Meteoric Metal Layer in Mars' Atmosphere: Steady-state Flux and Meteor Showers M. Crismani[1], N. Schneider[1], S. Jain[1], J. Plane[2], J. Carrillo-Sanchez[2], J. Deighan[1], M. Stevens[3], S. Evans[3], M. Chaffin[1], I. Stewart[1], & B. Jakosky[1] [1]Laboratory for Atmospheric and Space Sciences, University of Colorado, Boulder, CO, United States, [2]Department of Chemistry, University of Leeds, Leeds, United Kingdom [3]Computational Physics Inc., Springfield, Virginia, United States

Introduction: We report on a steady state metal ion layer at Mars produced by meteoric ablation in the upper atmosphere as observed by the Imaging Ultraviolet Spectrograph (IUVS). The response of the Martian atmosphere to meteoroid influx constrains cometary activity, dust dynamics, ionospheric production at Mars and meteoric smoke may represent a site of nucleation for high altitude clouds. The Mars Express Orbiter Radio Science Experiment detected a transient layer peaking between 65 and 110 km (found in only 1% of their observations) compared with predictions that the layer be permanent [1, 2, 3]. This layer's origin is attributed to the ablation of meteors and arises due to charge exchange of iron and magnesium, as we find on Earth and Venus [3].

At Earth, the metal ion layer is produced by the constant influx of sporadic meteors, and strong meteor showers do not produce significant perturbations, though this may not be the case for Mars. The first detections of metals in Mars' atmosphere occurred during the passage of comet Siding Spring in October 2014, when it was observed by IUVS [4]. Comet Siding Spring was a dynamically new Oort cloud comet in a retrograde hyperbolic orbit that made a close approach to Mars of 141,000 km (1/3 the distance between the Earth and the Moon). During this extremely unusual event, >2700 kg of cometary dust was deposited and IUVS detected bright emissions of Mg+, Mg, Fe+ and Fe at an altitude that peaked near 120 km.

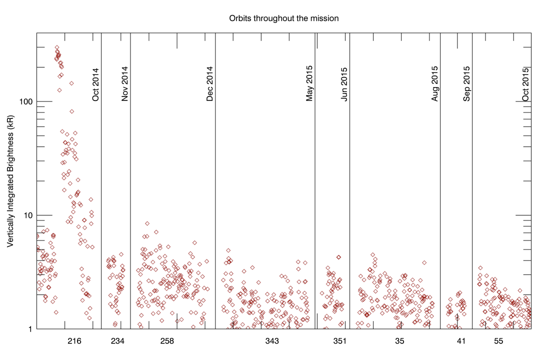

Figure 1: Vertically integrated brightness of Mg+ between 90-120 km, which is a proxy for the fluence of meteoric dust across the course of the mission. The contribution from comet Siding Spring's dust delivery is shown near Ls 216 (VIB = 300). These observations span half a Martian year, with perihelion occurring at Ls = 251 and aphelion at Ls = 71.

IUVS observations span more than an Earth year and cover a range of observation conditions, which allows us to determine the variability of the Mg+ layer seasonally and geographically. In December 2016, Mars encountered three predicted meteor showers, and analysis of these events will determine whether Mars' atmosphere responds to such events dramatically, as was the case with comet Siding Spring, or more similarly to Earth.

Modeling and Data Processing: Theoretical work on meteor ablation at Mars predates observations of the Mg+ layer, however the chemistry, longevity and uniformity of this layer were heretofore unconstrained. Ablation and the resulting chemistry are significantly different at Mars than at Earth due to the composition of Mars' atmosphere (~95% CO2). We use the Leeds Chemical Ablation Model (CAMBOD/1-D) that predicts the abundance of Mg and Mg+ at Mars, and has been validated at Earth for terrestrial meteor showers [5]. In the model, Mg+ comes from ablated meteors, recombines with CO2 and then dissociatively recombines with electrons.

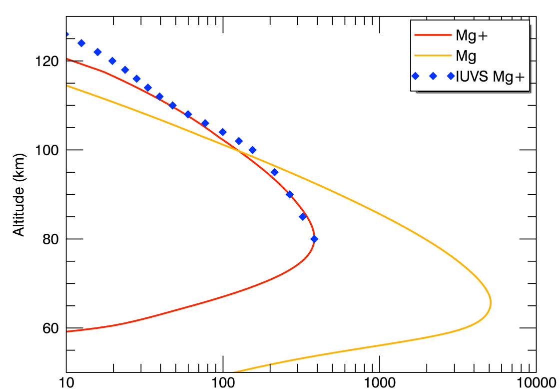

Figure 2: A model of chemical ablation using CAMBAD shows the concentration of Mg+ and Mg appropriate for Mars' atmosphere (red and orange). Retrieved Mg+ concentrations are shown for a single orbit (blue), where the lower limit to our observational altitude is constrained by contamination by scattered solar light in the MUV.

We use a Multiple-Linear Regression code to distinguish Mg+ from other emissions in our MUV channel. In the region between 265-300 nm, we fit the CO2 UV doublet, the solar spectrum, the CO Cameron bands, the wings of Oxygen 297.2 nm, the N2-VK bands as well as Mg (285 nm). Mg at 90 km is predicted to be brighter than Mg+ by a factor of six, yet we find them to be comparable at best. Mg retrievals are complicated by its proximity to the CO2 UV doublet centered near 290 nm, as well as instrumental effects that we are attempting to remove with refined data processing techniques, and expect to be able to report upper limits or detections soon. While additional data processing will improve our confidence, this difference in brightness is not expected to change dramatically, therefore this discrepancy between observation and theory still warrants attention.

The Neutral Gas and Ion Mass Spectrometer (NGIMS) on MAVEN provides complementary measurements of metals at Mars, but is unable to sample altitudes below 140 km regularly. During ‘Deep Dip’ campaigns, where periapse is lowered to sample near 125 km, we find good agreement between the IUVS and NGIMS concentrations for Mg+ in the region of overlap (~130 km).

Results: IUVS reports detection of Mg+ at Mars in a steady state layer attributed to meteoric ablation. Using observations that span more than an Earth year, we find this layer is global and steady state, contrary to previous observations, but in accordance with predictions. Mg is also detected, but Mg/Mg+ less than predicted by factor >3, indicative of undetermined chemical processes in the Mars atmosphere.

References: [1] Patzold M, et al. (2005) *Science* [2] Withers P., Mendillo M., & Hinson DP., (2008) *Journal of Geophysical Research Letters* [3] Pesnell, W., & Grebowsky, J., (2000) *Journal of Geophysical Reserach* [4] Schneider NM., et al. (2015) *Geophysical Research Letters* [5] Whalley CL , & Plane J. (2010) *Faraday discussions*