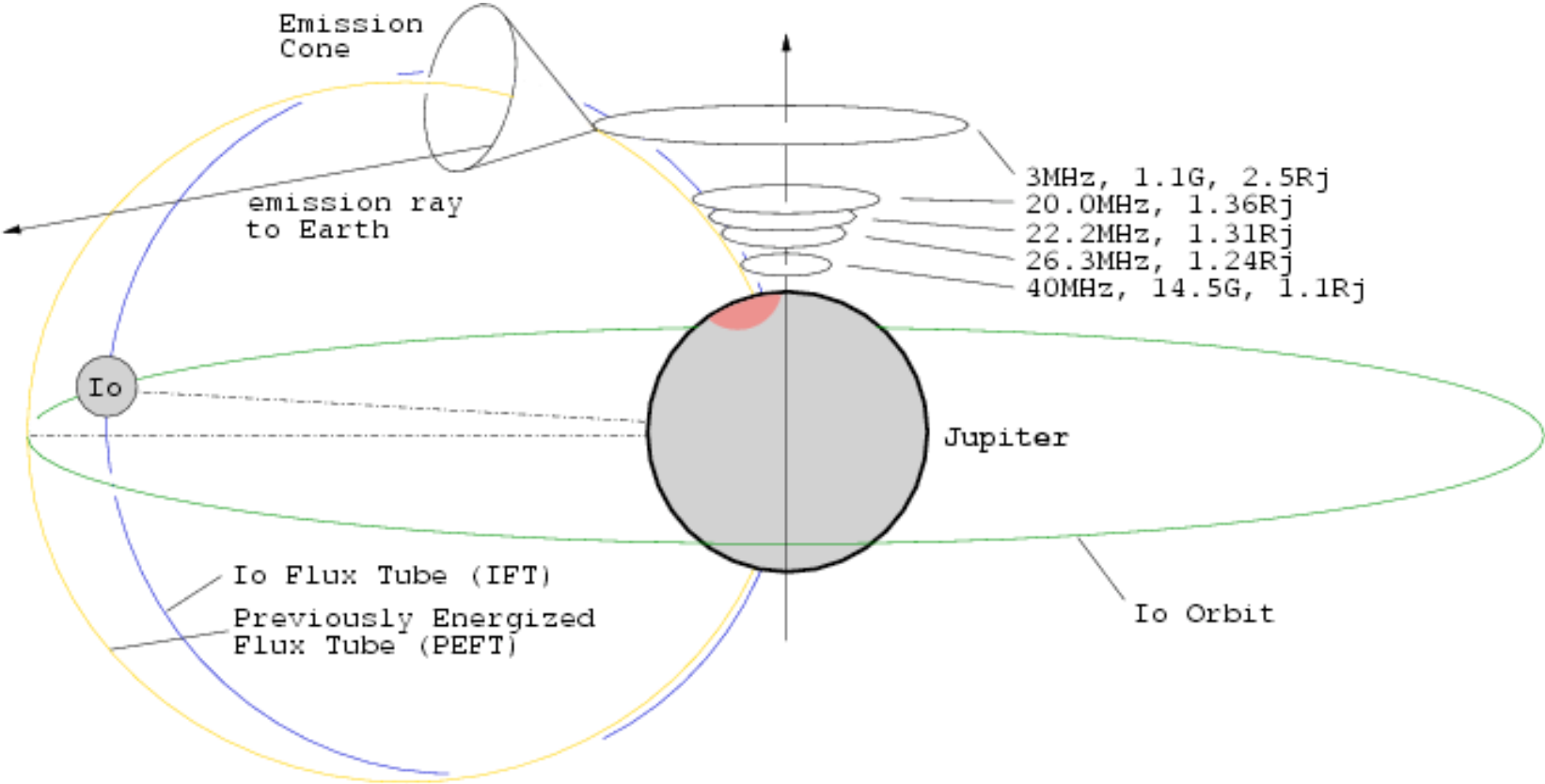
Relativistic electrons with  
40 minute intensity variations  
on the dusk side, high latitude

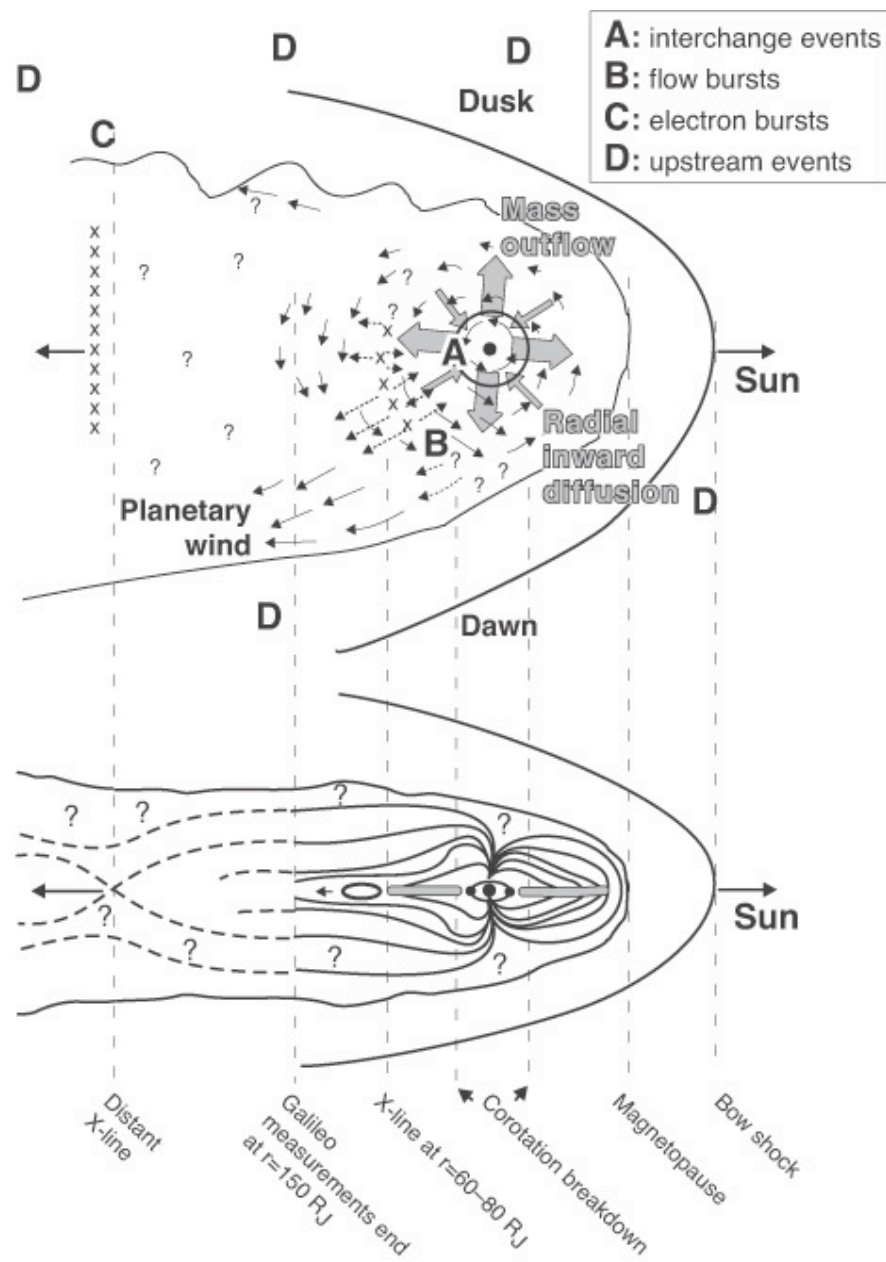
Quasi-periodic explosive  
magnetic merging process

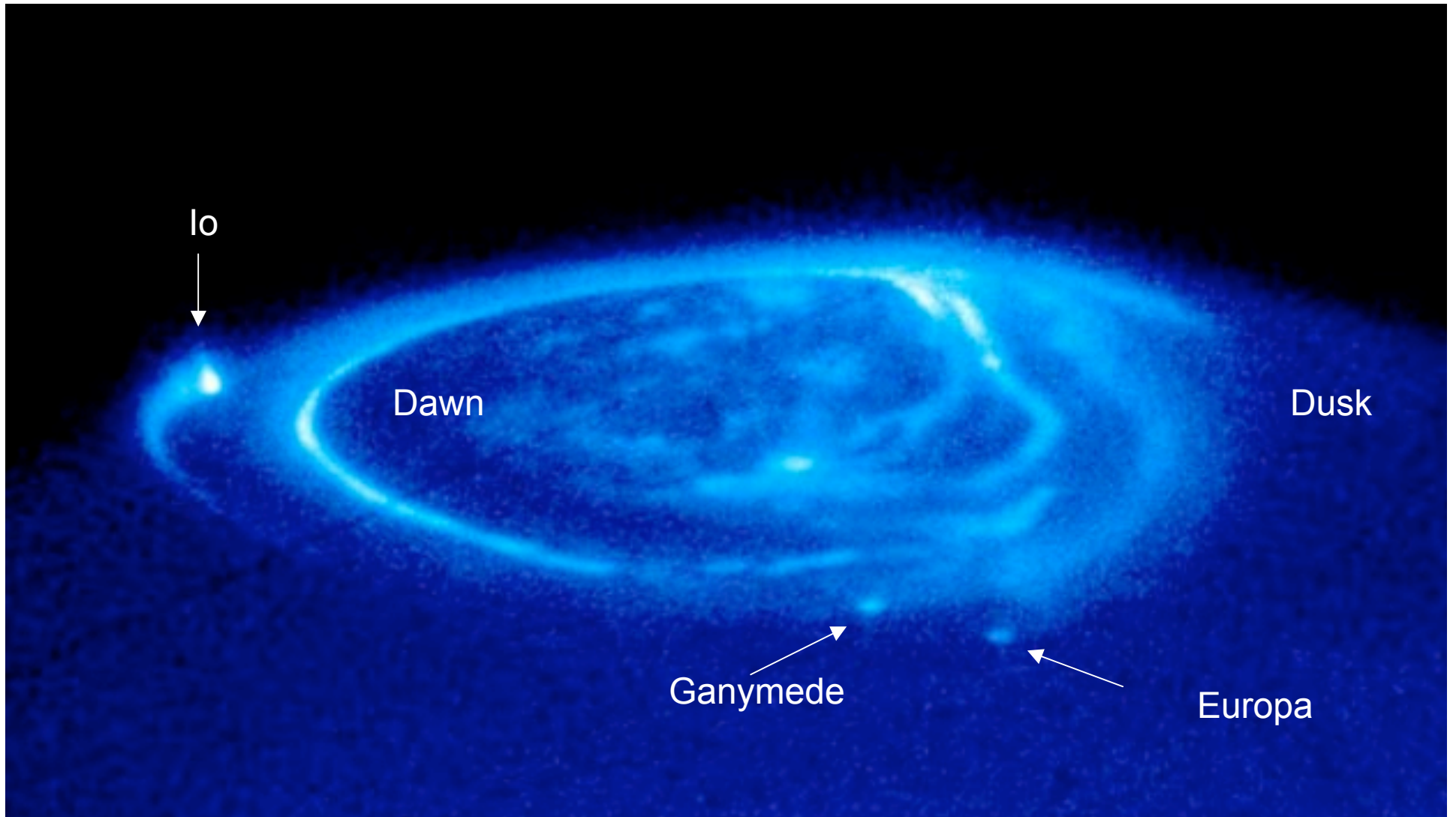


Brightness (R)

During quiet solar activity times, Jupiter a stronger radio source than the Sun

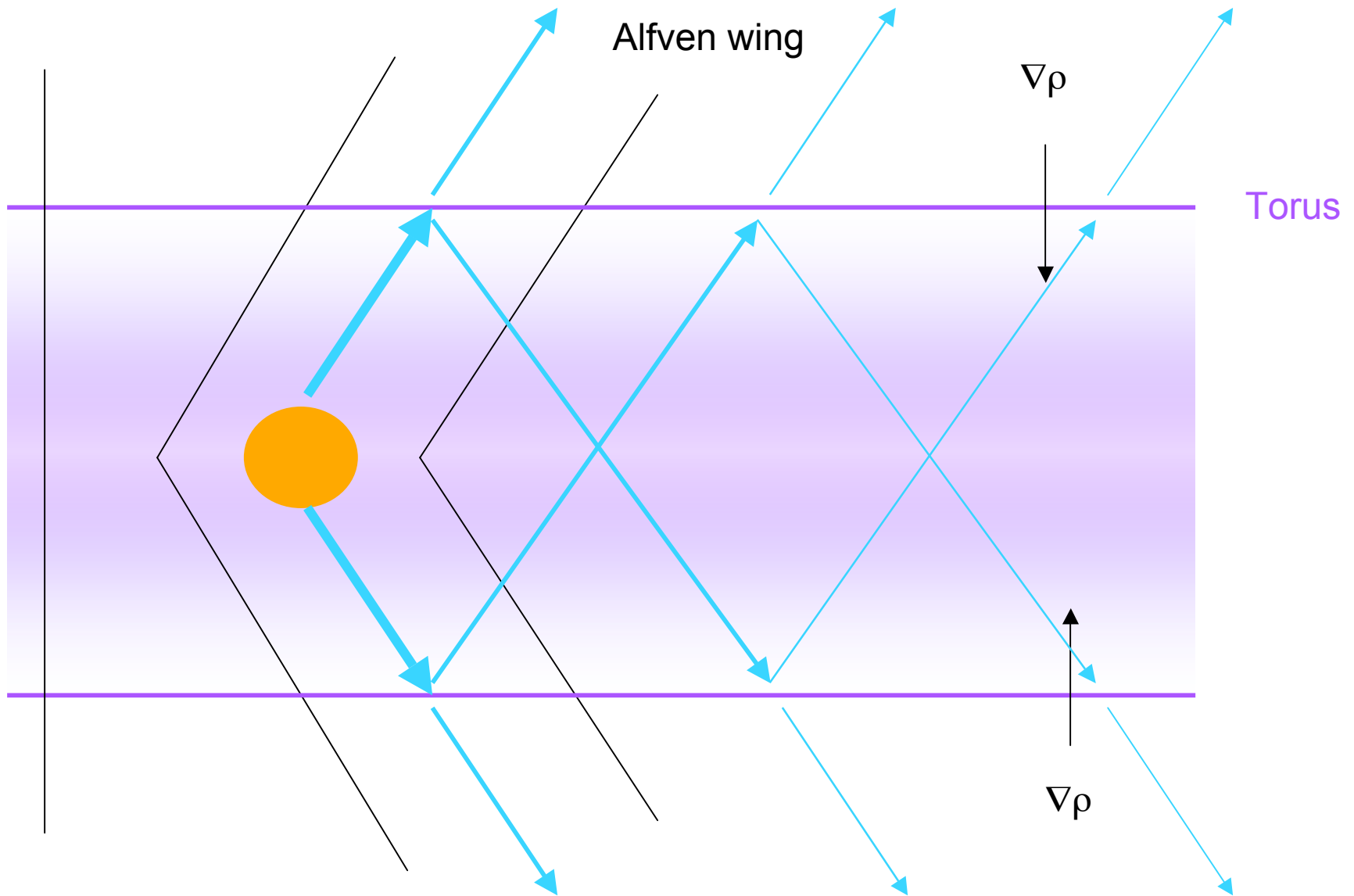




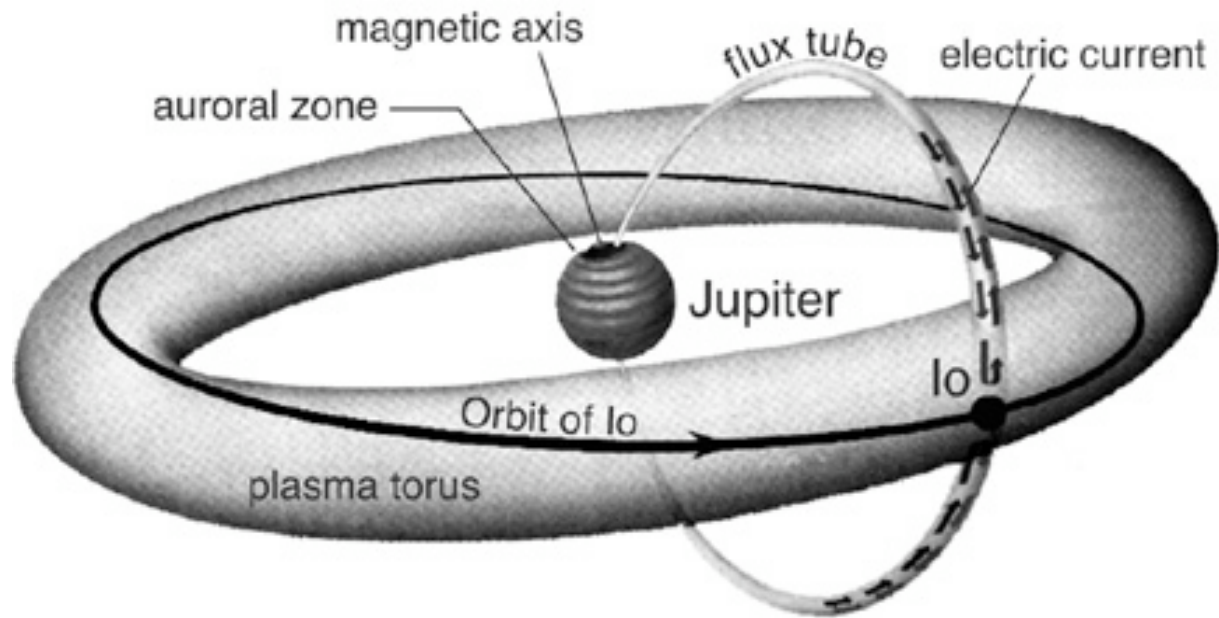


Closure of corotation currents in the auroral zone?

# Multiple Footprint Aurora





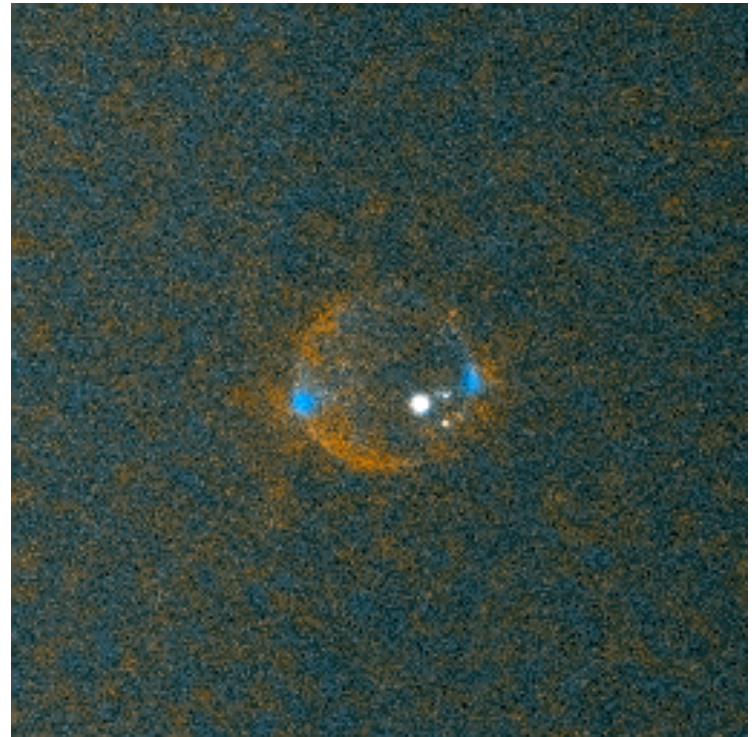
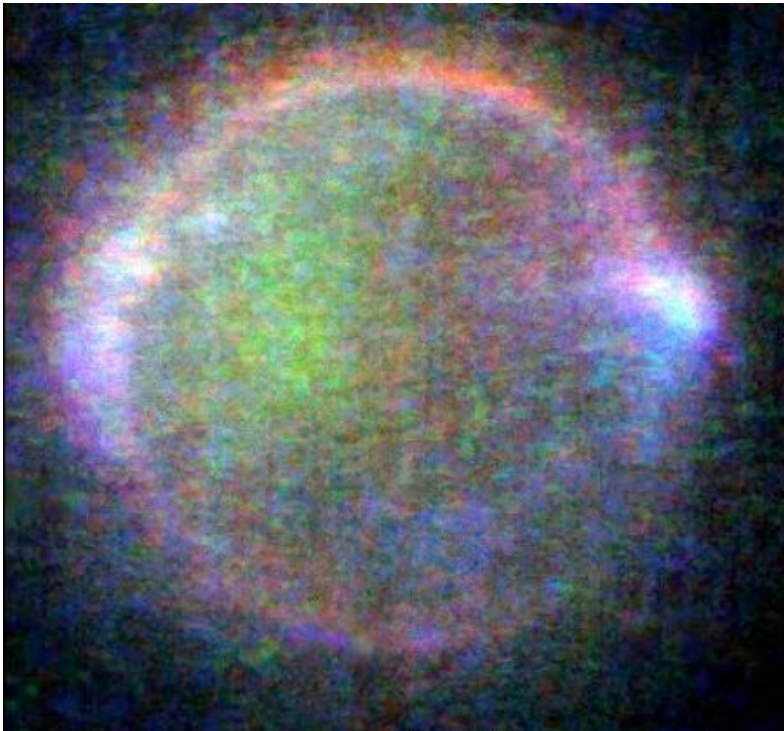


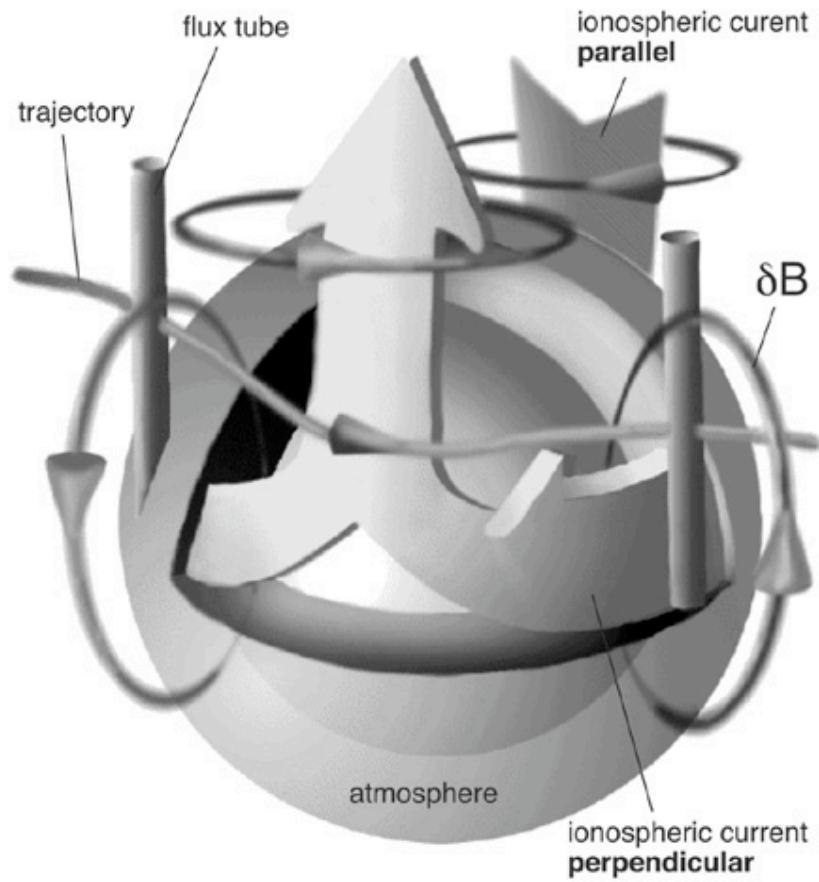
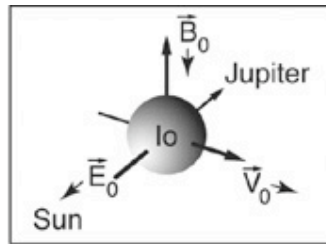
$$M_A = 0.3$$

$$\beta = 0.04$$

$M_s > 1$  but fast Mach number  $< 1$

Io has equatorial aurora





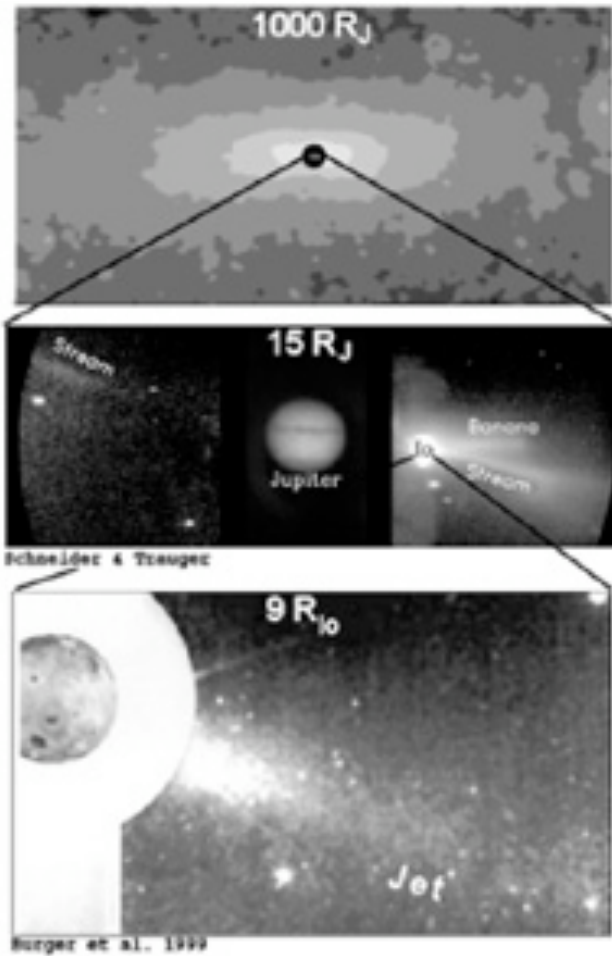
# Plasma Density and Flow

Io's ionosphere is strongly advections dominated

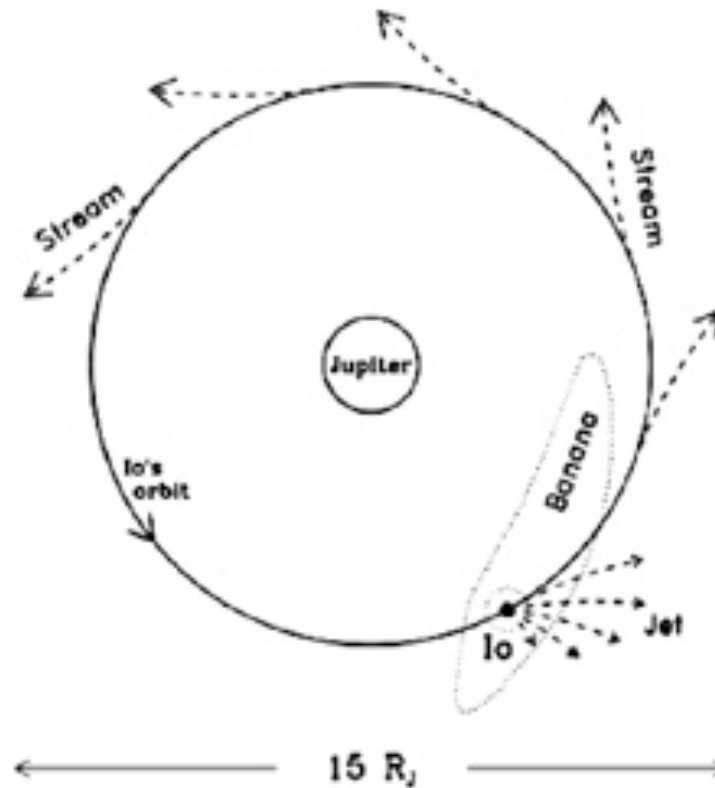
Plasma slowed in Io's ionosphere, redirected around moon, and then reaccelerated in the wake (by  $\sim 6R_J$ ).

Ionosphere has smaller density and smaller scale height on upstream side  
maximum density seen in the flanks  $\sim 10x$   
enhancement in wake  $\sim 5x$

How is mass supplied to torus? How is it heated/accelerated?

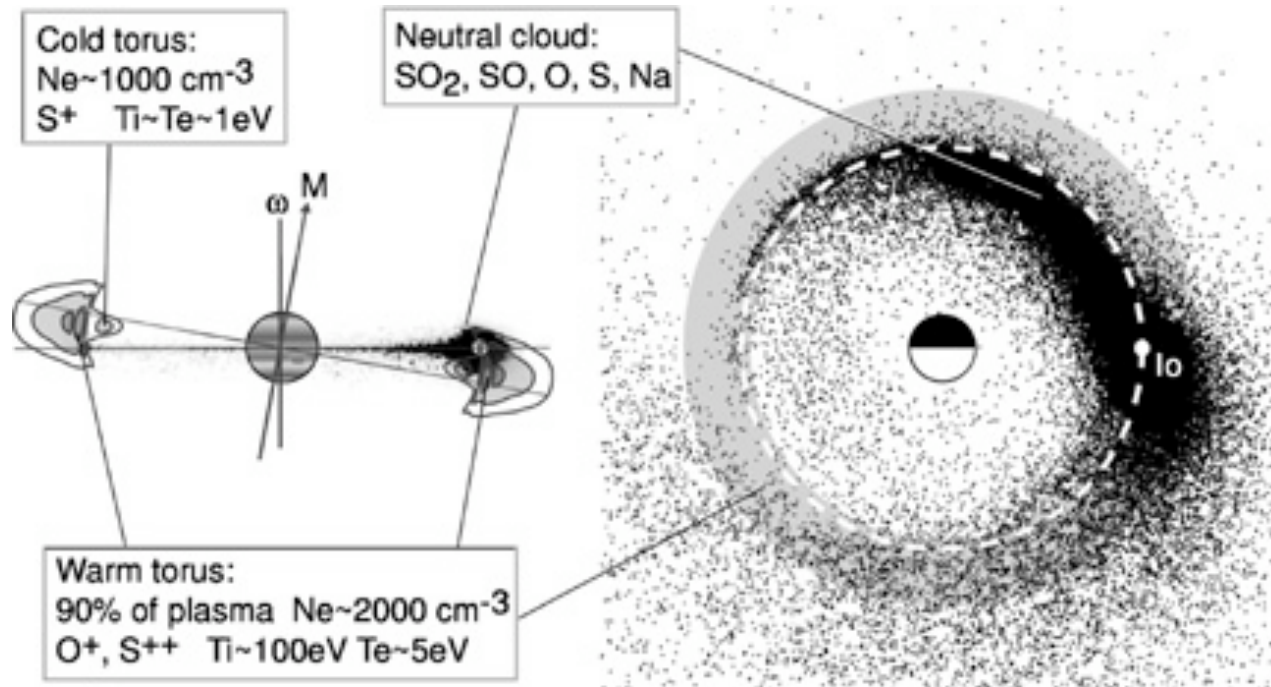


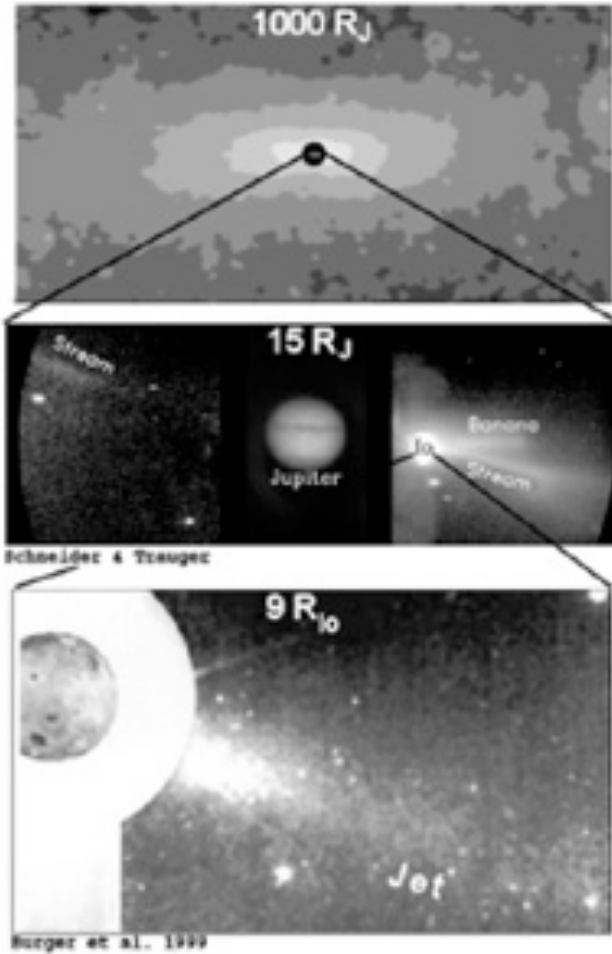
## IO SODIUM CLOUDS



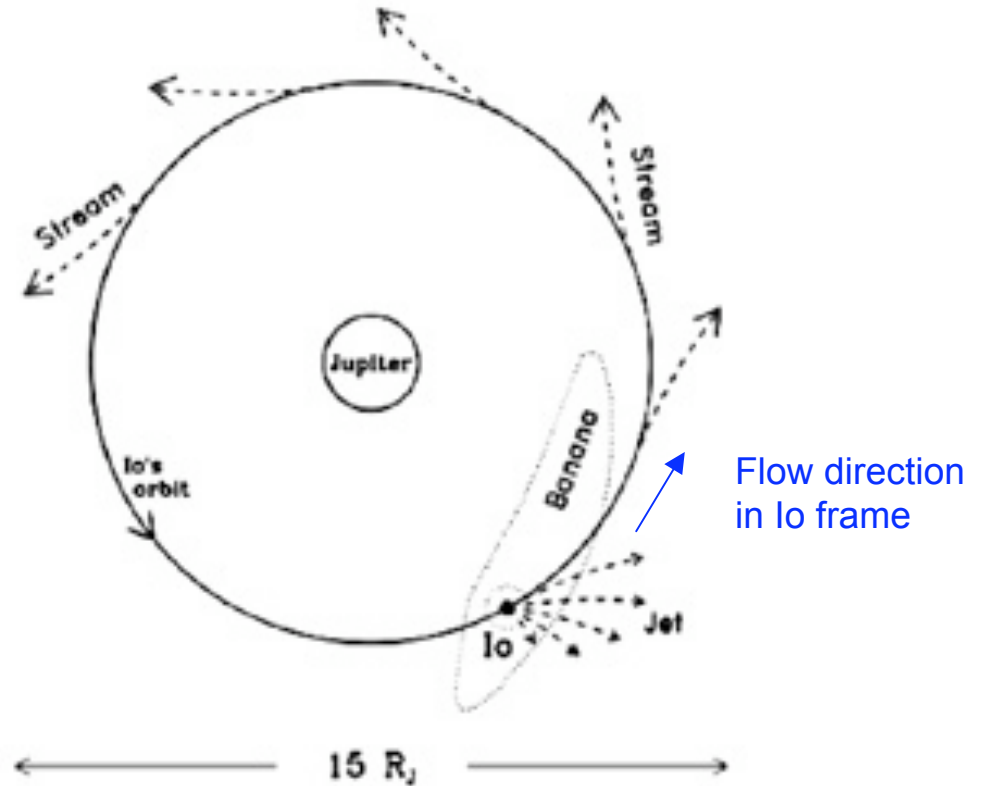
About 2/3 of iogenic material lost through charge exchange

# Neutral Cloud

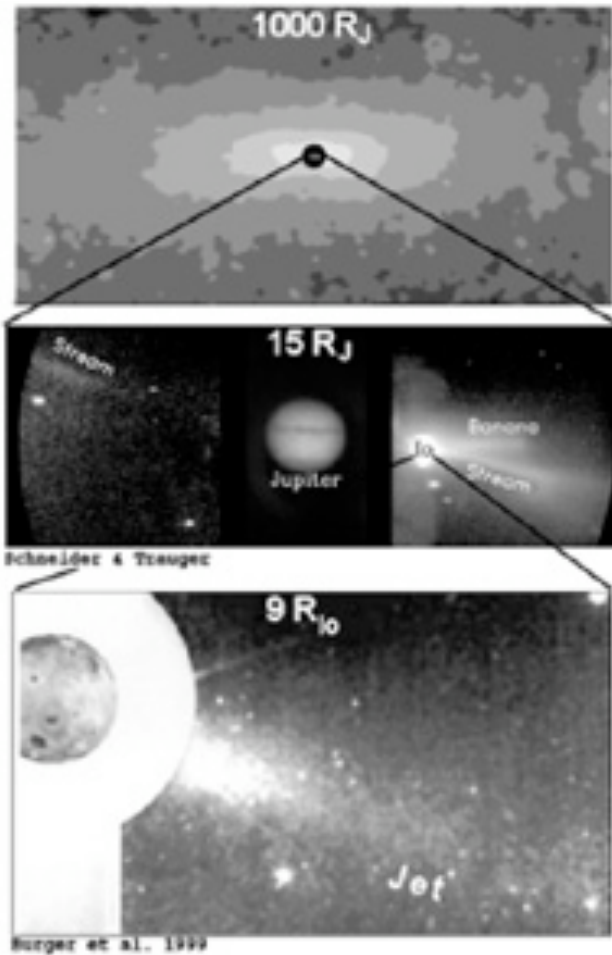




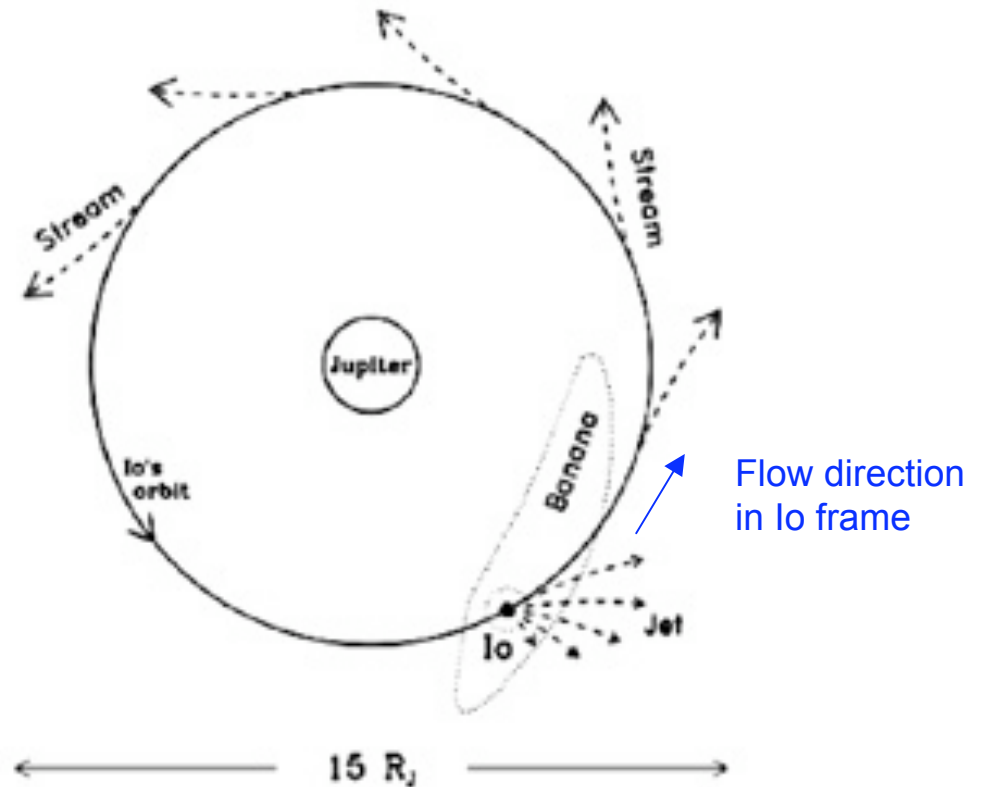
## IO SODIUM CLOUDS



Jet : Electric fields associated with Jupiter's magnetospheric interaction with Io rip ions out of Io's collisionally thick atmosphere.

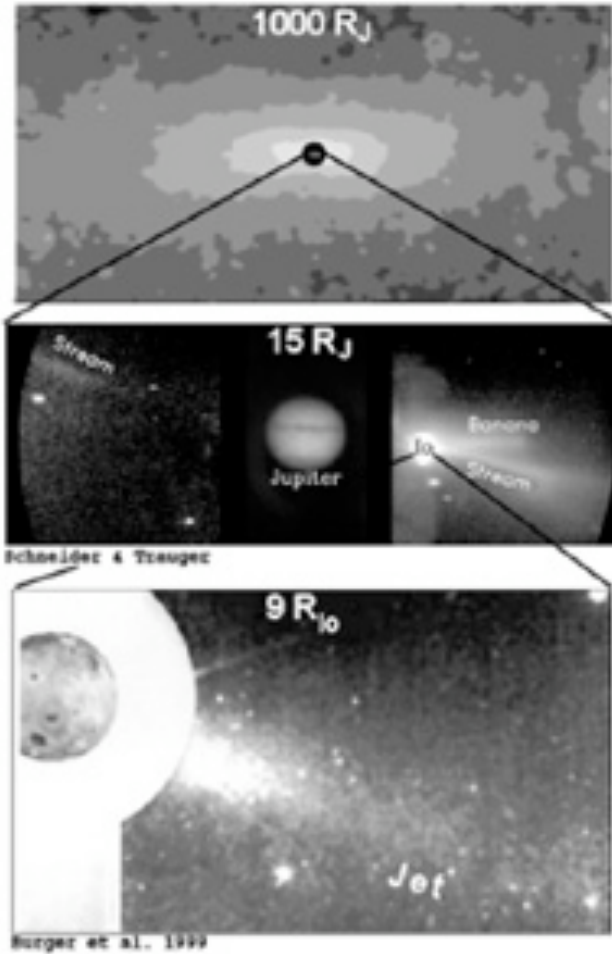


## IO SODIUM CLOUDS

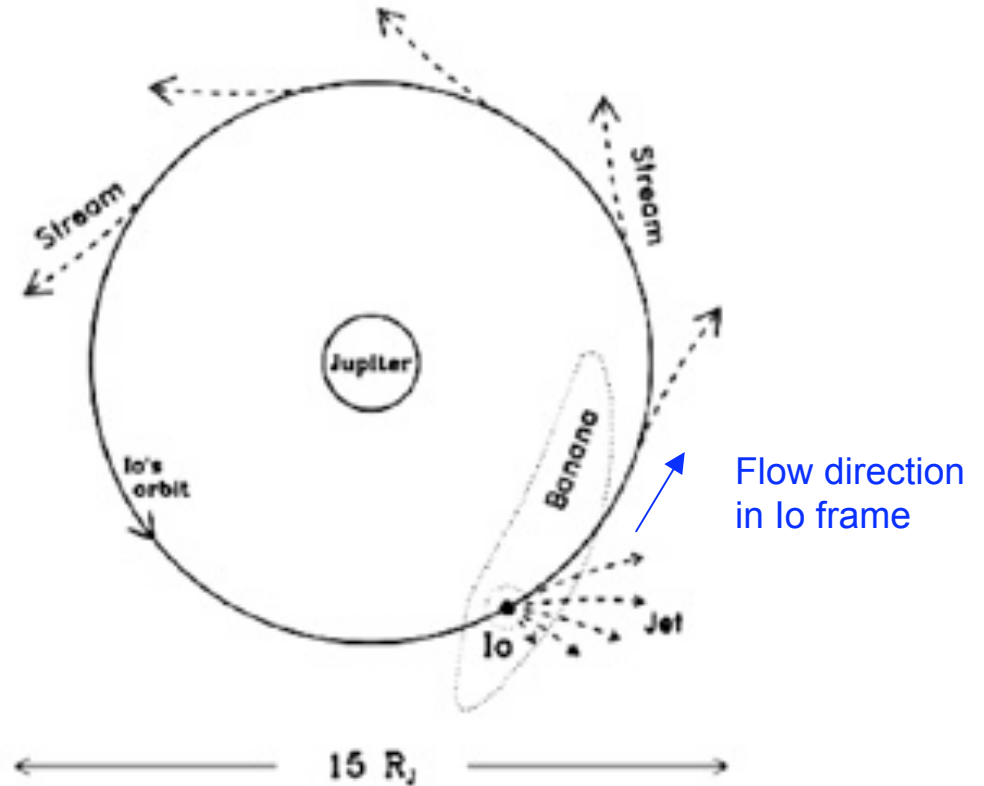


Stream : Leads Io's orbit and undulates above and below the centrifugal equator. Stream formed by  $\text{NaX}^+$ .





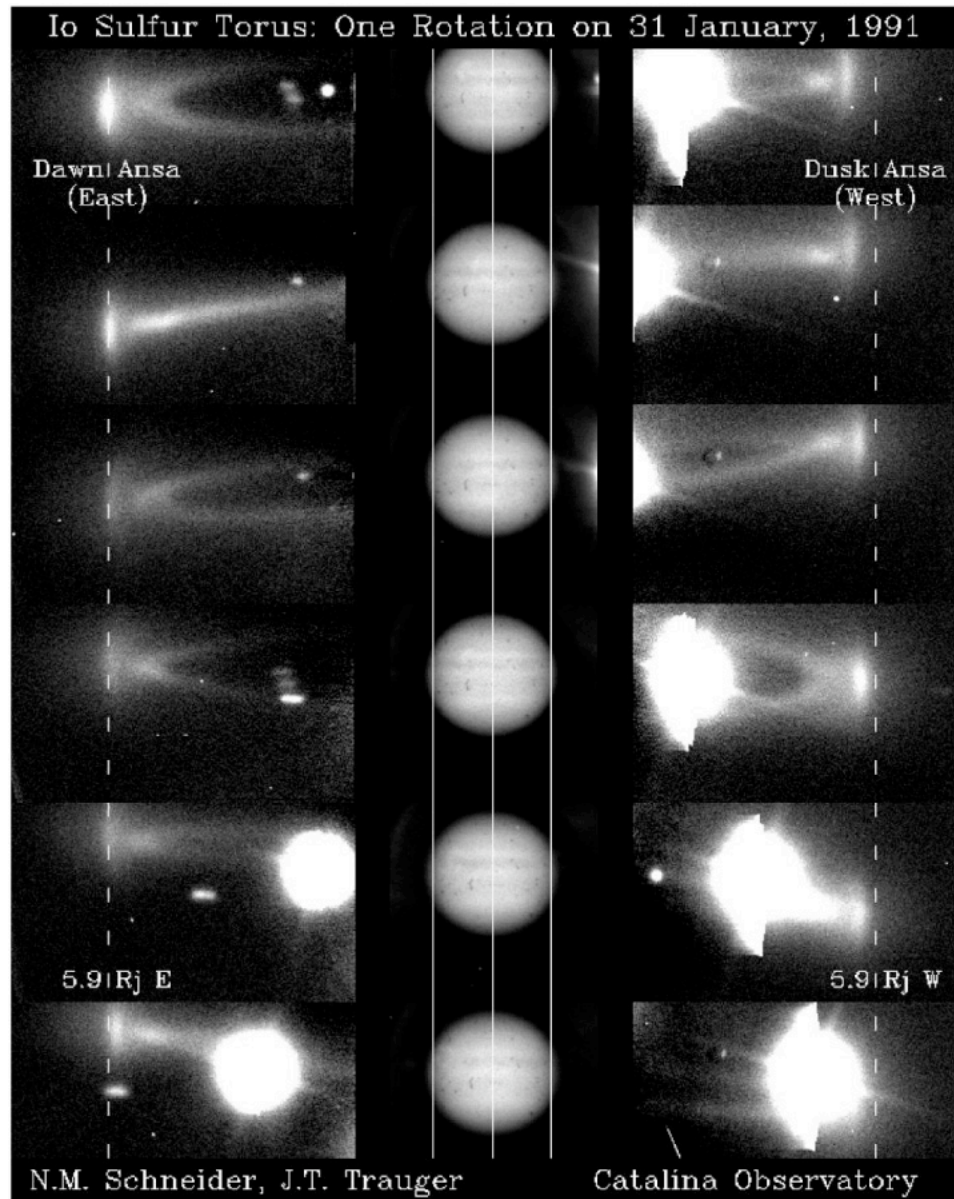
## IO SODIUM CLOUDS



Banana : Low energy neutral cloud generated by sputtering

# Ribbon - tracer for position of max density

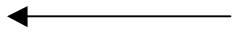
At the same radial distance as Io



Closer to Jupiter than Io, at  $\sim 5.6 R_J$

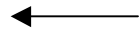
# Ribbon

*Jupiter* Cold torus



$T_i, n_e, n_i$  decrease  
 $n_e, n_i$  increase at  
 center to cold torus

Ribbon

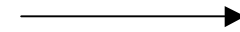


$T_i$  decrease  
 $n_e$  increase

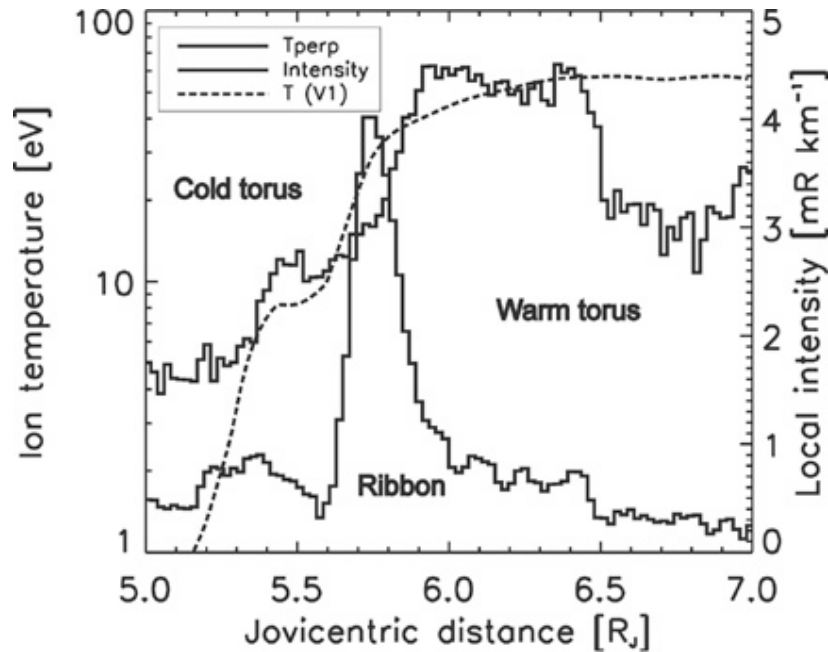
Io

$T_i$  peak

Warm torus



$n_e, n_i$   
 Decrease  
 $T_i, T_e$  ?



S<sup>+</sup> emissions