Electromagnetic Wave Power Observed Near the Moon during Terrestrial Bow Shock Crossings and Its Importance for Subsurface Sounding

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Introduction

- Electromagnetic (EM) sounding is a group of geophysical methods used to characterize the interiors of planetary bodies
- In the magnetotelluric (MT) method, surface measurements of the horizontal electric and magnetic fields are used to discern the subsurface conductivity structure

Table1:
Target layers, depths, and 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

- On the terrestrial planets, electromagnetic discharges (e.g., 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, shocks, and plasma waves can create source signals.
- The Moon encounters a wide variety plasma regimes and EM source signals over a broad range of frequencies in its orbit about Earth
- Here, we present observations of changes in the EM wave power in the lunar environment seen during crossings of the terrestrial bow shock

Observations

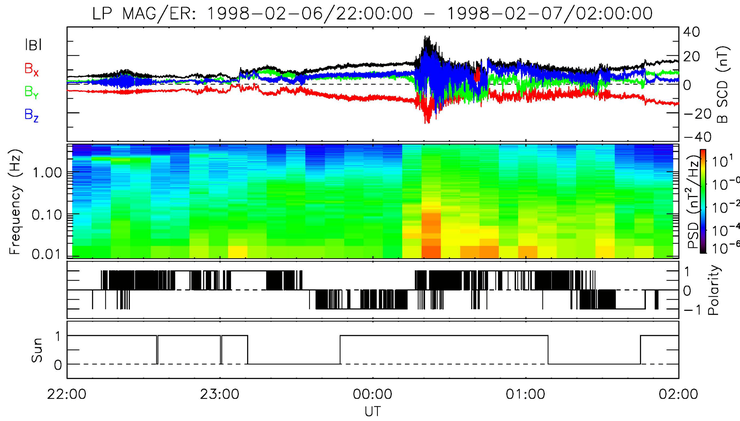

Figure 1: Lunar Prospector (LP) magnetometer data during a bow shock crossing. Top to bottom: magnetic field, FFT of 9 Hz magnetic field data, magnetic connectivity flag, and Sun flag.

Note the increase in magnetic field magnitude and fluctuations at the bow shock crossing.

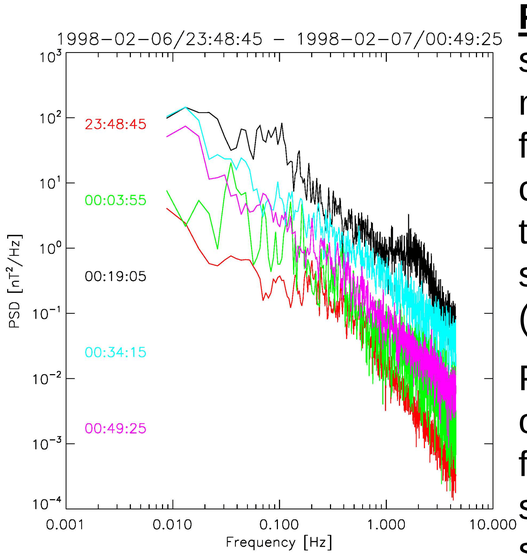

Figure 2: Power spectral density of magnetic field fluctuations centered on the time of the bow shock crossing (black curve).

Power increases over a range of frequencies from several mHz to several Hz.

Discussion

- The low frequency magnetic power increases by ~ 2 orders of magnitude across the bow shock
- Such an increase in magnetic power is also increases the source signal for MT sounding
- The observed frequency range corresponds to crustal to deep mantle penetration depths

➔ Magnetic fluctuations observed at bow shock crossings can provide a strong source signal for MT sounding of the deep lunar interior

Another Example

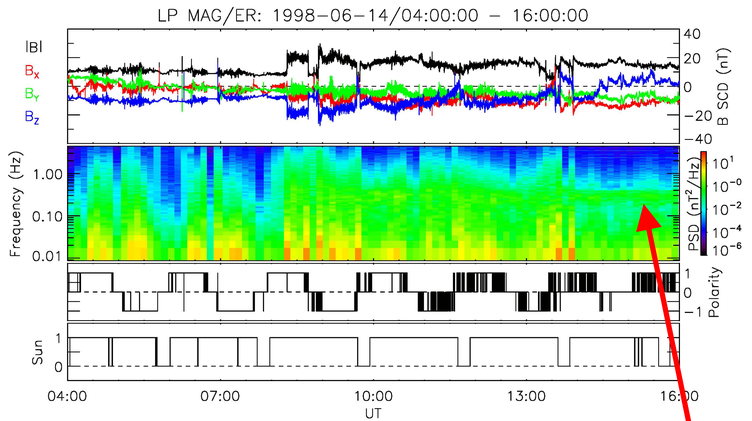

Figure 3: Multiple bow shock crossings are seen between 08 and 10 UT. Again, each transition is associated with an increase in wave power.

Note the narrowband increase in wave power near the end of the interval centered near 0.3 Hz. This emission is commonly seen by LP in the magnetosheath.