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An upper limit for the O_2 (a-X) dayglow on Venus from VIRTIS-Venus Express observations

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Abstract

Oxygen dayglow on Venus was observed on 1975 from ground, with a high resolution spectrometer, (spectral resolution ranging from 12 to 50×10^{-3} cm^{-1})[1]. Subsequent observations failed in detecting this phenomenon, both from ground and from space. The European mission Venus Express, orbiting the planet since April 2006, allowed to investigate in great detail both the dayside and the nightside of Venus with the imaging spectrometer VIRTIS (Visible and Infrared Thermal Imaging Spectrometer) on board the spacecraft. However, no evidence of the O_2 dayglow have been found in the VIRTIS data. An upper limit of 1 MR in limb view is derived for the O_2 (a-X) dayglow emission in the range of 90 to 150 km, which approximately means 20 kR in nadir view, posing the question about the altitude of the emission and/or its occasional appearance.

1. Introduction

The observations of the oxygen dayglow in the Venus' atmosphere detected about 30 years ago from ground [1], reported a mean value of 1.5 MR (1R = 10^6 photon cm^{-2} sec^{-1} $(4\pi ster)^{-1}$) for the (a-X)-(0,0) intensity, as observed in Nadir geometry. This value is very comparable with the retrieved nightglow intensity of the same band, 1.2 MR, coming from the same observations campaign.
Subsequent observations failed in detecting oxygen dayglow emissions. Thanks to the European mission Venus Express, we now have the opportunity to better investigate the day side of Venus with VIRTIS. The instrument covers in particular the infrared spectral range from 1 to 5 µm with a spectral sampling of about 10 nm.
Considering the difficulties in observing Venus from ground, a high resolution ($\lambda/\Delta\lambda \sim 300000$) ground-based telescope would be necessary to detect the dayglow on the planet. The requirement on resolution limits a lot the Venus dayglow observations from ground. However, the relatively low spectral resolution channel of VIRTIS is satisfactory to investigate such phenomenon. The wide coverage of the Northern hemisphere of Venus with limb data acquired in the first 3-years in orbit were used to derive an upper limit of the dayglow intensity, as observed by the instrument.

2. Method

Data acquired in limb mode and selected in the altitude range 90-150 km were analyzed in order to detect the dayglow emission, similarly to what performed systematically in the night side.

We used a standard method to derive the upper limit of the detectivity, already explained in [2, 3].
Continuum is estimated from adjacent bands and it is subsequently subtracted for each single spectrum and image. Resulting spectrum is then visualized as an histogram, considering data in the altitude range 100-140 km. The lower limit in the altitude range is due to the instrument limit: data at lower altitudes are not available because of the saturation limit due to the exposure time. The upper limit is set in order to exclude data that will not add scientific information but noise.
The distribution is fitted with a Gaussian curve. It is centred about zero, where the noise is the only contribution at the considered wavelengths. If a systematic error is present, then the distribution is shifted by a small amount towards positive or negative values.

Deviations from a Gaussian curve above 1σ, sometimes present, would potentially carry oxygen airglow information. They were checked with the result that they do not fit with dayglow profiles, but more likely due to stray light or solar contribution.
The detection limit is estimated to be equal to the FWHM resulting from the Gaussian fit.

3. Results

The O_2 emission on the day side of Venus does not seem to be present on the large available dataset. On the other hand, an upper limit for the O_2 dayglow emission, equal to 1 MR, as observed in limb view was set by our study. This would imply a detection limit equal to 20 kR as observed in Nadir mode view, significantly lower than the previous ground based detections.

The reason of this large discrepancy is not clear at the moment. The result would imply that either dayglow emission occurs at an altitude much different from that one explored in orbit, or its intensity, whether the emission is coming from the same region of altitude, is much lower than the value reported in the former observation from ground. The latter implying an emission sporadic at the time of its detection. New observations both from ground and from space are then desirable in order to solve this still unresolved puzzle.

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References

[1] Connes et al., 1979; [2] Fedorova et al., 2006; [3] Altieri et al., 2009.