PTYS544

Physics of the High Atmosphere

Basic details

- Location / Time
  - Tuesday & Thursday, 12:30 – 13:45
  - Kuiper Space Science (KSS)
- Instructor
  - Tommi Koskinen, KSS 421
  - tommik@email.arizona.edu

Temperatures in the thermosphere

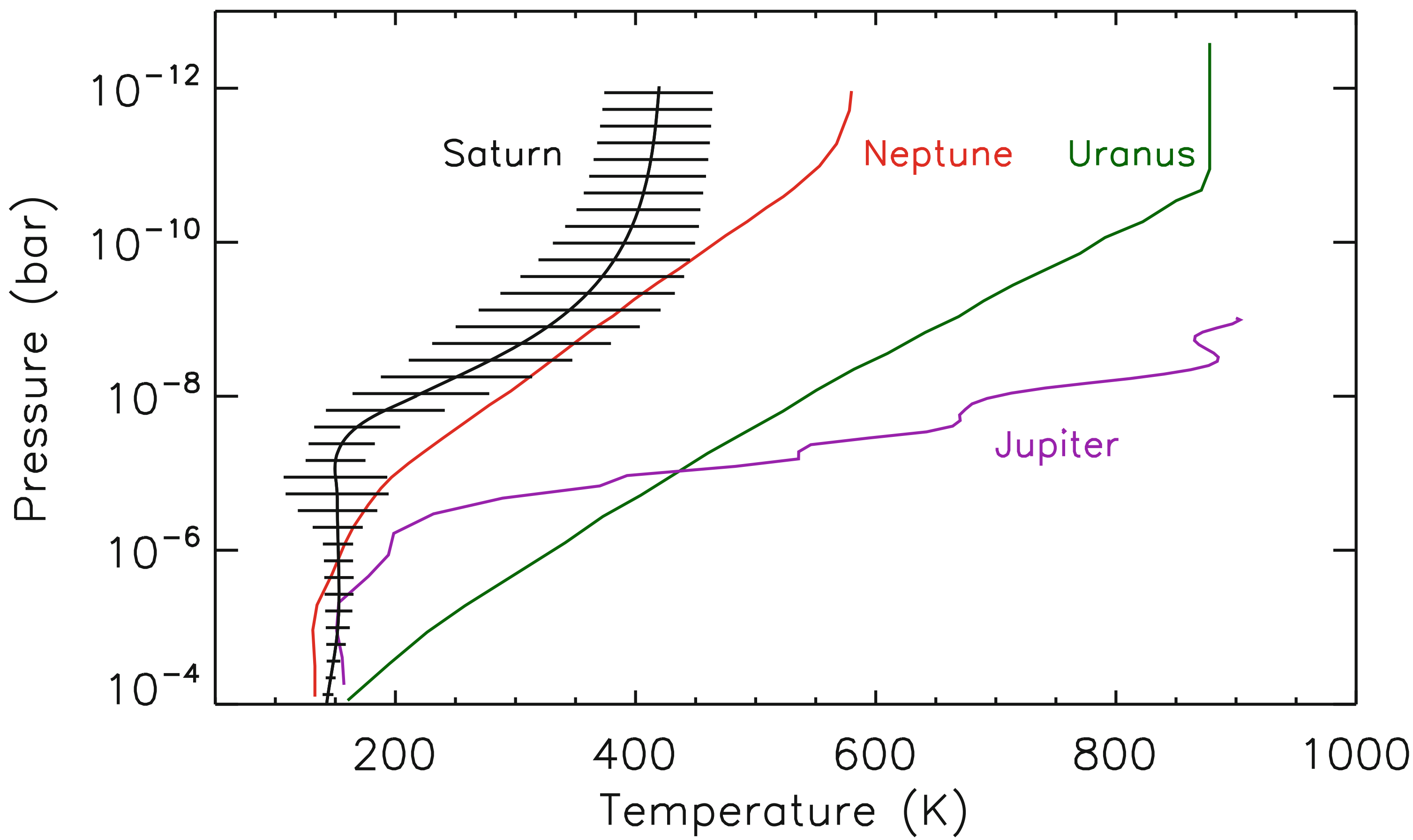
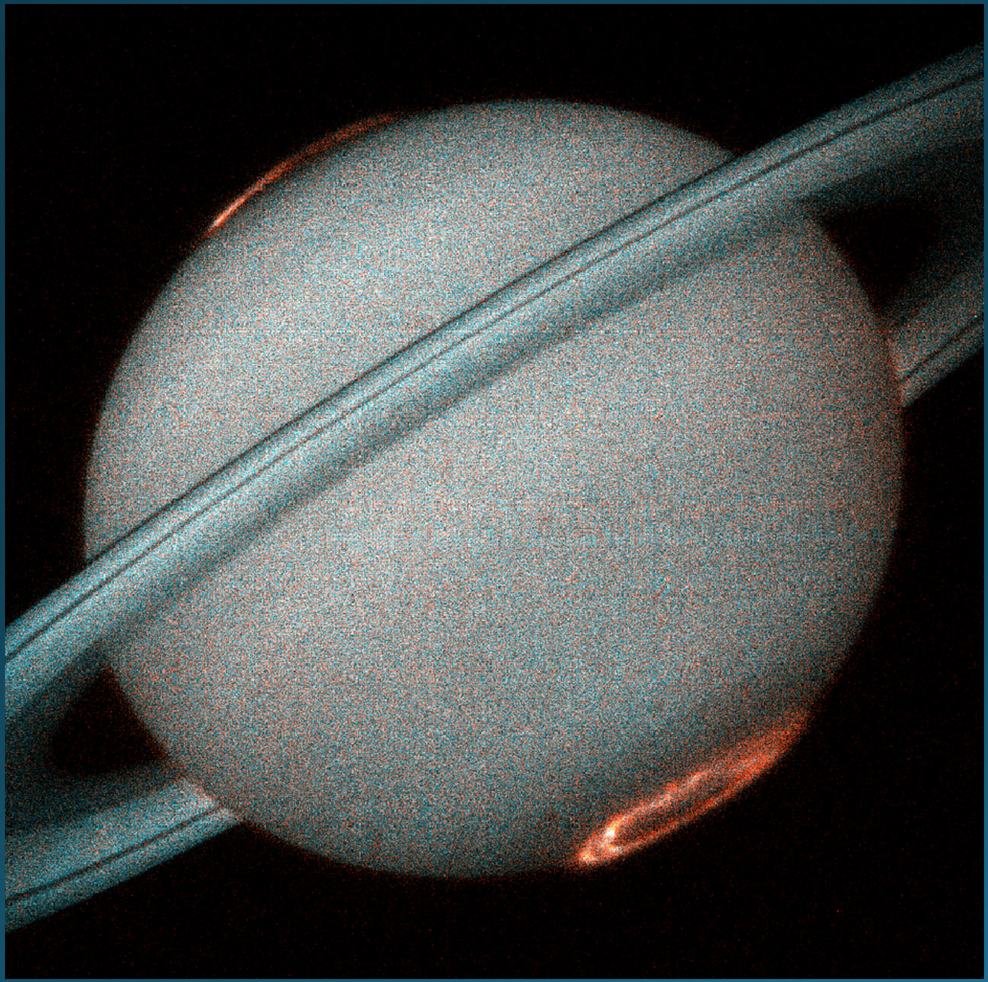
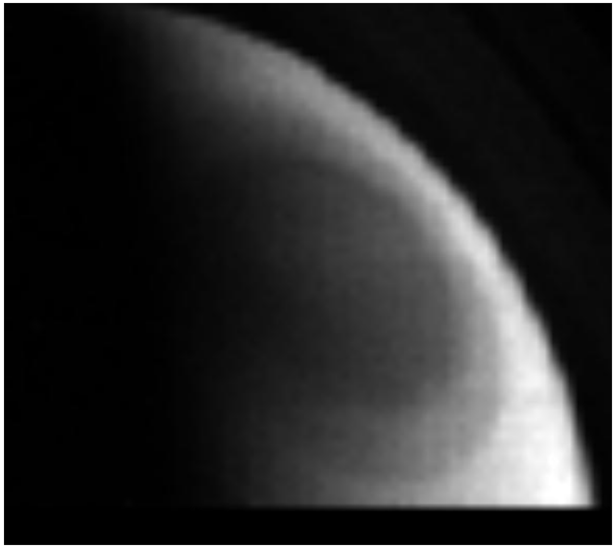


Figure from Garcia Munoz, Koskinen, Lavvas (2017)

The aurora on Saturn



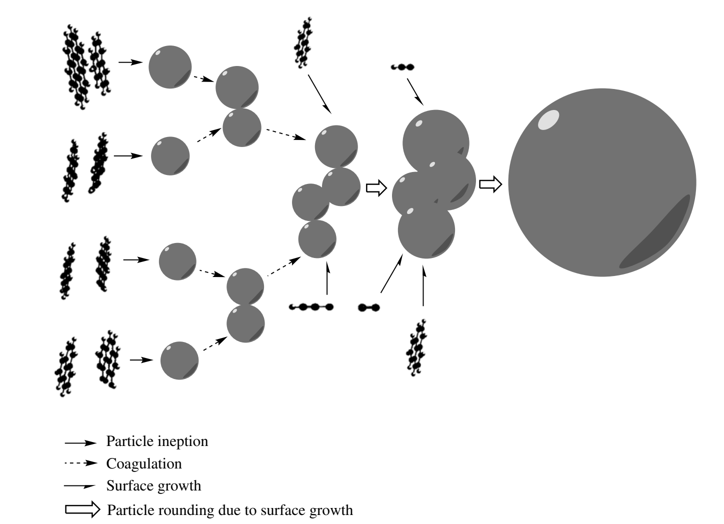
HST image of the UV aurora on Saturn (left), below is a UV image showing a dark polar hood (Saganaki et al. 2016).



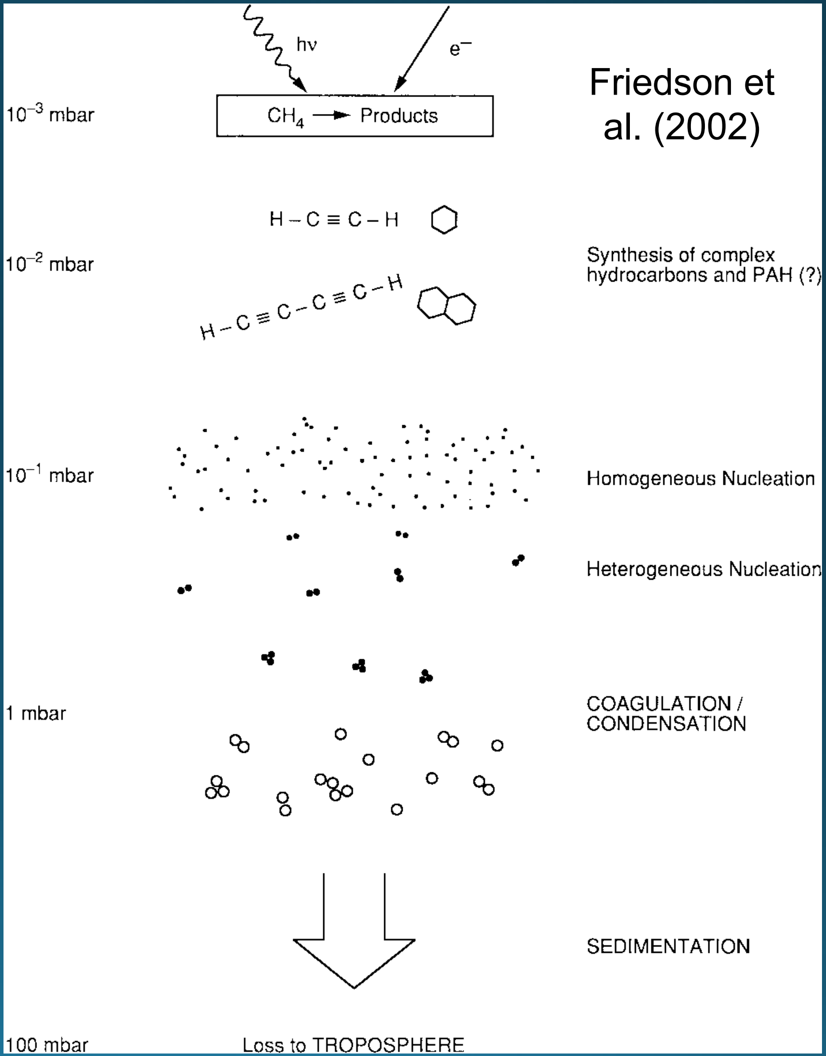
171.2-191.0 nm

The aurora and photochemical haze

Karkoschka and Tomasko (2005) conclusion from analysis of HST data: “The second principal variation is a variable optical depth of stratospheric aerosols. The optical depth is large at the poles and small at mid- and low latitudes with a steep gradient in-between.”

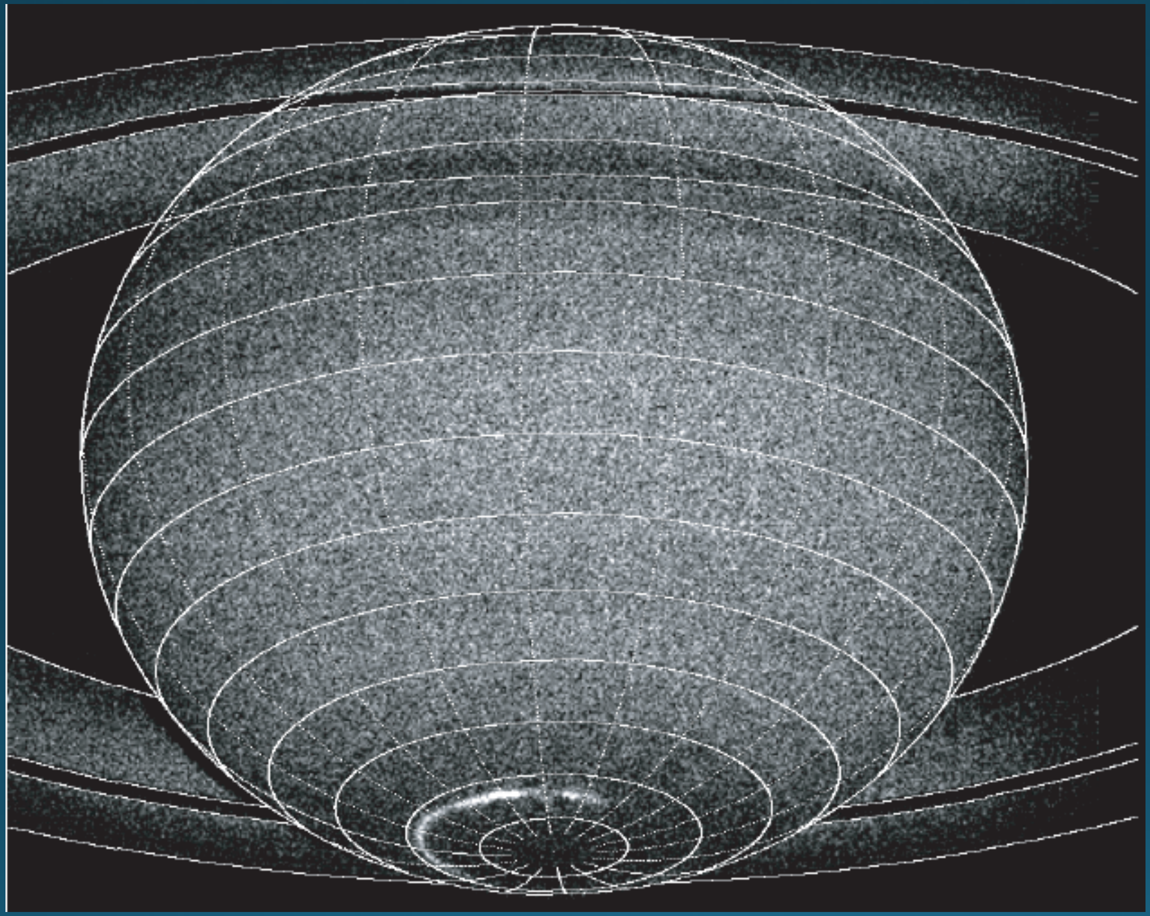


Growth of initial, spherical particles (Lavvas et al. 2011)



Friedson et al. (2002)

Auroral electrodynamics



HST/STIS UV image of Saturn aurora in the south
(Cowley et al. 2004a,b)

Plasma flows in the equatorial plane

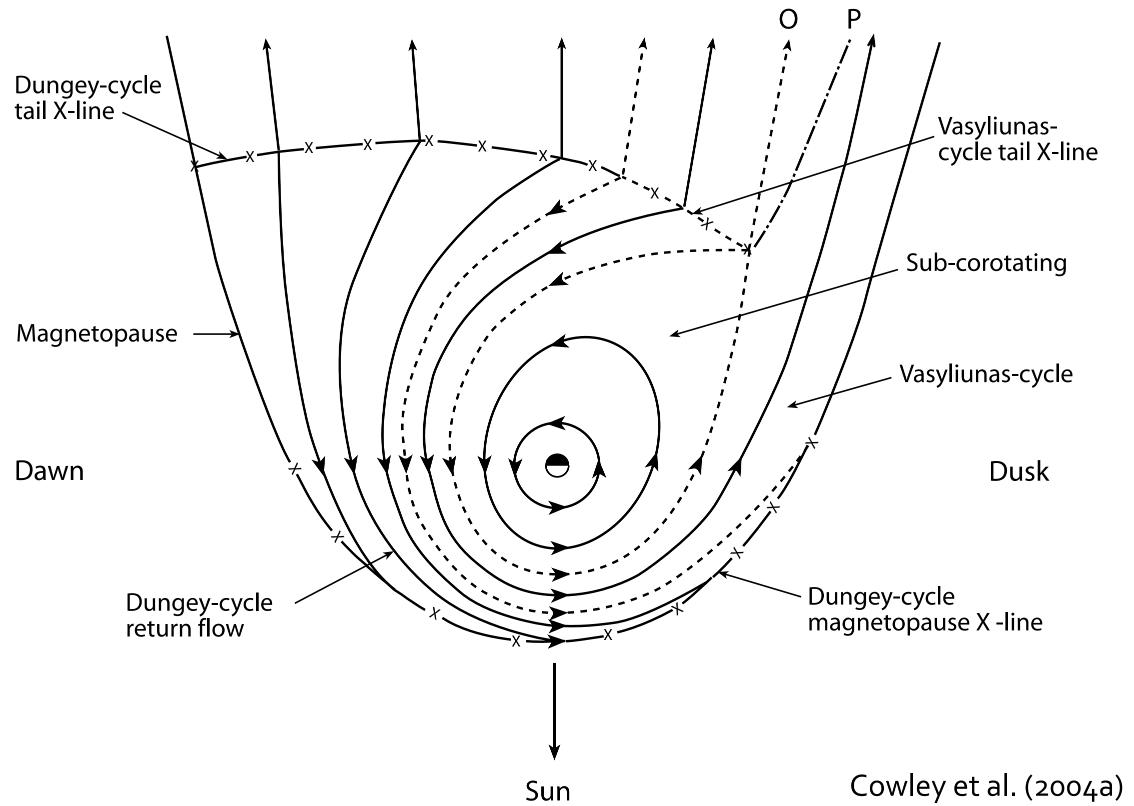


Fig. 2. Sketch of the plasma flow in the equatorial plane of Saturn's magnetosphere, where the direction to the Sun is at the bottom of the diagram, dusk is to the right, and dawn to the left. Arrowed solid lines show plasma streamlines, arrowed short-dashed lines the boundaries between flow regimes (also streamlines), the solid lines joined by Xs the reconnection lines associated with the Dungey cycle, and the dashed lines with Xs the tail reconnection line associated with the Vasyliunas cycle. The two tail reconnection lines are shown as being contiguous, but this is not necessarily the case. The line indicated by the "O" marks the path of the plasmoid O-line in the Vasyliunas-cycle flow (also a streamline), while "P" marks the outer limit of the plasmoid field lines, which eventually asymptotes to the dusk tail magnetopause.

Ionospheric flows

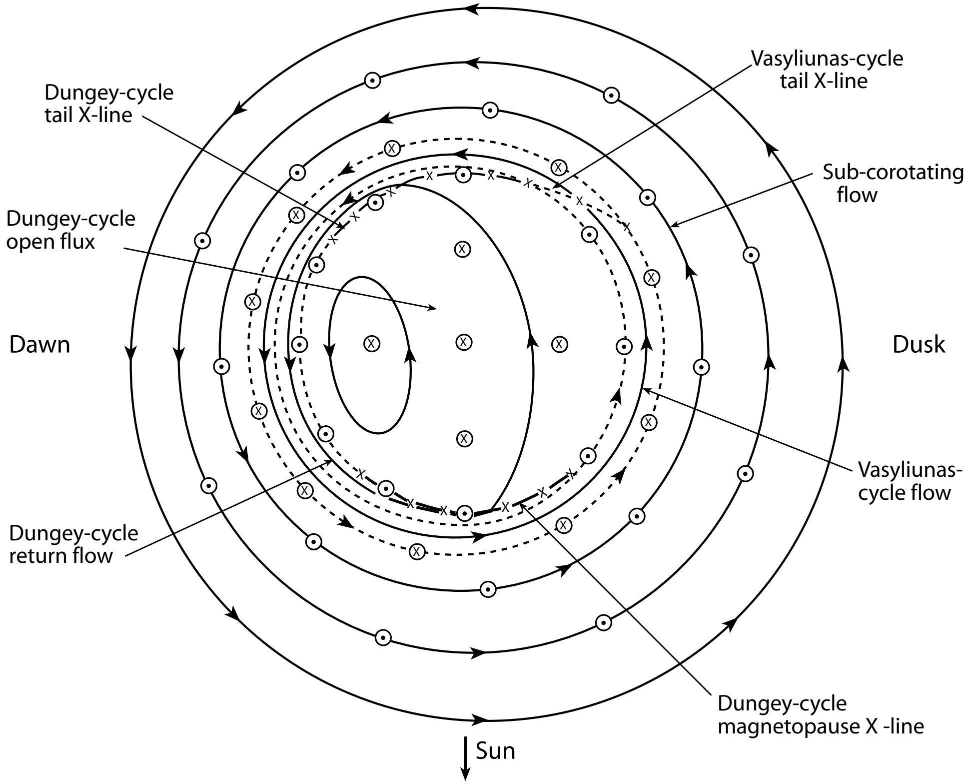


Fig. 3. Sketch of the plasma flow in the northern kronian ionosphere in a format following that of Fig. 2, where the direction to the Sun is at the bottom of the diagram, dusk is to the right, and dawn to the left. The outermost circle corresponds to a co-latitude of ~30° from the pole, which maps to the equatorial plane at a radial distance of ~3 R_S. Circled dots and crosses indicate regions of upward and downward field-aligned current, respectively, as indicated by the divergence of the horizontal ionospheric current. Hall currents flow generally anti-clockwise round the pole and close in the ionosphere, while Pedersen currents flow generally equatorward and close in the field- aligned current system shown.

Rotation in the equatorial plasma

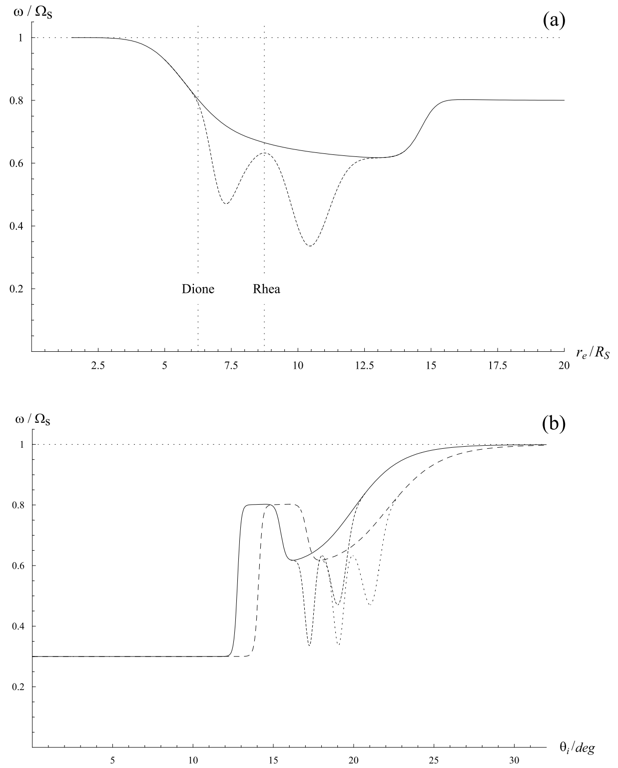
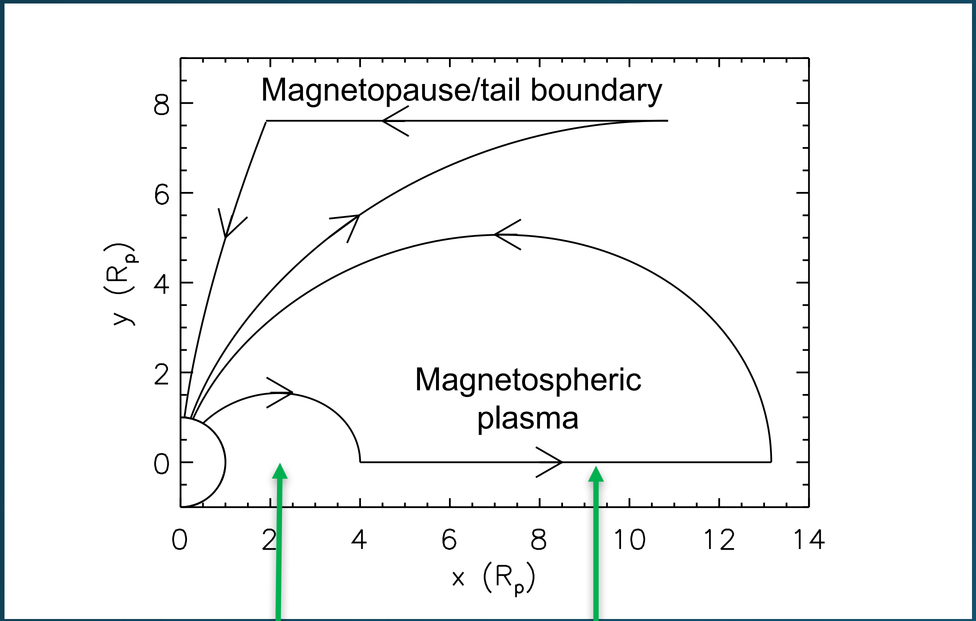
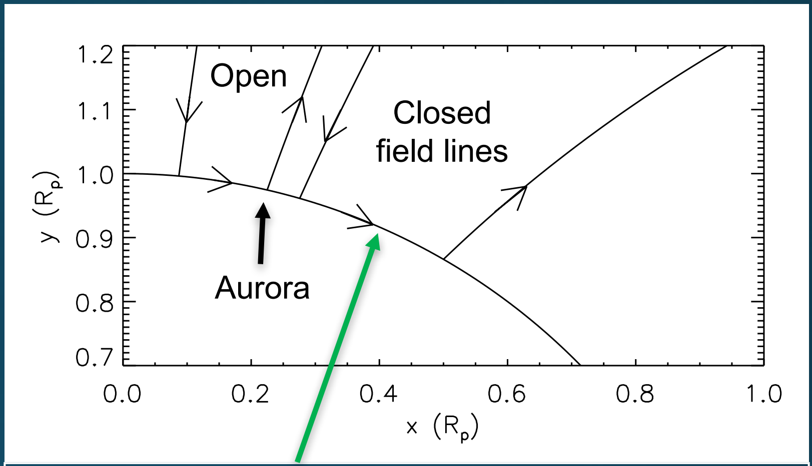


Figure 4. (a) Plot of the model (ω/Ω_S) profiles mapped along field lines into the equatorial plane and shown as a function of radial distance, r_e, from the planet, normalized to the conventional Saturn radius, R_S. The solid curve shows the closed field model given by equation (15), while the short-dashed curve shows the effect of adding the possibly moon-related angular velocity dips given by equation (16). The radial distances of the orbits of the moons Dione and Rhea are indicated by the vertical dotted lines, showing their relationship to these dips. (b) Plots of the model angular velocity profiles mapped along field lines into the northern and southern ionospheres and plotted versus the colatitude, θ_i, with respect to the corresponding pole. The solid and short-dashed curves show the profiles with and without dips in the northern ionosphere, while the long-dashed and dotted curves show the corresponding curves in the southern hemisphere. The profiles without dips correspond to the sum of equations (15) and (18), while the profiles with dips also add equation (16).

Based on Voyager data (Cowley et al. 2004b); time for me to update to Cassini data…

Polar heating





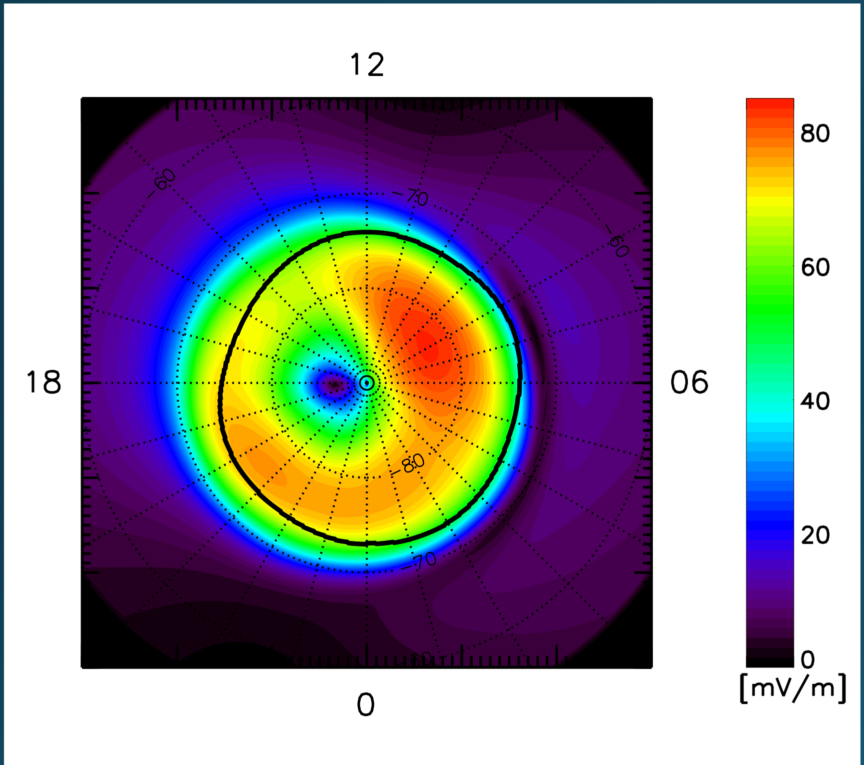
Perpendicular (Pedersen) current flows towards the equator in the polar ionosphere. Currents close along magnetic field lines.

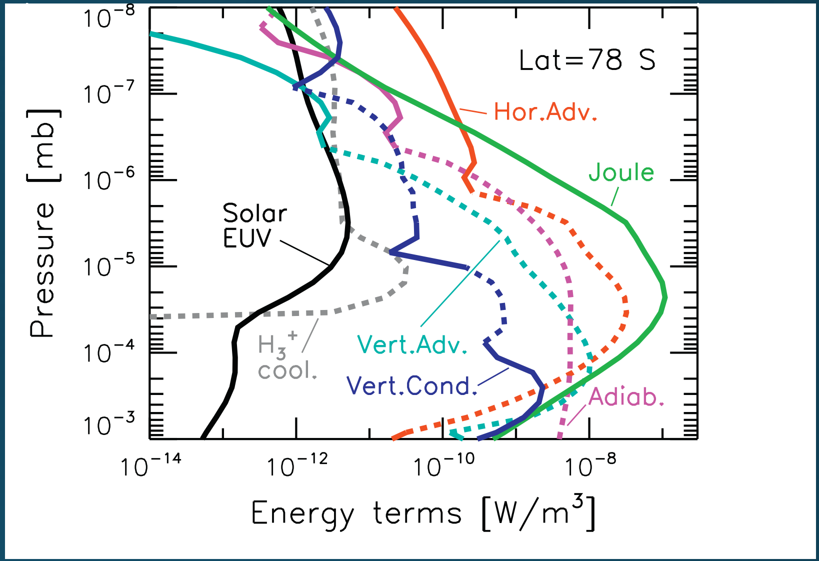
Co-rotating plasma

Sub-corotating plasma

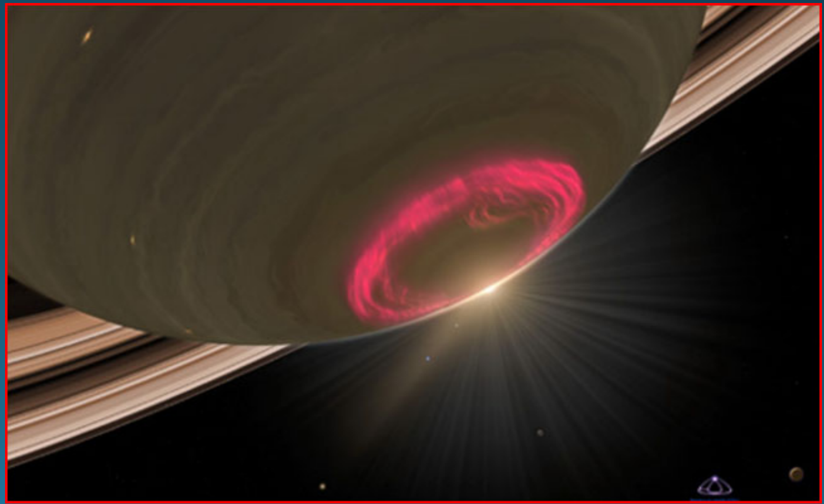
Joule heating provides ~4-8 TW of energy, solar heating provides 0.15-0.27 TW

Resistive (Joule) heating

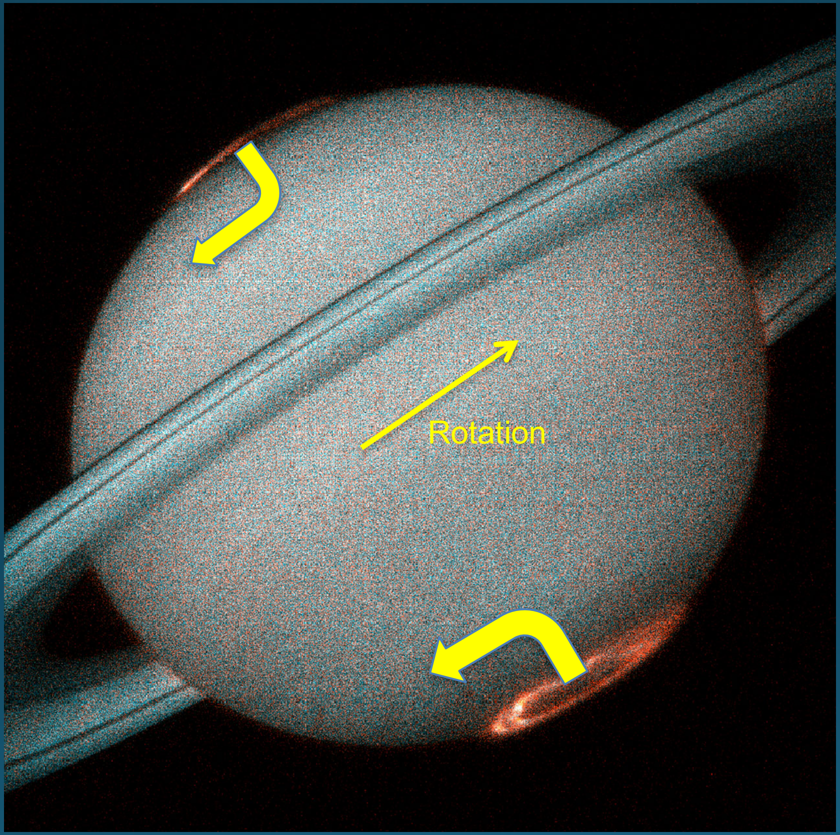




Simulated magnetospheric electric field mapped to the south polar region (Strobel, Koskinen, Muller-Wodarg, 2016). The black line tracks the auroral oval.

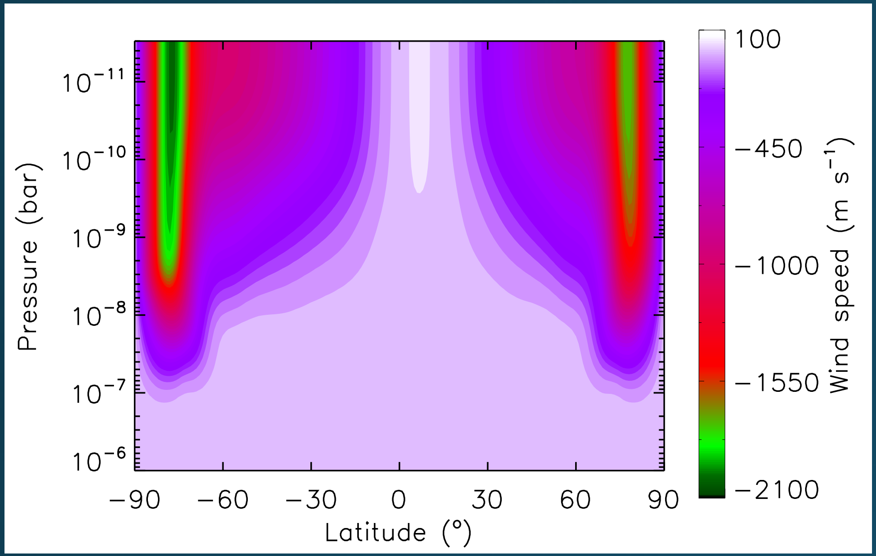


Coriolis and ion drag barrier



Westward Coriolis force (-2Ω x u), aided by ion drag (j x B), turns meridional flow from the poles into zonal flow and traps the energy at the poles (Smith et al. 2007, Muller-Wodarg et al. 2012).

Zonal winds and temperatures



Fast, easterly zonal wind appears in a narrow peak near the auroral oval and broad slower envelope at mid-latitudes (Muller-Wodarg et al. 2012). A comparison of model and observed temperatures is shown below (in prep).