



The OH Venus nightglow: morphology and relation to ozone in the upper atmosphere

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Abstract

An analysis of the spectral distribution of OH infrared nightglow spectra obtained with the VIRTIS spectral imager on board Venus Express will be presented. It will be compared with models of the intensity distribution among the $\Delta v=1$ and 2 bands and rotational lines calculated with recent quenching coefficients of OH* by CO₂ molecules. The total intensity will be compared with that expected from the reaction of ozone with atomic hydrogen, based on the O₃ abundance recently derived from stellar occultations.

1. Introduction

The presence of the OH airglow in the terrestrial mesosphere has been known since the early 50's. The reaction between ozone and hydrogen atoms leads to the production of vibrationally excited hydroxyl molecules in the X²Π state. OH infrared emission was recently detected in the spectrum of the Venus nightside mesosphere observed at the limb with the Visible and Infra-Red Thermal Imaging Spectrometer (VIRTIS) on board the Venus Express spacecraft [1]. The (1-0) and (2-1) transitions at 2.80 and 2.94 μm, respectively and the (2-0) band at 1.43 μm were clearly identified. Limb emission profiles have been extracted from the VIRTIS observations using spectral images integrated over appropriate wavelengths [2] following corrections for thermal background scattering by haze particles [3]. The brightness and the altitude of the ($\Delta v=2$) sequence emission was compared to that of the ($\Delta v=1$) sequence and a close correlation was observed between the two vibrational sequences. In a detailed study based on the full set of VIRTIS-M limb observations, it was found that the mean peak intensity along the line of sight of the OH $\Delta v=1$ sequence was 0.60 MR and was located at 96.4 ± 5 km. No dependence of the airglow layer altitude versus the antisolar angle was observed. The emission is

highly variable but, statistically, the peak brightness appears to decrease away from the antisolar point.

2. Comparative morphology of the O₂ and OH airglow

The two-dimensional distribution of the O₂ a¹Δ-X³Σ⁻ (0-0) band at 1.27 μm and the OH $\Delta v=1$ Meinel airglow measured simultaneously with VIRTIS will be presented. Both emissions are spatially structured and present regions of significant enhanced brightness. We show that they both present very similar spatial structures.

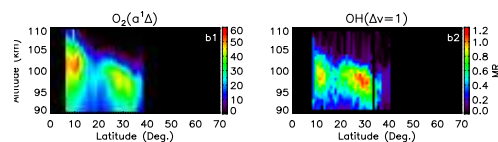


Figure 1: spatial distribution of the O₂ and OH airglow measured simultaneously with the VIRTIS spectral imager during Venus Express orbit 499

A cross-correlation analysis of the limb images in the two spectral ranges indicates that the highest level of correlation is reached with only very small relative shifts of the pairs of images. In spite of the strong spatial correlation between the morphology of the bright spots in the two emissions, we find that their relative intensity is not constant, in agreement with earlier statistical studies of their limb profiles. We suggest that the two emissions have a common precursor that controls the production of both excited species. We argue that atomic oxygen, which produces O₂(¹Δ) molecules by three-body recombination and is the precursor of ozone formation, also governs to a large extent the OH airglow morphology through the

$$\text{H} + \text{O}_3 \rightarrow \text{OH}^* + \text{O}_2 \quad (1)$$

reaction.

3. Ozone as a source of excited hydroxyl

Reaction (1) mainly produces OH molecules in the high vibrational quanta, by contrast with the spectrum of the Venus airglow which shows transitions from $v=1, 2$ and 3 . This indicates that non-radiative transitions occur which considerably reduce the intensity of bands originating from high-lying vibrational levels. Collisional deactivation by CO_2 molecules is expected to play a major role in the redistribution of the OH vibrational populations. We have used recent laboratory data to build models combining radiative transitions with collisional quenching [4].

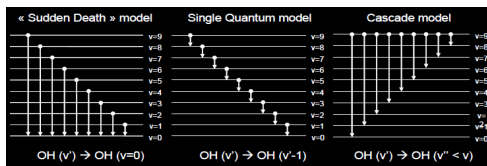


Figure 2: collisional quenching models of OH^* by CO_2 used in this study

Different assumptions concerning the dynamics of the cascade process are examined (sudden death, single quantum, cascades) and we conclude that a combination of single quantum and collisional cascades best reproduces the observed OH infrared spectrum. The absolute brightness of the OH emission is also compared with that expected from different scenarios based on the recent detection and density determination of ozone near 100 km by Montmessin et al. [5]. The compatibility between the intensity predicted by the different models based on the new ozone measurements and the VIRTIS observations will be discussed.

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