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Discovery of Diffuse Aurora on Mars

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Abstract

The Imaging Ultraviolet Spectrograph (IUVS, McClintock et al., 2014) onboard the MAVEN spacecraft has discovered diffuse aurora in Mars' northern hemisphere spanning a wide range of geographic latitudes and longitudes (Figure 1). This widespread aurora differs from the small auroral patches discovered by the SPICAM instrument onboard the Mars Express spacecraft (Bertaux et al., 2005; Leblanc et al., 2008; Gérard et al., submitted; Soret et al., submitted) restricted to regions of crustal magnetic fields in the southern hemisphere. Furthermore, the northern diffuse aurora appears to peak at altitudes below 100 km, while the crustal field aurora peaked around 120 km.

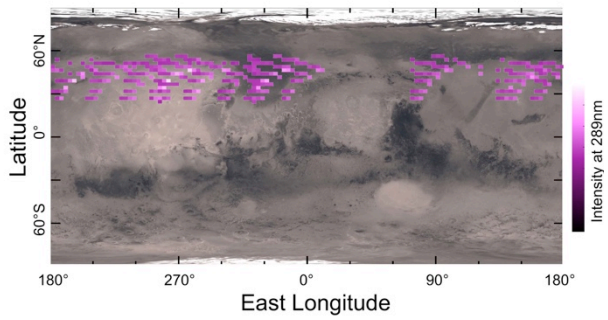

Figure 1: Mapping of the detection of the aurora.

1. Discovery of a new type of Martian aurora

An increase of the intensity of the CO_2^+ 289 nm nightside emission was observed by IUVS from Dec, 18th to Dec, 23rd, 2014. During the same period, the Solar Energetic Particle (SEP) instrument and the Solar Wind Electron Analyzer (SWEA) instrument on board MAVEN measured important high-energy electron fluxes. We suggest that high-energy electrons carried by the Interplanetary Magnetic Field (IMF) deposit their energy in the Mars' atmosphere to produce ultraviolet diffuse aurora.

2. Source of the aurora

The source of the energetic particles appears to be the Sun, based both on the depth of atmospheric penetration and the timing of a substantial increase in energetic electrons during the aurora. Electrons with ~20 keV measured by the SEP instrument over the same period than the detection of the ultraviolet aurora by IUVS are capable to travel along open field lines and penetrate in the Mars' atmosphere below 100 km. A second event of lesser magnitude was observed in both auroral emission and solar energetic particles on 3 March 2015, confirming the correlation.

3. Spectral analysis

The observed auroral spectrum resembles Mars dayglow (see Figure 2; e.g Leblanc et al., 2006; Stiepen et al., 2015), though the relative strength of spectral features differs due to the different excitation caused by 20 keV electrons in comparison with solar EUV radiation.

We carefully verified the presence of the CO_2^+ doublet at 289 nm and the CO Cameron bands on every spectrum taken by IUVS during the period the aurora was observed. During that period, the aurora could be spectrally identified in all IUVS nightside periapse observations.

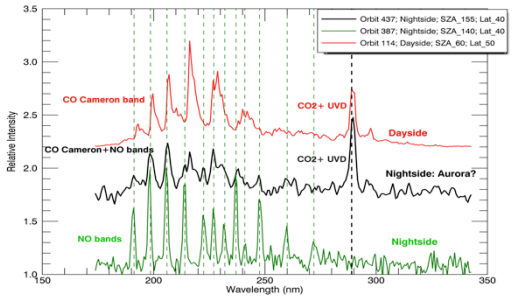

Figure 2: Comparison of IUVS dayglow (red), nightglow (green) and nightglow and auroral (black) spectrum

4. Summary and Conclusions

We report the discovery of diffuse ultraviolet aurora in Mars' Northern Hemisphere. We suggest that these auroras are produced by precipitation of high energetic electrons carried by the IMF.

MAVEN's complement of remote sensing and in situ instruments may offer the best opportunity to study diffuse auroral processes associated with open field lines, as may occur on unmagnetized or weakly magnetized bodies in the Solar System.

Future work will consist in quantitative comparison of the aurora brightness and altitude with electron precipitation models and further comparison to crustal field aurora.

Acknowledgements

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References

Bertaux, J.-L. et al., 2005, 2006. Gérard et al., submitted. Leblanc et al., 2006, 2008. McClintock, W. E. et al., 2014. Soret et al., submitted. Stiepen, A. et al., 2015.