Observations of the minor species Al, Fe and Ca^+ in Mercury's exosphere

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Abstract. We report the first detections of Al and Fe, and strict upper limits for Ca^+ in the exosphere of Mercury, using the HIRES spectrometer at the Keck I telescope. We report observed 4-σ tangent columns of $1.5x10^7$ Al atoms cm^{-2} at an altitude of 1220 km (1.5 Mercury radii (R_M) from planet center), and that for Fe of $1.6x10^8$ cm^{-2} at an altitude of 950 km (1.4 R_M). The observed 3-σ Ca^+ column was $3.9x10^6$ ions cm^{-2} at an altitude of 1630 km (1.67 R_M). A simple model for zenith column abundances of the neutral species were $9.5x10^7$ Al cm^{-2}, and $3.0x10^8$ Fe 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-σ detection of Al and Fe, and strict upper limits for 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-σ tangent column of Al atoms of $1.5x10^7$ 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-σ tangent column of Fe of $1.6x10^8$ cm^{-2} was found at an altitude of 950 km (1.4 R_M) on 3 May 2009. The observed 3-σ upper limit Ca^+ column was $3.9x10^6$ ions cm^{-2} at an altitude of 1630 km (1.67 R_M) on 080515, and $6.4x10^6$ ions cm^{-2} at an altitude of 510 km on 090503. A simple model for zenith column abundances of the neutral species are $9.5x10^7$ Al cm^{-2}, and $3.0x10^8$ Fe 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.