Traceable Line Strength Measurements using Cavity Ring Down Spectroscopy

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Introduction

Air pollutants have a considerable impact on human health and they form one of the main current threats to the environment. In order to control air pollution effectively accurate measurements of the levels of air pollutants and their time-evolution are needed. To monitor the levels of air pollutants with high selectivity and sensitivity, laser-based spectroscopic methods have recently gained ground. In the case of a known strength of an absorption line of a molecule of interest the amount of substance for such a molecular gas can be directly determined. In this poster the results of traceable line strengths measurements for CO_2 and $^{12}CH_4$ using cavity ring down spectroscopy are presented.

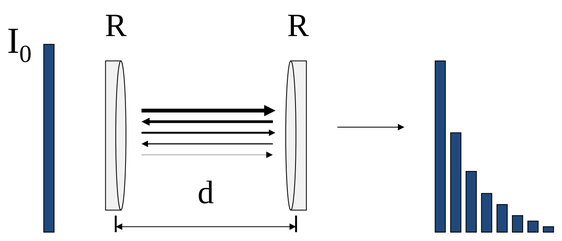
Motivation

- Need for accurate values of line strength for important greenhouse gases carbon dioxide and methane

Objectives

- Building Cavity Ring Down Spectrometer
- Perform spectral measurements in the region around 1.6 μm
- Line shape analysis

Principles of CRDS



Empty cell:

$$I(t) = I_1 e^{-\frac{c}{d}|\ln(R)|t}$$

Decay time:

$$t_0 = 1/\beta_0 = \frac{d}{c\,|\ln(R)|}$$

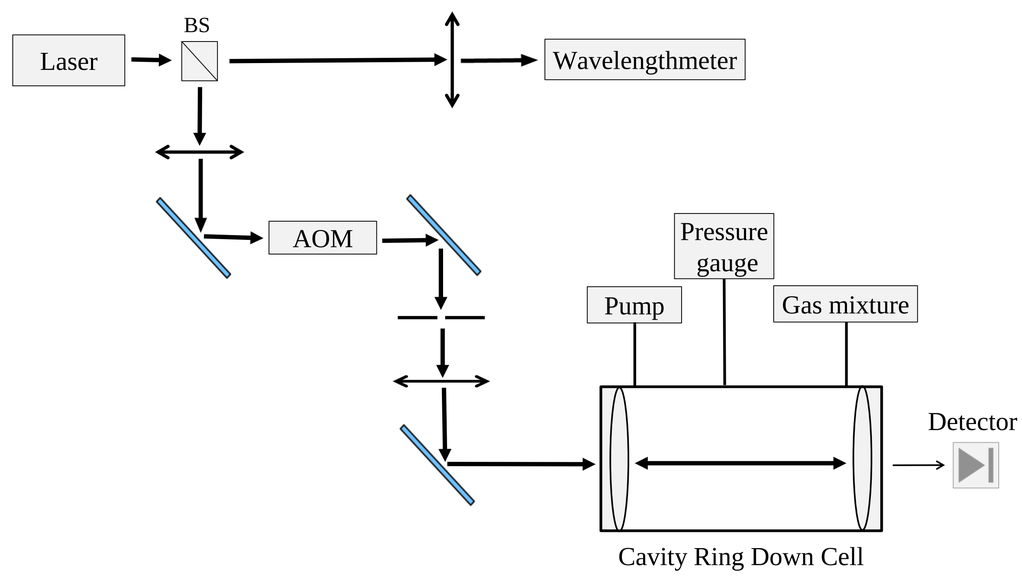
Cell with gas with extinction coefficient k :

$$I(t) = I_1 e^{-\frac{c}{d}(|\ln(R)| + k_\nu d)t} \longrightarrow k_\nu = \frac{\beta_\nu - \beta_0}{c}$$

Main advantages of CRDS

- High sensitivity due to long optical path length
- High selectivity due to high spectral resolution
- High signal to noise ratio due to independency from the intensity fluctuations of the laser source

CRD Spectrometer

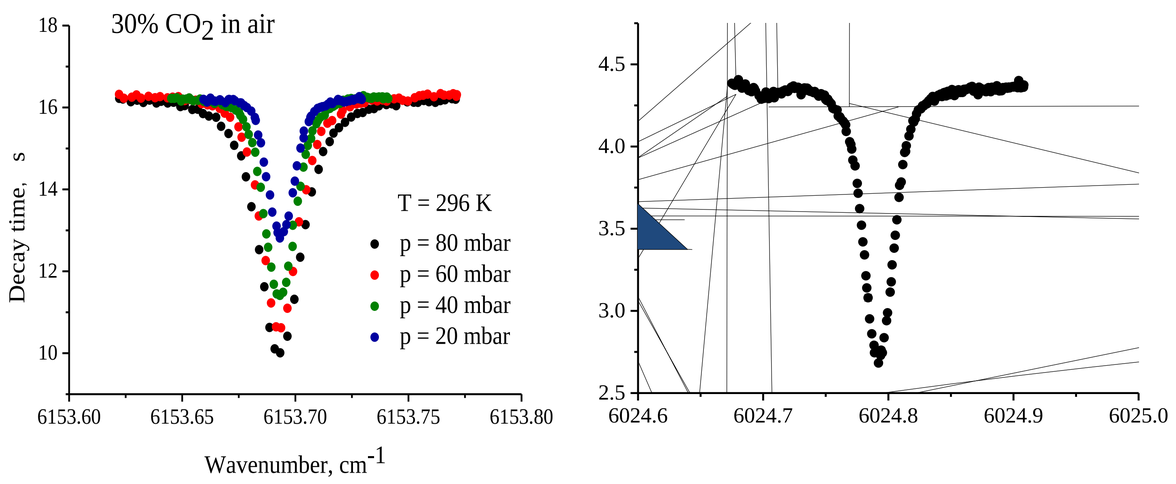


- Light source
  External Cavity Diode Laser (5900 6200 cm^{-1})
- AOM - Acousto optical modulator for measure-ments of the decay time
- Pressure gauge calibrated at MIKES
- Gas mixtures CO_2/air and $^{12}CH_4$/air prepared at VSL

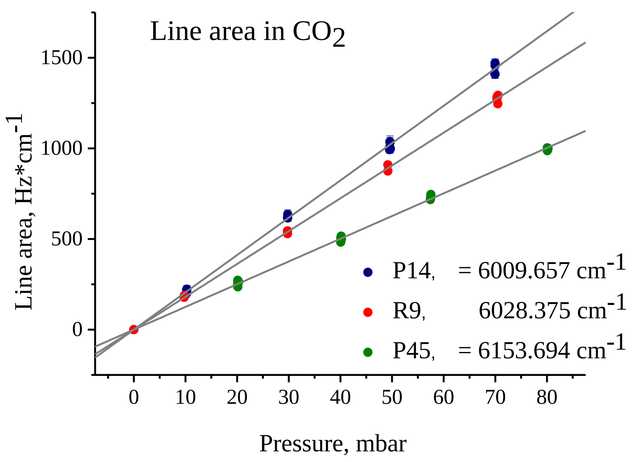
- Cavity ring down cell:
  distance between the mirrors d = 50 cm,
  reflectivity of the mirrors R 99,97%

→ Decay time 5 6 μs
Optical path length 1.5 2.0 km

Measurements



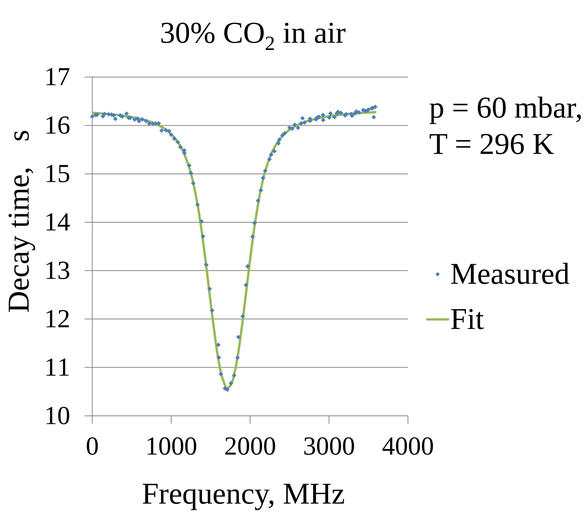
Results

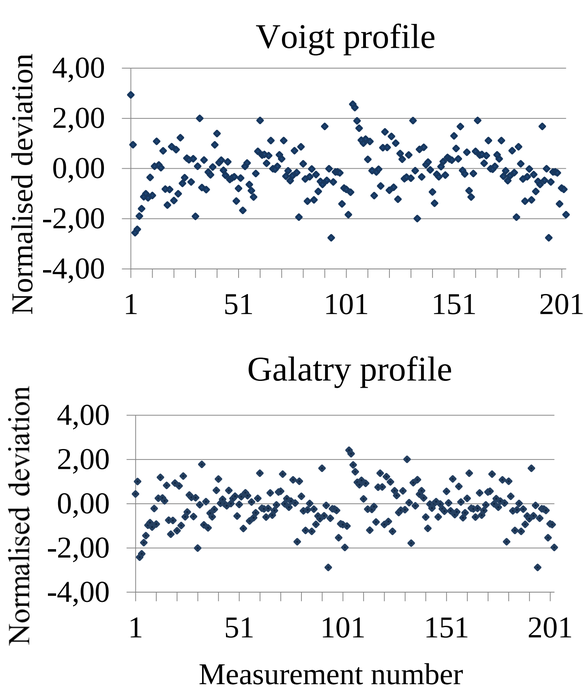


Line strengths in CO_2, cm/mol		
P14 line at 6009.657 cm^{-1}	R9 line at 6028.375 cm^{-1}	P45 line at 6153.694 cm^{-1}
(1) 9.269 0/ $^{-26}$ 1.4%	8.284 10^{-26} 5%	5.546 10^{-26} 5.3%
(2) 9.28 10^{-26} 4%	8.54 10^{-26} 4%	-
(3) 9.256 10^{-26} from 2 to 5%	8.347 10^{-26} from 2 to 5%	5.569 10^{-26} from 2 to 5%
(4) 9.24·10^{-26} ≤ 1%	**8.12·10^{-26} ≤ 1%**	**5.70·10^{-26} ≤ 1%**

(1)R.A. Toth et.al., JMS (2006), 239, 221-242
(2)B.V. Perevalov et.al., JMS (2008), 252, 190-197
(3)HITRAN 2008
(4)**Present work**

Line shape analysis





Conclusion

Cavity Ring Down Spectroscopy can be used for high accuracy measurements of absorption line strengths of different molecules

Acknowledgment

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