Oxygen Photoacoustic effect using an external cavity diode laser

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Introduction

In this report we will write about the experiment done during the first and second weeks of August in order to measure one "line"' in the visible part of the absorption spectrum (ATMOSPHERIC BAND/B-BAND?) of the Oxygen molecule using the photoacoustic effect. In order to excite the oxygen molecular orbitals we used a diode laser tuned with an external cavity. INSERT SMALL RESUME OF THE REPORT? FOR EXAMPLE (IN CHAPTER 1 WE WILL TALK ABOUT BLABLA, IN CHAMPTER 2 ABOUT BLIBLI ETC?)

1 Experimental apparatus

The setup we used featured the typical photoacoustic experiment characteristics. There was a source of light, a laser in our case, impinging on the gas into a cavity. A mechanical chopper provided a modulation of the light in order to match a proper frequency of the cavity. The acoustic signal, detected by microphones, was filtered by a lock-in amplifier referenced with the chopping frequency. The light path was controlled trough optical elements such as mirrors, lenses and beam-splitters. Some standard laboratory instrumentation was used as well, including:

- generator
- waveform generator
- oscilloscope
- optical fiber spectroscope
- membrane vacuum pump
- etalon
- analogic videocamera
- monitor

We'll now describe in more details the main elements of the apparatus.

1.1 The laser source

We used an external cavity laser device, formed by the following elements:

- a single mode multi-quantum well AlGaInP laser diode[1]. The lasing wavelength could be tuned from about 680 nm to 695 nm by adjusting the driving current and the diode temperature.
- a temperature controller case[2] to set the temperature of the diode.
- an external cavity, i.e. a setup that feeds back the laser diode with the first diffraction order of a 1800 grooves/mm grating. The external cavity allowed us to better select a given lasing mode, thus getting a smaller emission linewidth. The grating was put on a piezoelectric mechanical actuator, which permitted nm-order adjustments of its position. Since a grating diffracts different frequencies at different angles, moving the grating we could control the frequency fed back to the laser and thus enhanced. This is how we got a fine tuning of the frequency, and how we were able to make the HOWMANYGHz scan to see the absorption line.

[1] Hitachi HL6738MG: `http://pdf.datasheetcatalog.com/datasheets/50/502031_DS.pdf`
[2] Thorlabs TCLDM9: `http://www.thorlabs.de/Thorcat/1900/TCLDM9-Manual.pdf`

1.2 The acoustic chamber

The gas to analyze, pure O_2 at atmospheric pressure, was contained in a brass chamber, featuring :

- an internal cavity, about 13 cm long, where the gas actually resonated. Other two smaller cavities were present before and after the main cavity. Since we couldn't open the brass chamber, we had no way to accurately measure the dimensions and the position of the main cavity with respect to the other two ones. It should be noticed that our chamber had been recycled from another experiment and was not explicitly thought for the usage we do of it. However, there were two marks on the outer side of the chamber, that were supposed to indicate where the main cavity started and ended.

- four microphones put about halfway in the chamber, one for each side of it. Due to the fact that the chamber couldn't be opened, we don't know whether the microphones were actually halfway. According to the marks, they were not. In fact, they were 5 mm away from the supposed middle point.

- an active strain gauge vacuometer[3] measured the pressure in the chamber.

[3] Edwards ASG-1000-NW16: http://www.ultimatevacuum.dk/D35725880%20ASG%20user%20manual.pdf

A The etalon

The etalon is an optical device made of two perfectly parallel semi-reflecting surfaces. It can be thought as a Fabry-Pérot cavity, which walls are fixed.