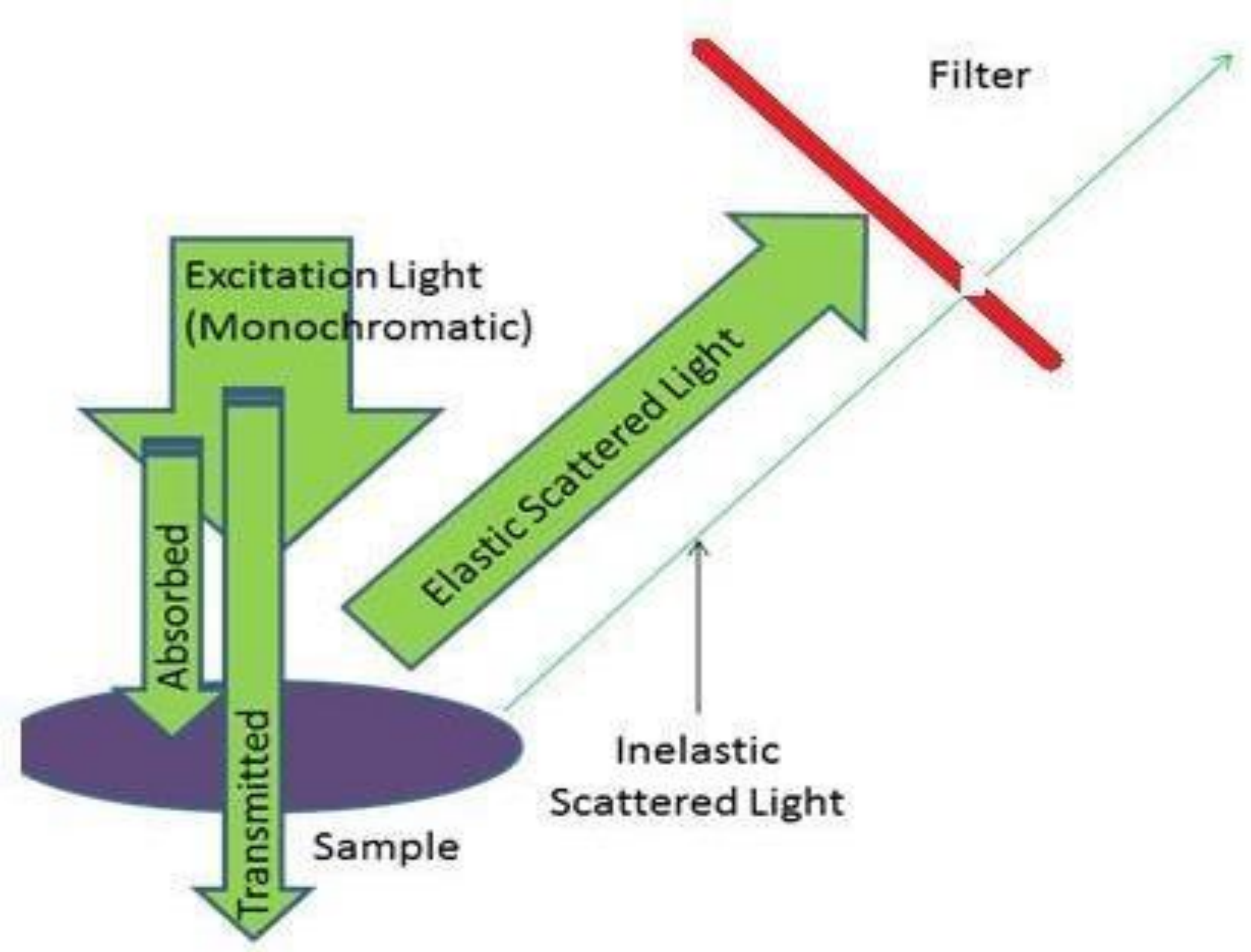
# MOLECULAR SCATTERING METHODS

Several additional processes, can occur when radiation interacts with matter. One of the most important of these is scattering of electromagnetic radiation. Scattering can be divided into two classes: **elastic scattering**, in which the scattered radiation is of the same energy ( wavelength ) as the incident radiation, and **inelastic scattering**, in which the scattered radiation has higher or lower energy than the incident radiation. Both of these types of phenomena have useful analytical applications.


Filter
Excitation Light
(Monochromatic)
Elastic Scattered Light
Absorbed
Transmitted
Sample
Inelastic
Scattered Light

**Rayleigh scattering :**

The scattering takes place either from the molecules themselves (Raman scattering ) or from small particles in colloidal suspension (Rayleigh scattering which will be used in nephelometry and turbidimetry methods of analysis) as will be discussed later.

## Raman Spectroscopy

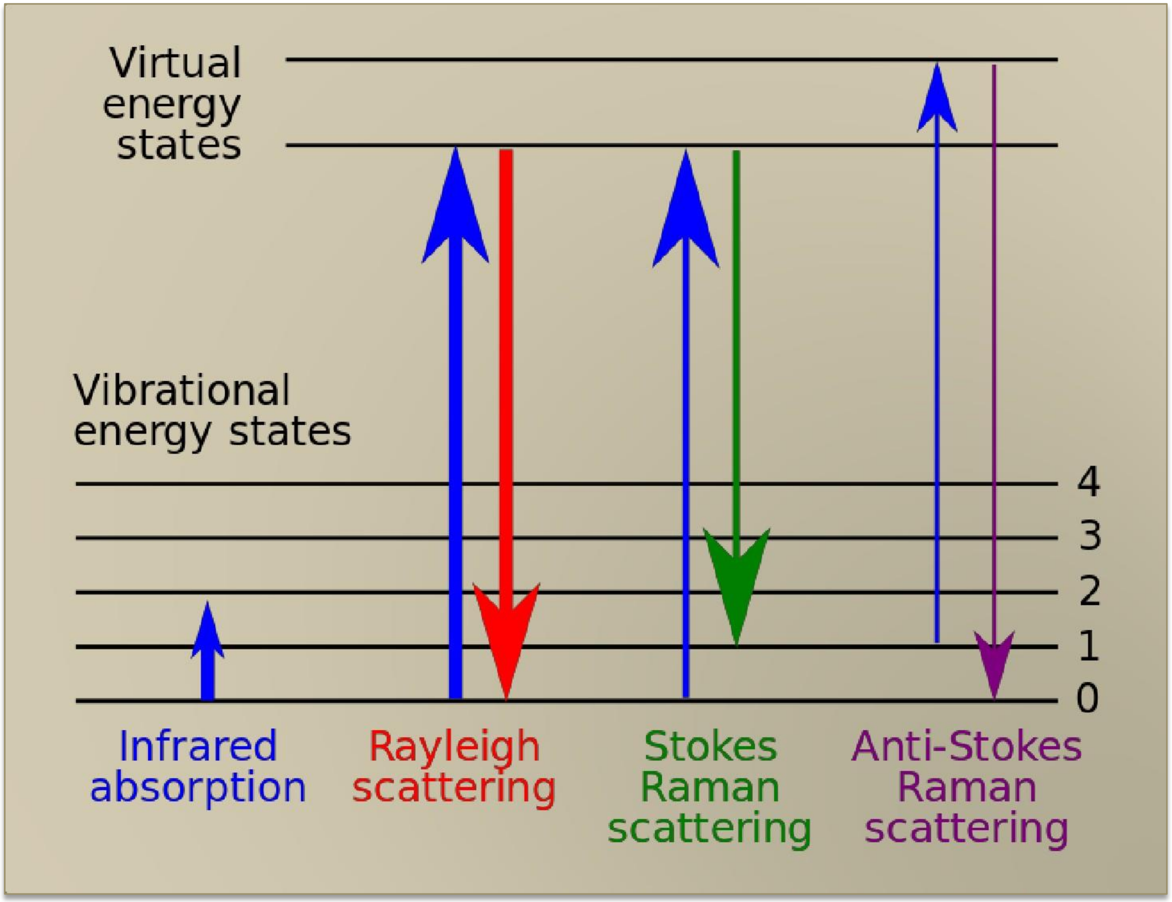
Raman Spectroscopy relies on inelastic scattering of monochromatic light, usually from a laser in the visible, near infrared, or near ultraviolet range. The laser light interacts with molecular vibrations, resulting in the energy of the laser photons being shifted up or down. The shift in energy gives information about the vibrational modes in the system. Infrared spectroscopy yields similar, but complementary, information.

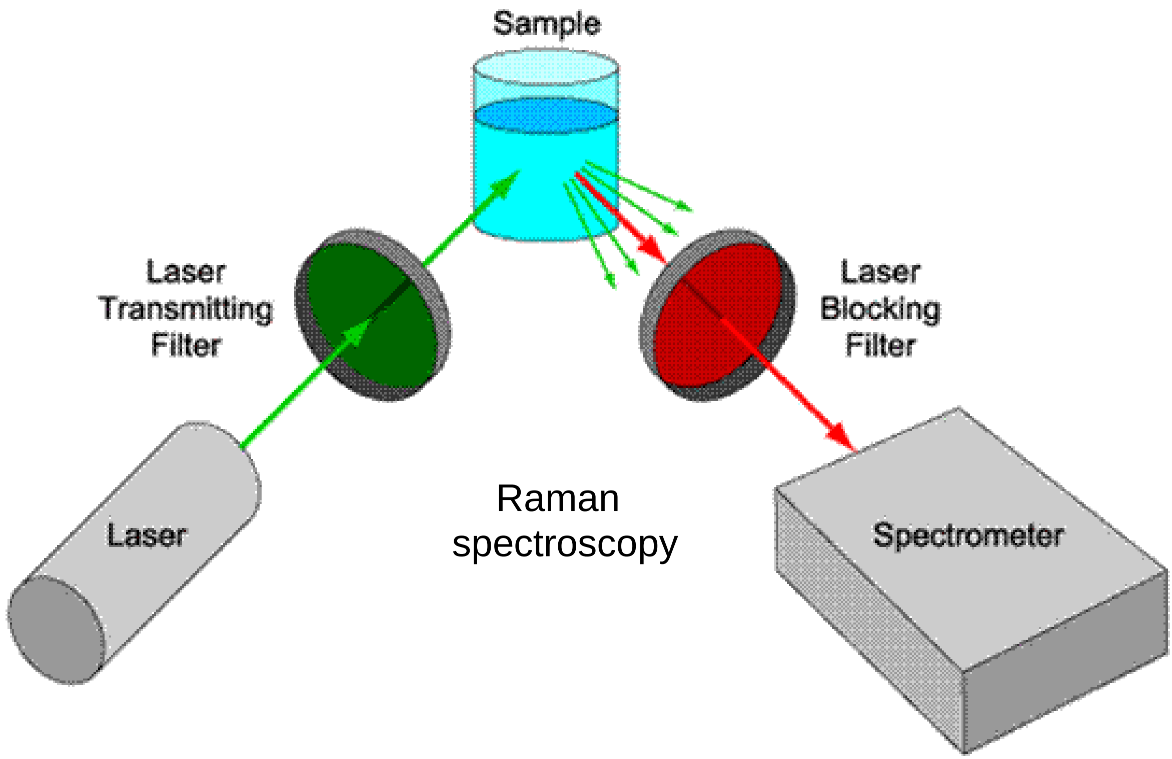
## Raman Spectroscopy … cont’d

Typically, a sample is illuminated with a laser beam. Electromagnetic radiation from the illuminated spot is collected with a lens . Elastic scattered radiation at the wavelength corresponding to the laser line is filtered out, while the rest of the collected light is dispersed onto a detector by a monochromator .

Since vibrational information is specific to the chemical bonds and symmetry of molecules. Therefore, it provides a fingerprint by which the molecule can be identified.

Raman scattering is typically very weak, and as a result the main difficulty of Raman spectroscopy is separating the weak inelastically scattered light from the intense Rayleigh scattered laser light.


Virtual
energy
states
Vibrational
energy states
4
3
2
1
0
Infrared
absorption
Rayleigh
scattering
Stokes
Raman
scattering
Anti-Stokes
Raman
scattering


Sample
Laser Transmitting Filter
Laser Blocking Filter
Laser
Raman spectroscopy
Spectrometer

## Applications of Raman Spectroscopy

Raman spectroscopy has become a practical method of chemical analysis & characterization applicable to many different chemical species.

It's spectra are important in such fields as polymers and semiconductors. The resulting vibration/rotation spectra are widely used to study combustion and gas phase reactions generally .It provides very good selectivity and can be used for the quantitative analysis of aqueous solutions where ir spect. can't be used .No sample preparation is needed and it is non – destructive technique .

# Nephelometry and Turbidimetry

When electromagnetic radiation strikes an insoluble particle in solution some of the radiation will be transmitted and some will be scattered as we mentioned earlier .The intensity of the transmitted radiation is proportional to the concentration of the insoluble particles and this is the base of turbidimetry. While The intensity of the sacattered radiation is also proportional to the concentration of the insoluble particles and this is the base of turbidimetry .

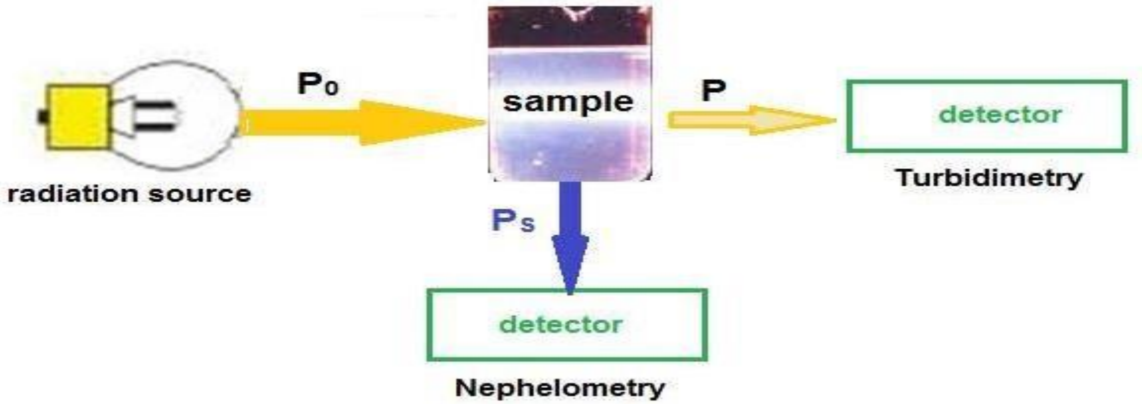
Radiation scattering depends on :
Particle size - wavelength – distance of observation – concentration and molecular weight of particles .

Turbidimetric measurements are made at $180^{o}$ while that of nephelometry at $90^{o}$ from the incident radiation .

Turbidimetry is similar to uv/vis spectrophotometry in that both measure transmitted radiation at $180^{o}$ but the first measure the scattering from colloidal solution while the second measure the absorption from true solution .

Also nephelometry is similar to fluorimetry in that both measure emergent radiation at $90^{o}$ but the first measures sacattered radiation (having the same wavelength as the incident radiation) from colloidal solution while the second measures emitted radiation ( with wavelength usually longer than incident radiation ) from true solution. Turbidimetry can be measured on most routine analysis by a spectrophotometer while the intensity of the scattered radiation in nephelometry is measured by nephelometer.

The longer the wavelength of incident radiation the more intense the transmitted radiation while the shorter the wavelength of incident radiation the more intense the reflected radiation via scattering.




The basic instrument contains : radiation source ( tungsten lamp ) , filters , sample cell and detector ( phototube ) .

Nephelometry is more sensitive and more accurate than turbidimetry .

## Qualitative analysis :

## Turbidimetry :

$S = \log P/P_0 = kbc$

Transmittance = $P/P_0$

S = Turbidance due to scattering

K = turbidity constant

b = path length

C = concentration of suspended particles

Calibration curve method ( S vs. C ) is usually applied .

## Nephelometry :

$I_S = KP_0 C$

IS = Scattered intensity

K = empirical constant

P0 = incident intensity

C = concentration of suspended material

Calibration curve method ( IS vs. C ) is usually applied.

| | Nephlometer | Turbidimeter |
|---|---|---|
| Definition<br><br>Instrument used | the measurement of the intensity of scattered light at right angles to the direction of the incident light as a function of the concentration of the dispersed phase ,It is most sensitive for very dilute suspensions (100 mg/L).<br>Nephlometery machine | Light passing through a medium with dispersed particles, so the intensity of light transmitted is measured.<br><br>spectrophotometer |
| Type of light measured | Scattered light | Transmitted light |
| Arrangement of photometer | measure the light scattered at right angle to the direction of the propagation of light from the source. It could be movable detectors which allow operator to vary the angle of detection | made in the same direction as the propagation of the light from the source. |
| Applications | Clinical uses<br>inorganic cations and anions<br>clarity of water and food products | Clinical uses<br>Inorganic cations and anions<br>clarity of water<br>and food products |