EPSC Abstracts
Vol. 6, EPSC-DPS2011-131, 2011
EPSC-DPS Joint Meeting 2011
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The He exosphere: from the Moon to Mercury

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Abstract

We model the He exosphere, first at the Moon, in order to constrain the physics of its formation and of its dynamic then at Mercury to underline what can be stated on the origins of the observed He exosphere. Partial energy accommodation of the He particles when interacting a surface is constrained using Apollo 17 measurement. Neither a partial energy accommodation as suggested by [1] nor a total energy accommodation as suggested by [2] can fit the Mercury's observations at nightside. The Lunar observations suggest that He atoms interact more than one time with the surface when they reimpact it. The present observations do not allow constraining the energy distributions of these particles when ejected or rejected. There remain significant unexplained features in Mercury's He exosphere. Any new observation on the diurnal variations of these exospheres or on the local altitude profiles would greatly help to further constrain the exosphere-surface interaction.

1. Introduction

One of the very first elements identified in the Lunar exosphere was the Helium atom. Apollo 17 measured the density of this species during four lunations and highlighted the diurnal cycle of this element. In particular, it confirms the expected day to night asymmetry of this exosphere with a peak of density on the nightside [3]. Few years later, the first detection by Mariner 10 of the He atoms around Mercury was published [4]. These observations highlighted a relatively similar behavior of the He exosphere at Mercury than at the Moon, as well as significant differences that remain poorly explained today. It is the purpose of this paper to analyze the origins of the He exosphere by first analyzing the Lunar He diurnal cycle, then by applying the conclusions of this first analysis to Mercury case.

2. Method

We developed a 3D Monte Carlo test-particles model of the Moon He exosphere. In this model, test-particles are ejected from the dayside and followed around the Moon surface. Density, column density and escaping flux are deduced from this modeling.

3. Results

We first compare the results of our modeling with Apollo 17 measurements (Figure 1) showing the excellent agreement between observation and model.

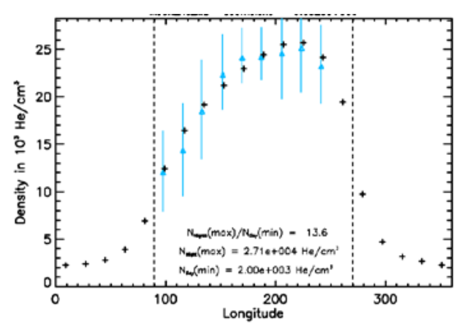

Figure 1: Longitudinal variation of the He density at a latitude of +20° North. 180° corresponds to midnight. The blue triangles correspond to the average density measured by Apollo 17 [3], whereas the bars correspond to the dispersion of the measured densities during 4 subsequent lunations [5]. The dark crosses correspond to the densities calculated by our model in the nominal case. Also indicated in legend are the maximum nightside density, the minimum dayside density and their ratio.

In the case of Mercury, we repeat the same comparison as shown in Figure 2. Here again, we obtain a very good agreement between observation and simulation.

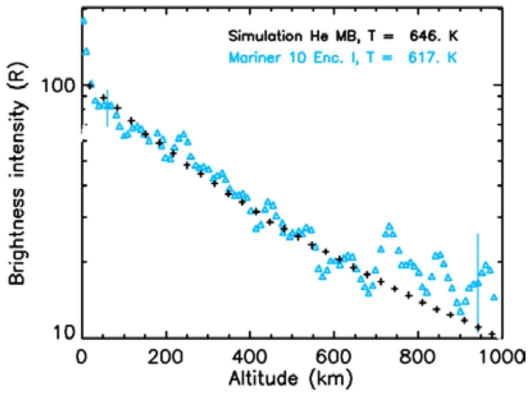

Figure 2: Comparison between Mariner 10 observations and the model of the He exosphere. In blue observations reported by [4] of the He emission. In dark reconstructed emission from the model. Emission profile from the subsolar region of Mercury obtained at 25000 km from Mercury. The observations were corrected from the interplanetary background.

However, Mariner 10 performed a second set of observations for which the agreement is less poor in particular in the nightside of Mercury (Figure 3).

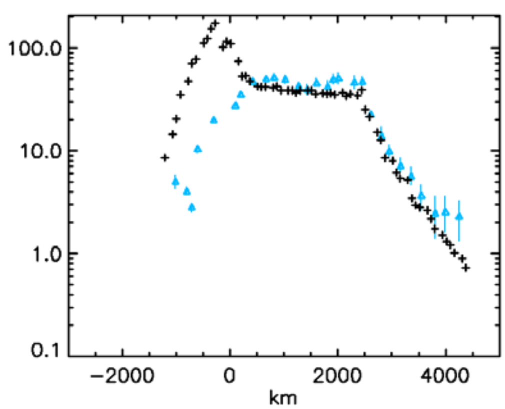

Figure 3: Comparison between Mariner 10 observations and the model of the He exosphere. In blue observation reported by [4] of the He emission. In dark reconstructed emission from the model. Emission profile obtained from 84000 km from the surface with a slit much larger.

4. Conclusions

The analysis of both the Moon and Mercury He exospheres reduces the possible key drivers of the formation of these exospheres. However, we still observe a significant difference between the observation of the nightside of the He exosphere at Mercury and our model despite a very good fit of the other data set [6].

Acknowledgements

This work was supported by the CNES in the frame of Bepi-Colombo/PHEBUS and PICAM instrumental developments.

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