Auroral Emission in the Venusian Atmosphere During Solar Minimum

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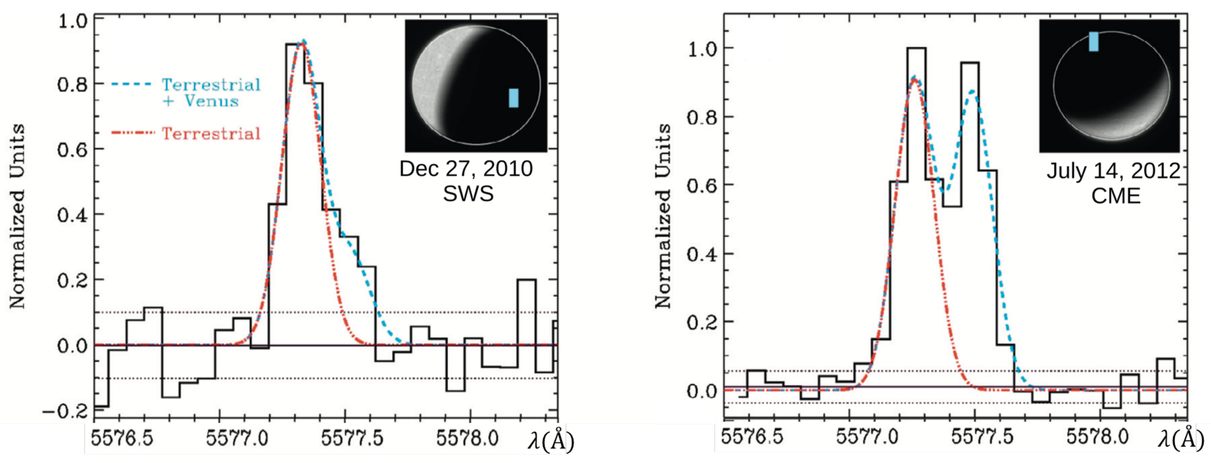
Abstract The solar wind is known to interact with the ionospheres and atmospheres of terrestrial planets, thus contributing to their atmospheric evolution. An essential component of this evolution is atmospheric stripping, the process of ionizing particles such that they escape the atmosphere. One feature of the solar wind is a stream interaction region (SIR), which is created when multiple solar wind streams are compressed to create regions with higher densities, stronger magnetic fields, and steeper velocity profiles. These low energy events are far more common than large solar storms and present throughout the entire solar cycle. Thus, while less intense, SIRs provide an equally important, but poorly understood, source of planetary atmospheric erosion. Ground-based Venus observations of large solar events have shown auroral emission in Venus's atmosphere, but the trigger for this emission is unknown. This study looked for auroral emission during solar minimum. Over a roughly three-week observing campaign, emission was not detected via the quiet solar wind. One observation taken as a SIR approached Venus and the IMF polarity inverted captured emission, showing promise for future solar minimum monitoring campaigns.

Motivation

The 5577Å oxygen green line emission is a common terrestrial auroral feature and was first discovered on Venus in 1999[1,2,3]. More recent target of opportunity observations[4] in 2010 - 2014 show green line emission when Venus is in the path of CMEs and solar flares, but it is unclear what triggers the emission. Our goals are to:

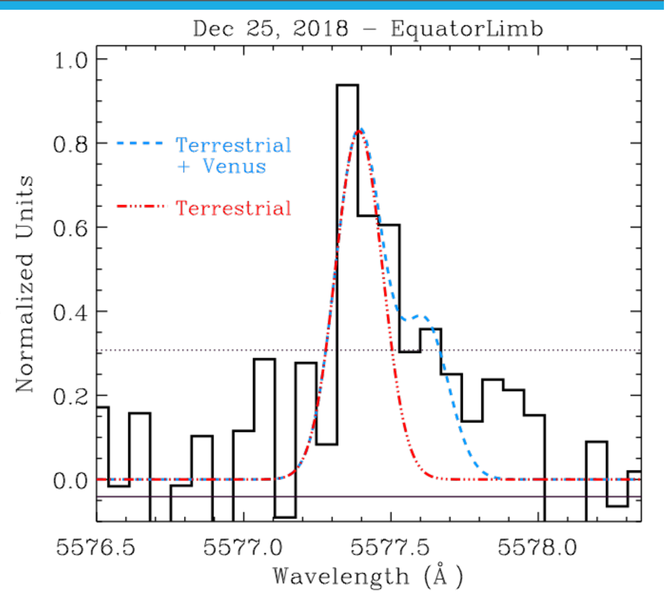
- Monitor the green line emission over longer periods of time to track its variability
- Utilize advanced solar wind models to predict the conditions at Venus
- Compare green line emission with varying solar wind conditions near Venus via modeling and in situ measurements



Detections of the oxygen green line during target of opportunity observations from Gray et al. 2014. (left) Weak detection during a dense solar wind stream (SWS) (right) Strong detection during a coronal mass ejection (CME)

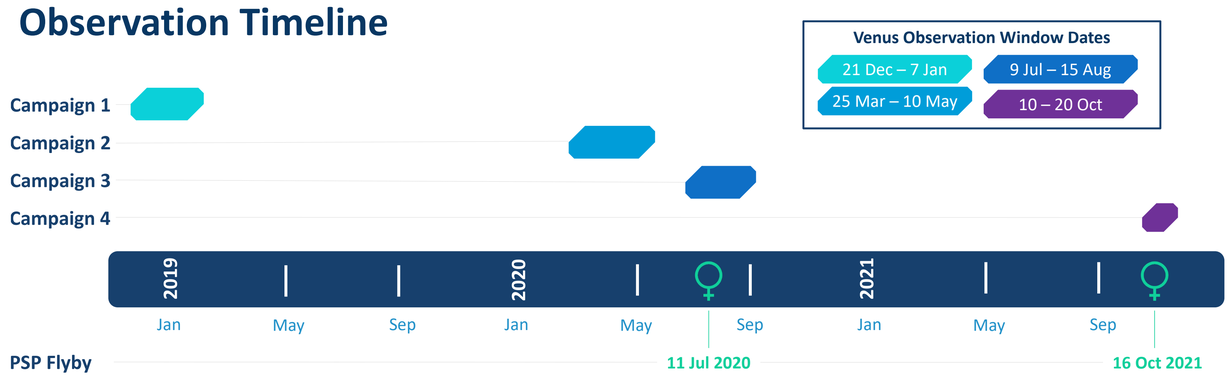
Observation Campaign

Observations taken in Dec 2018 - Jan 2019 with the Astrophysical Research Consortium 3.5m telescope equipped with an (R~31,500) echelle spectrograph at Apache Point Observatory. To observe the green line, the Venusian dayside must be less than half illuminated to limit scattered light, and Venus must be doppler shifted enough to separate the terrestrial and Venusian features.



This campaign collected over 12 nights of data, with a sole detection on 25 Dec 2018, when the solar wind model predicts a polarity inversion at Venus.

Observation Timeline



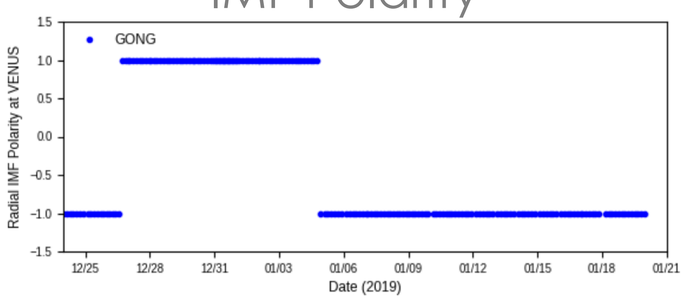
Windows for observations of Venus during the mission lifetime of Parker Solar Probe. Note that these dates are for observations at Apache Point Observatory and will change slightly if observed at other observatories.

Solar Wind Conditions

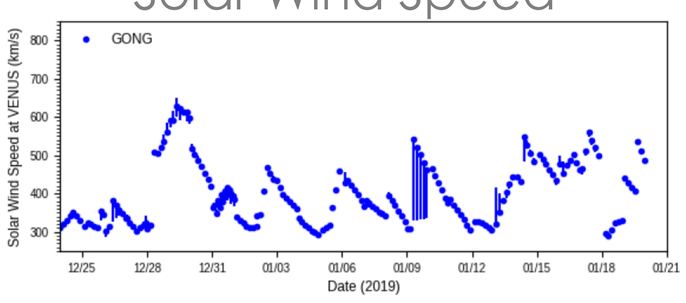
We utilize the Wang-Sheely-Arge (WSA[5]) solar wind model to determine the solar wind conditions near Venus during our observing campaign. Near the date of the detection, there is a heliospheric current sheet crossing, indicated by a change in polarity.

A change in polarity can cause magnetic reconnection to occur in the magnetotail, creating an ejection of particles into the night side of the planet, which may be responsible for the green line emission.

IMF Polarity



Solar Wind Speed



Future Observations with Parker Solar Probe

During PSP's next Venus flyby on 11 Jul 2020, we will conduct ground-based green line observations, which will provide us with in situ solar wind data at the same time as spectra. This encounter will allow us to gather real time information about the solar wind conditions responsible for aurora on Venus.

Acknowledgment

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Citations

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