

A Microwave Fourier Transform Spectrometer with a Single Microwave Source

M. Krüger and H. Dreizler

Abteilung Chemische Physik, Institut für Physikalische Chemie,
Christian-Albrechts-Universität zu Kiel

Z. Naturforsch. **45a**, 724–726 (1990); received January 31, 1990

Design and performance of a microwave Fourier transform spectrometer in the frequency region around 8 GHz are reported. Operation and experimental set-up are simplified compared to previous designs.

Introduction

We report on a modification of a microwave Fourier transform (MWFT) spectrometer with simplified operation and experimental set-up. The MWFT spectrometers described in detail previously [1–6] use superheterodyne detection, necessitating two phase stabilized microwave (MW) sources. Recently, Lovas and coworkers [7, 8] used a single sideband modulator to replace the microwave signal source in a molecular beam cavity spectrometer. We transferred this concept to MWFT waveguide spectrometers. In a cavity spectrometer, the cavity resonator behaves as a narrow bandpass filter and suppresses the second as well as higher order sidebands and the carrier frequency in the MW radiation. In a waveguide spectrometer, a tunable bandpass filter has to be introduced.

Operation

Presently, our single sideband spectrometer operates in a narrow frequency range around 8 GHz, due to small overlap of specified frequency ranges of some components.

The experimental set-up is shown in Fig. 1, and may be compared to the conventional set-up of Fig. 1 in [5]. The signal microwave source has been replaced by a branch starting at the directional coupler (5)*. The

sideband modulator (13) produces either one of the frequencies $\nu_{\text{signal}} = \nu_{\text{local}} \pm 160 \text{ MHz}$ with a conversion loss of 10 dB, suppressing the second sideband as well as the carrier by at least 18 dB. A further suppression by about 50 dB is achieved with the YIG tuned bandpass filter (18) (50 MHz bandwidth) prior to pre-amplification in (19) and power amplification in the travelling wave tube amplifier (TWTA) (26). Ambiguities in the detected transient molecular signal due to unwanted polarization are thus avoided.

Using radio frequency of 160 MHz to generate the pulsed polarizing microwave radiation allows us to use the double balanced mixer (15) as a phase modulator for the phase alternating pulse sequence (PAPS) [1, 4]. The relative phases of 0° and 180° at 160 MHz are transferred to the MW signal frequency.

The present set-up simplifies operation as well as eliminates the need for a second MW source and the corresponding phase stabilization equipment. The signal and local microwave are rigorously kept at a frequency difference of 160 MHz without phase jitter. The general set-up of the MWFT spectrometer and the principles of detection, A/D conversion and data processing remain unchanged [1–6].

Performance

Measurements with the presently described spectrometer are of equal quality as compared to the conventional set-up in the same frequency band [5]. As an example for comparison, Fig. 2 shows the same rotational transition of ethyl fluoride obtained a) with the conventional set-up and b) with the single sideband

Reprint requests to Prof. Dr. H. Dreizler, Abteilung Chemische Physik, Institut für Physikalische Chemie, Christian-Albrechts-Universität, Ludewig-Meyn-Strasse 8, D-2300 Kiel 1, FRG.

* Numbers in parentheses refer to Fig. 1 of this article.

0932-0784 / 90 / 0500-0724 \$ 01.30/0. – Please order a reprint rather than making your own copy.



Dieses Werk wurde im Jahr 2013 vom Verlag Zeitschrift für Naturforschung in Zusammenarbeit mit der Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V. digitalisiert und unter folgender Lizenz veröffentlicht: Creative Commons Namensnennung-Keine Bearbeitung 3.0 Deutschland Lizenz.

Zum 01.01.2015 ist eine Anpassung der Lizenzbedingungen (Entfall der Creative Commons Lizenzbedingung „Keine Bearbeitung“) beabsichtigt, um eine Nachnutzung auch im Rahmen zukünftiger wissenschaftlicher Nutzungsformen zu ermöglichen.

This work has been digitalized and published in 2013 by Verlag Zeitschrift für Naturforschung in cooperation with the Max Planck Society for the Advancement of Science under a Creative Commons Attribution-NoDerivs 3.0 Germany License.

On 01.01.2015 it is planned to change the License Conditions (the removal of the Creative Commons License condition “no derivative works”). This is to allow reuse in the area of future scientific usage.

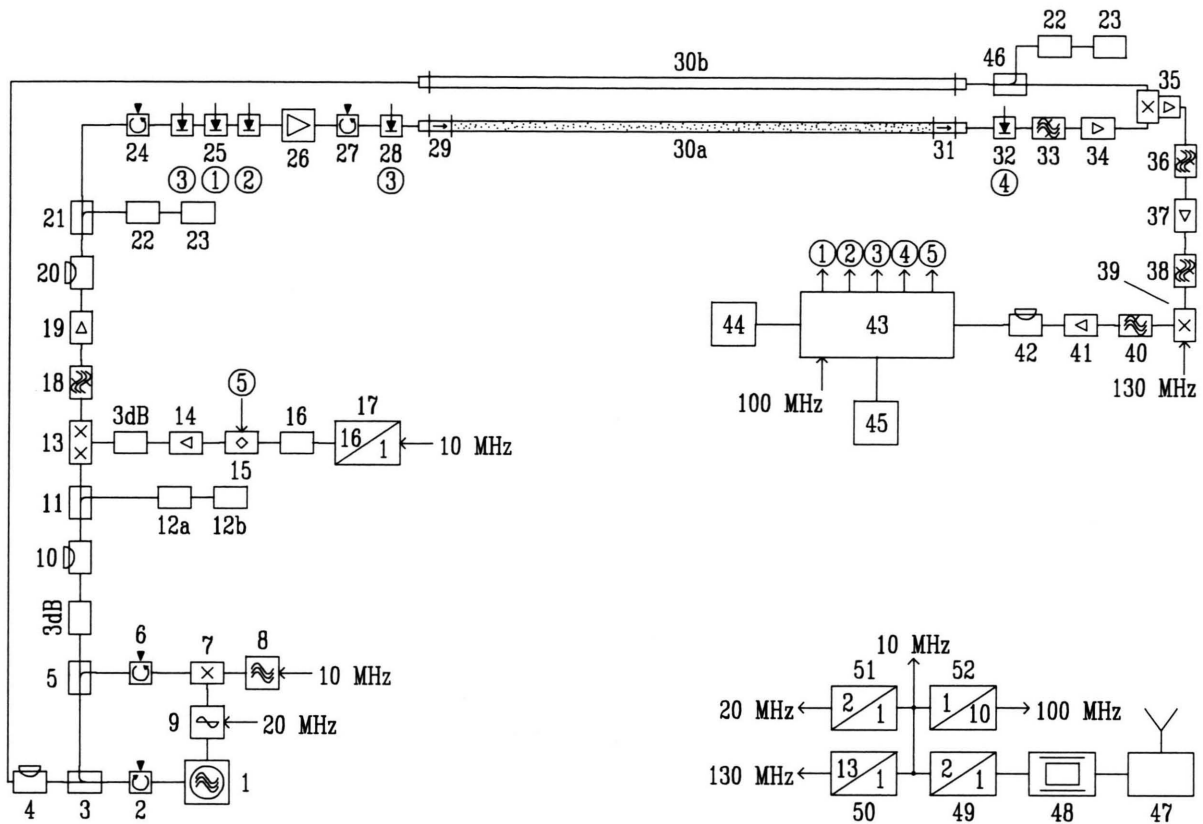


Fig. 1. Set-up of a single sideband MWFT Spectrometer.

- 1) Signal source, Watkins Johnson 2019-50, BWO 4–8 GHz, and power supply.
- 2) Coaxial isolator, P + H C1-C26314.
- 3) Coaxial directional coupler, Narda 3044-10, 10 dB.
- 4) Coaxial variable attenuator, Narda 792FM.
- 5) Coaxial directional coupler, Narda 3004-20, 20 dB.
- 6) Coaxial isolator, Microtek H40C80A2.
- 7) Coaxial mixer, MCL ZAM-42, M814316.
- 8) Signal Generator, Hewlett Packard (HP) 8656A, 0.1–990 MHz.
- 9) Synchronizer, HP 8709A.
- 10) Coaxial variable attenuator, Narda 4798.
- 11) Coaxial directional coupler, Narda 4014C-10, 10 dB.
- 12a) Power sensor, HP 8485A. 12b) Power meter, HP 435B.
- 13) Coaxial single sideband modulator, RHG IRDS8-18/160.
- 14) Amplifier, RHG ICFT16050.
- 15) Double balanced mixer used as phase modulator, Mini Circuits ZAD-3SH.
- 16) Attenuator 6 dB, Mini Circuits. 17) Frequency multiplier.
- 18) Digitally driven coaxial YIG-Filter, AvanteK AAFP-31821, 8–18 GHz.
- 19) MW-Amplifier, Dexcel DXA 5229-01, 12–18 GHz nominal.
- 20) Coaxial variable attenuator, Alan 50CA18-1172.
- 21) Coaxial directional coupler, 10 dB, Technical Research and Manufacturing DCS-108.
- 22) Power sensor, HP 8478B.
- 23) Power meter, HP 432A.
- 24) Coaxial isolator, Microtek H80X124A6.
- 25) Coaxial pin switches, HP 33144A, with driver HP 33190B.
- 26) Travelling wave tube amplifier, Hughes 1277H, 4–8 GHz.
- 27) Coaxial isolator, Microtek H40C80A0.
- 28) See 25).

29) Waveguide isolator, Microwave Ass. 80238.

30a) Rectangular waveguide sample cell, cross section $34.8 \times 15.8 \text{ mm}^2$, length 12 m, vacuum tight MW shielded windows and vacuum system.

30b) Waveguide for local MW frequency.

31) See 29).

32) See 25).

33) Bandpass filter 4–8 GHz, Filtronics F10345.

34) MW Amplifier, AvanteK AMT-8034M, 4–8 GHz.

35) Double balanced mixer with integrated amplifier, Honeywell-Spacecom MPA 048.

36) Bandpass filter, Lark Engineering SF-160-20-8AB.

37) Amplifier, RHG ICFH160LN.

38) Bandpass filter, Reactel 4B2-160-25B21.

39) Mixer, Mini Circuits ZAD1.

40) Lowpass filter, K&L Microwave 6L340-45-B/BP.

41) Amplifier, RHG ICFL3010.

42) Variable attenuator, HP 355C.

43) Analog to digital converter, averager, and experimental control unit, 10 to 100 ns sampling intervals, 1024 to 4096 data points, 75 kHz maximum repetition rate [9].

44) Personal computer, Tandon PCA 20.

45) Oscilloscope 60 MHz, Tektronix 2213A.

46) Coaxial directional coupler, AEL 10200, 20 dB.

47) Normal frequency receiver, Rhode and Schwarz XKE2.

48) Quartz frequency standard, Rhode and Schwarz XSD2, 5 MHz.

49) Frequency doubler.

50) Frequency multiplier.

51) Frequency doubler.

52) Frequency multiplier.

(1)–(4) Pin switch control.

(5) Phase Alternating Pulse Sequence (PAPS) control, $0^\circ/180^\circ$.

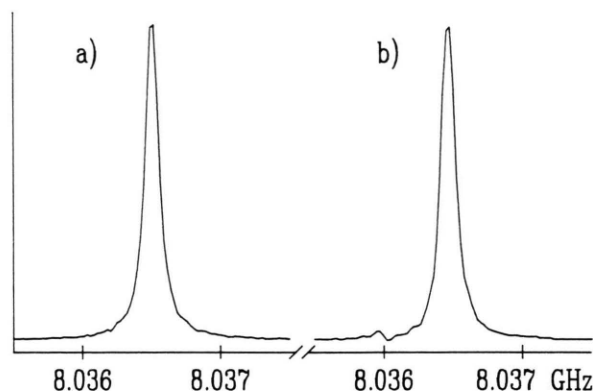


Fig. 2. $J' K'_{-} K'_{+} \leftarrow J K_{-} K_{+} = 34\ 12\ 23 \leftarrow 35\ 11\ 24$ transition of ethyl fluoride, $\text{CH}_3\text{CH}_2\text{F}$. a) Spectrometer according to [5]. Power spectrum, temperature 295 K, pressure 0.5 Pa (4 mTorr), pulse length 200 ns, 9.8×10^5 averaging cycles, sampling interval 10 ns, 2048 data points of the transient decay supplemented with 2048 zeros prior to Fourier transformation. Polarization frequency 8.036 GHz, transition frequency 8.036 482 GHz. b) Present spectrometer, identical experimental conditions. Transition frequency 8.036 482 GHz.

spectrometer. Having demonstrated the satisfactory operation of the single sideband MWFT spectrometer, we will confidently apply this concept to future set-ups in the frequency range from 8 to 18 GHz, one of which is under construction.

We thank the members of our group for fruitful discussions and advice. We also thank the Deutsche Forschungsgemeinschaft, the Land Schleswig-Holstein, the Fonds der Chemie and the Stiftung Volkswagenwerk for funds.

- [1] H. Dreizler, *Mol. Phys.* **59**, 1 (1986).
- [2] Ch. Keussen, N. Heineking, and H. Dreizler, *Z. Naturforsch.* **44a**, 215 (1989).
- [3] W. Stahl, G. Bestmann, H. Dreizler, U. Andresen, and R. Schwarz, *Rev. Sci. Instrum.* **56**, 1759 (1985).
- [4] G. Bestmann and H. Dreizler, *Z. Naturforsch.* **37a**, 58 (1982).
- [5] G. Bestmann, H. Dreizler, E. Fliege, and W. Stahl, *J. Mol. Struct.* **97**, 215 (1983).
- [6] H. Ehrlichmann, J. U. Grabow, H. Dreizler, N. Heineking, R. Schwarz, and U. Andresen, *Z. Naturforsch.* **44a**, 735 (1989).
- [7] R. D. Suenram, private communication 1988.
- [8] R. D. Suenram, F. J. Lovas, G. T. Fraser, J. Z. Gillies, C. W. Gillies, and M. Onda, *J. Mol. Spectrosc.* **137**, 127 (1989).
- [9] U. Andresen and B. Kleibömer, *Rev. Sci. Instrum.* **59**, 1088 (1988).