



Prof. Chandrashekhara Venkata Raman

Discovered the "Raman Effect" – a light scattering effect in 1928, won the Noble Prize in 1930 for Physics

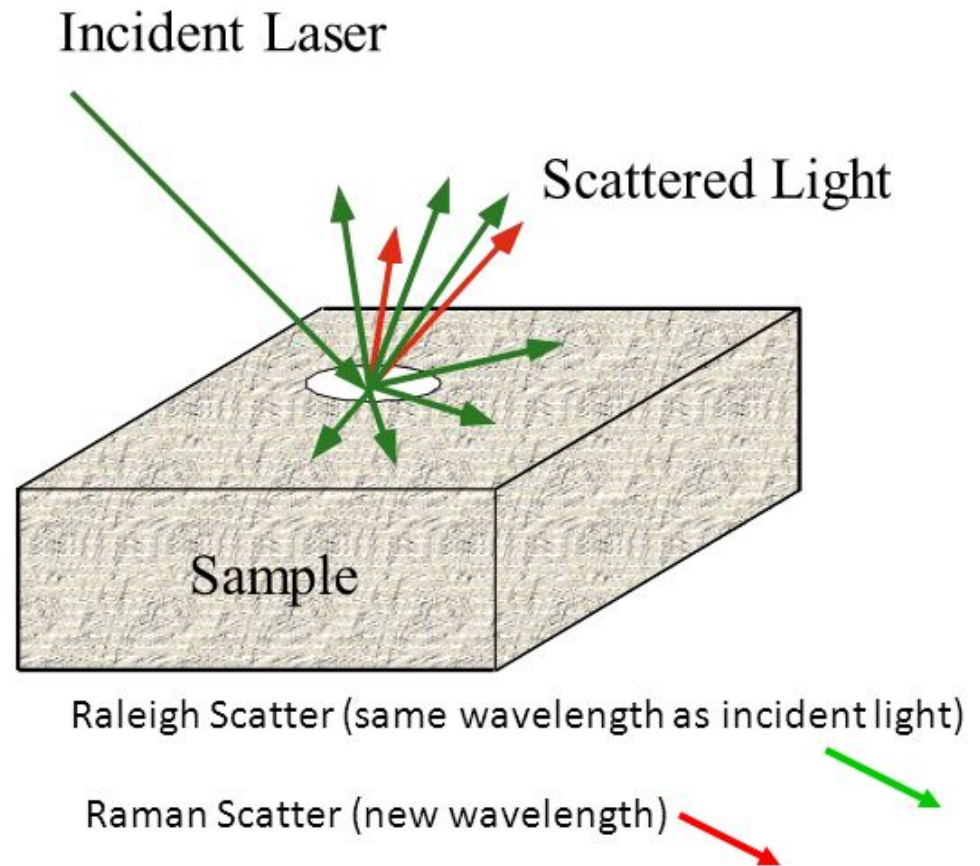
- Raman spectroscopy is the measurement of the wavelength and intensity of inelastically scattered light from molecules
- The Raman scattered light occurs at wavelengths that are shifted from incident light by the energies of molecular vibrations
- It is governed by the polarizability of electron cloud around the molecule

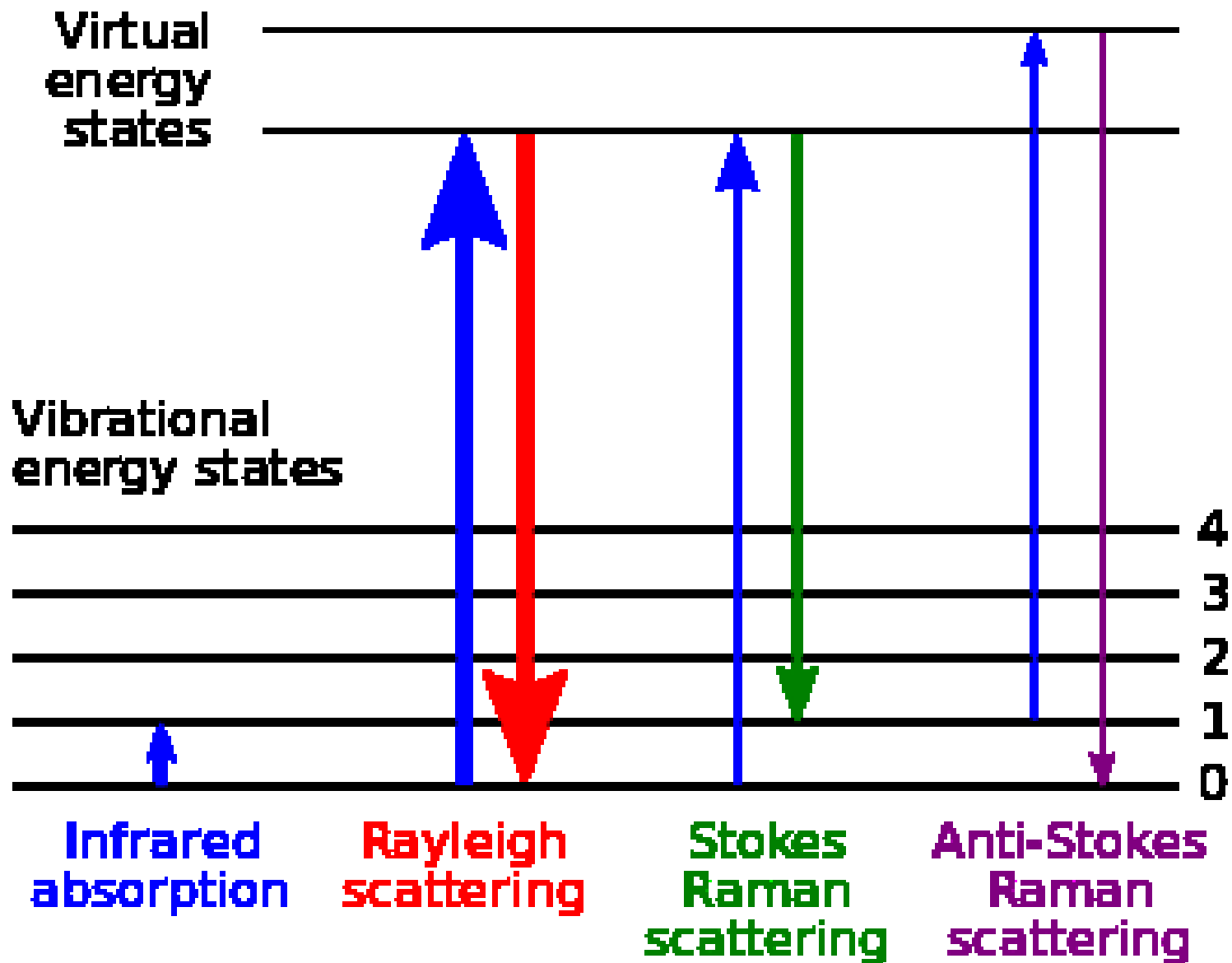


**Chandrasekhar Venkata Raman
(1888-1970)**

Principle of Raman Spectroscopy

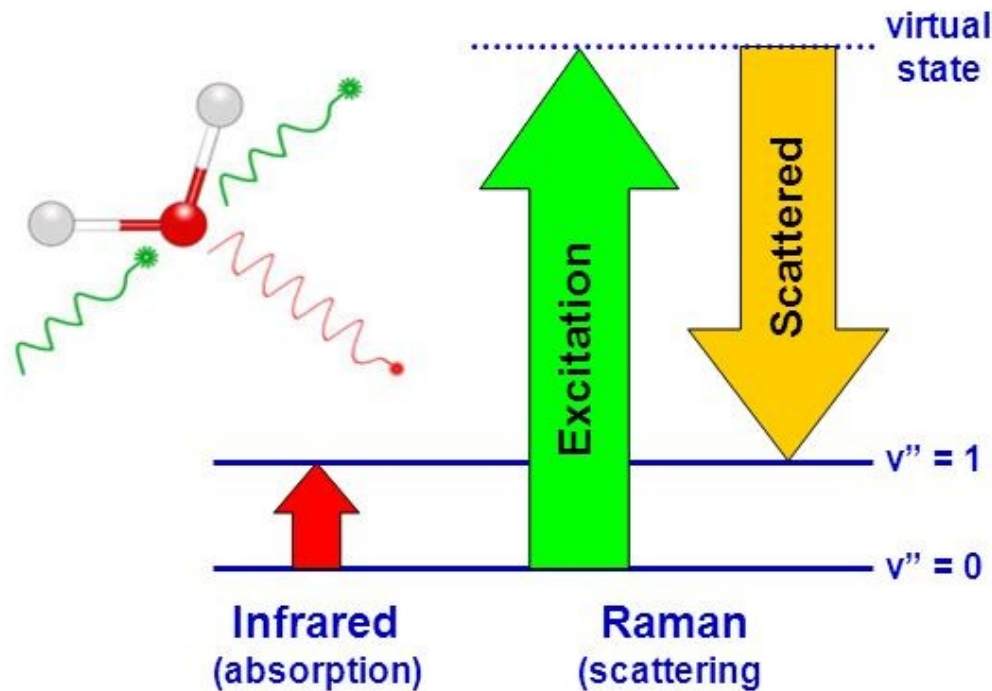
Raman spectra are acquired by irradiating a sample with a powerful laser source of visible or near-infrared monochromatic radiation. During irradiation, the spectrum of the scattered radiation is measured at some angle with a suitable spectrometer. At the very most, the intensities of Raman lines are very small of the intensity of the source; as a consequence, their detection and measurement are somewhat difficult.



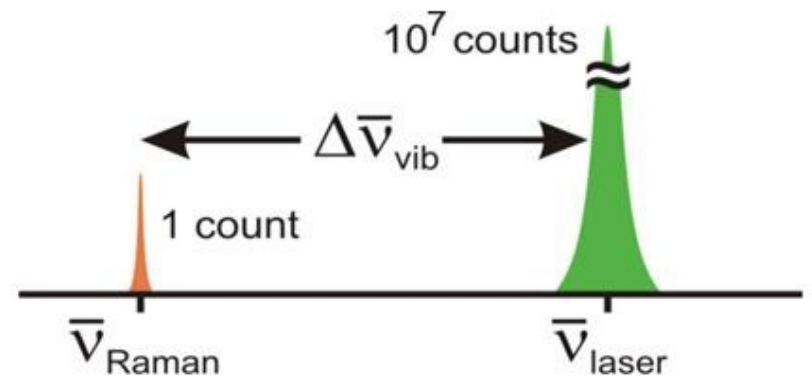


Raman Spectroscopy

1 in 10^7 photons is scattered inelastically



Rotational Raman
Vibrational Raman
Electronic Raman



Vibrational modes that are more polarizable are more Raman-active:

- **N₂** (symetric stretch): cause no change in dipole moment – **IR-inactive**, but cause a change of the bond length (change the polarizability of the bond) - **Raman-active**.
- **CO₂** (asymmetric stretch): cause a change in dipole moment (**IR-active**), polarizability change by bond lengthening is canceled by asymmetric stretch (**Raman-inactive**).
- Some bonds may be both IR and Raman active/inactive.

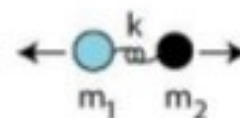
Raman Spectroscopy: Classical Treatment

- Number of peaks related to degrees of freedom

$$DoF = 3N - 6 \text{ (bent) or } 3N - 5 \text{ (linear) for } N \text{ atoms}$$

- Energy related to harmonic oscillator

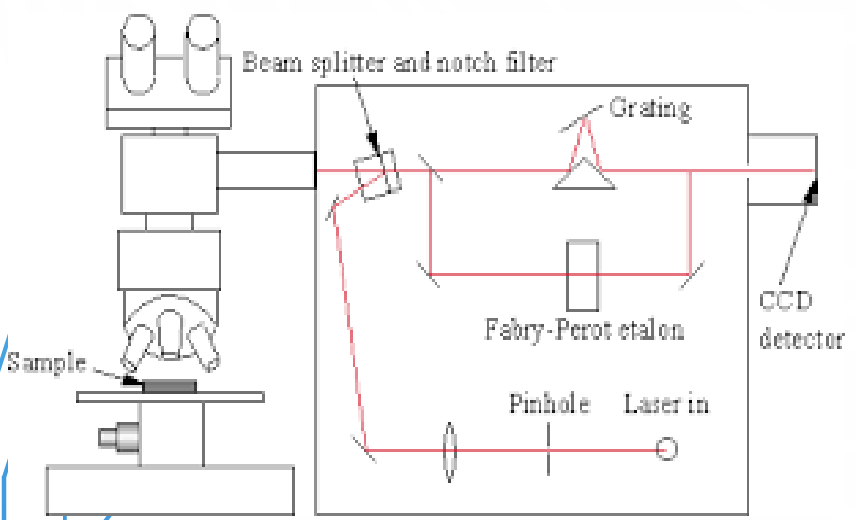
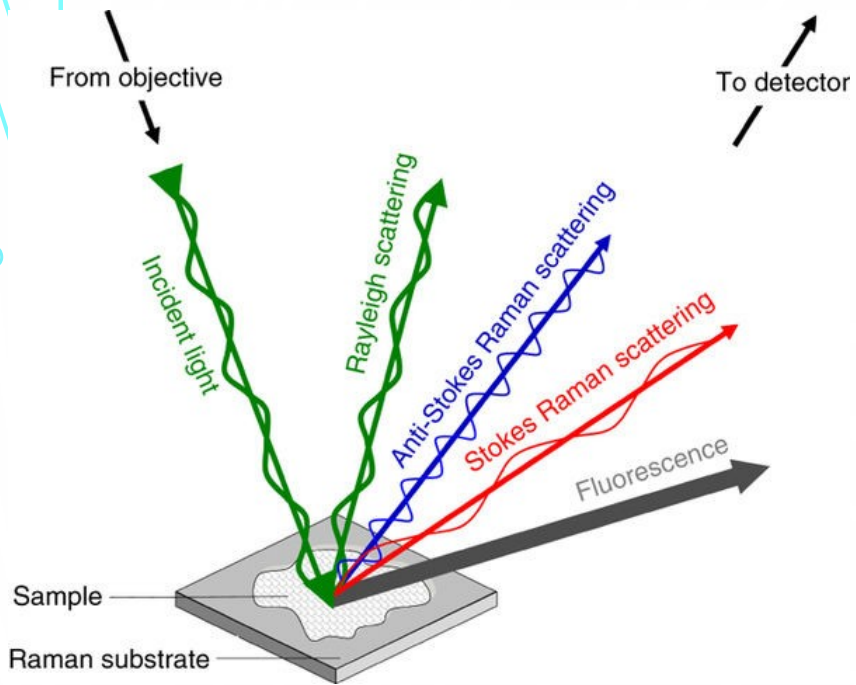
$$\sigma \text{ or } \Delta\sigma = \frac{c}{2\pi} \sqrt{\frac{k(m_1+m_2)}{m_1m_2}}$$



- Selection rules related to symmetry

Rule of thumb: symmetric=Raman active, asymmetric=IR active

CO ₂	H ₂ O
<p>Raman: 1335 cm⁻¹</p>	<p>Raman + IR: 3657 cm⁻¹</p>
<p>IR: 2349 cm⁻¹</p>	<p>Raman + IR: 3756 cm⁻¹</p>
<p>IR: 667 cm⁻¹</p>	<p>Raman + IR: 1594 cm⁻¹</p>



laser	UV 325 nm	VIS 532 nm	IR 785 nm
Excitation efficiency	high	medium	low
Fluorescence	high	medium	low
Heat absorption	low	medium	high