OBSERVATION OF INFRARED LAMB DIPS IN SEPARATED OPTICAL ISOMERS

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The energy levels of optical isomers which are mirror images of each other have been assumed to be exactly the same. However there has not been accurate experimental check of this by high resolution spectroscopy of separated optical isomers. The technique of inverse Lamb dips using infrared lasers enables us to perform such an experiment with a high accuracy. This kind of experiment has a significance in relation to recent theories that the effect of parity non-conserving interaction may appear in atomic and molecular physics(1,2).

The absorption in the 9.5 μm region corresponding to the bending of the —C*—(CO)—C— group (C* denoting the optically active carbon atom) in d- and l-camphor was chosen because of its coincidence with 9.4 μm CO_2 laser lines (Fig.1). First, we observed several IR-RF double resonance signals which confirmed that vibration-rotation transitions of camphor have coincidences with laser lines and are efficiently saturated by the laser radiation.

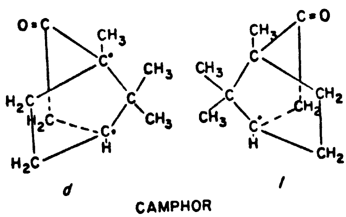

Fig.1

For the Lamb dip experiment a camphor sample at a pressure of ∿100 mTorr was placed inside the laser cavity and the laser output was observed while its frequency was scanned over the cavity profile. In order to increase the sensitivity of detection, Stark modulation and phase detection were used. Inverted Lamb dips were observed first for laser lines where double-resonance signals were observed and later also for neighbouring laser lines. In Fig.2 the inverted Lamb dip observed on a d-camphor sample using the R(24) laser line is shown. The high sample pressure was needed because the camphor absorption is weak due to large rotational and vibrational partition functions. The hwhm of the Lamb dips measured at a pressure of 55 mTorr was ∿400 KHz.

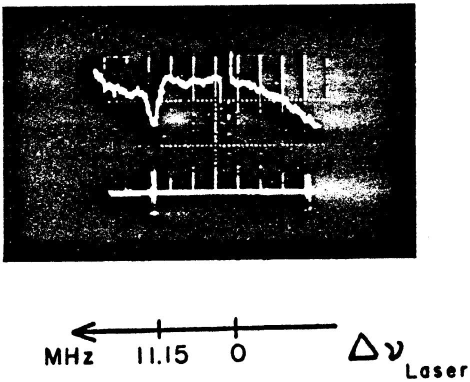

Fig.2 An example of oscilloscope traces of the d-camphor inverted Lamb dip and of the beat signal monitored through a tuned radio-receiver.

We observed that different laser oscillation conditions are required to obtain the best signal-to-noise ratio in each isomer. This behaviour has been qualitatively interpreted as due to the optical activity of our sample interacting with possible asymmetry of the optical system. The Lamb dip positions for d-camphor and l-camphor were compared by filling successively the sample cell with each optical isomer while keeping the same optical and electronic conditions.

The Lamb dip position was measured accurately by comparing the frequency of the CO_2 laser containing the camphor with that of another CO_2 laser stabilized to the CO_2 4.3 μm fluorescence Lamb dip. The beat note between the two lasers was measured at the camphor Lamb dip position. The accuracy in the comparison of transition frequencies in d- and l-camphor was limited by the laser stability and the linewidth of the observed signals when best conditions for both isomers are realized. For the measurements so far conducted, the transition frequencies of d- and l-camphor agree to within an uncertainty of $\sim$300 KHz which corresponds to an accuracy of 1.10^{-8}.

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