Instrument and Payload Concepts Posters

# Signal Strength and Bandwidth for Magnetotelluric Sounding of the Interior of the Moon [#2475]

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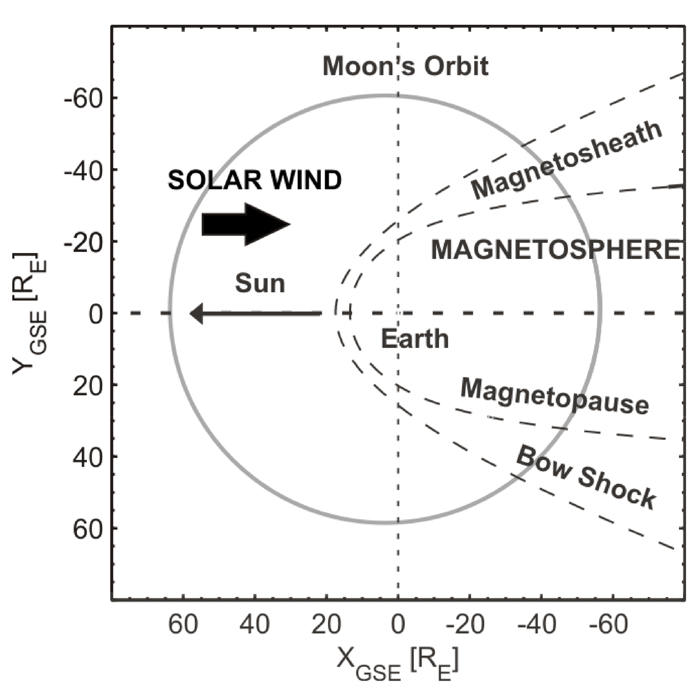
## Introduction

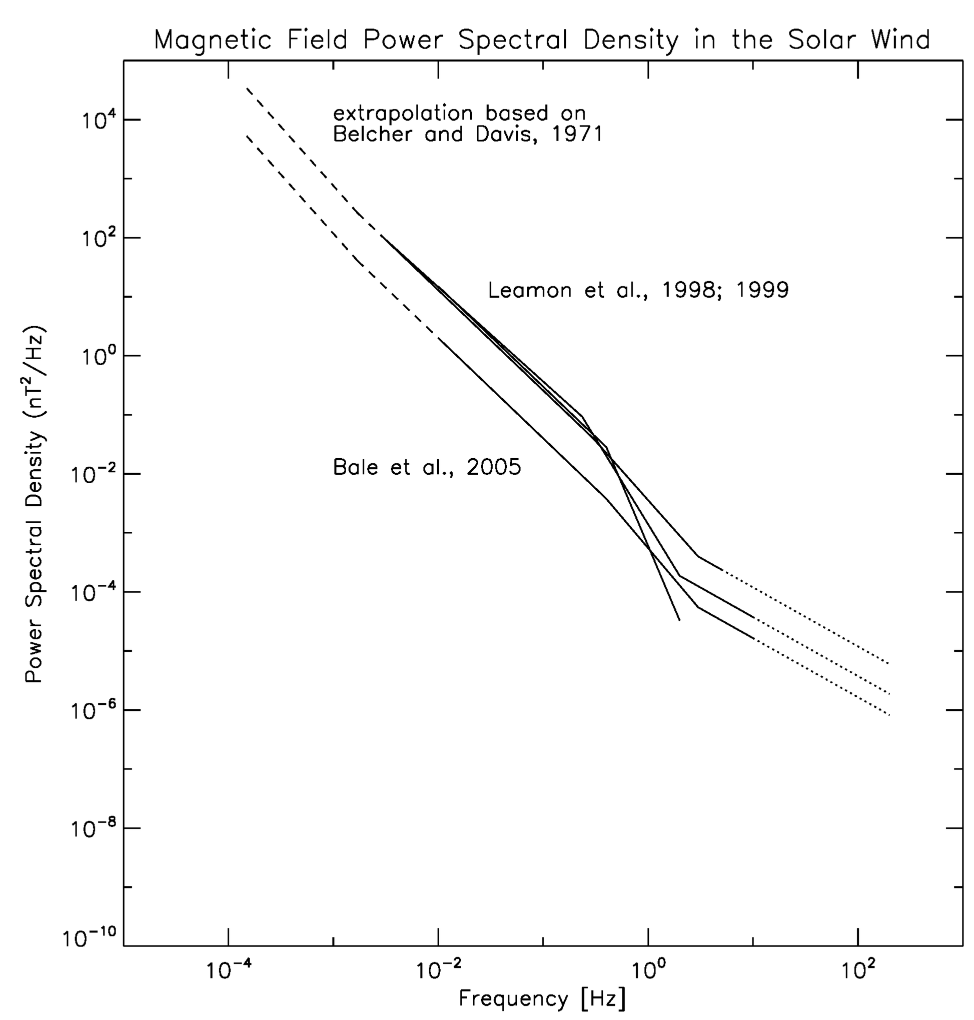
- Electromagnetic (EM) sounding is a group of geophysical methods used to characterize the interiors of planetary bodies from 1 m to > 1000 km
  - Previous EM soundings of the Moon performed during the Apollo Era utilized a transfer function method and *required both orbiting and surface magnetometers*
- In the magnetotelluric (MT) method, the orthogonal components of the horizontal electric and magnetic *fields measured on the surface* are used to discern the conductivity structure
- The Moon encounters a wide variety of plasma regimes and EM source signals over a broad range of frequencies (above and right)




- Here, we consolidate previous observations to develop a catalog of EM disturbances at the Moon that will be useful for surface MT measurements.

## Source Signals

- On the terrestrial planets, electromagnetic discharges (lightning) or magnetic field variations due to interactions with the solar wind can provide MT source signals.
- On airless bodies such as the Moon, solar wind turbulence and other plasma waves can create source signals.




***Power spectral density as a function of frequency for magnetic fluctuations in the solar wind (above) and Earth's magnetosphere (below right)***

Table 1: Target layers, depths, and EM frequency ranges necessary for MT sounding of the Moon:

| Target | Depth | Frequency |
|---|---|---|
| Crust | 0 - 60 km | > 1 Hz |
| Mantle | 60 - 1500 km | $10^{-3}$ - 1 Hz |
| Core | > 1500 km | < $10^{-3}$ Hz |

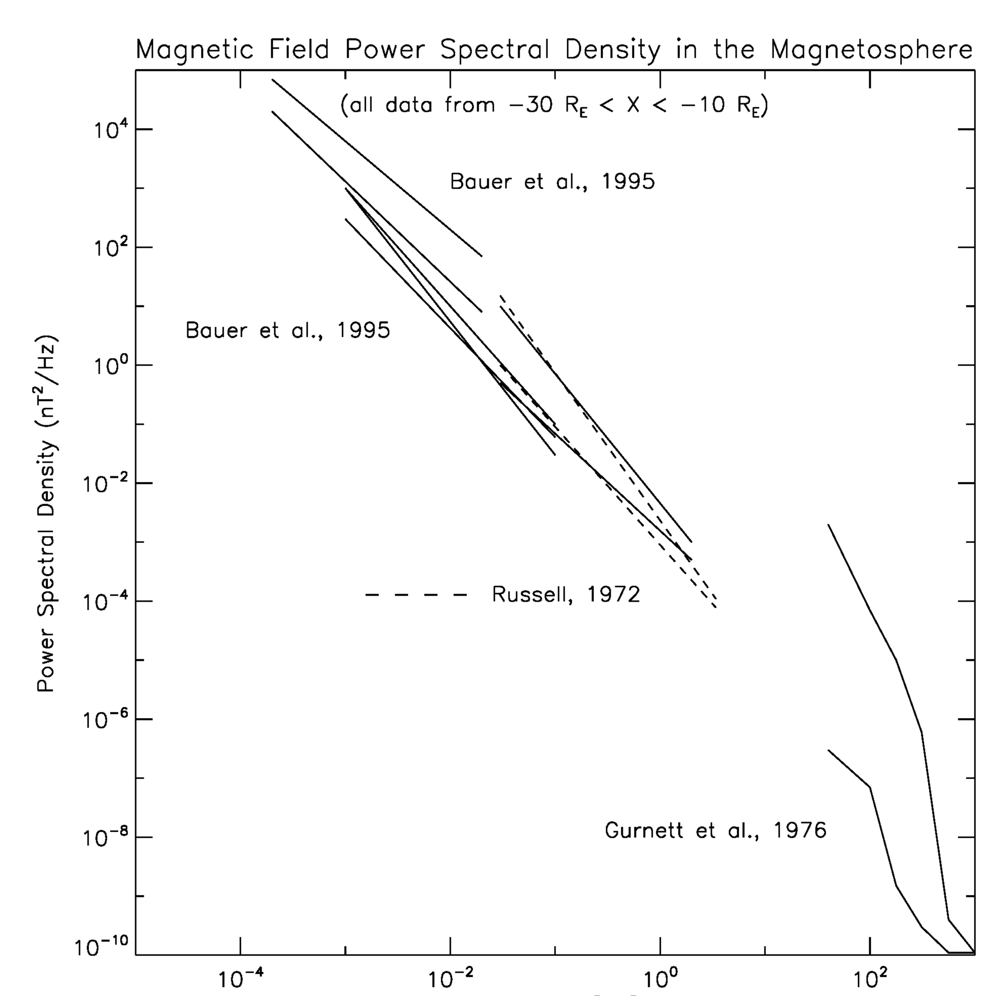
The Moon spends ¾ of its orbit in the solar wind

Observations show that solar wind turbulence can provide a robust source of electromagnetic fluctuations spanning frequencies from < $10^{-4}$ Hz to > $10^{2}$ Hz

The Moon spends the remaining ¼ of its orbit in Earth's magnetosphere

Waves in Earth's magnetosphere also provide a robust source of electromagnetic fluctuations from $10^{-4}$ Hz < $f$ < $10^{2}$ Hz

At the highest frequencies, source signal strengths appear slightly lower in the magnetosphere than in the solar wind




## Analysis Methodology

- In MT, assuming a simple planar geometry, the *apparent resistivity* as a function of frequency, $\rho_a$, is determined from E & B (1), with each wave penetrating the subsurface according to its *skin depth*, $\delta$ (2)

$$\rho_a = \frac{1}{5f}\frac{E_y^2(uV/m)}{B_x^2(nT)} \text{ ohm-m} \quad (1)$$

$$\delta = \frac{1}{\sqrt{\pi f \mu \sigma}} \sim 500\sqrt{\frac{\rho}{f}} \text{ m} \quad (2)$$

- Using (1) and (2), inversion procedures convert apparent resistivity, $\rho_a$, to true resistivity as a function of depth, $\rho(z)$
- This result can be generalized to apply to spherical geometries at longer wavelengths using a response function, $c(\omega)$, as outlined by *Weidelt* [1972]:

$$c(\omega) = E(r_M,\omega)/i\omega B(r_M,\omega) \quad \rightarrow \quad \rho_a = \omega\mu|c(\omega)|^2$$

Again, the apparent resistivity, $\rho_a$, can be inverted to find conductivity versus depth

## Missions/Instruments

- Electric & magnetic sensors for *Lunette* mission: Neal et al., #2832