Prediction of Neutral Mg in Mercury's Exosphere


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**Abstract**

The region around Mercury is filled with ions that originate from interactions of the solar wind with Mercury's space environment and through ionization of its exosphere. MESSENGER observations of Mercury's ionized exosphere by the Fast Imaging Plasma Spectrometer (FIPS), the low-energy portion of the Energetic Particle and Plasma Spectrometer (EPPS) instrument aboard MESSENGER, yielded estimates for relative abundances of Na⁺, O⁺, and K⁺ during its first flyby [1], limited primarily by counting statistics. In this paper we estimate Mg⁺/Na⁺ to predict the neutral Mg abundance in Mercury's exosphere by scaling the Mg⁺/Na⁺ ratio. Mg ions are present; the Mg⁺/Na⁺ ratio is constrained by FIPS, with a first rough estimate of ~0.4. We assume that the ratio of Mg/Na in the exosphere is related to the Mg⁺/Na⁺ ratio in the ionosphere by the scaling factor

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\frac{\text{Mg}}{\text{Na}} = \frac{\text{Mg}^+}{\text{Na}^+} \frac{R_{\text{ion}}(\text{Na})}{R_{\text{ion}}(\text{Mg})},
\]

The ionization rate for Na at Earth during quiet solar time is 5.92 x 10⁻⁶ [2]. The ionization rate for Mg also for quiet Sun at Earth orbit has been calculated by Huebner (unpublished) as 5.66x10⁻⁷. Assuming that the column abundance of Na in the exosphere is 2x10¹¹ cm⁻², then the scaling equation (1) gives the Mg column abundance to be 8.3x10¹¹ cm⁻² if the Mg⁺/Na⁺ ratio is 0.4. Another plausible value for Mg⁺/Na⁺ from the FIPS data is ~0.3, which implies a column abundance for neutral Mg of 5.6x10¹¹ cm⁻². These two values bracket the neutral Mg column abundance of Mg predicted by Morgan and Killen [3] for a refractory surface composition (i.e., 6.7x10¹¹ cm⁻²). The higher value above is 32 times that predicted for a "volatile" composition. Measurements with progressively lower uncertainties will be obtained during the next two flybys and the orbital phase of the mission. The emission at maximum Doppler shift for the 285.3-nm Mg line would be 788 kiloRayleighs for a zenith column of 8.3x10¹¹ cm⁻². At zero Doppler shift the emission would be 26% of the maximum value. Either of these estimated column abundances yield emission that is easily observable with the MESSENGER Mercury Atmospheric and Surface Composition Spectrometer (MASCS) instrument [4].

Observations are planned for the second MESSENGER flyby of Mercury to search for both ionized Mg with FIPS [1] and neutral Mg in the exosphere using MASCS [4].

**References**