Image-Tube Streak Photography of Raman Spectra

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SOME RECENT WORK has been done on the application of time-resolved spectroscopy to the Raman spectra stimulated by a Q-spoiled ruby laser.

The Raman effect can be described as the interaction between a photon and a molecule with the result that some of the photon energy is converted into rotational and vibrational states and the resulting energy change is recorded as a frequency shift. Raman light of lower frequency than the exciting beam is termed Stokes whereas higher frequency components are termed anti-Stokes. The normal Raman effect is a low cross section scattering process and the shifted lines are of low intensities whereas in the stimulated Raman effect kilowatts of Raman can be generated.

There are two possible ways of producing stimulated Raman scattering. First, there is the intra-cavity method in which the Raman cell lies within the laser cavity. Second, there is the extra-cavity method in which the cell is external to the laser and the effect is produced either in a linear or focused system. The latter was used for this experiment.

The characteristics of the effect are: (1) there is a threshold laser intensity for the process; (2) Stokes, anti-Stokes and harmonics are generated; (3) in general, only the lines with high intensity/unit line width are generated; and (4) anti-Stokes lines are emitted at angles of a few degrees and are generated only in the extra-cavity method. In both methods, self-focusing, i.e., the formation of hot filaments within the laser beam, has been observed.

Experimental

The technique of time resolved spectroscopy was applied to investigate (1) the simultaneity of the process, (2) the time sequence of harmonics and fundamentals and (3) spatial effects caused by self-focusing. The experimental set-up is shown in Fig. 1. The system is such that the focal region is imaged after dispersion in the spectrometer as a series of points so that spatial as well as temporal effects are recorded. Alignment is effected with a He-Ne laser so that each component can be fixed with respect to a given reference axis. Power is measured by means of a combination of a "rat's nest" and a photodiode. The point spectrum is streaked with an image converter camera (T.R.W) at a streak speed of 100 mm/μs. Triggering was effected optically by the laser pulse. Because of the inherent time delay in the optics and electronics it was found necessary to use a multiple-pulse system with the first pulse as a trigger. A slow Q-switch, rotating roof prism at 15,000 r/m was found suitable.

Results

Time resolved spectra of the stimulated Raman of benzene were recorded and the sequential development of the lines found. The process is Stokes, anti-Stokes, 2nd harmonic Stokes. A typical picture is shown in Fig. 2.

Spatial effects were also recorded and evidence of beam constriction during the Raman generation is visible.

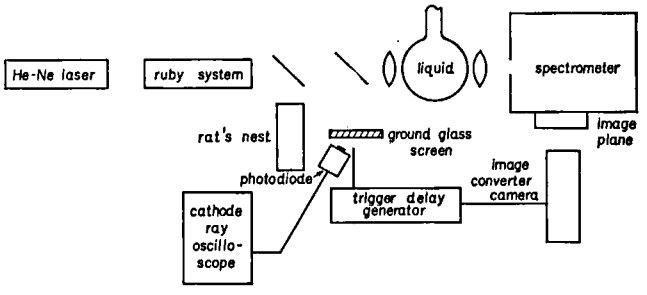

Fig. 1. Experimental set-up.

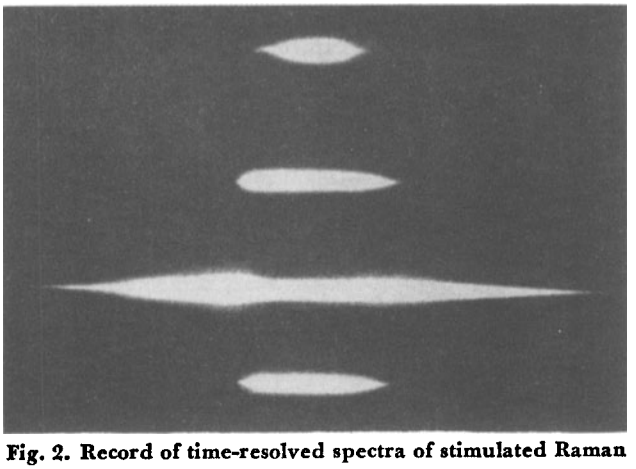

Fig. 2. Record of time-resolved spectra of stimulated Raman of benzene.