Studying Mars’ Exobase

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The Martian Atmosphere

- 6 mbars pressure
- 95% CO₂
- Barely any water
Early Mars Atmosphere Loss
MAVEN
Mars Atmosphere and Volatile Evolution Mission
Solar Wind Strips the Atmosphere
Atmospheric Escape
Significance of Studying the Exobase

• Altitude above which molecules are unlikely to collide with something before leaving the planet
• Knowing the exobase and how it varies will help determine escape rates
Formal Definition of Exobase

- Altitue at which the mean free path of a molecule is equal to the scale height of the atmosphere.

- Scale Height: The altitude at which the atmosphere density drops off by a factor of $e$.

- Mean Free Path: Distance a molecule travels between collisions.
Analysis Overview

• Instrument and data used
• Calculations and computations
• Plots
• Results and Interpretation
• Future work
Instrument Used

**NGIMS**
Neutral Gas and Ion Mass Spectrometer

**Articulated Payload Platform**
(IUVS/STATIC/NGIMS)
Data Used

• Inbound CO$_2$ number densities
  – October, November, February – June
  – Altitudes between 150 km and 250 km
Analysis

For each orbit:

• Extracted scale height from fitting parameters
  – \( H = \frac{kT}{mg} \)

• Calculate exobase number density
  – \( H = \frac{1}{n\sigma} \)
  – \( \sigma \) is the collision cross section for \( CO_2 \)

• Calculate exobase altitude
  – \( n(z) = n_o e^{-z/H} \)
Plotted the CO$_2$ number densities vs altitude in log space.

Fit the data and extracted scale height H which is used to extract an exobase number density.

Used exobase number density to calculate an exobase altitude.
Creating the Exobase Plots

For each exobase altitude, extracted the corresponding:

• Longitude and latitude
• Local time
• Solar zenith angle
• Season
Longitude and Latitude
Local Time
Season

- Winter Solstice: $L_S = 270$
- Autumnal Equinox: $L_S = 180$
- Spring Equinox: $L_S = 0$
- Summer Solstice: $L_S = 90$

- Perihelion
- Aphelion
Solar Zenith Angle

\[ \theta \]
Comparsion with Simiar work
Future Work

• Further sampling of different periapse locations will help determine the driving factor(s) behind the variation in exobase altitudes.
• Finding the homopause altitude
• Finding the isotope ratios
• Using the Rayleigh distillation formula to back out how much of the atmosphere was lost
Solving Mysteries

Extremely high altitude plumes
200 – 250 km
Conclusions

• Calculated the exobase altitudes for the months of October, November, February to June and plotted them vs diff. parameters.
• In the plots we can see that the exobase varies with different parameters such as solar zenith angle, local time and latitude.
• Variation is convoluted by sampling of different periapse locations.
• Cannot make conclusions yet on what is causing this Variation.