Variations in Martian Proton Aurora as Observed by MAVEN/IUVS

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I. Introduction and Background

Proton Aurora: a third type of aurora (in addition to diffuse and discrete) newly identified at Mars

- Formed by penetrating protons from solar wind charge exchange
- Not constrained by a global magnetic field
- Expected to occur only on Mars' dayside

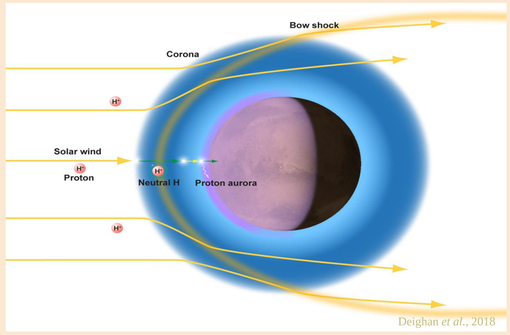


Figure 1: Mechanism for Martian proton aurora originating from solar wind charge exchange

Project Goals:

- Better understand solar wind's interaction with Mars' hydrogen corona
- Create a comprehensive catalog characterizing Martian proton aurora

II. Data and Methods

Using data from the Imaging UltraViolet Spectrograph (IUVS) onboard the Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft, we evaluate the hydrogen Lyman-alpha emission (121.6 nm) from periapsis limb scans throughout the entire mission (~1.5 Martian years).

Data Collection and Reduction Process:

1. IUVS limb scans taken during orbit periapse
2. FUV and MUV spectral and spatial data collected; spectral intensity profile created
3. Data corrected by subtracting background Ly-α, applying flat field, and kR conversion.
4. Altitude profile created by summing intensities under Ly-α curve (one point for each mirror position and slit position); data binned by altitude

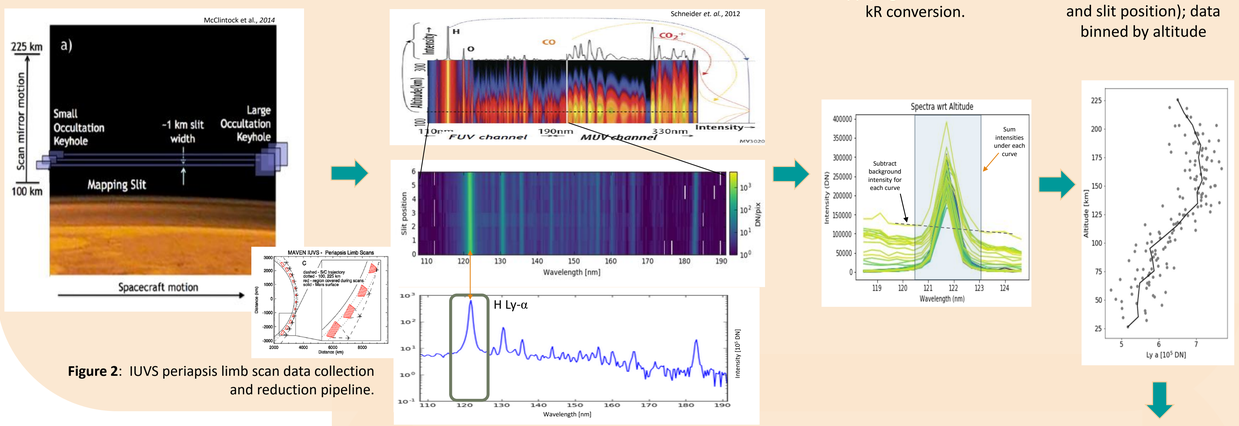
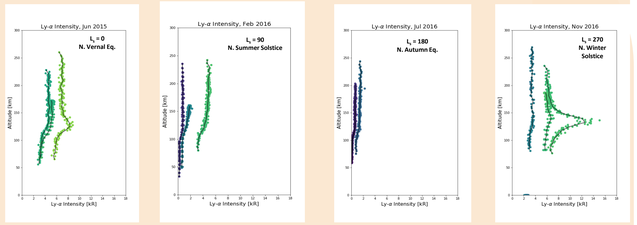


Figure 2: IUVS periapsis limb scan data collection and reduction pipeline.

Proton aurora exhibit enhanced brightness peak between ~120-150 km altitude (*e.g.,* June 2015 & Nov. 2016 in Fig. 3)



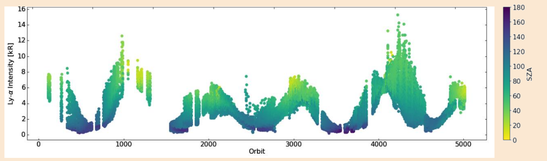


Figure 3: Top: Profiles of maximum, minimum, and median (at 150 km altitude) for select months; color corresponds to SZA & solid lines are binned averages. Bottom: Ly-α Intensities and SZA's for all orbits.

Detection Method: "Global statistic Method"

1) Separate data into peak and high altitude regions
2) Difference: 2nd highest peak alt intensity – median high alt intensity
3) Threshold: standard deviation of differences of *entire* dataset (*e.g.* 3σ in this study).

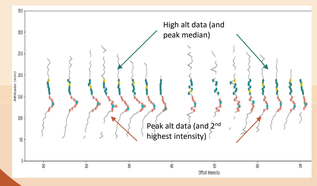


Figure 4: (left) Example of data used in step 1 and step 2 of detection method

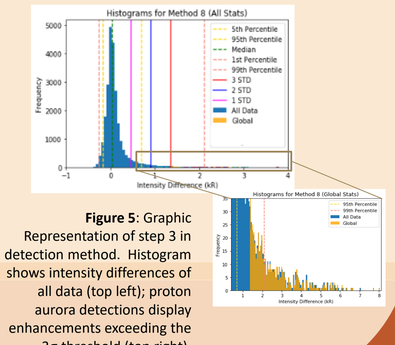
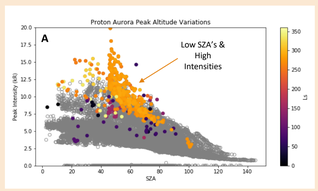
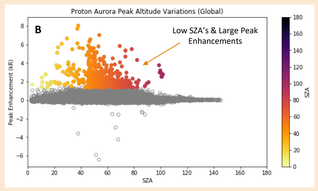


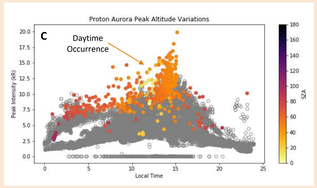
Figure 5: Graphic Representation of step 3 in detection method. Histogram shows intensity differences of all data (top left); proton aurora detections display enhancements exceeding the 3σ threshold (top right).

III. Observations

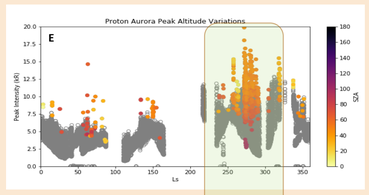


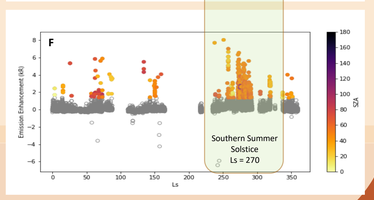


- Proton aurora events correlated with low SZA's, high intensities, and large peak enhancements (A & B)

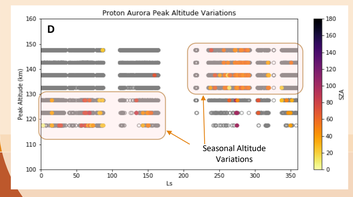


- Proton aurora observed only on day side of planet (apparent "exceptions" occur at high latitudes and/or near summer) (C)
- Highest intensities, emission enhancements, and frequency of events occur near S. Summer solstice (L_s = 270) (E & F)





Altitude of peak enhancement varies with season:



- Low L_s events (~0-160) have low peak altitudes
- High L_s events (~245-340) have higher altitudes
- Variations due to inflated CO_2 atmosphere in southern summer

Figure 6 (A-F): Variations in proton aurora events. Proton aurora detections (colored) overlain on non-detections (grey).

IV. Summary and Conclusions

- Using current rigorous detection constraints (3σ threshold), **we identify 486 individual profiles exhibiting definite proton aurora events, from 137 unique orbits** (only 9 detections reported prior)
- May be **more common than previously thought** (definitive proton aurora detections occurring in >2% of profiles and >5% of orbits)
- Correspond with **low SZA's** and **occur almost entirely in daytime**
- Some interesting seasonal variations: **peak altitudes, emission enhancements, intensities and frequency of proton aurora events are all higher near S. Summer.**

V. Outstanding Questions and Future Work

- What are the locations (geographic, temporal, etc.) of proton aurora events at Mars? Is there any interaction with an upstream magnetic field?
- Compare selected altitude profiles to model predictions, possibly via a model challenge

Acknowledgments

Many thanks to Coauthors, Collaborators, and funding sources, including:

- CEDAR Student Travel Funding
- John Mather Nobel scholarship
- NASA Astrobiology Early Career Collaboration Award
- Florida Space Grant Consortium

References

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