

THEMIS Na exosphere observations of Mercury correlated with *in-situ* magnetic field measurements by MESSENGER

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Abstract

The exosphere of Mercury is a tenuous collision-less cloud of gas surrounding the planet, and it derives from the many interactions occurring among the exposed surface, the interplanetary medium (Solar wind, photons and meteoroids) and the planetary and interplanetary magnetic fields. Due to a weak intrinsic magnetic field, Mercury's magnetosphere is strongly coupled with the Interplanetary Magnetic Field and its wide magnetospheric cusp areas are expected to allow a direct precipitation of the solar wind plasma on the dayside high-latitudes. Since several Na emission patterns are recurrently observed in the Hermean exosphere, as the peaked emission in the Northern and/or Southern high-latitudes, a correlation between IMF orientation and sodium emission features is likely to exist. We performed a simple statistical analysis to check if such correlation exists or not.

1. Introduction

The process of resonant scattering acting on Na is particularly efficient at Mercury and, in addition, it produces emission in a wavelength region that is free from the many telluric lines occurring in Earth-based observations. For this reason Na, though not one of the major species of Mercury's exosphere, has often been used as a tracer of the dynamics of the whole exospheric environment. In particular, after its first detection in 1985 [4], it often showed a peculiar two-peak pattern, with two peaks occurring at mid-latitude regions, in a position that may be easily related to the magnetic cusp footprints of Mercury.

2. Data

An Earth-based campaign of observation of the Na exosphere of Mercury is carried out by a French-Italian team at the THEMIS telescope in the Canary Islands since 2007. THEMIS [3] is a solar telescope with a 0.9 m primary mirror and a 15.04 m focal length, and is located at 2400 meters a.s.l. on the Teide volcano in Tenerife (Canary Islands). The use of a solar telescope allows day-long observations and high resolution imaging with a spectral resolving power of at least $\lambda/\Delta\lambda = 220000$, by using two individual cameras observing Na doublet at 589 nm at the same time. Good quality images of the Mercury sodium exosphere can be obtained by applying tip-tilt corrections at ~ 1 kHz to decrease the image distortions induced by atmospheric aberrations. THEMIS data reduction is performed by using devoted IDL libraries and routines; for detailed description see [1] and [2]. The runs used for the present analysis are listed in Table 1.

The magnetometer MAG onboard MESSENGER spacecraft is a three-axis, ring-core fluxgate detector, designed to characterize Mercury's magnetic field in detail. The MAG sensor is mounted on a 3.6-meter boom and has its own sunshade to protect it from the Sun. MAG may collect magnetic field samples at 50-millisecond to one-second intervals. Depending on the orbit position, it will collect data from both the IMF and the intrinsic magnetic field of the planet Mercury. The MESSENGER spacecraft is orbiting around Mercury since March 2011, and up to 3 years of contemporary data of global exospheric Na mapping and *in-situ* measurements of the IMF B-field are now available [5].

Table 1: THEMIS and MAG contemporary data in 2011, 2012 and 2013.

[5] PDS: the Planetary data System (<http://pds.jpl.nasa.gov/>)

2011	2012	2013
May 28- June 2	June 5-10	May 18-25
July 14-15	June 19-20	
Sept. 10-17	Sept.19-23	

3. Discussion

To allow a direct comparison with the unperturbed IMF data, we selected from the dataset the Na measurements achieved when MESSENGER was in the free Solar Wind (i.e. outside the Hermean magnetosphere), by looking at the steep changes in the IMF module that occur when the spacecraft enters or exits the magnetosphere itself. A statistical analysis was then performed by matching the occurrence of typical Na exospheric emission patterns (single peak, double peaks ...) with averages of IMF Bx, By and Bz components computed during each Na measurement (spanning about 1 hour) and during an equivalent time interval shifted one hour ahead. The two datasets are cross-checked, and results are discussed in details.

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