COHERENT RAMAN SPECTROSCOPIES FOR MEASURING MOLECULAR FLOW VELOCITY

C. Y. She
Department of Physics
Colorado State University
Fort Collins, Colorado 80523

GENERAL

1. Molecular flow velocity can be measured directly by probing the velocity dependent Raman shift (Doppler effect) of the flowing molecules. No seeding is required.

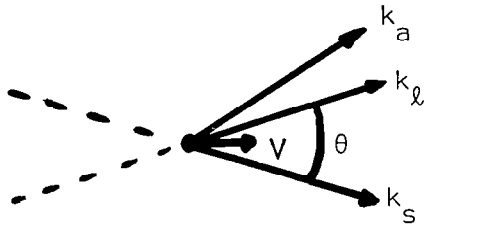
2. Because of the small Doppler shift (∿1 GHz), high frequency resolution is required. Thus, spontaneous Raman scattering will not work; any type of coherent Raman spectroscopy (SRGS, CARS, IRS, or CSRS) will do.

3. The direction as well as the magnitude of the velocity is measured. The measurement is easier for faster flow which gives a larger Doppler shift.

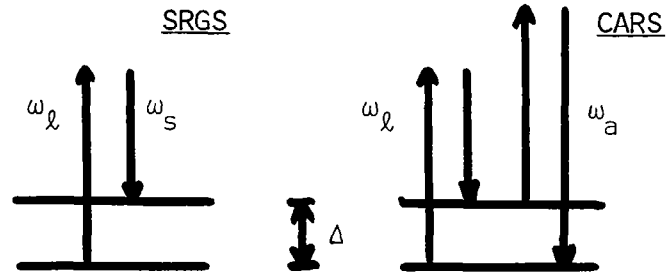
4. When pressure broadening dominates, backward scattering geometry is preferred ($\theta \sim 180°$).

5. High spatial resolution may be achieved by crossing pump and probe beams.

PROCESSES



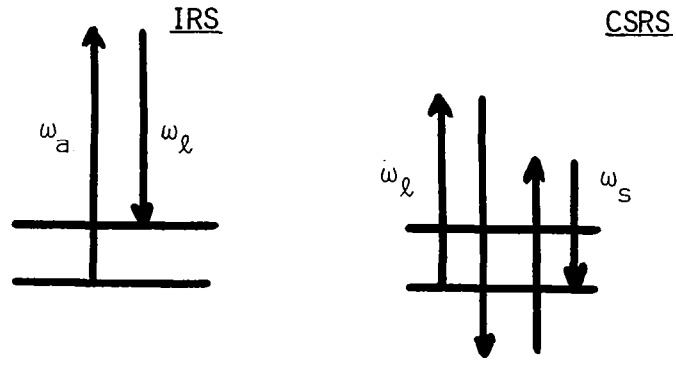
$(\omega_\ell - k_\ell V) = (\omega_s - k_s V) + \Delta$



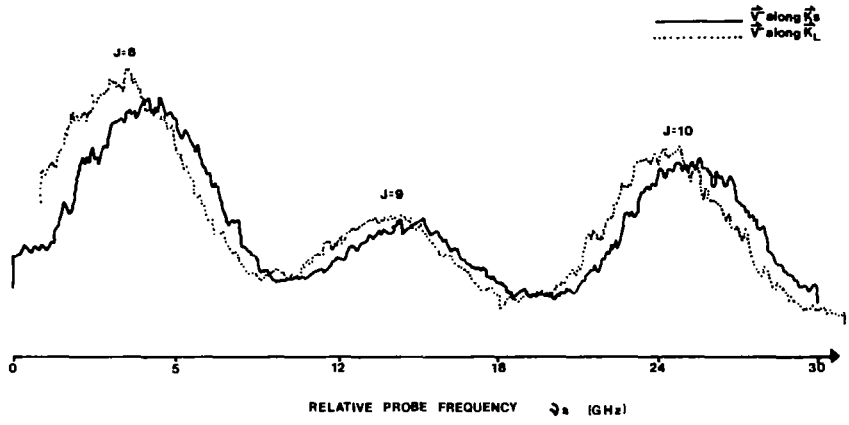
SRGS: $\omega_s = (\omega_\ell - \Delta) - (k_\ell - k_s)V$

CARS: $\omega_a = (\omega_\ell + \Delta) + (k_\ell - k_s)V$

IRS & CSRS: $(k_\ell - k_s) \rightarrow (k_a - k_\ell)$



INITIAL EXPERIMENT



SRGS of the Q-branch N_2 vibrations at 2331 cm^{-1} with oppositely directed flows (backward scattering). Pump: 5 MW, 5320 Å, Q-switched; Probe: 20 mW, single-frequency dye.

POTENTIAL

1. Much better S/N can be obtained if lasers with lower intensity and frequency fluctuations are used. IRS experiments using a pulsed dye amplifier and a single-frequency argon-ion laser are in progress.

2. Using a 3-D phase matching arrangement, two-dimensional velocity vectors can be measured by CARS and CSRS.

3. With currently available electronic technology, CARS and CSRS spectra can, in principle, be taken on single-shot basis. This will reduce the measurement time from 10 min. to less than 1 sec.

4. Such spectra contain information on species concentration and temperature as well. The proposed method has the potential for measuring all interesting flow parameters.