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Mars Aurora: A Comparison of MAVEN/IUVS and EMM/EMUS Observations

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Mars' lack of a global magnetic field led to initial expectations of minimal auroral activity. Mars Express's SPICAM instrument nonetheless discovered an unusual form of aurora in 2005. The ultraviolet emissions were confined near Mars' strong crustal field region, showing that even weak magnetic fields can be responsible for aurora. These discrete aurora emissions were identified in 19 observations over SPICAM's decade of observations.

The MAVEN spacecraft arrived at Mars in 2014 carrying the Imaging UltraViolet Spectrograph (IUVS). Thanks to its high sensitivity and observing cadence, IUVS increased detections of discrete aurora twenty-fold. IUVS also discovered two new widespread forms of aurora. *Diffuse aurora* is a planet-engulfing phenomenon, caused by solar energetic protons and electrons directly impacting the entire unshielded planet. *Proton aurora* is caused by solar wind protons charge-exchanging into the atmosphere and causing Lyman alpha emission across the dayside. IUVS studies the aurora at mid- and far-UV wavelengths in both limb scans and nadir imaging.

The Emirates Mars Mission (EMM) arrived in 2021 carrying the Emirates Mission UltraViolet Spectrometer (EMUS). EMUS quickly added to the menagerie of auroral phenomena thanks to its high far-UV sensitivity. Discrete aurora emissions were seen in a substantial fraction of nightside observations, and appear to take on new forms not seen by IUVS (*sinuous*, *"non-crustal field"*, among others). Furthermore, EMUS detected a spatially-variable form of proton aurora called *patchy proton aurora*. EMUS studies the aurora through nadir imaging at far- and extreme-UV wavelengths.

The net result of the tremendous influx of new observations is a lag in cataloguing and cross-comparing the types of observations made with different instruments at different wavelength ranges in different observing modes. We now have the perspective to identify the causes of these auroral phenomena, which gives a more physics-based nomenclature:

- **suprathermal electron aurora**: hot electrons from the Mars environment appear to be responsible for most forms of discrete aurora

- **solar energetic particle aurora**: SEP electrons and protons from the Sun cause the planet-wide diffuse aurora
- **solar wind aurora**: solar wind protons charged-exchange into the atmosphere to cause dayside aurora

This presentation seeks to give that broader context, highlighting

- what phenomena IUVS and EMUS observe, depending on their distinct instrumental capabilities
- whether they're actually seeing the same phenomena or different ones,
- how can one type of observation can complement the other,
- where one's capabilities are unique, and
- what are the best directions for collaboration;
- how *in situ* measurements of particles and fields can contribute to the next stage of understanding of the conditions for particle precipitation

A more coherent observational perspective, as outlined above, may grant a framework for developing a deeper physical understanding of Mars unexpected diverse auroral processes.