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Ground-Based Heterodyne Observations of CO_2 Non-LTE Emission at 10μm on Comet C/2012 S1 (ISON)

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Abstract

We report on future observations of the atmosphere of comet C/2012 S1 (ISON) during its solar approach in November 2013. Ground based investigation of the CO_2 non-LTE emission around 10μm will be performed to investigate the comets thermal properties, as well as outgasing rates and molecular abundances of CO_2 .

1. Introduction

The ultra high spectral resolution of heterodyne spectroscopy ($\frac{\nu}{\Delta\nu} > 10^7$) offers the capability to investigate single molecular transition features. Non-LTE emission of CO_2 occurs on the sun lit side of planetary atmospheres, i. e. Mars and Venus, at a low pressure level of 1 μbar. The CO_2 molecules get excited by absorbing solar radiation at 4.3 μm. For decreasing pressure, the molecular collision rate decreases too and de-excitation takes place through spontaneous emission at 10.6 μm. Hence, the narrow emission peak is purely Doppler broadened, yielding multiple physical parameters, such as the kinetic temperature of the molecule. Analysis of CO_2 non-LTE emission in planetary atmospheres has been performed since many years [1].

2. Observations

Ground-based measurements shall be conducted by applying the Cologne based Heterodyne spectrometer THIS [2] at the McMath-Pierce Solar Telescope on Kitt Peak, AZ, USA, during the comets solar approach, shortly before perihelion on November 28th 2013. Since the solar angular separation of the comet will be very small, the use of a solar telescope is unavoidable.
The comets perihelion distance will be as short as 0.0125 AU. During the time of observations it will stay within a solar distance of less than 0.3 AU.

3. Temperature Retrieval

A typical non-LTE emission spectrum is displayed in Fig. 1. The best fit was found using the radiative transfer code (CODAT [3]). The Doppler width of the emission line yields the kinetic temperature according to Eq. (1).

$$\Delta\nu_D = \frac{\nu_0}{c}\sqrt{\frac{8k_B T_{kin} ln(2)}{m}} \quad (1)$$

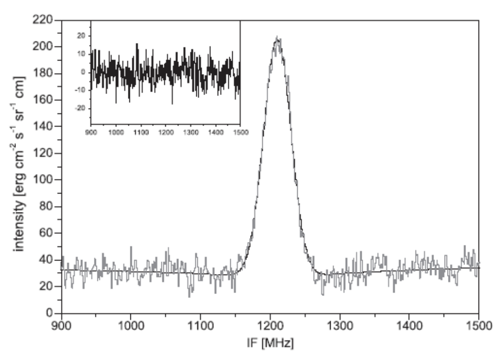

Figure 1: *A typical non-LTE CO2 emission spectrum from Venus [1]. Plotted is the intensity vs. the intermediate frequency for the P(16) line at 947.74198 cm^{-1} with an integration time of ∼4 minutes. Plotted over the data is a fit to the observed line using a radiative transport code. The inset plot shows the residuals. The line width yields the temperature.*

4. Calculation of CO_2 Density

To obtain a line intensity as shown in the spectrum in Fig. 1, a beam integrated column density of $n_{CO_2} \approx 1.9 \cdot 10^{19}\ \frac{mol}{m^2}$. Assuming a cometary outgasing rate $Q \approx 1 \cdot 10^{29}$ within a solar distance of < 0.3 AU [4], the minimum column density will add up to $\approx 4 \cdot 10^{20}\ \frac{mol}{m^2}$ which is of magnitude of the Venus observations.

5. Summary and Conclusions

Preliminary calculations on the emitting radiation of comet C/2012 S1 (ISON) predict a promising result for heterodyne observations. The line intensity of the CO_2 non-LTE feature from the comet is expected to be in order of magnitude of the Venus observations. A sophisticated analysis on the thermal properties of the comet can be deduced.

References

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