Behavior of the OI 557.7 "oxygen green line" and discovery of CO B-A 483.5 nm aurora on Venus

C. Gray[1] , C. Schmidt[2], P.Lierle[2], [1]Apache Point Observatory, New Mexico State University (candaceg@nmsu.edu), [2]Boston University (full mailing address and e-mail address).

Introduction: Venus has been known to exhibit auroral emission during solar energetic particle (SEP) storms associated with solar flares, coronal mass ejections (CME), and solar wind streams (SWS) (Phillips et al 1986, Slanger et al. 2001, Gray et al. 2014). The first auroral detection was with Pioneer Venus Orbiter in 1982 when the 130.4 nm OI emission was observed after a large CME impact. In 1999, the OI 557.7 auroral green line was detected using HIRES on Keck by Slanger et al 2001. Gray et al. 2014 showed that this green line detection coincided with a series of CME impacts. Using the Astrophysical Research Consortium Echelle Spectrograph (ARCES) on the 3.5m ARC telescope at Apache Point Observatory (APO), Gray et al. 2014 conducted a study during solar max and found bright green line emission after intense CME impacts but no emission when SEP storms were not present. The red line was not detected for any of these observations. It is hypothesized that the green aurora is also a diffuse aurora, occurring globally, similar to the 130.4 UV aurora and driven by SEP precipitation (Gray et al. 2024 in review).

Observations: To determine the spatial distribution of the green line, an observing campaign was conducted from APO in September 2023 while Venus was a very thin crescent, only 15% illuminated. A 1.6x3.2" slit was placed at multiple positions across the nightside of the disk, including the equatorial limb. In order to estimate solar wind conditions near Venus, we use the Advanced Composition Explorer (ACE) spacecraft. A solar wind stream (SWS) passed over Earth and Venus during the time of our observation.

Results: While green line emission was detected across the nightside of the planet, we found the first detection of CO (B-A) aurora at 483.5 nm, the (0,1) Angstrom band, as seen in Figure 1. CO Angstrom emission has never been detected before. Bright emission was seen in only one exposure, when the slit was placed on the nightside limb of the planet, close to the dawn terminator.

Given the shape of the Parker Spiral and that Venus was leading Earth in its orbit by 15 degrees, Venus is expected feel the effects of SWS and magnetic inversion slightly before Earth. Figure 1 shows observations from the Advanced Composition Explorer. While SEPs were only mildly enhanced, strong magnetic inversions were present near the time of observations. Given the near lack of emission from the Angstrom band during other exposures that night, the CO aurora may be a patchy aurora on Venus. Intriguingly, the CO (B-A) (0,2) band at 519.8 nm, which is expected to be brighter than the (0,1) band, was not readily detected, nor was the (0,3) band at 561.0 nm or the (0,0) band at 510.8 nm.

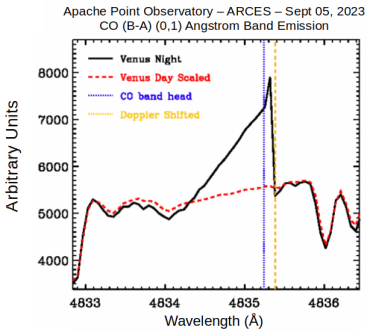

Figure 1: *Detection of CO (0,1) Angstrom band. Integration on the nightside limb is shown in black while a short integration of the dayside limb is shown in red. The CO band head is marked by the blue vertical dashed line while a Doppler shifted wavelength corresponding to the velocity of Venus is marked by the vertical gold dashed line.*

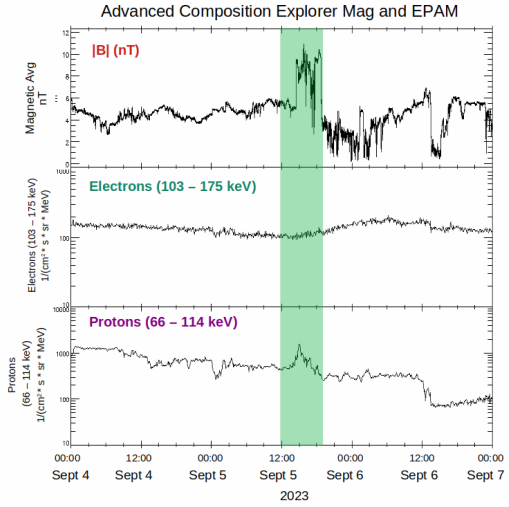

Figure 2: *Solar wind magnetic field strength, electron flux, and proton flux measured by the ACE spacecraft at the time of our observation. The vertical green bar denotes the expected solar wind behavior at Venus. A magnetic inversion and increase in proton energies is observed during the time of CO emission.*

References: [1] Phillips et al 1986, [2] Slanger et al. 2001, [3] Gray et al. 2014, [4] Gray et al. 2024 in review.