As we outlined in our submitted proposal, progress towards making DFWM spectroscopy quantitative has been achieved. This work makes explicit how the magnitude of the DFWM signal depends on the polarizations of the three incident beams under the weak and strong-field limits. We have been using DFWM to investigate acetylene (C2H2) and methyl radical (CH3) molecules in an atmospheric pressure flame and in a low-pressure hot-filament reactor. To calibrate the measurement, acetylene is measured in the free flow of a C2H2/O2 mixture, and also in the pre-reaction zone of a C2H2/O2 flame -- both with a fast flow rate of 40-50 m/s at the nozzle outlet of the mixture. The DFWM signal falls in the weak field limit (far from saturation), which means the DFWM signal is proportional to the products of the three incident beam intensities (IaIbIp).
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Degenerate Four-Wave Mixing (DFWM) is a nonlinear optical process that can be used as a noninvasive in situ diagnostic of hostile environments such as plasmas, flames, arcs and explosions. By identifying molecular species and measuring their concentration, temperature and internal-state population, we can understand better complex chemical environments and mechanisms.

As we outlined in our submitted proposal, progress towards making DFWM spectroscopy quantitative has been achieved [1][2] (mainly by Dr. Skip Williams, who graduated in January, 1994 and who is a post-doctoral fellow at Los Alamos National Laboratory). This work makes explicit how the magnitude of the DFWM signal depends on the polarizations of the three incident beams under the weak and strong-field limits.

We have been using DFWM to investigate acetylene (C₂H₂) and methyl radical (CH₃) molecules in an atmospheric pressure flame and in a low-pressure hot-filament reactor [3] in collaboration with Professor C. Kruger, Department of Mechanical Engineering, Stanford University. We have measured DFWM spectra of the Ā¹Aᵤ − Ħ¹Σ₆₂ transition in acetylene at wavelengths around 216 nm. To calibrate the measurement, acetylene is measured in the free flow of a C₂H₂/O₂ mixture, and also in the pre-reaction zone of a C₂H₂/O₂ flame --- both with a fast flow rate of 40-50 m/s at the nozzle outlet of the mixture. The DFWM signal falls in the weak field limit (far from saturation), which means the DFWM signal is proportional to the products of the three incident beam intensities (I₁I₂I₃). When the reactor is filled with 1 atm pressure of acetylene, only an unknown DFWM spectrum is recorded, which we speculate is from the products of acetylene dissociation because acetylene is not transported to the detection zone as efficiently as in the fast flow. Similar results occur for the DFWM of the methyl radical. Molecules like electronically excited acetylene or methyl radical are metastable species that predissociate; for DFWM to succeed the only alternative is to avoid the electronic excitation region of the above species and shift to the vibrational excitation region in the near IR. This shift needs a totally new laser system to initiate it.

A new optical diagnostic: cavity ring-down spectroscopy [4] is another possibility to overcome the above problems at 216nm; by this means methyl radicals have been detected and more detailed measurements are in progress.

The AASERT student's grades are satisfactory.
References


