Characterizing the Lunar Charging Environment

SSPVSE: Earth, Lunar, Planetary Environments Discussion Group

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What we know: Lunar surface charging

Surfaces in space charge to a potential such that the total currents to it sum to zero.

At the Moon, the important currents are due to ambient electrons, ambient ions, and photoelectron emission.

Large negative lunar surface potentials in sunlight and shadow

J. S. Halekas, R. P. Lin, and D. L. Mitchell

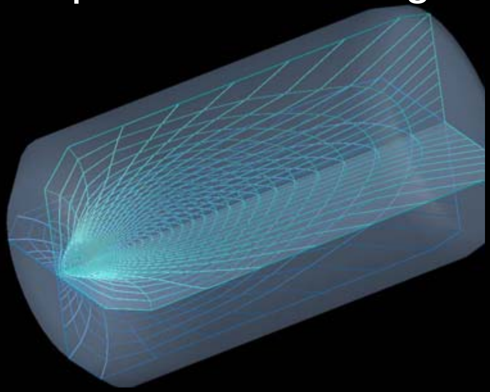
GEOPHYSICAL RESEARCH LETTERS, VOL. 32, L09102, doi:10.1029/2005GL022627, 2005

- Halekas et al. found that the surface of the moon can charge to very large negative potentials.
- The majority of large potentials are found when the moon is located in the geomagnetic tail’s plasma sheet, and when the surface is in shadow.

Characterizing the Lunar Environment using an MHD model

Lyon-Fedder-Mobarry (LFM) global MHD model

- Solves the ideal MHD equations
- $+30\ R_E < X < -300\ R_E$; $-100\ R_E < Y, Z < +100\ R_E$
- Couples to a 2D height integrated ionospheric model.



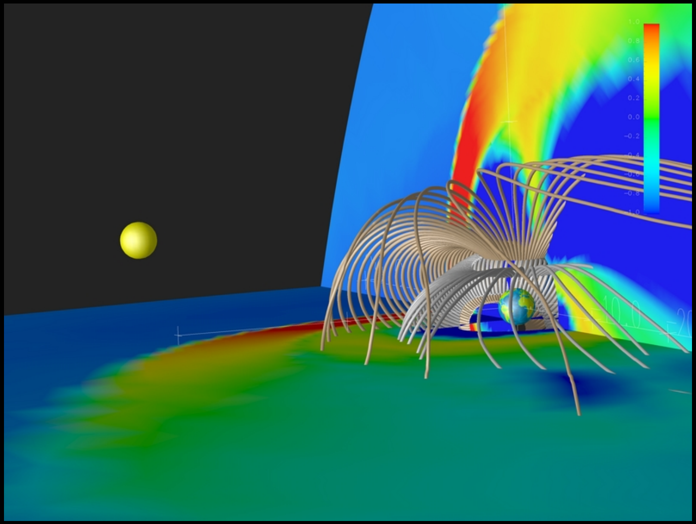
$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \vec{u}) = 0$$

$$\rho \left[\frac{\partial \vec{u}}{\partial t} + (\vec{u} \cdot \nabla)\vec{u} \right] = -\nabla \left(p + \frac{B^2}{2\mu_0} \right) + \frac{1}{\mu_0} \vec{B} \cdot \nabla \vec{B}$$

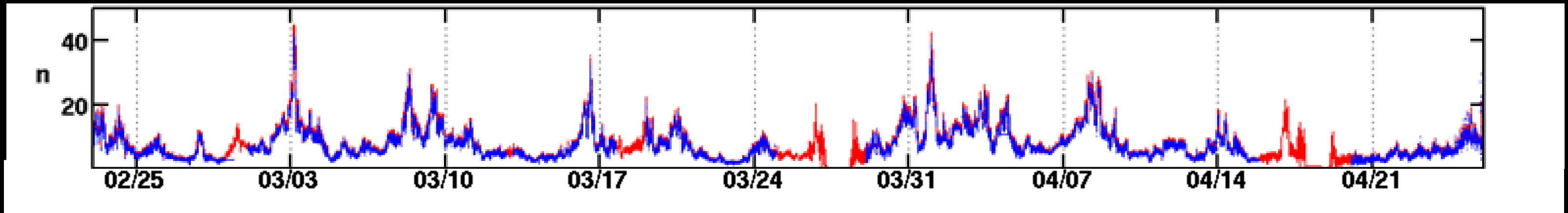
$$\frac{\partial}{\partial t} \left(\frac{p}{\rho^{\gamma}} \right) = 0$$

$$\frac{\partial \vec{B}}{\partial t} = \nabla \times \left(\vec{u} \times \vec{B} \right)$$

$$\nabla \cdot \vec{B} = 0$$



Use the model to simulate 2 months (Feb-Apr 1996) using WIND solar wind input.

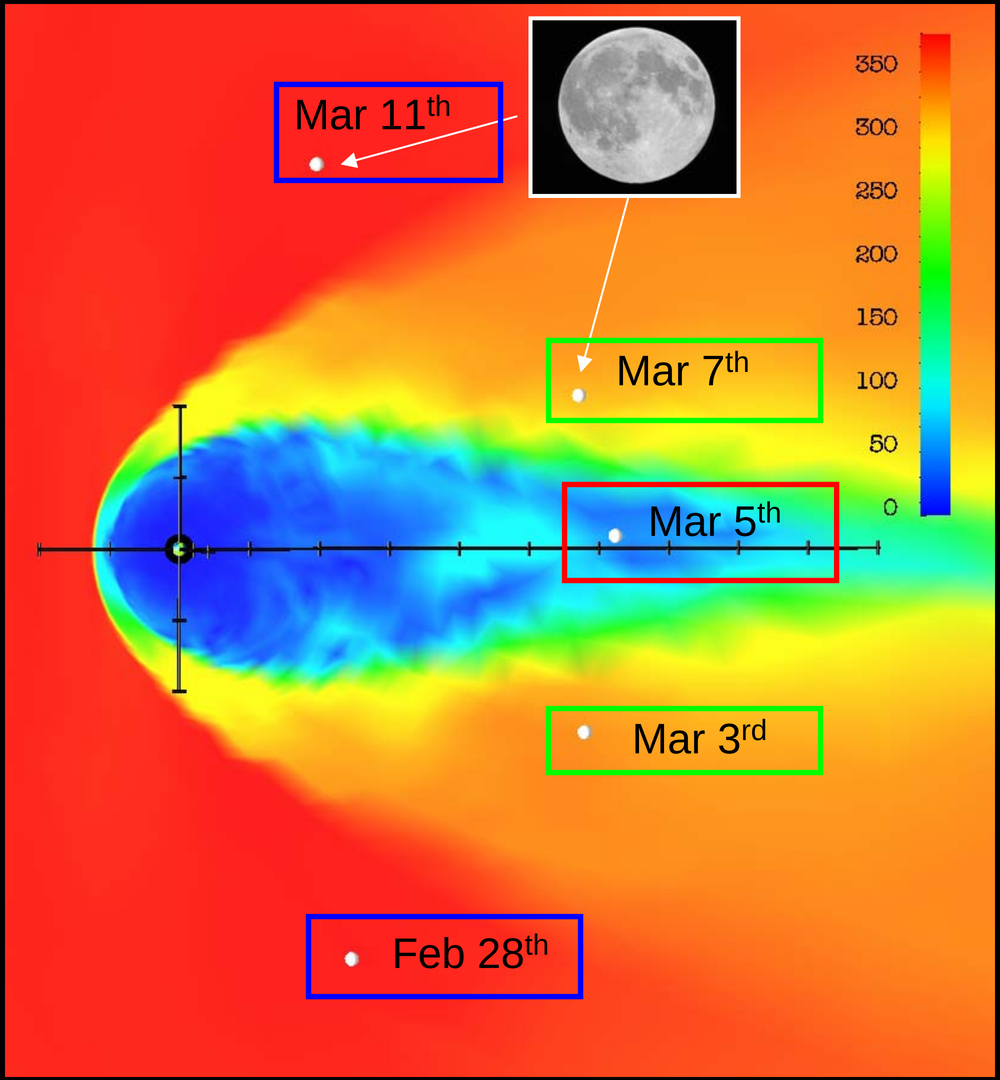


Plasma Regions encountered by the Moon

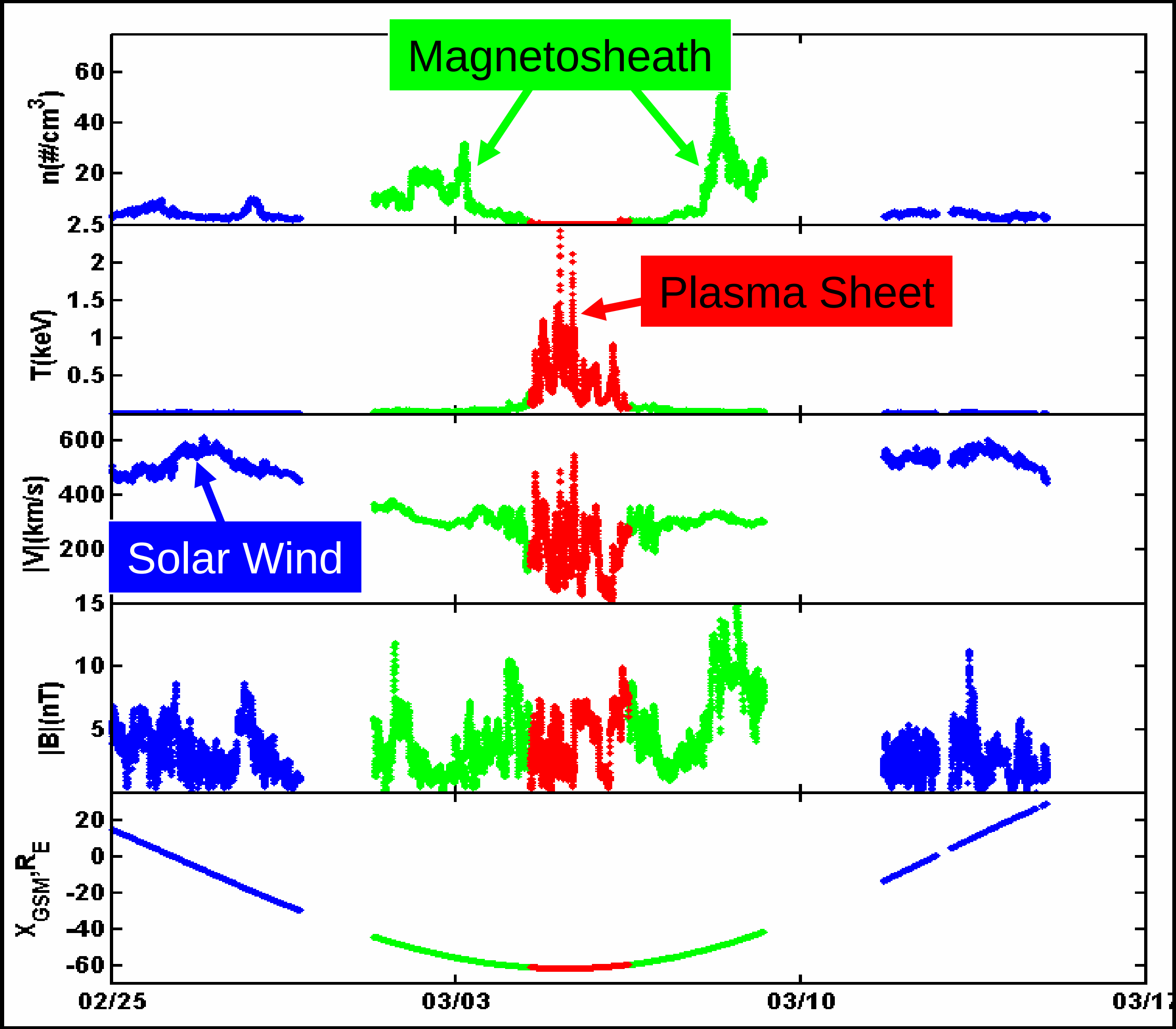
- White spheres illustrate the locations of the Moon at various points in it's orbit during this February-March tail pass.

- Color scale indicates the magnitude of flow speed in the GSM equatorial plane.

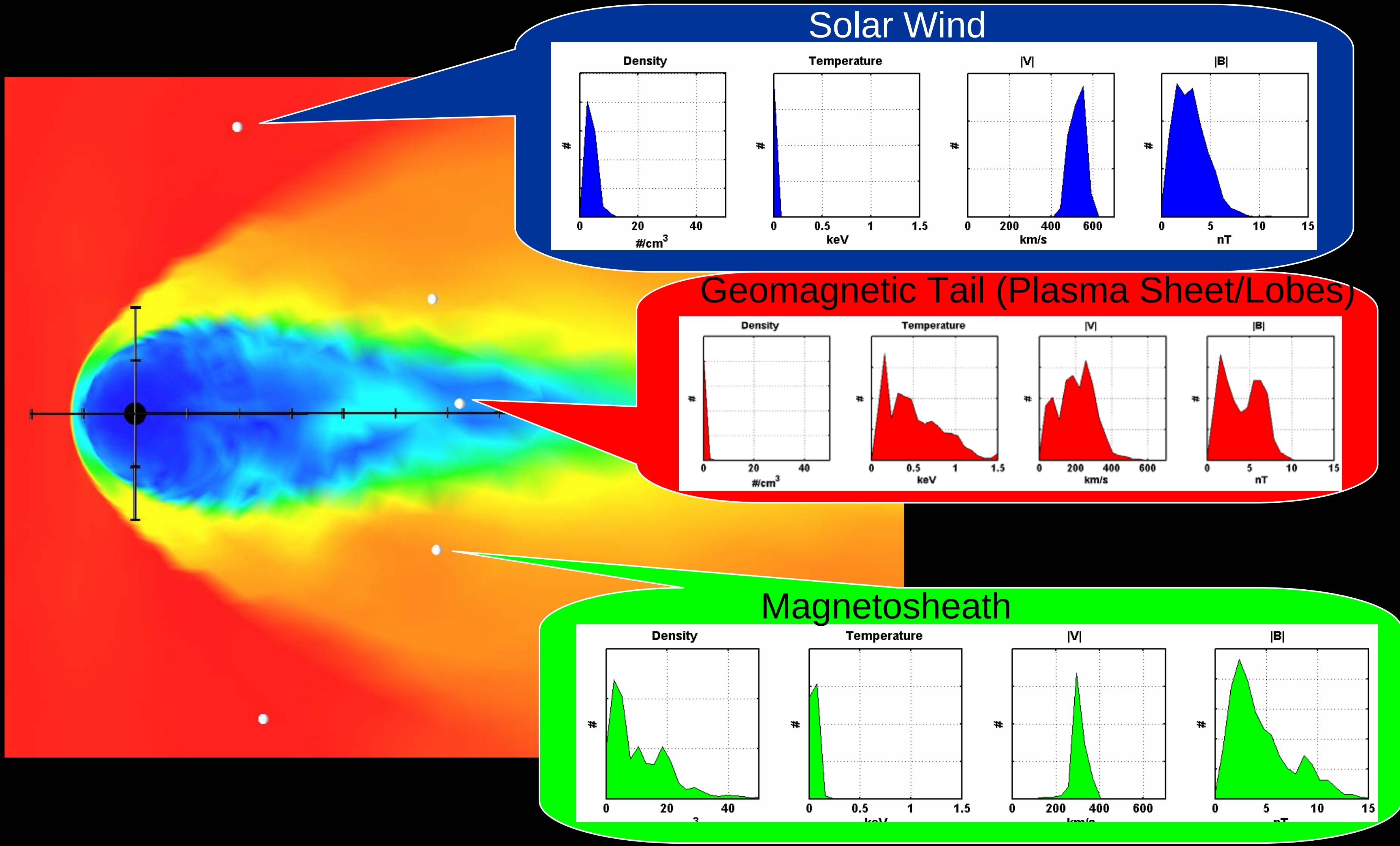
- Each lunar snapshot is embedded within a particular plasma region, the solar wind, magnetosheath, and the plasma sheet.



One representative tail pass



Distributions within regions



Implications for charging

- During this lunar pass, the moon spent 2 days in the plasma sheet (7% of it's orbit).
- That duration can vary
  - The IMF can influence the width of the plasma sheet, the plasma population within it.
  - Very seasonally dependent

and for that report…

- What we know:
  - There are large potentials on the lunar surface, especially in shadow, especially in the plasma sheet.
  - Does not depend on surface characteristics (terrain & surface ages)
- What do we need to know?
  - Surface electrical characteristics.
  - Magnetospheric boundary prediction.
  - Plasma sheet temperature predictions.
- How do we get there?
  - Comprehensive surface environment investigation.
  - Dynamical magnetospheric model to forecast plasma sheet boundaries, temperatures, based on solar/solar wind observations.