A Pulsed Molecular Beam Microwave Fourier Transform Spectrometer with Parallel Molecular Beam and Resonator Axes

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We report on first experiences with a pulsed molecular beam microwave Fourier transform spectrometer with parallel molecular beam and resonator axes. This setup shows up a high resolution and sensitivity.

Introduction

Pulsed molecular beam microwave Fourier transform (MB-MWFT) spectrometers are widely used for the measurement of highly resolved rotational spectra. Usually the beam nozzle is installed at a position where the axis of the molecular beam is perpendicular to the axis of the mirrors which form the microwave cavity. With this arrangement, the lines are split into more or less resolved Doppler doublets with lines of an individual width of a few kHz depending on various parameters like stagnation pressure, nozzle configuration and delay between molecular pulse and polarizing microwave pulse.

We now made first tests with a spectrometer where the beam nozzle is installed at a position where the axis of the produced molecular beam points along the resonator axis.

Experimental

The complete setup of our MB-MWFT spectrometer [1] will not be presented here. The resonator consists of two 600 mm aluminum mirrors with 1000 mm radius of curvature mounted in a distance of 750 mm. We drilled a hole in the rear side of one of the mirrors to fit a home made nozzle plate for a commercial magnetic valve (General Valve). The valve is located as close as possible to the microwave antenna in the center point of the mirror.

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For test purposes we used argon containing 2% carbonylsulfide at a stagnation pressure of $4 \cdot 10^4$ Pa (0.4 atm).

As an example we show the $J = 1-0$ transition of [^{13}C, ^{34}S]-carbonyl sulfide, which is split due to the

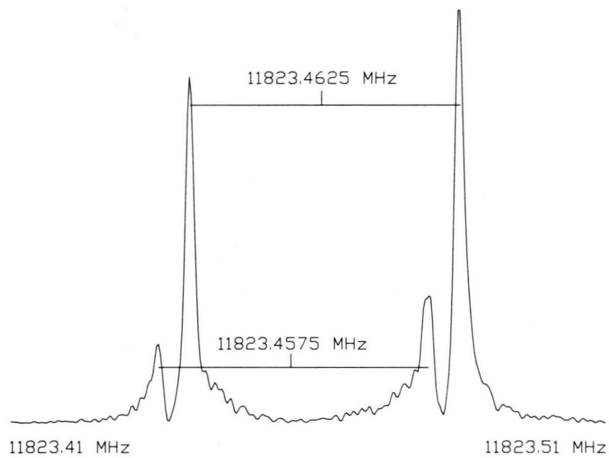

Fig. 1. 100 kHz section of the $J = 1-0$ transition of [^{13}C, ^{34}S]-carbonyl sulfide in natural abundance with hyperfine structure caused by ^{13}C spin rotation coupling. Each line is split due to the Doppler effect by 45 kHz, the line width is 1 kHz (HWHH). Recording conditions: 100 ns sample interval, 8 k data points, extended with 24 k zeros prior to FFT, 1000 experiment cycles, 6 Hz experiment repetition rate.

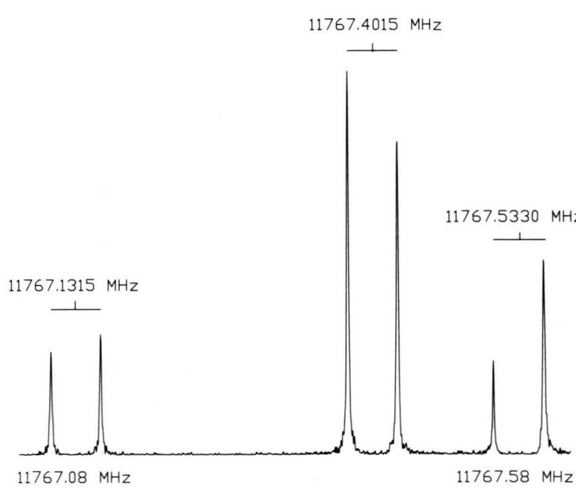

Fig. 2. 500 kHz section of the $J = 1-0$ transition of [^{17}O]-carbonyl sulfide in natural abundance with ^{17}O nuclear quadrupole hyperfine structure. The Doppler splitting is 45 kHz, the line width 1 kHz (HWHH). Recording conditions: 100 ns sample interval, 8 k data points, extended with 24 k zeros prior to FFT, 500 experiment cycles, 6 Hz experiment repetition rate.

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spin-rotation coupling of the ^{13}C nucleus by 5 kHz. The line width is 1 kHz (HWHH), the Doppler splitting 45 kHz (Figure 1).

A further example is the $J = 1 - 0$ transition of [^{17}O]-carbonyl sulfide, where a splitting is caused by nuclear quadrupole and spin rotation interaction of the [^{17}O] nucleus (Figure 2).

First Conclusions

First experiments have shown that a parallel arrangement of molecular beam axis and mirror axis provides advantages over a perpendicular setup. We have found no perturbation of the cavity mode pattern being caused by the nozzle orifice in the surface of the mirror. The lines have become significantly narrower and the sensitivity of the spectrometer has been increased. In the case of extremely narrow splittings the completely resolved Doppler splitting may be useful.

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[1] U. Andresen, H. Dreizler, J.-U. Grabow, and W. Stahl, to be published.