Synthesis of Submillimeter Radiation for Spectroscopy

A low-power, lightweight radiation source operates over a wide frequency range.

NASA's Jet Propulsion Laboratory, Pasadena, California

The frequency-multiplier submillimeter spectrometer (FMSS) is a laboratory apparatus for far-infrared molecular spectroscopy, embodying several advances over prior such apparatuses. The most innovative part of the FMSS is a source of monochromatic submillimeter-wavelength radiation that can be tuned over a wide frequency range, as needed for trace gas analyses and molecular-structure studies for which such apparatuses are typically used.

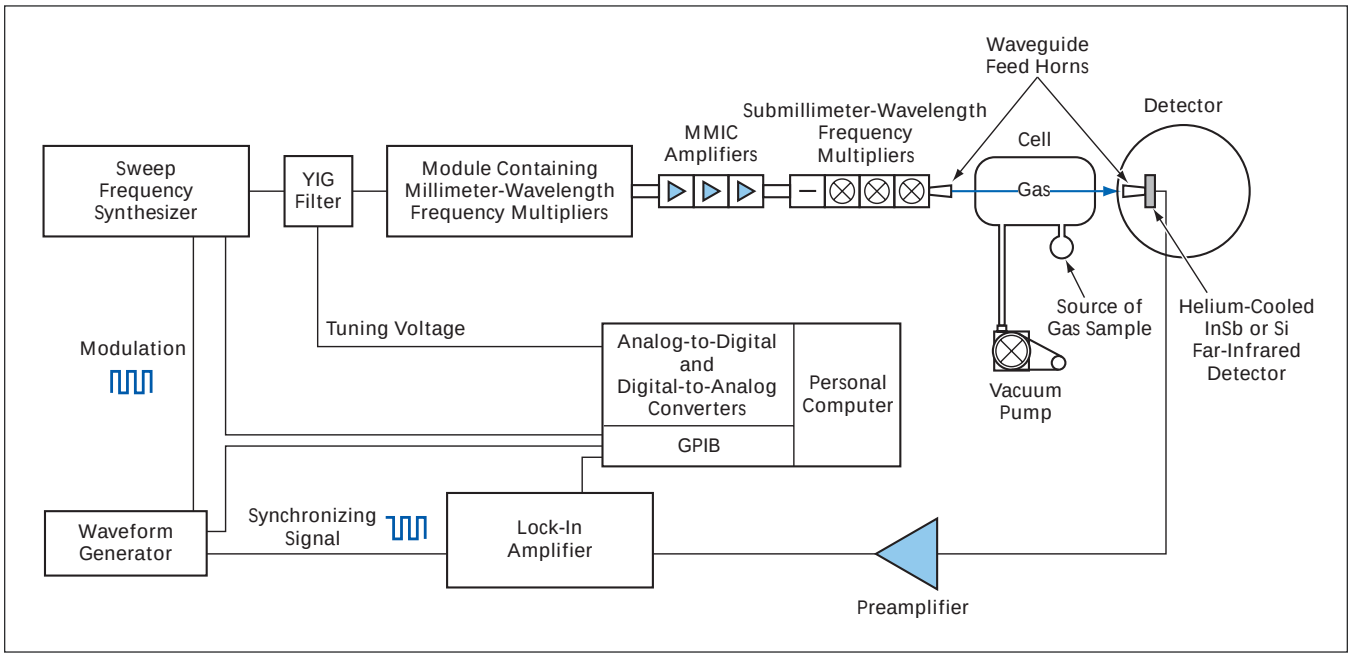
The radiation source features a modular design and is built mostly from commercially available components. It includes a computer-controlled radio-frequency synthesizer, amplifiers, and frequency multipliers of a type heretofore used in local oscillators for heterodyne far-infrared receivers. In conjunction with the rest of the apparatus, this source makes it possible to perform measurements over large portions of the submillimeter-wavelength spectrum with resolution, accuracy, and sensitivity greater than those achievable in Fourier-transform infrared spectroscopy. In comparison with prior laboratory submillimeter-wavelength radiation sources, this source is much lighter in weight, less cumbersome, less power-hungry, and capable of sustained operation with less intervention by laboratory personnel. Also, unlike some prior submillimeter-wavelength sources, this source does not require a high-voltage power source.

As shown in more detail in the figure, the radiation source includes a sweep frequency synthesizer connected to an external waveform generator, the output of which is used as a reference signal. The synthesizer is computer-controlled through a standard general-purpose interface bus (GPIB) and is operated in phase-locked continuous-wave mode for all measurements. The synthesizer output ranges in frequency from 11 to 18 GHz. For suppression of frequency spurs and harmonics, the output of the frequency synthesizer is fed through a tunable yttrium iron garnet (YIG) filter, which is swept in frequency simultaneously with the frequency synthesizer.

The output of the YIG filter is fed through a series of modular Schottky-diode frequency multipliers and monolithic microwave integrated-circuit (MMIC) amplifiers that can be arranged in various combinations to obtain the desired submillimeter-wavelength radiation for spectroscopy, generally in the frequency range from 0.50 to 2.60 THz. By means of waveguide feed horns, the radiation is quasi-optically coupled through a cell containing a low-pressure gas to be analyzed. After passing through the cell, the radiation is detected by use of phase-sensitive electronic circuitry, and demodulated absorption signals are digitized and recorded in a computer. The absorption signals can subsequently be analyzed: for example, they can be compared with known absorption spectra in a database to determine the concentrations of molecular species of interest in the gas.

This work was done by Frank Maiwald, John Pearson, and Brian Drouin of Caltech for NASA's Jet Propulsion Laboratory. For further information, contact iaoffice@jpl.nasa.gov.

NPO-43091



The **Frequency-Multiplier Submillimeter Spectrometer** is built around a radiation source that includes a computer-controlled radio-frequency synthesizer followed by a chain of multipliers and amplifiers that bring the output up to the 0.50-to-2.60-THz frequency range.