

Raman Scattering

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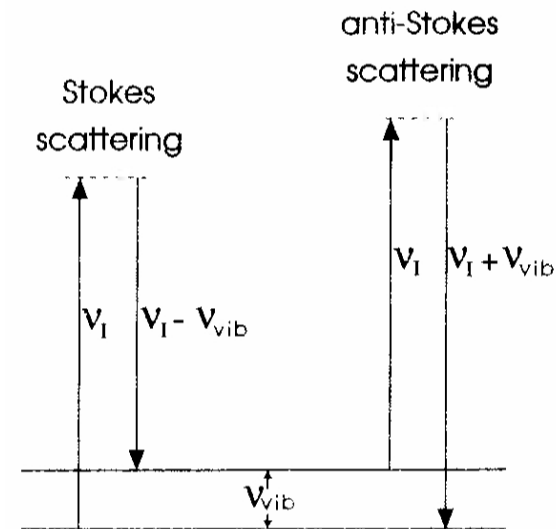
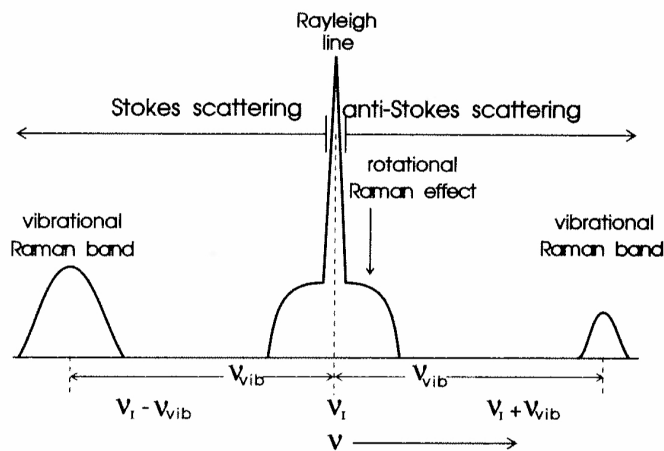
Raman Scattering

- Raman scattering is an inelastic process that results in a change in quantum state.
- It occurs because of modulation of the scattered radiation by state to state transitions.

$$\alpha = \alpha_0 + \alpha_1 \cos(\omega t)$$

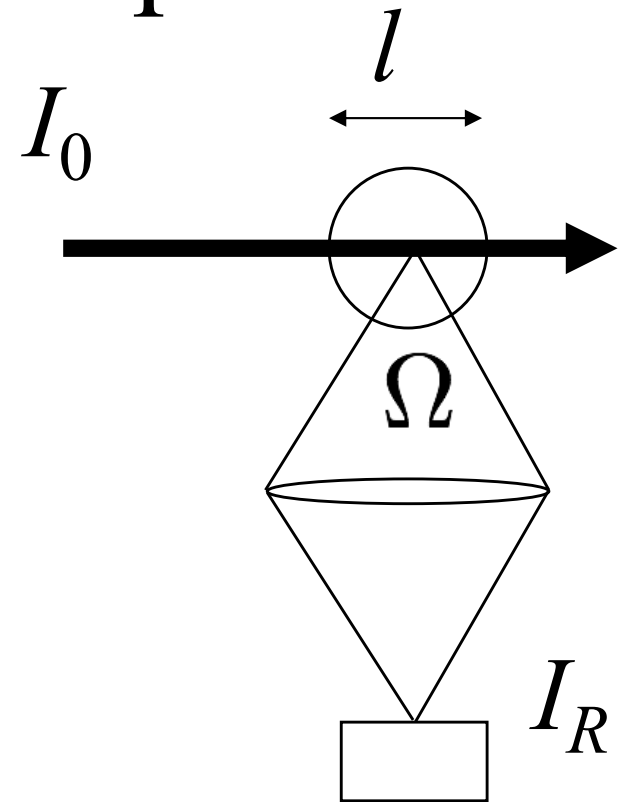
Raman Scattering

- If the process results in an increase in molecular energy, it is called Stokes scattering.
- If it decreases the molecular energy it is called anti-Stokes scattering.
- Like Rayleigh scattering it is non-resonant, but causes a change in quantum state.



A Measurement Setup

$$I_R = I_0 N_i l \Omega \epsilon \left(\frac{d\sigma}{d\Omega} \right)_i$$



Detector

- I_0 Incident radiant power
- I_R Collected radiant power
- Ω Solid angle
- l Pathlength
- ϵ Optical Efficiency
- N_i Number concentration for species i
- $\left(\frac{d\sigma}{d\Omega} \right)_i$ Raman cross section for species i

Vibrational Raman

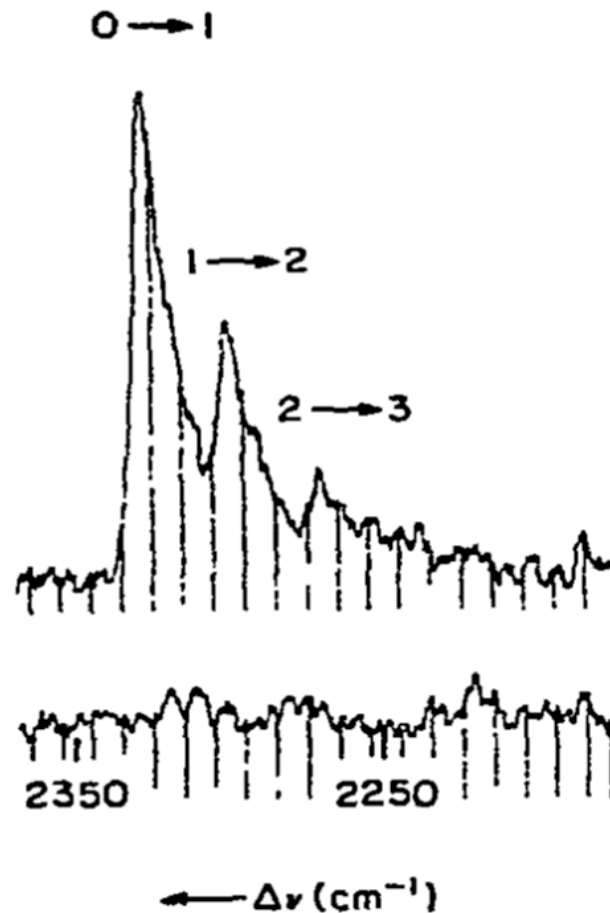


Fig. 1. Stokes vibrational Raman spectrum of N₂ in a 1 atm H₂ diffusion flame in air. Laser excitation is 21.5 W at 488 nm, 4.5 cm⁻¹ resolution, 0.25 cm⁻¹/s scan rate, 3 s time constant. Marker lines are 10 cm⁻¹ apart.



Rotational Raman

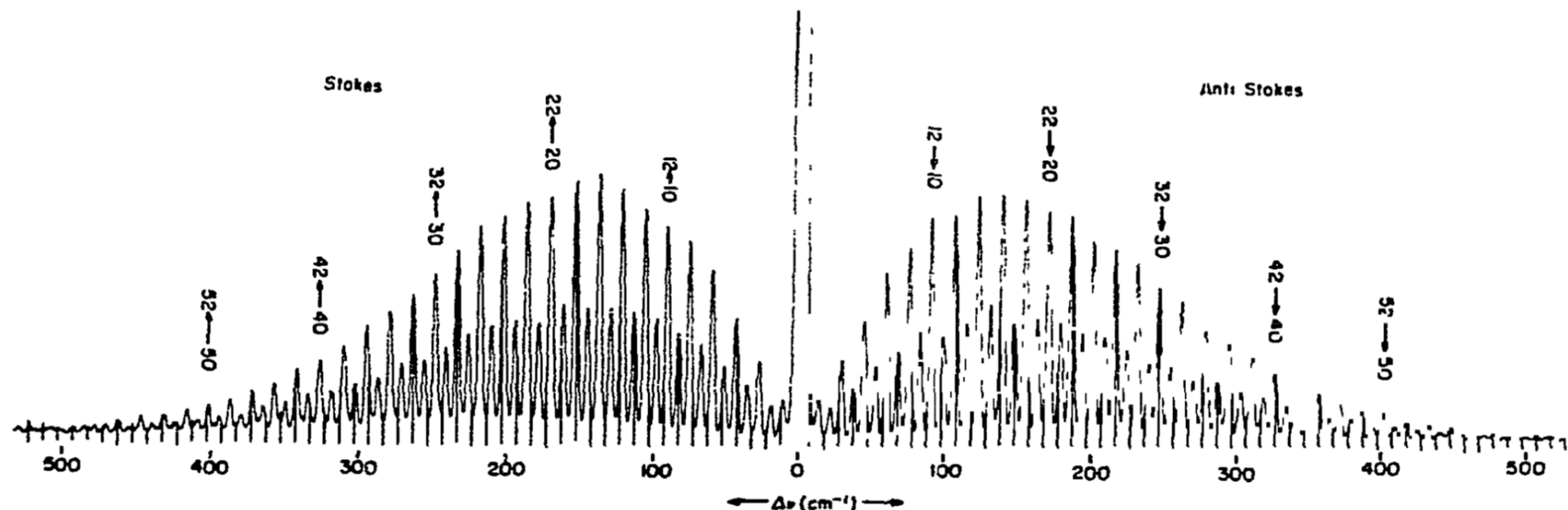


Fig. 2. Stokes and anti-Stokes rotational Raman spectra of N₂ in the same flame as fig. 1, 9.5 W excitation at 488 nm, 2.5 cm⁻¹ resolution, 0.25 cm⁻¹/s scan rate, 3 s time constant, 1 hour total scan time.

Flame Temperatures from Raman Scattering
M.C. Drake and G.M. Rosenblatt, Chemical
Physics Letters 44, 313 (1976).

Raman Cross Sections

Species	Vibrational Frequency (cm ⁻¹)	$\sigma/\sigma_{\text{N}_2}$
N ₂	2331	1.0
CO	2145	1.0
H ₂	4161	1.6
NO	1877	0.27
CO	1388	1.4
N ₂ O	1285	2.2
SO ₂	1151	5.2
C ₆ H ₆	3062	7.0

$$\sigma_{\text{N}_2} = 3.3 \times 10^{-21} \text{ cm}^2/\text{sr}$$

