Raman spectroscopy, principles and applications

BY

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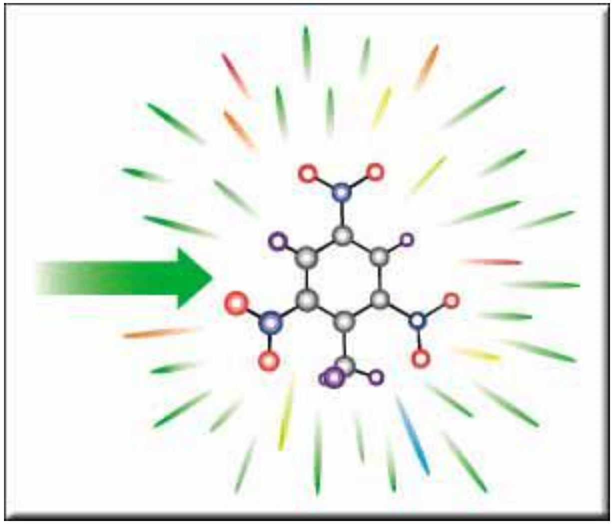


Introduction

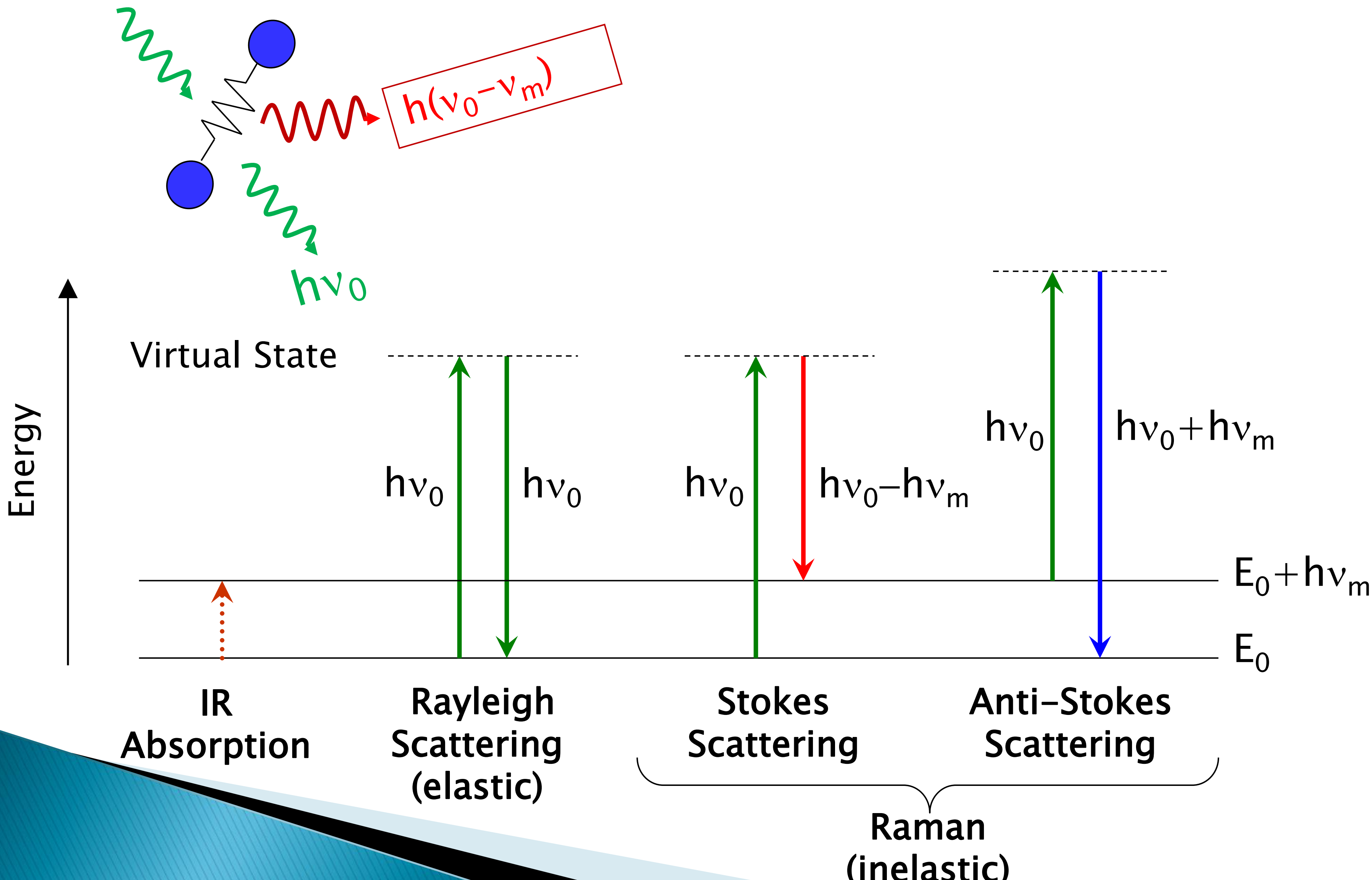
- Prof. Chandrashekhara Venkata Raman
- Discovered the "Raman Effect“ – a light scattering effect in 1928
- Won the Noble Prize in 1930 for Physics

❖ Ramam 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 govern by the polarizability of electron cloud around the molecule

Principles of Raman spectroscopy



Conditions for Raman Spectroscopy

Vibrational modes that are more polarizable are more Raman-active

Examples:

– N_2 (dinitrogen) symmetric stretch

cause no change in dipole **(IR-inactive)**

cause a change in the polarizability of the bond – as the bond gets longer it is more easily deformed (Raman -active)

– CO_2 asymmetric stretch

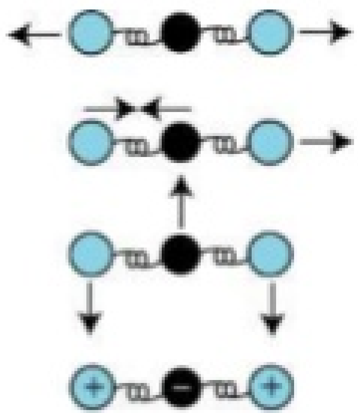
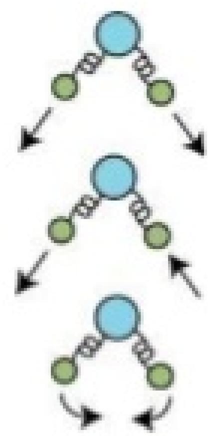
cause a change in dipole **(IR-active)**

Polarizability change of one C=O bond lengthening is cancelled by the shortening of the other – no net polarizability (Raman-inactive)

Some modes may be both IR and Raman-active, others may be one or the other!

- Selection rules related to symmetry

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

CO_2		H_2O	
	Raman: 1335 cm^{-1}		Raman + IR: 3657 cm^{-1}
	IR: 2349 cm^{-1}		Raman + IR: 3756 cm^{-1}
	IR: 667 cm^{-1}		Raman + IR: 1594 cm^{-1}

Applicable Lasers

Examples of Laser wavelengths used for Raman spectroscopy:

	532nm	785nm	1064nm
Excitation efficiency	high	medium	low
Fluorescence	high	medium	low
Heat absorption	low	medium	high

The most obvious difference is the excitation efficiency.

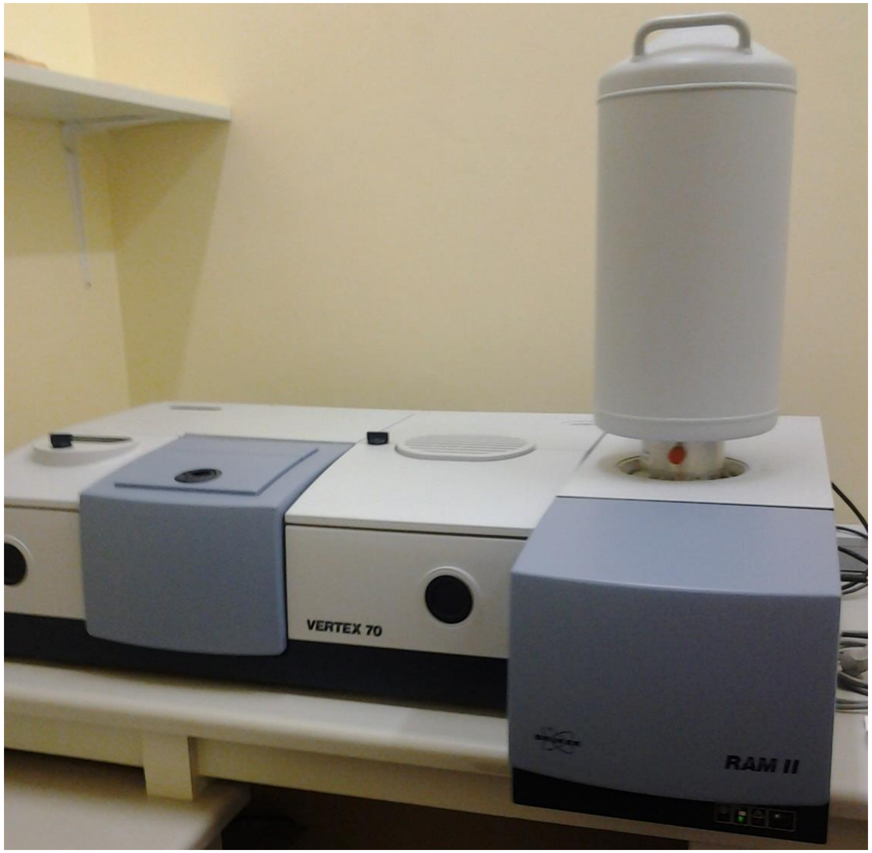
The choice of laser wavelength has an important impact on experimental capabilities:

Sensitivity.

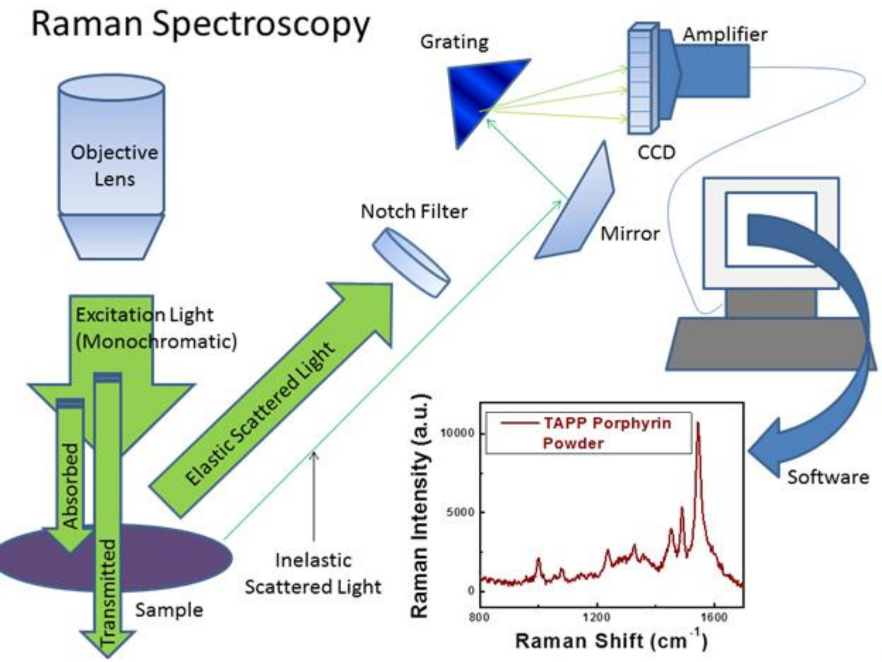
- R is proportional to λ^{-4} (where R is the raman scattering efficiency/intensity).

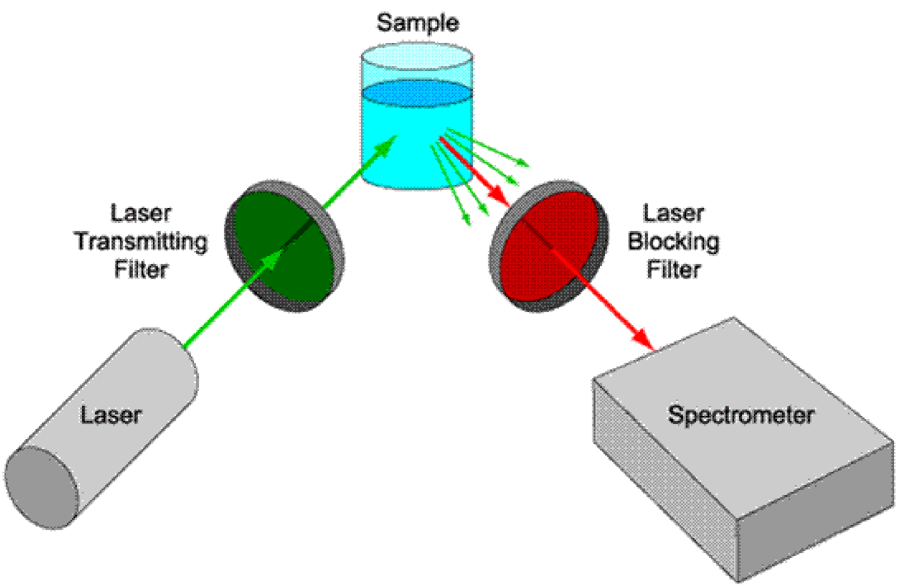
- For example, Raman scattering at 532nm is a factor of 4.7 more efficient than at 785nm and 16 times better than at 1064nm, effectively meaning that scan time is much longer at higher wavelengths as compared to 532nm, assuming that all other conditions remain the same.

Our Raman Equipment



Operation of Raman spectroscopy





[http://www.foxnews.com/images/268784/1_61_zawahri_ayman.jpg]

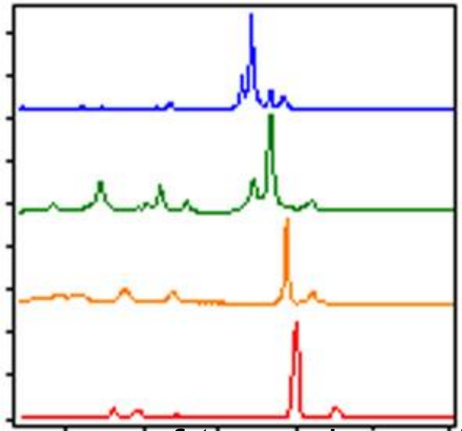
Applications

Carbon Materials
- Purity of carbon nanotubes (CNTs)
- sp^2 and sp^3 structure in carbon materials

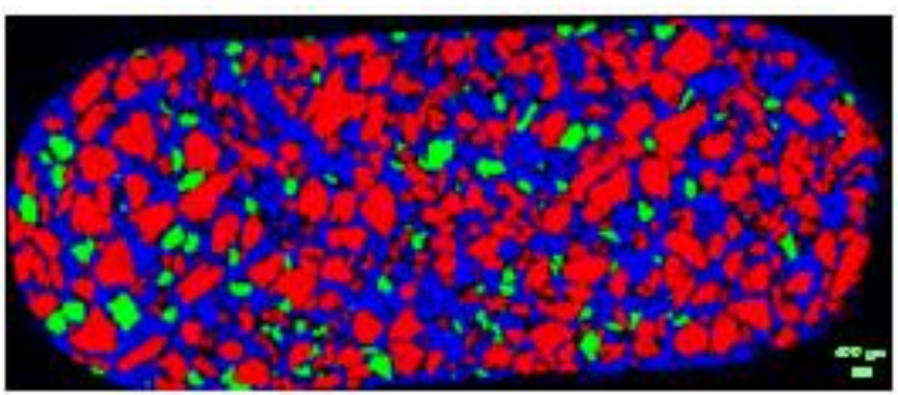
Pharmaceuticals and Cosmetics
- Compound distribution in tablets
- Polymorphic forms
- Contaminant identification

Life Sciences
- Bio-compatibility
- DNA/RNA analysis
- Drug/cell interactions
- Photodynamic therapy (PDT)

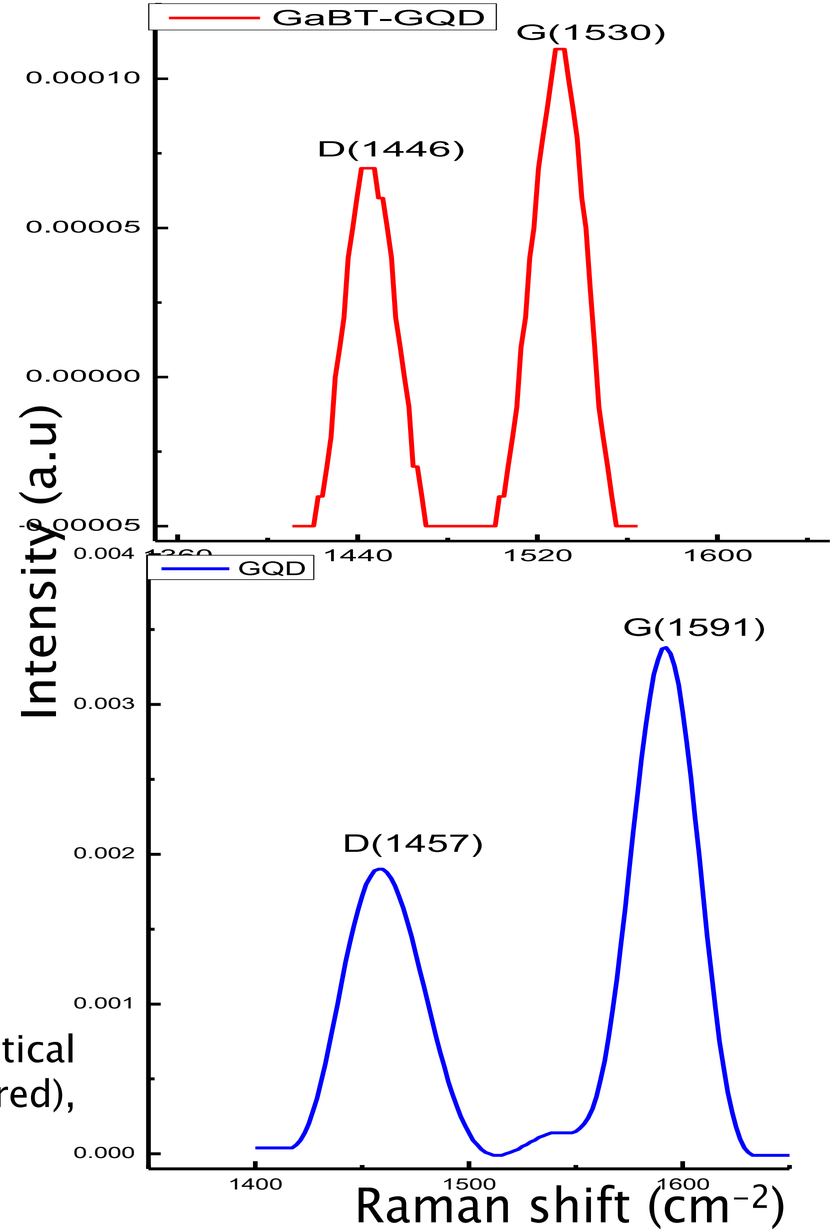
Geology and Mineralogy
- Gemstone and mineral identification
- Fluid inclusions
- Mineral and phase distribution in rock sections
- Mineral behaviour under extreme conditions



Raman spectra of (top to bottom) olivine, apatite, garnet and gypsum illustrating how Raman can be used for fast mineral ID.



Raman spectral image of a whole pharmaceutical tablet, showing the distribution of aspirin (red), caffeine (green) and paracetamol (blue)



Conclusion

- It is due to the scattering of light by vibrating molecules
- Little or no sample preparation is required for analysis
- It has a wide range of applications
- Raman spectroscopy is a complimentary method to IR

Thank You

''Success can only come to you by courageous devotion to the task lying ahead of you''