Energetics in Titan’s ionosphere: Application to TA flyby

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Forcing upon an upper atmosphere

Ionospheric e- heating

Creation of an ionosphere

Auroral energetic particles

Solar photons (soft X-rays – EUV)

Neutral

Aurora and airglow

Photoe-

Ionospheric e- heating

Creation of an ionosphere
Cassini spacecraft at Titan

Configuration during the first Cassini flyby of Titan, TA: October 26, 2004
Two electron populations considered

Suprathermal electrons
(e.g., photoelectrons, secondary electrons)

Thermal electrons
from the ionosphere

Boltzmann equation

Energy balance equation

Intensity \((s, E, \theta)\)

Temperature \((s)\)

Heating rate \(Te\)
To identify the main energy source upon the *sunlit* ionosphere (inbound)

For the TA flyby near closest approach: solar forcing
To assess the energy budget in the *sunlit* ionosphere (inbound)
Magnetic field line configuration at Titan

3D representation of the modeled magnetic field line crossing the location of Cassini at 100 s before CA during TA.

Cassini trajectory during TA

Cassini location at -100 s from CA

Draped magnetic field line and its projection

Projection of Titan’s exobase and Titan’s solid body

Solar direction

[after Backes et al.]
To assess the energy budget in the *sunlit* ionosphere (inbound)

- Neutral densities & temperature
- Configuration of B field
- Ionospheric model including electron transport
- Energetic electron intensity
- Electron temperature
- INMS
- MHD model + MAG
- Caps
- Rpws

*The complex magnetic field line configuration is critical for aeronomical studies at Titan*
Angular distribution of the energetic electrons

- Isotropic distribution observed by CAPS/ELS during the inbound part of the TA flyby

- Can only be explained if the complex magnetic field line configuration is taken into account
Titan TA MHD results

[Backes et al.]

[Ma et al.]
Identification of the energy source in the *sunlit* ionosphere (inbound)

-Cassini/CAPS/ELS observations
- Transport model output (solar input only)

Modeling results based on the close magnetic field line configuration (Ma et al.)

* Same conclusion as with the draped model by Backes et al.
  - Solar photons are the major energy source
  - Magnetic field configuration is critical for the energy budget
Something strange at t=150 s
Open B in Backes et al.
Closed B in Ma et al.

Cravens et al. 2005
To identify the main energy source upon the \textit{darker} ionosphere (outbound)

- Cassini/CAPS/ELS observations
- Transport model output

hv only
Te = 680 K

hv only + e-
Maxw: \( E_m = 500 \text{ eV} \)
Q0 = 5e-3 mW m-2

Te = 850 K

Lower than Te (RPWS) = 1330 K

- Additional heating source (other than solar photons and magnetospheric e-)?
- Or different magnetic field line configuration (than that predicted by models)?
Conclusion

• **Inbound Ta flyby:**
  – Major energy source of Titan’s ionosphere: solar photons (sza = 82°)

• **Multi-instrumental study** has also highlighted the important role of the magnetic field line configuration for aeronomic studies at Titan

• **Prediction of the magnetic field line geometry:**
  – Models do not agree!

• **Outbound Ta flyby:**
  – $T_e$ does not seem to be explained assuming solar photons and magnetospheric e- as incident energy sources
    • Different magnetic field line configuration?