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# FREQUENCY MEASUREMENT OF THE $J = 1 \leftarrow 0$ ROTATIONAL TRANSITION OF HD[1]

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## ABSTRACT

The frequency of the astronomically important $J = 1 \leftarrow 0$ rotational transition of hydrogen deuteride (HD) at 2.7 THz (90 $cm^{-1}$) has been measured with tunable far-infrared radiation with an accuracy of 150 kHz. This frequency is now known to sufficient accuracy for use in future astrophysical heterodyne observations of HD in planetary atmospheres reported by Bezard *et al.* in 1986 and the interstellar medium reported by Bussoletti *et al.* in 1975.

*Subject headings:* interstellar: molecules — laboratory spectra — molecular processes

A spectrometer using the coherent radiation resulting from the nonlinear mixing of two $CO_2$ lasers in a metal-insulator-metal diode (Evenson, Jennings, and Petersen 1984) was used to generate the far-infrared radiation. The spectrometer, previously described (Evenson *et al.* 1985), has been used to measure rotational spectra in MgH (Leopold *et al.* 1985), NaH (Leopold *et al.* 1987), OH (Brown *et al.* 1986), $ArH^+$ (Brown *et al.* 1988), HF (Jennings *et al.* 1987), and CO and HCl (Nolt *et al.* 1987).

The HD was observed in a 19 mm inside diameter and 3.94 m long copper tube, in single transit of about $10^{-7}$ W of far-infrared radiation used to detect the signal shown in the figure. HD was created in a hollow cathode discharge in a mixture of equal parts of $H_2$ and $D_2$ by running the discharge for about 3 minutes. A 20% peak absorption was observed at a pressure of 930 Pa (7 torr). See Figure 1. This absorption is somewhat larger than that expected using a value of $8.83 \times 10^{-4}$ debye for the dipole moment (Drakopoulos and

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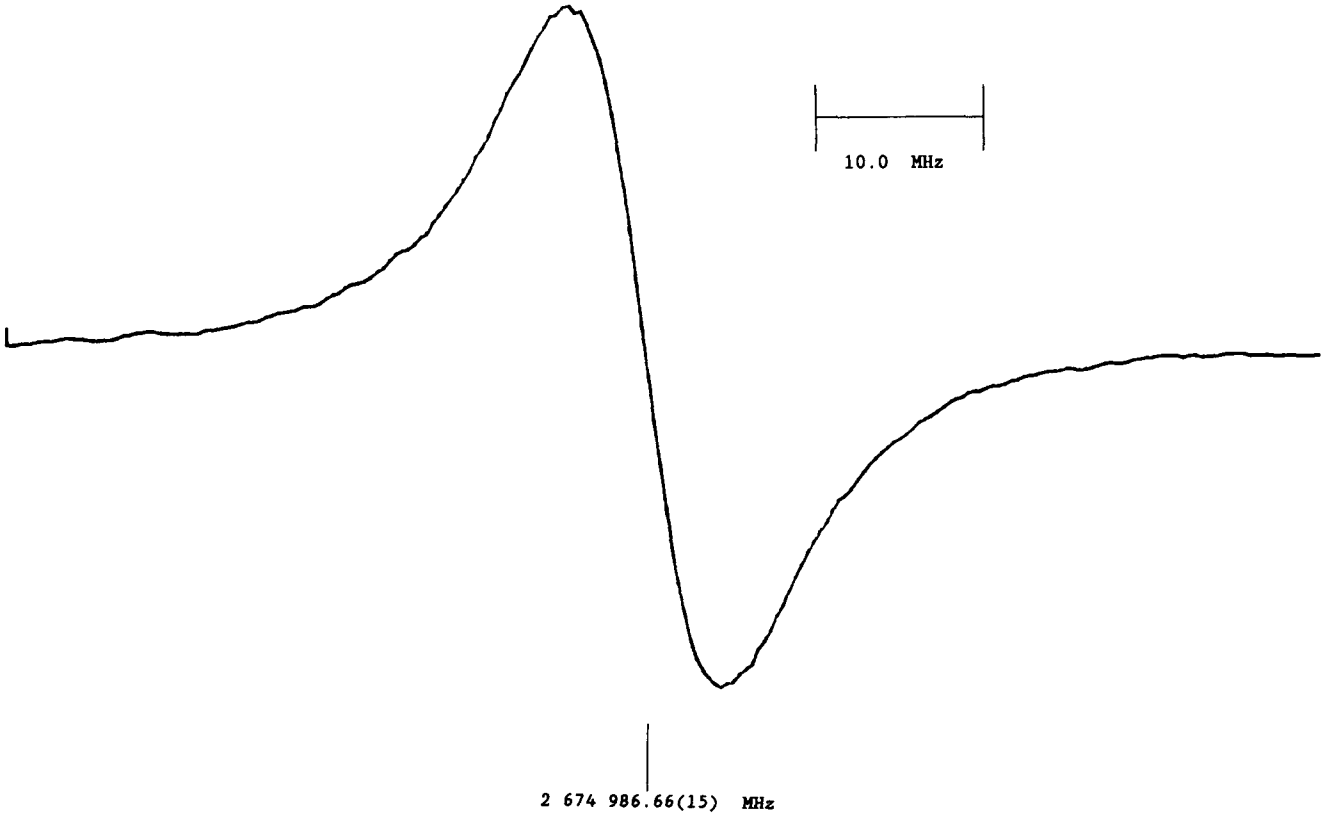


FIG. 1.—Derivative of the HD adsorption line taken at 930 Pa (7 torr) with a 0.5 s time constant. A 3.5 m path length and a 5 MHz frequency modulation at a 500 Hz rate was used to observe the signal. A gallium-germanium photoconductor detector was used to observe the absorption using approximately $10^{-7}$ W of tunable far-infrared radiation.

Tabisz 1987) and an estimated 50% concentration in the cell. However, the line is somewhat narrower than is expected from the Doppler width, probably due to Dicke narrowing (Nazemi and Javan 1983). This would increase the peak absorption compared with a Doppler-broadened line (Townes and Schalow 1955).

The center frequency is 2,674,986.66(15) MHz which is consistent with the best previous value of 2,674,992(35) MHz obtained using Fourier transform spectroscopy (Rich, Johns, and McKellar 1982). However, the new number has an uncertainty which is two orders of magnitude smaller.

This result provides a reference frequency for radio astronomers and should facilitate the detection of interstellar and interplanetary HD, which, among other things may lead to a definitive determination of the hydrogen-to-deuterium ratios in interstellar regions (Bussoletti and Stasinska 1975) and in planetary atmospheres (Bezard, Gautier, and Marten 1986).

Further measurements of the $J = 2 \leftarrow 1$ are also within the frequency range of our spectrometer and will be attempted in the near future along with a study of the observed Dicke narrowing.

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