Influence of ions on the Hermean and Lunar exospheres

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Abstract

Sputtering caused by ions upon surface impact has been considered as a source of energetic neutrals for a variety of planetary objects lacking a substantial atmosphere. At Mercury, where a magnetosphere exists, solar wind ions precipitate primarily along magnetically open fieldlines, whose footprints are regulated by the IMF. Quantitative estimates of the Hermean ion sputtering source, which is highly variable given the large eccentricity of Mercury's orbit (0.31-0.47 AU), are derived using Helios data and an Earth-based analytical magnetospheric model (Toffoletto-Hill 93) which has been adapted for Mercury. Results indicate that the precipitating flux is expected to increase by a factor of four from aphelion to perihelion, while up to 22 percent of the surface is open to the solar wind and cusp footprints move equatorward to latitudes of ~20-30 degrees.

Our own Moon is a great laboratory to constrain the physical processes that support and deplete exospheres. Ions there are uninhibited on impacting the lunar surface except during passages through the Earth's magnetosphere. The total electron flux in the lunar exosphere, measured by the Electron Reflectometer onboard Lunar Prospector during such a period (June 7-16, 1998), is strongly correlated with variations in the column abundance of equatorial sodium observed coincidentally from the Earth. At the same time, the exospheric temperature increased rapidly upon entry into the magnetosphere, and decreased slowly after the moon reemerged in the magnetosheath. A comparison of different source mechanisms, using the measured electron flux as the proxy for the ion flux, provides strong evidence that the primary effect of ion impact for volatile species is to enhance the photon-stimulated desorption yield. Inside the magnetosphere, where the ion flux and the associated photon-stimulated desorption yield decrease, the contributions from impact vaporization to the observed column abundance and temperature are found to be substantial. In the solar wind ion-enhanced photon-stimulated desorption is shown to be the dominant source of exospheric sodium. The contribution by direct ion sputtering is found to be relatively inefficient. Implications for MESSENGER and BepiColombo measurements will be discussed.