and uses echoes off of the reflector plate with (BS) and without the sample present (M"), as well as using the echo off of the sample front surface (FS). (The FS echo may require specialized signal processing to “de-noise” and amplify it if it is received off of a foam front surface.)

This work was done by Ron Roth for Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18262-1/3-1.

Compact Microwave Fourier Spectrum Analyzer

Large delays needed for time-domain autocorrelations would be realized photonically.

NASA's Jet Propulsion Laboratory, Pasadena, California

A compact photonic microwave Fourier spectrum analyzer [a Fourier-transform microwave spectrometer, (FTMWS)] with no moving parts has been proposed for use in remote sensing of weak, natural microwave emissions from the surfaces and atmospheres of planets to enable remote analysis and determination of chemical composition and abundances of critical molecular constituents in space.

The instrument is based on a Bessel beam (light modes with non-zero angular momenta) fiber-optic elements (see figure). It features low power consumption, low mass, and high resolution, without a need for any cryogenics, beyond what is achievable by the current state-of-the-art in space instruments. The instrument can also be used in a wide-band scatterometer mode in active radar systems.

The basic advantage of the proposed instrument is its wide bandwidth along with high resolution, enabling microwave hyperimaging of the planetary atmospheres and surfaces. For example, the analyzer will have similar resolution to the Cassini Titan Radar Mapper operating in the scatterometer mode, and will have at least two orders of magnitude wider bandwidth, compared with the same instrument operating in the radiometer mode. This will allow collecting a hundred times more data during the same observation period.

The analyzer has significant advantages for remote detection of chemical components from space. It uses microwave radiation to record the rotational spectrum of a molecule in the microwave spectral region, i.e., between approximately 6 GHz and 40 GHz. For instance, FTMWS can be used for the accurate remote detection of water vapor as well as for the study of hydrogen isotopic ratio.

The analyzer has a very long, mile-range, maximum delay realized with photonics techniques. This capability is ultimately crucial for achieving a high resolution with the Fourier transform spectrum analyzer. To obtain the 1-MHz spectral resolution necessary for resolving the microwave emission spectrum of water in remote sensing, it would ordinarily be necessary to use microwave delay lines having lengths up to 300 m. Such long microwave delay lines would not be practical. However, the instrument would exploit the fact that compact delay lines can be realized photonically.

It has Fellgett (multiplex) advantage taken from Fourier spectroscopy. A typical microwave spectrum analyzer sequentially measures the microwave power within each of a number of narrow spectral bands. The new instrument would simultaneously measure the time-domain autocorrelations of the microwave emission signal of interest using a number of different delays, then calculate the spectrum of that signal by use of a fast Fourier transform. Hence, the instrument would constantly and simultaneously provide data on all the bands of the spectrum.

It has all the advantages of a static Fourier transform spectrometer. There are no moving parts, which eliminates many potential mechanical problems onboard the spacecraft. The instrument has no need for a reference laser since the detector array samples the interferogram always at the same points. The analyzer obtains full interferogram at once so it is insensitive to the flicker noise or fluctuations of the input signal. This is critical, e.g., for spectroscopy of a constantly changing planetary environment. As shown in the figure, the incoming

![Diagram of Microwave Spectrum Analyzer](https://ntrs.nasa.gov/search.jsp?R=20090008638)
A microphotograph shows the 255-GHz Amplifier MMIC. A second metal serves as a ground plane and covers most of the circuit area. The transmission lines and HBT device are “drawn” in the photograph. Die size is 0.55 mm × 0.55 mm.