

Bulletin of the AAS • Vol. 54, Issue 8

Venus and Mars' global diffuse aurora: common for non-magnetic planets?

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Published on: Oct 20, 2022

URL: <https://baas.aas.org/pub/2022n8i216p01>

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The interaction of the solar wind with Venus and Mars is unique given each planet's lack of a global magnetic field, leading to unique auroral activity. Global diffuse aurora has been observed on both planets during intense solar storms, such as coronal mass ejections (CMEs). On Mars, global CO_2^+ UVD aurora (peaking near 60 km) was observed after a solar energetic particle (SEP) event (Schneider et al 2018). On Venus, global OI 130.4 nm aurora was observed after what was likely a large CME passage (Phillips et al. 1986). Venus also exhibits auroral emission event during solar minimum. The Venusian 557.7 nm OI ($^1\text{S} - ^1\text{D}$) “oxygen green line” has been consistently detected not only after after large particle storms, such as CMEs, but also during weaker particle events such as the passage of a stream interaction region (SIR) or co-rotating interaction region (CIR).

While the altitude of the OI (^1S) state is unknown, the fact that the OI($^1\text{D}-^3\text{P}$) “oxygen red line” is not detected indicates that emission is occurring below 150 km. Radio sounding of the Venusian nightside ionosphere from Venus Express (VEX) revealed that the low nightside ionosphere, near 120 km, shows significant electron density increases during CME passages coinciding with green line emission (Gray 2015), suggesting the green line originates near 120 km. Similar nightside low ionospheric behavior is also observed on Mars (Withers et al 2012). The increase in low ionospheric electron densities during solar storms indicates the presence of high energy particle precipitation. Resent ROSE observations show enhanced low altitude (70 km) electron densities during a CIR passage when SEP protons were detected but not SEP electrons (Withers et al. in review).

Altitude emission profiles of the Martian CO_2^+ global aurora were modeled by Nakamura et al (2022), who showed that while both electrons and protons contribute to emission, the inclusion of SEP protons provided a better match to the observed emitting altitude. On Venus, SEP protons are observed for every detection of the Venusian green line (Gray et al in prep). While an examination of both the contribution of SEP electrons and protons are required, it may be that the Venusian aurora is also a low altitude SEP aurora with important contributions from protons. Given these similarities between ionospheric density and auroral behavior during SEP events, global diffuse aurora may not be unique but, in fact, standard for non-magnetic planets.