EPSC Abstracts
Vol. 6, EPSC-DPS2011-1837, 2011
EPSC-DPS Joint Meeting 2011

Limb observations of CO_2 non-LTE emission in Mars atmosphere as observed by OMEGA/Mars Express

A. Piccialli (1), P. Drossart (2), M.A. Lopez-Valverde (3), A. Määttänen (4), B. Gondet (5), F. Altieri (6), O. Witasse (1), J. P. Bibring (5)

(1) ESA, ESTEC, Keplerlaan 1, 2201 AZ Noordwijk, The Netherlands, (2) LESIA, Observatoire de Paris, 5 place Janssen, 92195 Meudon, France, (3) IAA, Glorieta de la Astronomía, 18008 Granada, Spain, (4) LATMOS/CNRS, Université Versailles Saint-Quentin-en-Yvelines (UVSQ), Guyancourt, France, (5) IAS, Orsay University, 91405 Orsay, France, (6) IFSI – INAF, via del Fosso del Cavaliere 100, 00133 Rome, Italy (arianna.piccialli@esa.int / Fax: +31-(0)-71-565-4697)

Abstract

We report here on OMEGA/MEx day-side limb observations of non-Local Thermodynamic Equilibrium (non-LTE) CO_2 emission at 4.3 µm. Since January 2004 more than 500 limb profiles have been acquired at various locations, seasons and illuminations. The variability of the non-LTE emission with latitude, altitude, solar illumination and season was analyzed and compared to predictions derived by non-LTE model.

1. Introduction

Ground-based observations of CO_2 laser bands at 10 µm in the atmospheres of Venus and Mars [1] were identified as non-LTE emissions by several atmospheric models developed in the 1980s [2, 3]. More recently, CO_2 non-LTE emission at 4.3 µm was detected in the upper atmosphere of Mars and Venus by various experiments on board the European spacecrafts Mars Express and Venus Express [4, 5, 6]. These observations led to the development of a more comprehensive non-LTE model for the upper atmosphere [7, 8]. According to these models, during daytime the solar radiation in several near-IR bands from 1 to 5 µm produce enhanced state populations of many CO_2 vibrational levels which cascade down to lower states emitting photons in diverse 4.3 µm bands. These emissions produce what is observed.

2. Observations

The OMEGA experiment on board the ESA mission Mars Express is a visible and near-infrared imaging spectrometer functioning in two channels in the wavelength range 0.38-5.1 µm [9]. The instantaneous field of view (IFOV) of each pixel is 1 mrad, corresponding to a vertical spatial resolution of few kilometers.

3. Preliminary results

The CO_2 emission observed at 4.3 µm is interpreted as non-LTE fluorescent emission in the upper atmosphere (Fig. 1). Two distinct emission peaks are observed, one around 4.3 µm, produced by a combination of several CO_2 bands of the main isotope (626), and another one around 4.4 µm, mostly due to the 636 isotopic bands.

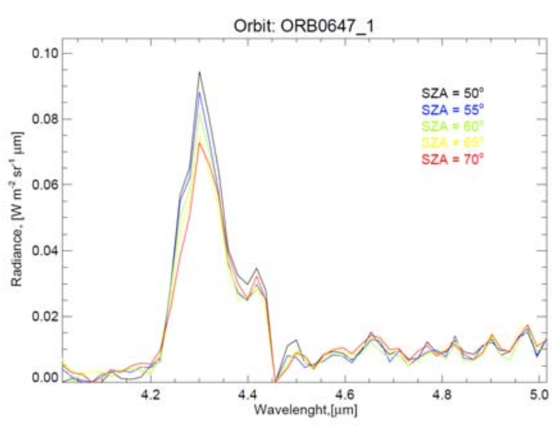

Figure 1: Omega spectra taken at the limb at an altitude of ~68 km and at different solar zenith angles: (black) 50º; (blue) 55º; (green) 60º; (yellow) 65º; and (red) 70º. The non-LTE emission at 4.3 µm is clearly visible.

The variations of the emission with geophysical parameters, like the emission height and the solar illumination (SZA), are analyzed in detail. Fig. 2 shows the SZA-altitude cross section of the radiance at 4.3 µm.

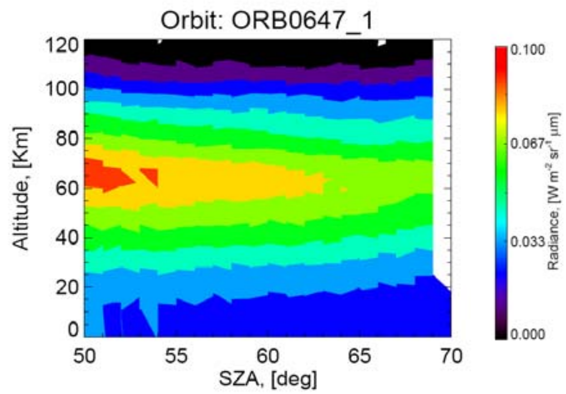

Figure 2: SZA-altitude contour plot of OMEGA radiances (W m^{-2} sr^{-1} μm^{-1}) at 4.3 µm.

Two strong variations can be observed in the radiances: (1) the emission reach a peak at the altitude of ~70 km, (2) the intensity of the emission decreases with increasing solar zenith angle. Both variations are well explained by the non-LTE model [7, 8], as a solar driven pumping of multiple CO_2 bands in the 4.3 µm region. Similar results have also been obtained by the Planetary Fourier Spectrometer, on board Mars Express [4]. We are currently analyzing the whole OMEGA dataset with a double goal: to validate the non-LTE model and to describe the variability of the Martian upper atmosphere, for the first time using this emission.

References

[1] Deming, D., Espenak, F., Jennings, D., Kostiuk, T., Mumma, M., and Zipoy, D.: Observations of the 10-micron natural laser emission from the mesospheres of Mars and Venus, Icarus, Vol. 55, pp. 347-355, 1983.

[2] Deming, D., and Mumma, M. J.: Modeling of the 10-micron natural laser emission from the mesospheres of Mars and Venus, Icarus, Vol. 55, pp. 356-368, 1983.

[3] Lopez-Puertas, M., and Taylor, F. W.: Non-LTE radiative transfer in the atmosphere, World Scientific Publishing, Singapore, 2001.

[4] Formisano, V., Maturilli, A., Giuranna, M., D'Aversa, E., and Lopez-Valverde, M. A.: Observations of non-LTE emission at 4-5 microns with the planetary Fourier spectrometer abord the Mars Express mission, Icarus, Vol. 182, pp. 51-67, 2006.

[5] Drossart, P., López-Valverde, M. A., Comas-Garcia, M., Fouchet, T., Melchiorri, R., Bibring, J. P., Langevin, Y.; Gondet, B.: Limb observations of infrared fluorescence of CO_2 from OMEGA/Mars Express, Second workshop on Mars atmosphere modelling and observations, February 27 - March 3 2006 Granada, Spain, 2006.

[6] Gilli, G., López-Valverde, M. A., Drossart, P., Piccioni, G., Erard, S., and Cardesín Moinelo, A.: Limb observations of CO_2 and CO non-LTE emissions in the Venus atmosphere by VIRTIS/Venus Express, J. Geoph. Res., Vol. 114, 2009.

[7] López-Valverde, M. A., López-Puertas, M., López-Moreno, J. J., Formisano, V., Grassi, D., Maturilli, A., Lellouch, E., Drossart, P.: Analysis of CO_2 non-LTE emissions at 4.3 µm in the Martian atmosphere as observed by PFS/Mars Express and SWS/ISO, Planet. Space Sc., Vol. 53, pp. 1079-1087, 2005.

[8] López-Valverde, M. A., López-Puertas, M., Funke, B., Gilli, G., Garcia-Comas, M., Drossart, P., Piccioni, G., and Formisano, V.: Modeling the atmospheric limb emission of CO_2 at 4.3 µm in the terrestrial planets, Space Sc., 2010.

[9] Bibring, J. P., and 20 colleagues: OMEGA: Observatoire pour la Minéralogie, l'EAU, les Glaces et l'Activité, ESA SP 1240, pp. 37-49, 2004.