The Response of Photoelectrons in the Martian Atmosphere to Variable Solar Input

Isabel Mills, Whitman College ’17
Frank Eparvier, Ed Thiemann, LASP
Research courtesy of NSF REU Grant 1157020

The MAVEN Mission

The Mars Atmosphere and Volatile Evolution Mission
Launch Date: November 2013
Orbit Period: 4.5 Days

The Question: Geological evidence indicates that liquid water used to exist on the surface of Mars. This indicates that at some point, a heavier atmosphere was present.

The Method: A variety of instruments collect data from atmospheric and solar inputs. MAVEN’s highly elliptical orbit allows data to be taken from a large portion of the Martian atmosphere. Understanding the different layers of the atmosphere is crucial because different processes dominate at different altitudes.

The Ionosphere

The ionosphere is a layer of the Martian atmosphere that has a high concentration of ions and electrons. Neutral CO₂ and O are both present in the ionosphere. We focus on the double ionization of these in this research. The ionosphere overlaps the exobase and the homopause; their definitions are helpful in understanding why the ionosphere is critical in understanding atmospheric escape.

Exobase: Where the mean free path becomes larger than the scale height
Homopause: The boundary at which particles adapt individual scale heights. Below this the atmosphere is well mixed.
Left: The orbit of MAVEN
Scale Height: The height at which the density of a ceratin species falls by a factor of e
Mean Free Path: The average distance travelled by a particle before a collision

One process that occurs in the ionosphere is the Auger Effect: A high energy photon hits an atom, knocking off an electron from the inner shell and leaving a vacancy. An upper electron drops to fill this vacancy and to conserve energy, another electron is ejected. This second electron is the auger electron. We can detected Auger electrons because they are produced with a characteristic energy.

Filtering Data: In order to isolate Auger electrons, we only look at data that is below 250 km to ensure we are in the ionosphere. To ensure we are observing the sun, we only look at solar zenith angles (SZA) below 90 degrees. (See left)

The Goal: The purpose of MAVEN is to understand the processes that control atmospheric loss and the timescales over which they occur.

Data Analysis: October 2015

I. Create Cross Section/Irradiance convolutions from Models
Cross Section: A qualification of how likely it is that a particular molecule will absorb radiation

II. Find Energy Distribution from SWEA: We find the integrated electron flux for energy bins surrounding the Auger peak

III. Plot SWEA and Model data together

IV. Plot the two Variables against each other:
If SWEA and model data were perfectly correlated, the scatter plot would be a straight line. Each plot to the right corresponds to integrating over a different range of energy bins

V. Pearson Correlations:
A Pearson correlation of 1 means that two variable are perfectly positively correlated

Conclusion

- Both models (FISM and SynRed), are able to predict the behavior of Auger electrons with decent accuracy
- FISM, a coarser model, shows slightly higher correlation than SynRef when it comes to integrating over multiple energy bins
- SynRef correlates higher at the Auger peak, and therefore, as suspected, is better at predicting fine details
- Regarding the two statements above, the small difference in correlation coefficients between the two models may not be significant

Future Research

Short term:
- Fit slopes to the correlation plots
- Compute correlations with more combinations of SZA and altitude

Long Term:
- Adjust models (change assumed temperature of the sun) to find higher correlations