EPSC Abstracts
Vol. 11, EPSC2017-753, 2017
European Planetary Science Congress 2017

Short-term variations of Mercury's cusps Na emission

S. Massetti[1], V. Mangano[1], A. Milillo[1], A. Mura[1], S. Orsini[1], and C. Plainaki[2]

(1) INAF-IAPS, Institute for Space Astrophysics and Planetology, Rome, Italy

(2) ASI, Italian Space Agency, Rome, Italy.

Abstract

We illustrate the analysis of short-term ground-based observations of the exospheric Na emission (D1 and D2 lines) from Mercury, which was characterized by two high-latitude peaks confined near the magnetospheric cusp footprints. During a series of scheduled observations from THEMIS solar telescope, achieved by scanning the whole planet, we implemented a series of extra measurements by recording the Na emission from a narrow north-south strip only, centered above the two emission peaks. Our aim was to inspect the existence of short-term variations, which were never analyzed before from ground-based observations, and their possible correlation with interplanetary magnetic field variations. Though Mercury possesses a miniature magnetosphere, characterized by fast reconnection events that develop on a timescale of few minutes, ground-based observations show that the exospheric Na emission pattern can be globally stable for a prolonged period (some days) and can exhibits fluctuations in the time range of tens of minutes.

Background

The study of Mercury's exosphere and its dynamics via ground-based observations of the bright sodium doublet emission (5890-96 Å) is an important way to understand the key processes lying behind the generation of the tenuous (collisionless) atmosphere of the small solar system bodies. The physical processes expected to play a role in the surface Na release are: strong bombardment by Solar Wind plasma driven by IMF-magnetosphere coupling, micrometeoroids impacts, Solar UV and thermal radiation, all weighted by the surface abundancies. Observations of the Na exosphere exhibit very often two high-latitude peaks usually symmetrically located in both hemispheres, along the subsolar meridian, but which also differ in intensity and/or extent. Their morphology and dynamics are conceivably associated to the direct precipitation of SW ions onto the surface (e.g. due to ion-sputtering & PSD processes), driven across the magnetospheric cusps by magnetic reconnection, since none of the other known release processes is able to produce such distinctive emission pattern by itself [1].

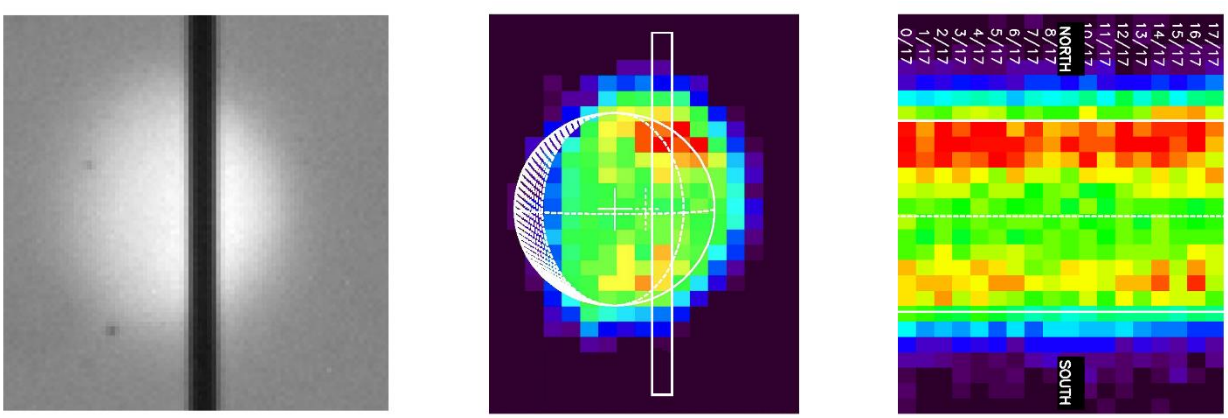

Figure – Sketch of the fixed-slit acquisition used by the authors to inspect short-term Na emission from the cusps. LEFT: spectrograph slit position over Mercury's disc (white light). CENTRE: slit position superimposed to a standard full disc Na image. RIGHT: time evolution of Na emission from 18 sequential North-South scans.

Data of the Na exosphere of Mercury are obtained by means of the THEMIS solar telescope (Tenerife, Canary Islands, Spain). THEMIS is equipped with a 0.9 m primary mirror with 15.04 m focal length that, thanks to its optical design, is characterized by a low level of scattered light. Because of this capability, it can be used during the daylight to image the Na exosphere of Mercury with a high contrast (with respect to sky brightness), for several hours per day.

Analysis and Conclusions

We inspect the time evolution of a steady double peaked Na exospheric emission at the Mercury's cusps that was observed to persist for more than three consecutive days (June 7-9, 2012). The southern Na emission was always narrower and weaker that the northern one, a fact which seems to conflict with the magnetic field model based on new data from Messenger [2], implying a wider southern cusp area. Given that the observed high-latitude Na emission is believed to be linked to the SW entry through the cusps, then a broader signal should be frequently observed from the southern hemisphere.

The lack of any significant one-to-one relationship between the observed Na exospheric emission intensity/morphology and the in-situ IMF data, matches the results of recent works that show that a low upstream Alfvénic Mach number - resulting in a low plasma β in the magnetosheath - can drive high reconnection rate at Mercury, nearly irrespective of the IMF direction [3][4].

A set of complementary fixed-slit observations show that the Na exospheric emission from both the North and the South hemispheres undergo a series of in-phase intensity oscillations on a timescale of 10-15 minutes. On the base of the available data is not possible to understand if these oscillations are real Na emission variations induced by SW perturbations, or just artifacts caused by atmospheric fluctuations (e.g.: changes in transparency).

Nevertheless, by means of a simple numerical model we show that such short-term variations, in the range 10-15 minutes, are compatible with the response time of the Na exospheric release, as induced by impulsive events (likely caused by ion precipitation).

Finally, by comparing the three fixed-slit images recorded on the first day (June 7), we detected a longer-term variation in the South/North emission ratio, on a timescale of about 1 hour, which definitely seems decoupled by local atmospheric fluctuations. This 1-hour variation is compatible with the Na photoionization lifetime and the fastest decay lifetime of simulated global Na exosphere, which takes place at small TAAs (≈ 0°- 60°), as in the present observations.

The results of this work have been recently published on Geophysical Research Letters [5].

Acknowledgements

Ground-based observation campaign of Mercury's Na exosphere from THEMIS was started and organized by F. Leblanc; the INAF participation is leaded by V. Mangano. Authors thanks the THEMIS staff in Tenerife (Canary Islands, Spain) for their fruitful help during the observation campaigns. This work was supported by the ASI-SERENA contract no. I/081/09/0 "SERENA: scientific activity". MESSENGER MAG data used in this study are available from the NASA Planetary Data System.

References

[1] Mangano et al. (2015), THEMIS Na exosphere observations of Mercury and their correlation with in-situ magnetic field measurements by MESSENGER. PSS, 115, 102-109, doi: 10.1016/j.pss.2015.04.001, 2015.

[2] Anderson et al. (2011), The Global Magnetic Field of Mercury from MESSENGER Orbital Observations, Science, 333, 1859-1862.

[3] DiBraccio et al. (2013), MESSENGER observations of magnetopause structure and dynamics at Mercury. J. Geophys. Res. Space Physics 118, 997-1008, doi:10.1002/jgra.50123.

[4] Slavin et al. (2014), MESSENGER observations of Mercury's dayside magnetosphere under extreme solar wind conditions, J. Geophys. Res. Space Physics, 119, 8087–8116, doi:10.1002/2014JA020319.

[5] Massetti et al. (2017), Short-term observations of double peaked Na emission from Mercury's exosphere. Geophys. Res Lett. 44, doi:10.1002/2017GL073090.