EPSC Abstracts
Vol. 9, EPSC2014-399-1, 2014
European Planetary Science Congress 2014

Experimental setup used to characterize gases at typical planetary atmospheric conditions

S.Stefani (1), G.Piccioni (1), M.Snels (2) and A.Adriani (1)
(1) IAPS-INAF Rome Italy , (2) ISAC-CNR Rome Italy
(Stefania.Stefani@iasp.inaf.it / Fax: +390645488188)

Abstract

Here we present three experimental setup used to study the optical properties of gases, in particular CO_2 and H_2, at typical planetary conditions. Two dedicated gas cells have been integrated with a Fourier Transform InfraRed (FT-IR) spectrometer.
The first, High Pressure High Temperature (HP-HT) gas cell, is designed to support pressures up to 200 bar, temperatures up to 570 K and characterized by an optical path of 2 cm. The second one, Multi Pass (MP), is a cell with a variable optical path from 2.5 to 30 m, able to work with pressure up to 10 bar and temperature up to 600 K. The last experimental apparatus is a cell projected to support pressures up to 100 bar and uses the Cavity Ring Down (CRD) technique to record the loss rate of different gases.

1. Introduction

The measurements in the lab are of major importance to implement the input parameters of the radiative transfer models. In particular we study the optical properties of gases at typical planetary conditions to better interpret the data coming from VIRTIS instrument on board VENUS-EXPRESS [1] and JIRAM [2] on JUNO. Furthermore, the experimental data, will support the study of our solar system bodies and will also contribute significantly to the understanding of the exoplanets which, in great part of the cases explored until now, present conditions most different from those terrestrial. For these reasons we build up different experimental apparatus which allow us to reproduce the same physical-chemical conditions found in the atmospheres of Venus and Jupiter. The experimental data obtained a different spectral resolution will be used to update the common tools of radiative transfer calculations in order to improve the accuracy of remote sensing data analyses.

2. Experimental setups

The HP-HT allows us to recreate the same chemical and physical conditions found in the deep atmosphere of Venus and to understand the behavior from 50 down to 16 km of altitude (see figure 1a). This facility is not sufficient to study the so called ''atmospheric windows'' which allow to observe from an orbiting spacecraft the planet Venus down to its surface, where the pressure reaches 92 bars and the temperature 450°C. For this reason we realized a CRD system, shown in figure 1b, which produces an effective optical path of about 5 km. Finally, to study in more details small absorptions and important phenomena such as Collision-Induced-Absorption (CIA), particularly relevant for Jupiter, line mixing and far wings, we need an additional tool which uses a Multi-Pass (MP) gas cell characterized by a variable optical path (see figure 1c).

2.1 Results and discussions

We reproduced in our HP-HT gas cell the real Venusian physical conditions for CO_2 in a grid from the VIRA profile [3], varying the pressure from 1 to 30 bar and the temperature from 298 to 600 K. For each point of the grid we measured the absorbance of the gas. Some results are shown in figure 2a) [4]. Using a DFB laser to illuminate the CDR gas cell, we measured the carbon dioxide loss rate in the spectral range from 1179 to 1182 nm, varying the pressure from 1 up to 38 bar and maintaining the temperature constant at 294 K. As you can see in figure 2b), the attenuation due to CO_2 varies both linearly and quadratically with the density [5]. Using the MP gas we have performed the preliminary H_2 measurements at different pressures, room temperature and 15 m of optical path. The spectra obtained in the spectral range of interest are shown in figure 2c).

3. Figures

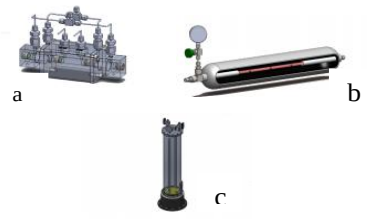

Figure 1: experimental setups used to characterized the behaviour of gases at typical atmospheric conditions.

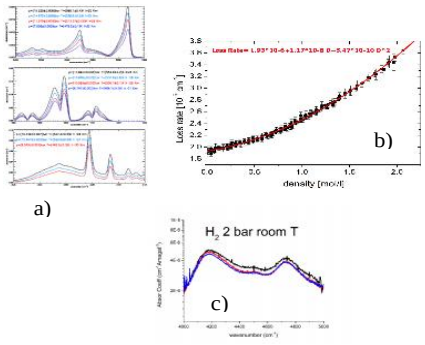

Figure 2: Experimental data recorded using the three different experimental setups

6. Summary and Conclusions

The CO_2 spectra have been measured for a wide range of temperatures, pressures and for a large spectral range. All data are now available and can been downloaded from: eaxact.iaps.inaf.it. A theoretical model including line mixing effects as well as far wings corrections for the strongest absorption bands reproduces the laboratory spectra excellently, for all pressures and temperatures[6]. The first measurements, obtained using the innovative design for the Cavity Rind Down gas cell, have been performed on carbon dioxide in the 1180 nm transparency window of Venus. The quadratic component measured varying the pressure from 38 down to 1 bar is in good agreement with analyses performed by [7,8] on Venus emission spectra. The preliminary H_2 spectra recorded at different pressure are in good agreement with the model of Borysow [9].

Acknowledgements

This work has been supported by an ASI (Italian Space Agency) grant nr: I/050/10/0.

References

[1] Piccioni G. et al.: VIRTIS: the Visible and Infrared Thermal Imaging Spectrometer. Eur. Space Agency Spec. Publ., ESA SP-1295, 2007.

[2] Adrian A. et al: JIRAM, the Image Spectrometer in the Near Infrared on Board the Juno Mission to Jupiter. Astrobiology, Vol. 8, Issue 3, 2008.

[3] Seiff A. et al: Models of the structure of the atmosphere of Venus from the surface to 100 Kilometers altitude, *Adv. Space Ree.* Vol.5**,** No.11, pp.3-58**,** 1985

[4] Stefani S. et al: Experimental CO_2 absorption coefficients at high pressure and high temperature, JQRST, vol. 117, pp21-28, 2013

[5] Snels M. et al: Carbon dioxide absorption at high densities in the 1.18 μm nightside transparency window of Venus, JQRST, vol. 133, pp. 464-471,2014

[6] H. Tran et al.: Measurements and modeling of high pressure pure CO_2 spectra from 750 to 8500 cm^{-1}. I- central and wing regions of the allowed vibrational bands, JQRST vol. 112, 925-936, 2011

[7] Bézard B. et al.: Water vapor abundance near the surface of Venus from Venus Express/VIRTIS observations. Journal of Geophysical Research (Planets) vol. 114, pp 12, 2009

[8] Bézard B. et al.: The 1.10- and 1.18-μm nightside windows of Venus observed by SPICAV-IR aboard Venus Express. Icarus vol.216, Issue 1, pp 173–183, 2011

[9] Borysow, L. et al. :Modeling of pressure-induced far-infrared absorption spectra. Molecular hydrogen pairs Astrophysical Journal, vol. 296, pp. 644-654, 1985