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High-Throughput Microwave Spectroscopy for Chemical Kinetics and Trace Detection

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Recent developments in high-speed digital electronics have made it possible to develop a new generation of broadband microwave spectrometers for molecular spectroscopy. These spectrometers acquire a broadband microwave spectrum (up to 12 GHz bandwidth in the current designs) in a single data acquisition event. Chirped pulse excitation is employed to efficiently polarize a molecular gas sample over the 12 GHz bandwidth using a pulse duration of about 1 microsecond. Following sample polarization, the free induction decay signal from the molecular rotational spectrum is directly digitized using a high-speed digital oscilloscope. The frequency domain spectrum is obtained by Fourier transform following coherent, time-domain signal averaging. The spectrometer design provides new capabilities for high-throughput chemical analysis. Applications to chemical identification of molecules of astrochemical interest will be presented. The broadband technique is well-suited to laser experiments where isomerization kinetics of highly excited molecules can be measured on the picosecond time scale through line shape analysis. Microwave-laser experiments for chemical reaction dynamics in pulsed jet samples and room-temperature gases will be presented.