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SO_2 absorption of the CO_2-laser emission measured by the photoacoustic technique

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Abstract. Spectra of coincidence of SO_2 IR absorption with CO_2-laser emission at pressure of 50, 100 and 450 Torr were recorded by the use of a photoacoustic detection method in the whole range of CO_2-laser emission. The spectra show that SO_2 absorbs many CO_2-laser lines in the range 1084–1071 cm^{-1} with the strongest absorption at 1082·29 cm^{-1}, laser line $R(26)$. The intensities of all absorptions rise with increasing pressure, but some absorptions change their relative intensity with respect to one another. In addition, the fine structure of line spectra, characteristic of lower pressure samples, disappear as pressure is increased.

Keywords. SO_2; photoacoustics; CO_2-laser; IR spectroscopy.

1. Introduction

Sulphur dioxide (SO_2) is a molecule which attracts considerable practical as well as theoretical interest in laser photochemistry, gas detection and laser development. It is an all present gas pollutant originating from many kinds of fuel burning and combustion processes. Interest has also been stimulated by its detection in planetary atmospheres. Sulphur dioxide is a major constituent in the atmosphere of Io, a satellite of Jupiter.

The SO_2 molecule has been a subject of a number of vibrational energy transfer investigations based on vibrational laser excitation (e.g. Siebert and Flynn 1974, 1975). Recent thermal lensing studies (R T Bailey, F R Cruickshank, D Pugh and B B Radak 1990, unpublished), have indicated that a better insight into SO_2 absorption of the laser is required for a more thorough elucidation of the energy transfer mechanism.

The present work was done with the aim of obtaining the spectra of SO_2 absorption of the CO_2-laser lines at several pressures of the neat gas, which allows the observation of pressure effects. The photoacoustic (PA) technique was used.

* For correspondence

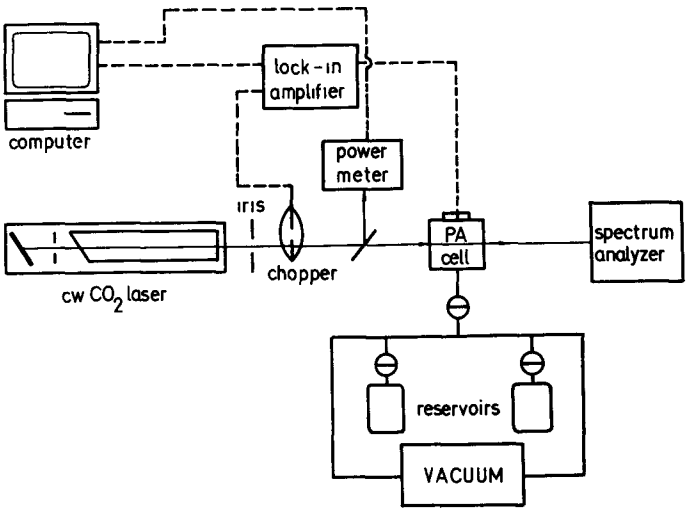

Figure 1. Schematic of the experimental apparatus.

2. Experimental

A schematic of the experimental apparatus is presented in figure 1. The excitation source was a CW CO_2-laser, basically the same as described earlier (Radak *et al* 1988) operated typically at several watts of continuous wave output power. The photoacoustic detection system was based on a cylindrical brass cell of 12 mm inner dia and 40 mm length, with a Knowless BT-1759 microphone mounted in its centre, flush with the wall. The cell was connected to a vacuum line and sample reservoirs. The sound signal from the microphone was processed through phase sensitive electronics and the output divided by the laser power, the results being the true photoacoustic signal. In this way, laser photoacoustic spectra were obtained by scanning through about 60 laser lines. The samples were 50, 100 and 450 Torr of SO_2.

3. Results and discussion

In figures 2, 3 and 4 laser photoacuostic spectra of SO_2 at 50, 100 and 450 Torr, respectively, are shown. These spectra actually present the levels of coincidence of CO_2-laser emission with vibrational absorption of SO_2.

The PA signals obtained are quite strong, although SO_2 has no strong IR absorption bands within range of the CO_2-laser emission line. A similar situation has also been observed in thermal lensing experiments (R T Bailey, F R Cruickshank, D Pugh and B B Radak 1990, unpublished) with the same gas. According to literature data on infrared absorption of SO_2 (Shelton *et al* 1953) the ν_1 fundamental occurs at 1153·38 cm^{-1} and the ν_2 fundamental at 517·69 cm^{-1}. The strongest absorption at 50 and 100 Torr was found at 1082·29 cm^{-1}, laser line $R(26)$. The most probable candidate for absorption around this region is the absorption band at 1153·38 cm^{-1}, which seems to be close enough for the laser to detect the "tail" of its R-branch. A possible contribution may also be expected from a weak second harmonic of the ν_2

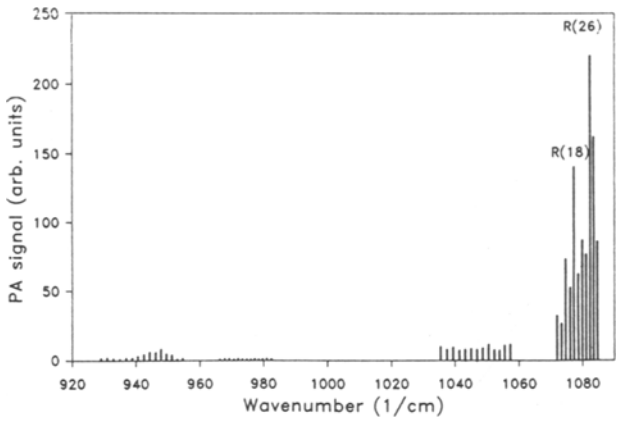

Figure 2. Photoacoustic spectrum of SO_2, 50 Torr.

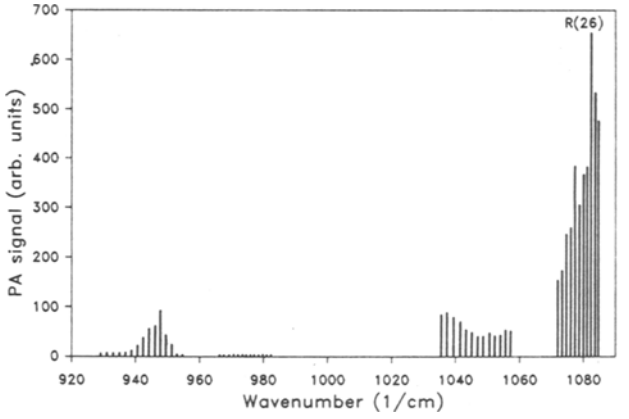

Figure 3. Photoacoustic spectrum of SO_2, 100 Torr.

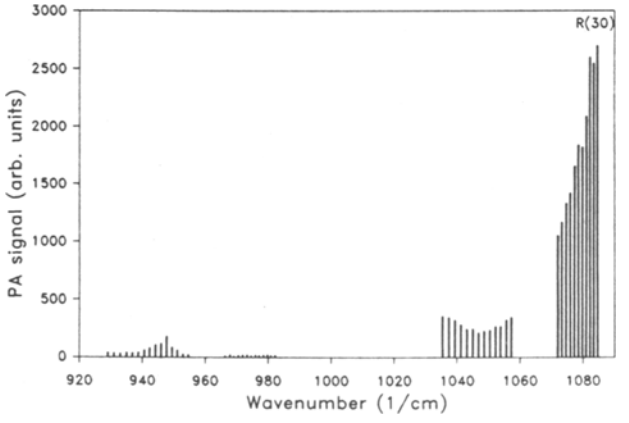

Figure 4. Photoacoustic spectrum of SO_2, 450 Torr.

mode at 949·48 cm^{-1}. On the whole, however, the major part of the PA signals can be associated with background absorption of SO_2, easily picked up by the sensitive technique employed, and showing no distinctive features in the spectrum. The exceptions are a few prominent lines in the 50 Torr spectrum. However, these structures in the line spectrum disappear as pressure is increased. In addition to that, many absorptions change their relative intensity with respect to one another. Even if this can partly result from nonlinearities possible with stronger signals, there are absorptions which, when observed in pairs, qualitatively exchange their relative intensity with one another, so that the absorption which was lower than the other at one pressure is higher at another pressure. Clear examples are absorptions at laser lines $R(18)$ and $R(30)$, 1077·30 cm^{-1} and 1084·63 cm^{-1}.

Similar pressure effects have been observed with other molecules as well, and attempts are made to discuss them in the context of pressure broadening and, possibly, shifting of absorption lines. An important fact to take into account here is that a laser emission line usually overlaps more than one (or part of one) absorption line of a molecule like this.

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