

Observations of the minor species Al, Fe and Ca<sup>+</sup> in Mercury's exosphere

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***Abstract.*** We report the first detections of Al and Fe, and strict upper limits for  $\text{Ca}^+$  in the exosphere of Mercury, using the HIRES spectrometer at the Keck I telescope. We report observed 4- $\sigma$  tangent columns of  $1.5 \times 10^7$  Al atoms  $\text{cm}^{-2}$  at an altitude of 1220 km (1.5 Mercury radii ( $R_M$ ) from planet center), and that for Fe of  $1.6 \times 10^8$   $\text{cm}^{-2}$  at an altitude of 950 km (1.4  $R_M$ ). The observed 3- $\sigma$   $\text{Ca}^+$  column was  $3.9 \times 10^6$  ions  $\text{cm}^{-2}$  at an altitude of 1630 km (1.67  $R_M$ ). A simple model for zenith column abundances of the neutral species were  $9.5 \times 10^7$  Al  $\text{cm}^{-2}$ , and  $3.0 \times 10^8$  Fe  $\text{cm}^{-2}$ . The observations appear to be consistent with production of these species by impact vaporization with a large fraction of the ejecta in molecular form. The scale height of the Al gas is consistent with a kinetic temperature of 3000 - 9000 K while that of Fe is 10500 K. The apparent high temperature of the Fe gas would suggest that it may be produced by dissociation of molecules. A large fraction of both Al and Fe appear to condense in a vapor cloud at low altitudes.

## **Introduction**

A 4- $\sigma$  detection of Al and Fe, and strict upper limits for  $\text{Ca}^+$  in the exosphere of Mercury were measured at the Keck I telescope with the High Resolution Echelle Spectrograph in May of 2008 and 2009. A 4- $\sigma$  tangent column of Al atoms of  $1.5 \times 10^7$   $\text{cm}^{-2}$  was measured at an altitude of 1220 km (3660 km from planet center, or 1.5 Mercury radii ( $R_M$ )) on 14 May 2008; and a 4- $\sigma$  tangent column of Fe of  $1.6 \times 10^8$   $\text{cm}^{-2}$  was found at an altitude of 950 km (1.4  $R_M$ ) on 3 May 2009. The observed 3- $\sigma$  upper limit  $\text{Ca}^+$  column was  $3.9 \times 10^6$  ions  $\text{cm}^{-2}$  at an altitude of 1630 km (1.67  $R_M$ ) on 080515, and  $6.4 \times 10^6$  ions  $\text{cm}^{-2}$  at an altitude of 510 km on 090503. A simple model for zenith column abundances of the neutral species are  $9.5 \times 10^7$  Al  $\text{cm}^{-2}$ , and  $3.0 \times 10^8$  Fe  $\text{cm}^{-2}$ . The observations appear to be consistent with impact vaporization of surface material with a large fraction of the ejecta in molecular form. The derived temperature of the Al gas is about 3000 - 9000 K while that of Fe is 10500 K, although the temperatures are not well constrained because of limited spatial coverage.