An Automatic Scan Waveguide Microwave Fourier Transform Spectrometer

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The design and performance of an automatic scan waveguide microwave Fourier transform spectrometer is described, which is of great help in assigning microwave spectra.

In 1990 we reported on a waveguide microwave Fourier transform (MWFT) spectrometer with a single microwave source [1] which provided the same performance concerning resolution and sensitivity as former set ups [2–4]. The advantage of the spectrometer is its simpler construction and operation.

This scheme is now in use in the frequency ranges 8–18, 2–4 [5], and 4–8 GHz. In the appendix we give the MW parts we use.

We added a modification to the spectrometers which allows an automatic frequency sweep to produce survey spectra. Thus the MWFT spectrometers, which work at a selectable fixed frequency and cover a frequency band of some ten MHz depending on the polarization conditions, are converted to scanning instruments.

The hardware of the spectrometers is similar to that given in Fig. 1 of [1]. An essential modification is the replacement of the phase stabilized MW source (parts **1**–**3**, **5**–**9** of Fig. 1 [1]) by a MW synthesizer connected to the reference frequency 10 MHz of the spectrometer.

We tested and used the synthesizers Hewlett-Packard (HP) 8340B, 0.01–26.5 GHz (1–4 Hz), HP 8673G, 2–26.5 GHz (1–4 kHz) and Rohde & Schwarz SMPD, 0.005–2720 MHz, with frequency doubling ([5], Fig. 1) (2 Hz). The numbers in parentheses give the minimal frequency step width. The output power of the synthesizers is from 10 to 13 dBm. The frequency and MW power is set via an IEEE bus by the computer **44** [1]. The center frequency of the digitally driven YIG-Filter **18** [1] is also adjusted by the computer.

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After a selected number of experiment cycles the averaged transient decay is stored in the computer memory. For each polarizing frequency the sum of the magnitudes of all signal values of the decay (decay sum), the maximum amplitude of the whole spectrum and the sum of the spectrum amplitudes within a small intervall around the center frequency are calculated and printed. This procedure is repeated after increasing the polarizing frequency in selectable frequency steps. The usual step widths are 0.5 to 5 MHz. From the data list transitions may be localized. To give a better visual picture, a spectrum can be calculated by overlaying all spectra in the covered frequency range. An example is given in Figure 1. Here a range of 315 MHz is displayed of the direct l-type resonance spectrum [6] of trifluoroethane in its $v_{12}=1$ vibrational state. In addition part of the Fortrat diagram is given.

The scan time depends on the number of averaging cycles and the frequency step width. In the example of Fig. 1 the scan time was about 2 hours for 315 MHz with the given instrument settings.

The scanning version of the MWFT spectrometers proved as very useful for assigning spectra in the last three years. This modification allows a more effective use of the spectrometers similar to that reported in [7]. It should be noted that each line has to be remeasured individually to gain highest sensitivity, resolution, and frequency accuracy.

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Appendix

Compare Fig. 1 of [1].

Single sideband modulator **13**:

M/A-COM RHG, IRDS 1–4/160, 1–4 GHz, modulation frequency (MF) ± 160 MHz,
M/A-COM RHG, IRDS 2–26/160, 2-26 GHz, MF = ± 160 MHz,
Watkins-Johnson (WJ), WJ-M34C-4, 8–18 GHz, MF = ± 80 to ± 160 MHz,
WJ-M34C-5, 8–18 GHz, MF = ± 100 to ± 200 MHz.

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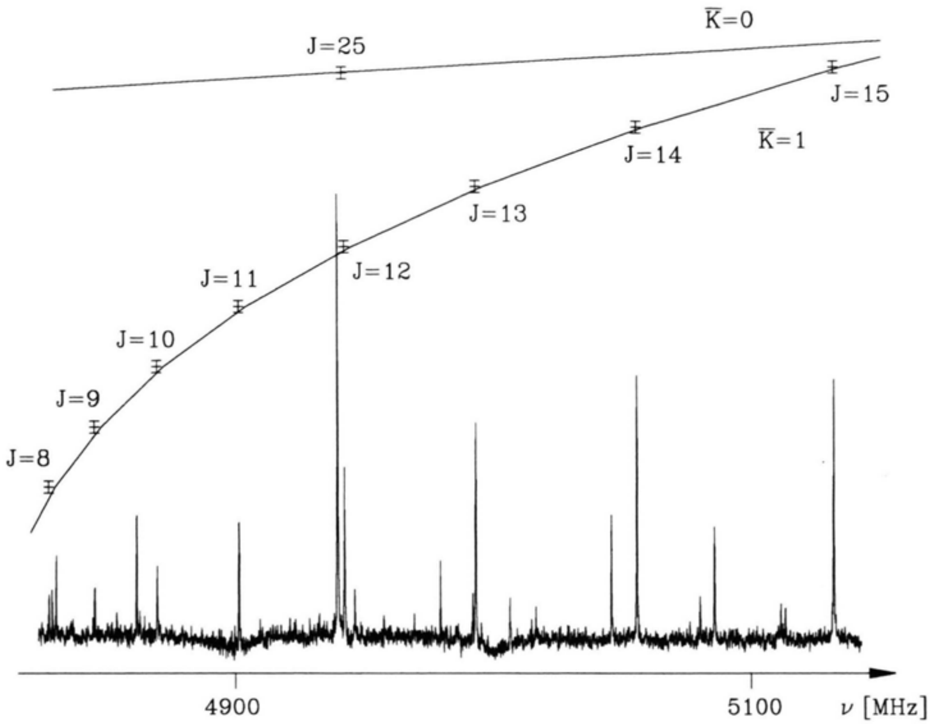

Fig. 1. An automatic frequency scan with a waveguide MWFT spectrometer from 4825 to 5140 MHz. Part of the direct l-type resonance spectrum of trifluoroethane, CH_3CF_3, in its vibrational state $v_{12}=1$ is displayed. In addition, part of the Fortrat diagram with $\bar{K}=|K-l|$ is given. The instrument settings are: pressure about 1 Pa (8 mTorr), room temperature, $1.6 \cdot 10^6$ experiment cycles for each polarizing frequency, 10 ns sample interval, 1024 data points of the transient decay, 2 MHz frequency step width, polarizing MW power approximately 1 W, scan time 2 hours.

YIG-filter with 12 bit digital driver **18**, *3 dB bandwidth approx. 40 MHz:*

WJ, 5272-004DA, 1–4 GHz,
Ferretec, FD 1072 C-DD, 2–8 GHz,
Avantek, AFPD-31821, 8–18 GHz.

Amplifier **19** *for compensation of the conversion loss of* **13** *and insertion loss of* **18**:

Trontech, P42GA, 1–4 GHz, gain 42 dB, output +30 dBm, Omega Microwave, 1-002908, 6–18 GHz, gain 48 dB, output +18 dBm.

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