

# Introduction to Raman Spectroscopy

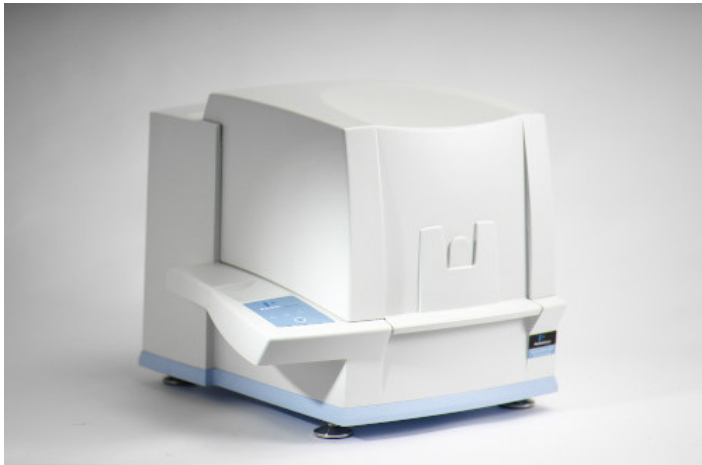
## ***Know Your Theory and History !!***

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- **First postulated by Smekal in 1923**
  
- **Dr. Chandrasekhara Venkata Raman**
  - **First observation of Raman Scattering**
  
  - Discovered by the Indian scientist Sir C. V. Raman (1928, together with K. S. Krishnan). Raman won the Nobel Prize in Physics in 1930 for this discovery



# ***Our New Raman Spectrometer ..... 2007***



**“ ..... This instrument combines the latest improvements in Raman design with proven standard spectrometer components. It is priced well below other Raman spectrometers of similar or inferior performance capabilities” 1954**

## **The light photons can either**

- 1) Have no interaction with the molecule and pass straight through**
- 2) Can be absorbed ..... IR, UV/Visible, acoustic, NMR spectroscopy**
- 3) Can be absorbed and re-emitted at a different wavelength ..... fluorescence emission spectroscopy**
- 4) Scattered ..... Raman spectroscopy, particle size measurements.**

**Source covering a range of frequencies (wavelengths)**

**Energy of an incident photon corresponds to the energy gap between the ground state and an excited state of a molecule.**

**Photon is absorbed and molecule is promoted to a higher energy state**

**The loss of this frequency of radiation from the beam is detected and measured.**

**An absorption spectrum is the measurement of this loss of energy at these specific frequencies.**

**Uses a single frequency source of radiation (laser).**

**The photon interacts and distorts (polarizes) the electrons in the bond to form a short-lived “virtual state”**

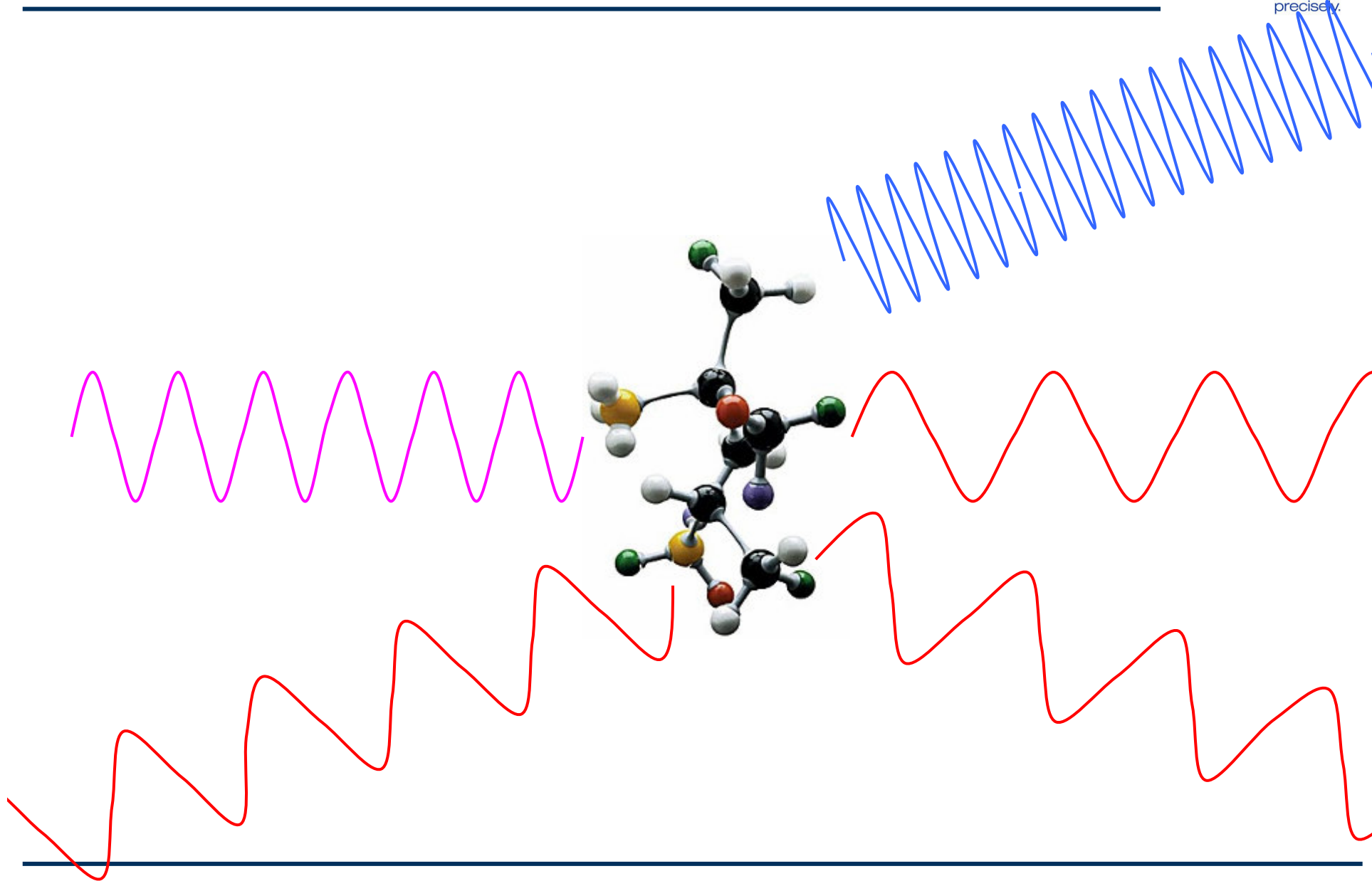
**Return from this “virtual state” to ground state can either result in**

**1) no change to the frequency of the radiation .....Rayleigh scattering (elastic scattering)**

**2) increase or decrease in the frequency of the radiation ..... Raman scattering (inelastic scattering)**

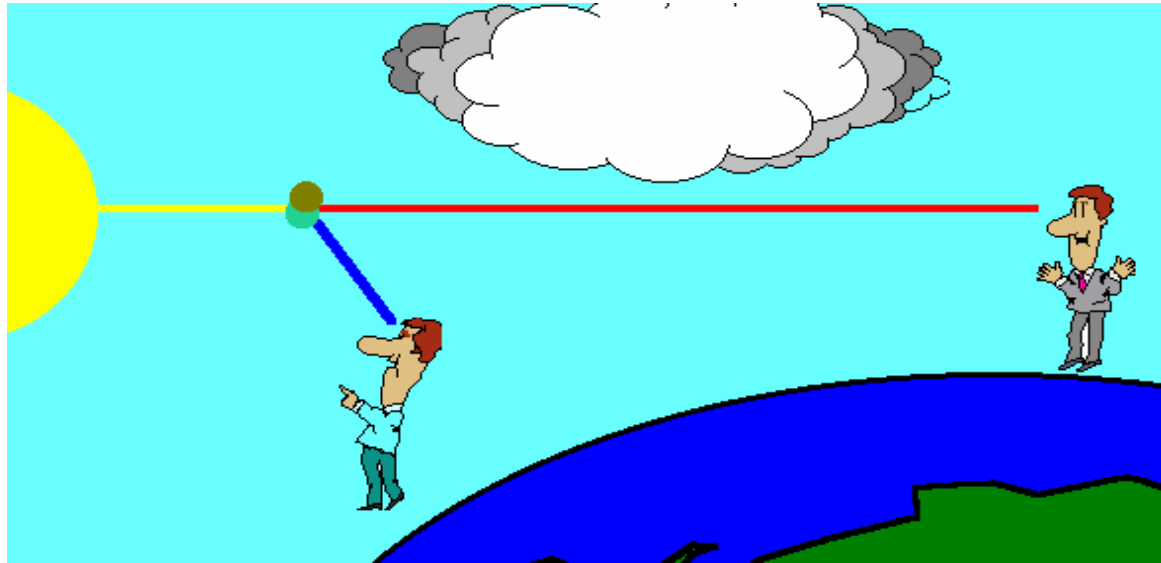
# What Is Raman Scatter?

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## ***Light scattering is all around us .....***

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**Sun is source of all visible wavelengths**

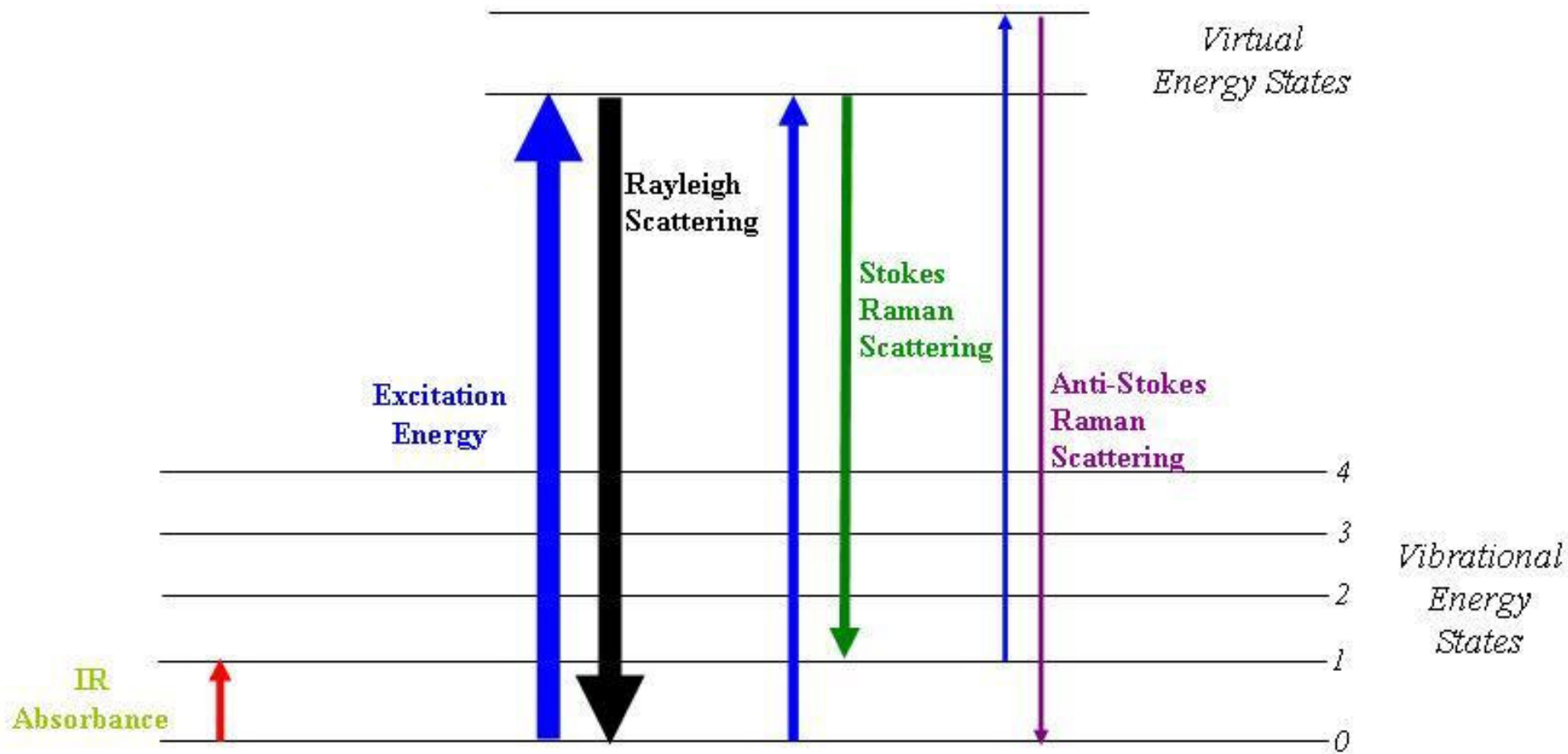
**Blue light is scattered from atmospheric molecules more than red light**

**This means that at mid-day we see a blue sky**

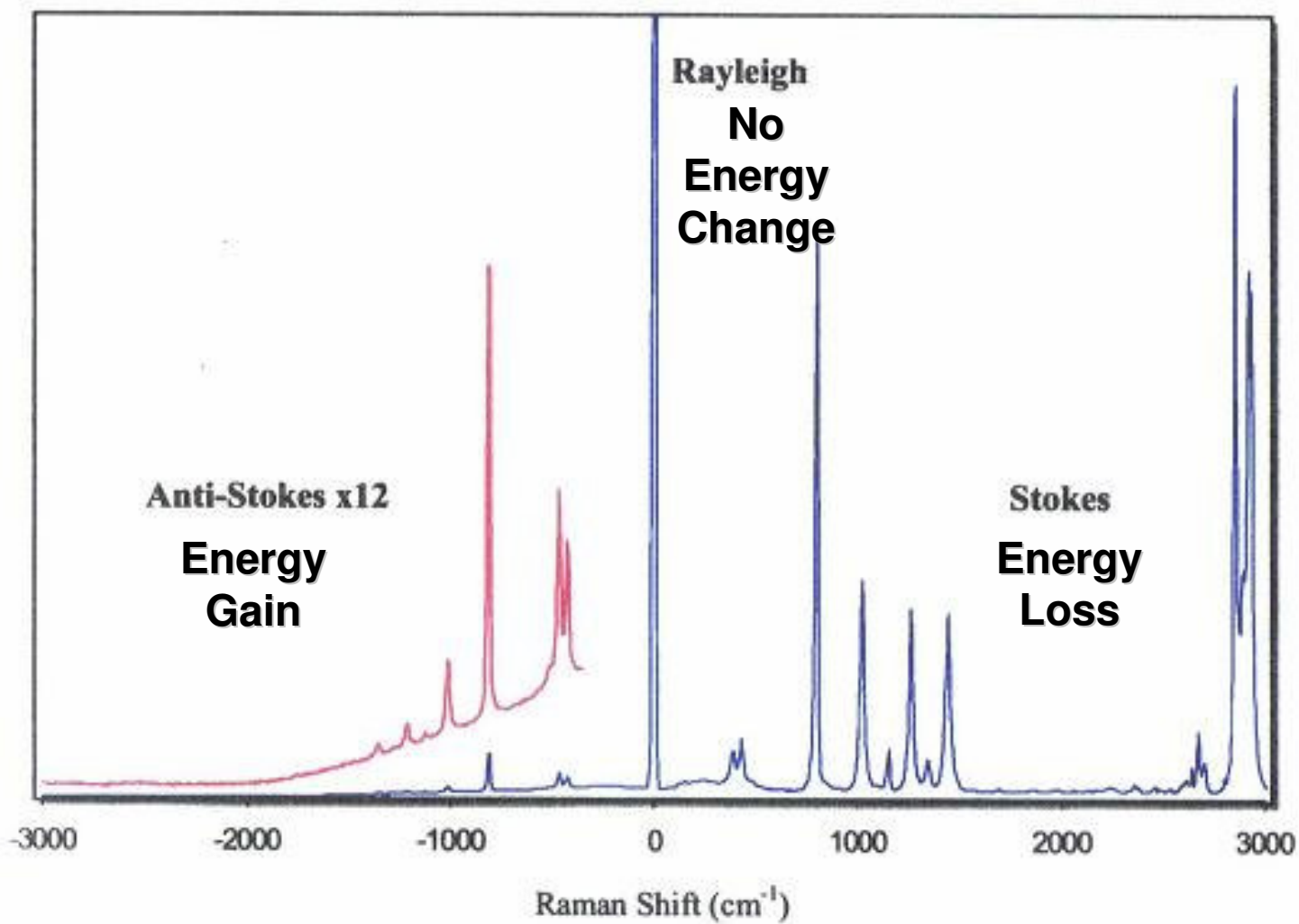
**At sunset the blue light has been scattered leaving the red light**

**Larger water droplets in a cloud scatter all wavelengths equally and are therefore white in colour**

# What the Electrons Do



# Stokes and Anti-Stokes Raman Cyclohexane Spectra



## ***Effect of Laser wavelength***

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**Intensity of Scatter =  $KI(\text{Pol})^2 \nu^4$**

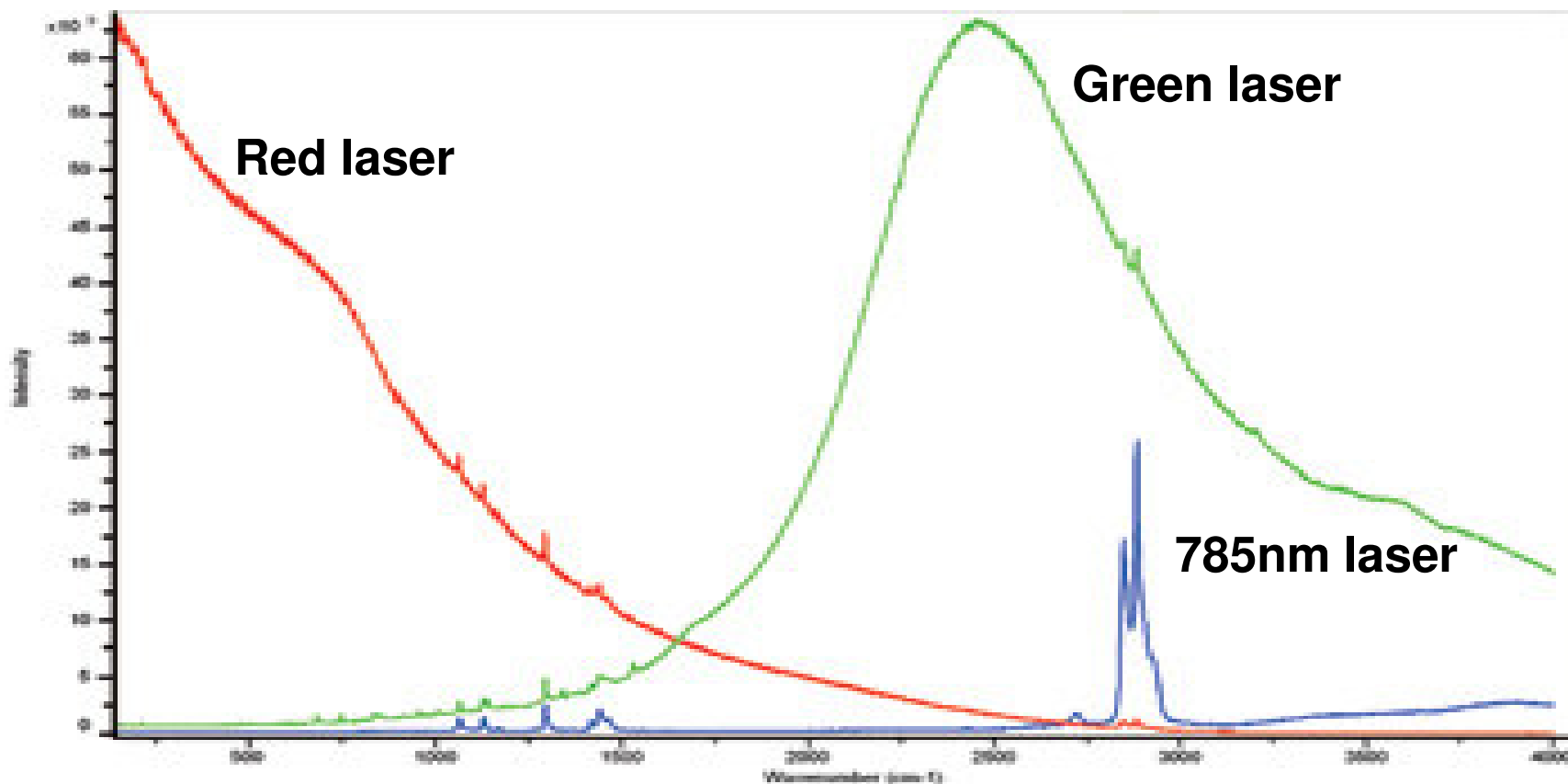
***This means that a “blue” laser should give a stronger signal than a “red” or “Near-IR” laser.***

***However, fluorescence competes with scattering and if it is present is normally much stronger than scattering and hence masks the Raman spectrum.***

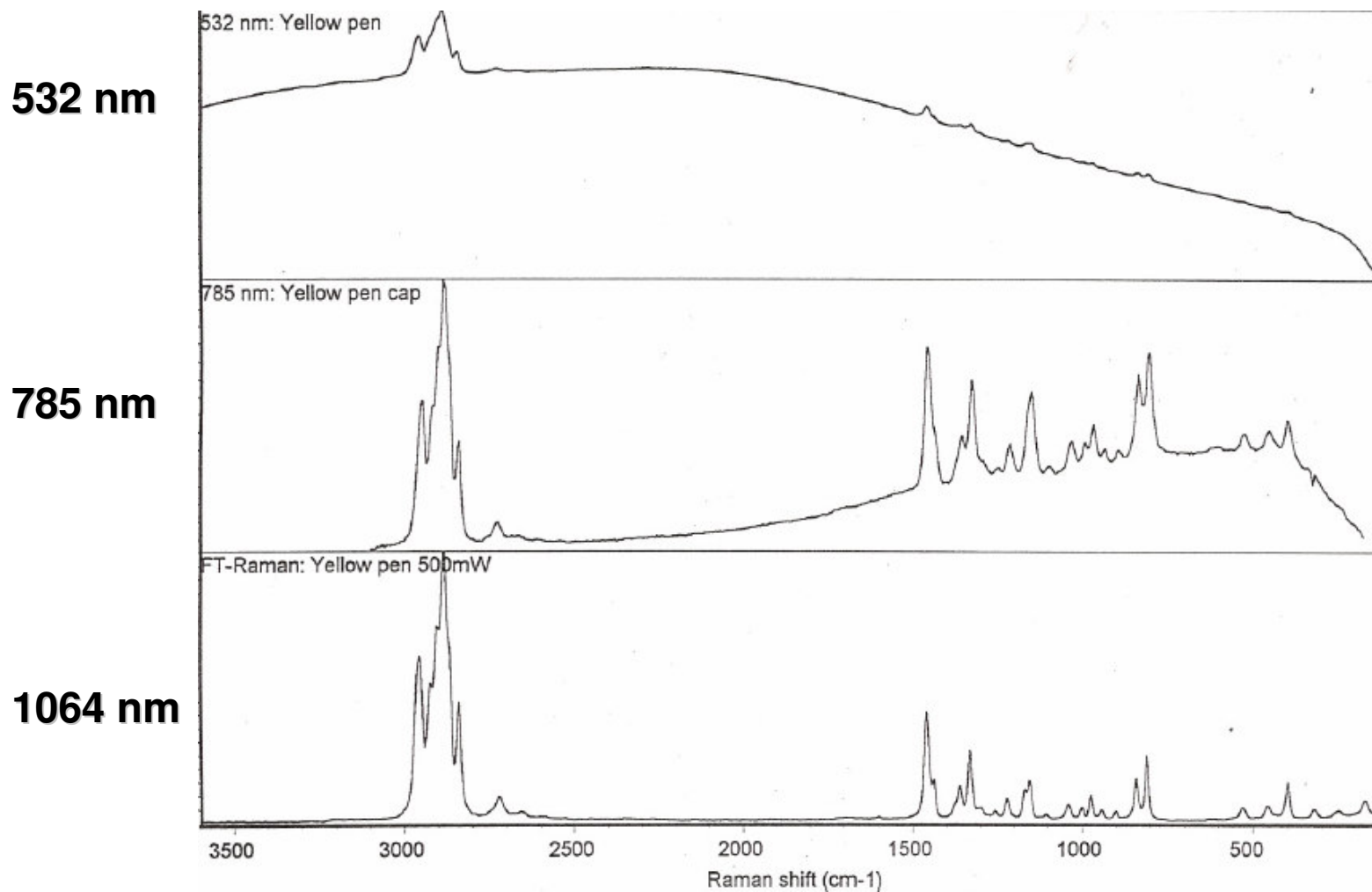
***This is the main reason why some laboratories use Near-IR FT-Raman***

## ***Fluorescence as a Raman Interference***

**Green, Red and 785 nm laser excitation of a fluorescent sample. The strong background seen with the green and red lasers swamps the Raman signal, whereas the 785 nm excitation is outside of the fluorescence range, enabling the Raman to be detected.**



***This is More Typical***



***...Cosmetic Fluorescence with 785nm laser***

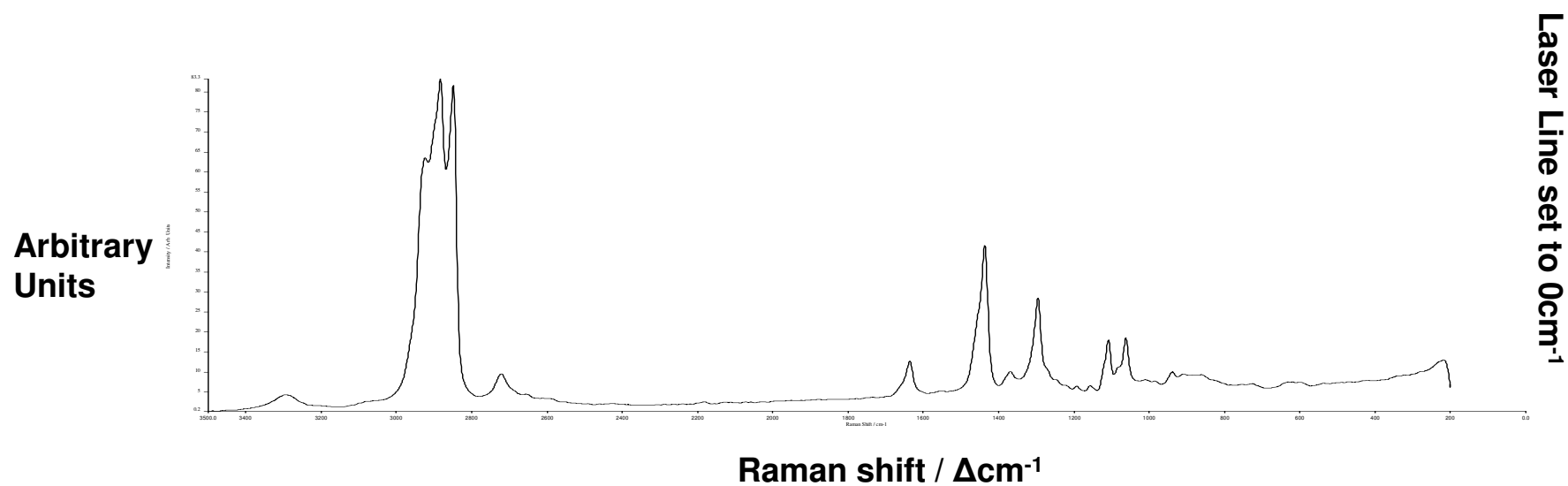
**The RamanStation uses a 785nm laser which is becoming accepted as the best “all-round” laser source.**

- a) good scattering efficiency**
- b) can make use of high sensitivity Charge Coupled Detector (CCD)**
- c) reduced or no fluorescence**

**The Spectrum GX FT-Raman instrument uses a 1064nm Near-IR laser.**

- a) little or no fluorescence**
  - b) weaker scattering efficiency and less sensitive detectors.**
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# Displaying a Raman Spectrum

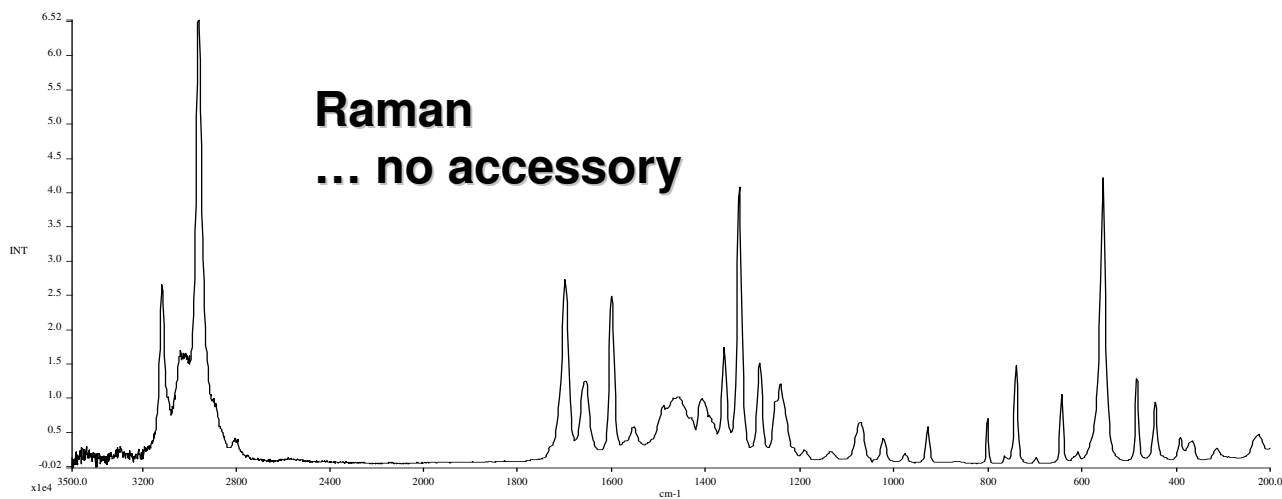
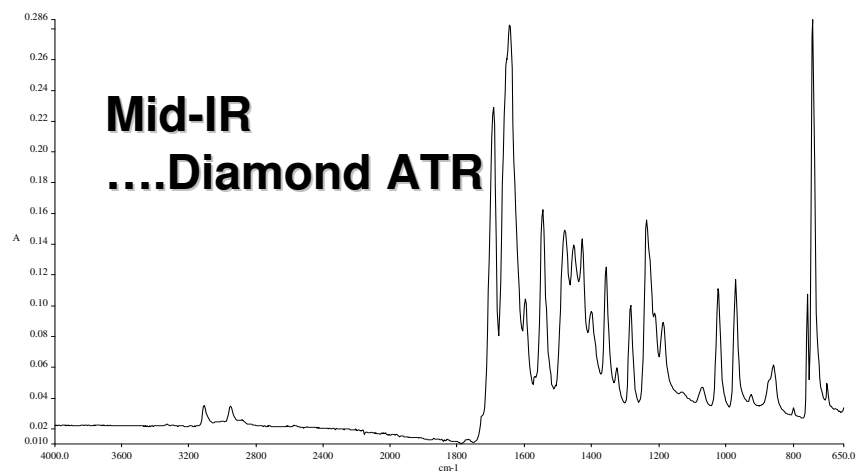


# Comparison of Vibrational Spectroscopy Techniques

	Raman	Mid IR	Near IR
<b>Phenomenon</b>	Scattering	Absorption	Absorption
<b>Information</b>	Fundamental Vibrations (Fingerprint Detail) Sharp, well-defined peaks	Fundamental Vibrations (Fingerprint Detail) Sharp, well-defined peaks	Overtone/combination Broader, overlapping More difficult to interpret
<b>Type of Sample Analyzed</b>	Organics and Inorganics	Organics and Inorganics	Organics mainly Containing C-H, N-H, O-H
<b><u>Sampling Issues</u></b>			
<b>Sample Preparation</b>	None, no contact	Often KBr Pellet or ATR (compression)	None, no contact
<b>Sample State</b>	Solid, Liquid, slurry, paste, gel, suspension, etc  Gases..... very limited	Solids and liquids requiring varying degrees of sample preparation.  Gases..... very good	Solid, Liquid, slurry, paste, gel, suspension, etc  Gases .....very limited
<b>Glass Vials</b>	Minimal problem with Glass	Interference from Glass	Minimal problem with Glass
<b>Water</b>	No Problem with Water	Interference from Water	No Problem with Water
<b>Remote Sampling</b>	Over many hundreds of meters	Very limited	Over many hundreds of metres

- **It is one of the most attractive techniques now and in it is becoming a standar in laboratories (all the limitations in the past are over)**
  - **lasers, detectors, computers, imaging (stage), optics...**
- **The information provide is easy to identify and provides a new valuable tool in many areas, eg. Pharma, control process, forensics ...**
- **The technique has become friendly of use (RamanStation400)**
- **Prices are now accessible to all laboratories/industries**
- **Every user has a different and unique need in the laboratory, PerkinElmer is making tools to help YOU to resolve your needs!!!!**

# Comparison of Vibrational Spectroscopy Techniques



**Mid, Near and Raman Spectra of Caffeine (all at 4cm<sup>-1</sup> resolution)**

# *RamanStation 400 – Ease of Use and Sampling Options*

- **Go Button**
- **Multiple Samples**
- **Sample Bottles**
- **Cuvettes**
- **Vials**
- **Capillaries**



**End**

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➤ **Thank you for your attention.**

