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Cavity Ring Down measurements on CO2 at high pressure at 1.18 «m

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Abstract

Here we present a Cavity Ring Down (CRD) system which consists of a DFB laser coupled to a stable optical cavity. An innovative design avoids to expose the cavity ring down mirrors to mechanical stress and allows to operate the CRD apparatus up to pressures of about 100 bar. Here we present the first laboratory measurements performed on carbon dioxide, the main constituent of the Venus's atmosphere, at pressures from 1 up to 38 bar and at a temperature of 294K, in the Venus' atmospheric window at 1.18 micron.

1. Introduction

The interpretation of emission/absorption spectra from the Venus' atmosphere presents a challenge to the science community. Indeed, due to the high values of the pressure and CO_2 volume mixing ratio, the contributions to the absorption spectra of complex phenomena such as Collision-Induced Absorption, line mixing and far wings absorption, must be accurately taken into account. In particular, the so called atmospheric windows, one of which is at 1.18 μm, 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. The accurate knowledge of the atmospheric optical properties in the windows is then very important to reduce the uncertainty of the retrieved parameters. In order to study weak absorptions due to collisions, it is necessary to work at high densities with very long optical paths. Our Cavity Ring Down (CRD) experimental setup allows to achieve an effective optical path of more than 5 km in the laboratory.

2. Experimental Setup

The experimental apparatus consists of a DFB laser used to illuminate a stable optical cavity. The cavity, consisting of an inner quartz tube formed by two highly reflecting plano-concave mirrors (R>99.98%), is placed inside a stainless steel container capable to support a pressure up to 100 bar (see figure 1). The Cavity Ring Down (CRD) can reach an equivalent optical path of 5 Km. This innovative design allows to use the cavity under stringent pressure conditions without affecting its performance otherwise compromised by the mechanical stress. In order to eliminate possible residual gases adsorbed, the cell was passivated by pumping and filling it repeatedly. The loss rate was recorded continuously during the experimental procedure, starting with an empty cell and proceeding from the highest initial pressure, gradually to lower pressures in steps of about 1 bar.

2.1 Results and Discussions

Using the DFB laser, whose full scan range is from 1179 to 1182 nm, we measured the carbon dioxide loss rate varying the pressure from 1 up to 38 bar and maintaining the temperature constant at 294 K. Results are shown in figure 2, were black squares are experimental data and the red curve represents the best fit. The attenuation due to CO_2 varies both linearly and quadratically with the density. The linear attenuation of $1.17(5)*10^{-8}$ $cm^{-1}Amagat^{-1}$ is due to Rayleigh scattering . The second is due to absorption by far wings of bands outside the spectral window and to the so-called continuum absorption, which includes contributions of very far bands and Collisional Induced Absorption (CIA).

This contribution is 5.47(14)*10^{-10} $cm^{-1}$$Amagat^{-2}$ and is smaller than the far wings and continuum absorption estimated from analyses of VIRTIS and SPICAV observations [1,2] (about 10(4)*10^{-10} $cm^{-1}$$Amagat^{-2}$). One must bear in mind, however, that the laboratory measurements have been performed at 294 K, while the VIRTIS/SPICAV analyses refer to temperatures between 600 and 730 K.

3. Figures

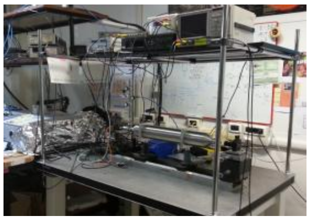

Figure1: Cavity Ring Down realized in our laboratory

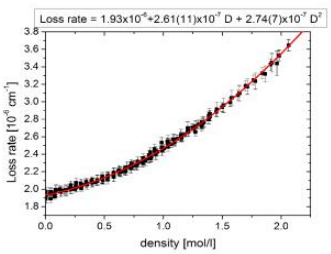

Figure 2: Loss rate vs density recorded at different pressures and room temperature in the 1.18 μm

6. Summary and Conclusions

A newly constructed high pressure cavity ring down cell is presented, with the goal to measure weak absorptions in planetary atmospheres at pressures up to 100 bar (the cell has been tested up to 38 bars up to now, but is certified up to 100 bar). The first measurements have been performed on carbon dioxide in the 1180 nm window , and revealed a dependence on density which has a linear and a quadratic component. The quadratic component is smaller than that obtained from analyses performed on Venus emission spectra [1,2], but one has to consider the difference in temperature. Further work is in progress, extending the measurements to higher pressures and temperatures. These measurements can be also extended to other spectral regions by using different laser sources and by substituting the pre-aligned

Acknowledgements

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References

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