OBSERVATION AND ASSIGNMENT OF TORSIONAL TRANSITIONS IN FIR EMISSION FROM OPTICALLY PUMPED CH$_3$OH

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Using output coupling by reststrahlen reflection from NaCl we have observed 14 new FIR lines in the wavelength range between 30 μm and 60 μm. Two of them have been identified as torsional $n=1 \rightarrow 0$ transitions in the CO stretch vibration. Together with lines previously reported in the literature they are the basis for an identification of 41 FIR lines associated with torsionally excited states.

Key words: optically pumped far infrared laser, CH$_3$OH, internal rotation, CO stretch vibration.

Introduction

Since the early days of optically pumped FIR lasers, methanol has attracted particular interest (1). It is favored by experimentalists because the large number of coincidences with CO$_2$ laser lines leads to FIR lasing over an exceptionally wide range of wavelengths, stretching at present from 33.5 μm to 1224 μm. From a theoretical point of view, its favorable properties can be traced to the existence of an internally rotating OH group with a large permanent electric dipole moment and a small moment of inertia. Precisely this feature of a large amplitude torsional mode makes the molecule something of a challenge also to the theoretician.
The number of observed lines at present amounts to 330, and considerable efforts have been expended trying to tackle the problem of assigning as many of them as possible. This has assisted in establishing a model for the torsional ground state of the CO stretch vibration, and 90 observed FIR laser lines have now been associated with transitions within this band (2).

Transitions involving torsionally excited CO stretch states, identified at an early stage, suggested that the molecular parameters used successfully for describing the torsional \( n=0 \) state of the CO stretch, were inadequate for describing the \( n=1 \) states (3). Since then, very few additional \( n=1 \) lines have been assigned, although the available data base has been expanded radically. In this paper we first present the results of an experimental search for lines in the wavelength range 30 to 60 \( \mu m \). The rationale behind focusing on this range is that it is typical of \( n=1 \rightarrow 0 \) transitions, which provide a solid link to the well mapped \( n=0 \) states of the CO stretch. Based on the results of this search in conjunction with data reported in the literature, we next assign a total of 31 transitions involving \( n=1 \) states, using the techniques described in (4).

**Experiments**

The FIR cell is a conventional 1 m long open resonator with one flat mirror and one spherical mirror with \( R=3m \). In the coupling arrangement, which is shown in Fig. 1, the FIR output coupling scheme used for observing short wavelength lines.

![Fig.1](image-url)