MSE 310 Lecture 17

Raman Spectroscopy

6/4/2021

Introduction

In the year 1928, C.V.Raman discovered the inelastic scattering of photons from the molecules such that they are excited to higher levels known as Raman scattering or Raman effect. He was awarded the Nobel Prize for Physics in the year 1930.

Elastic Collision or Scattering

An elastic collision is one where there is no net loss in kinetic energy in the system as the result of the collision.

Inelastic Collision or Scattering

An **inelastic collision or scattering** is a type of collision where this is a loss of kinetic energy. The lost kinetic energy is transformed into thermal energy, sound energy, and material deformation.

Introduction

- It is a spectroscopic technique used to observe vibration , rotational, and other low-frequency modes in a system.
- Raman spectroscopy is commonly used in chemistry to provide a fingerprint by which molecules can be identified.
- When the radiation pass through the transparent medium the species present scatter a fraction of the beam in all direction
- Raman scattering result from the same type of the quantities vibration changed associated with IR spectra
- The difference in wavelength in between the incident and scattered visible radiation correspond to wave length in mid IR region

Rayleigh and Raman scattering

Rayleigh scattering is elastic scattering. The photon's energy and the state of the molecule after the scattering events are unchanged.

In Raman scattering the frequency of photons present in the monochromatic light changes when interacted with the vibrational states, or modes, of a molecule.

Raman Scattering

Raman scattering is defined as the scattering of photons by the excited molecules that are at higher energy levels. It is also known as the Raman effect. The photons are inelastically scattered, which means that the kinetic energy of an incident particle is either lost or increased and is composed of Stokes and anti-Stokes portions.

Inelastic scattering of photons is similar to the concept of an inelastic collision, which states that the total microscopic kinetic energy is not conserved.

What Is Raman Spectroscopy?

Raman spectroscopy was discovered by C.V.Raman in the year 1928 to study the vibrational, rotational, and low-frequency modes of the molecules. It finds application mainly in chemistry to get the information related to fingerprints.

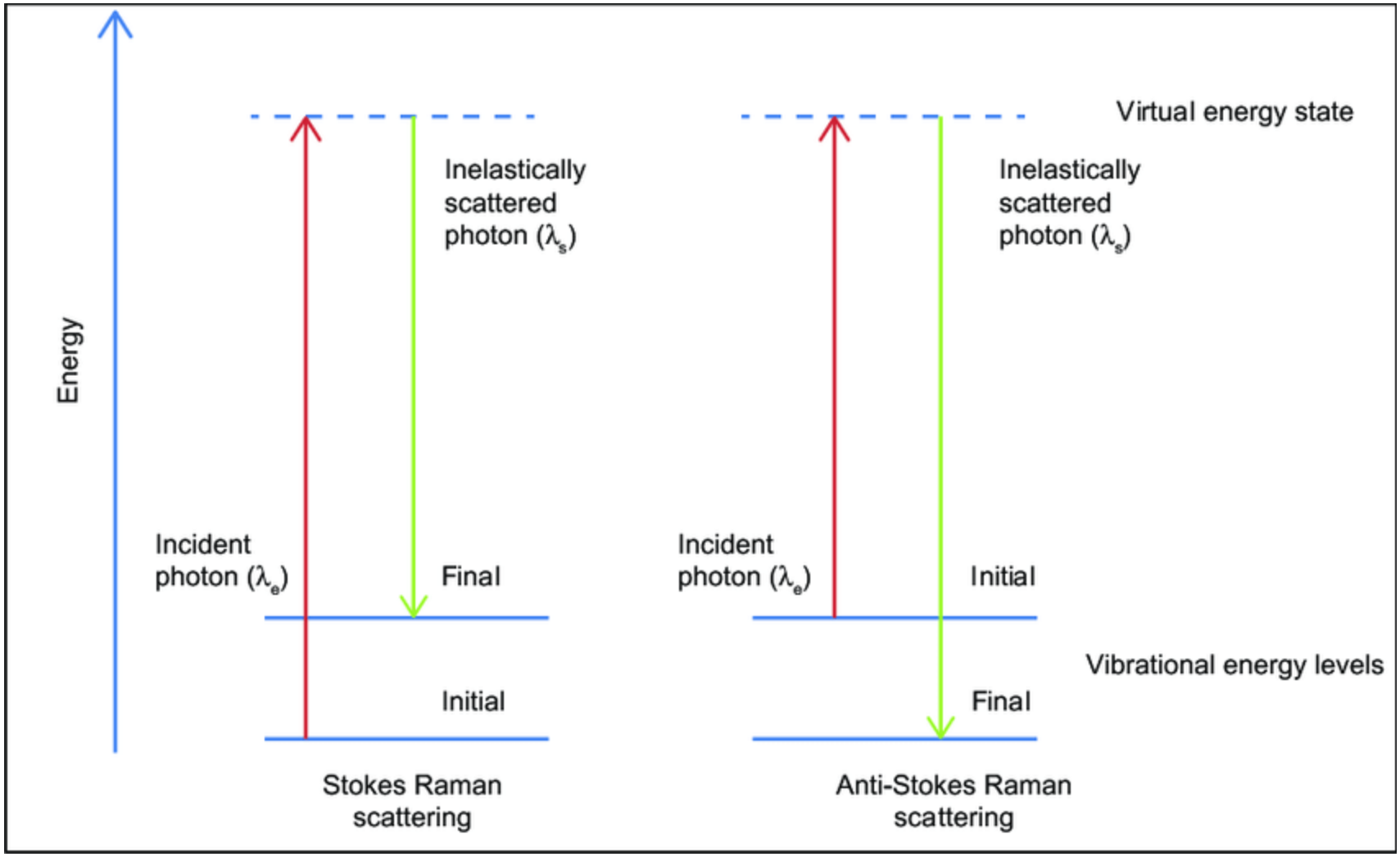
Principle Of Raman Spectroscopy

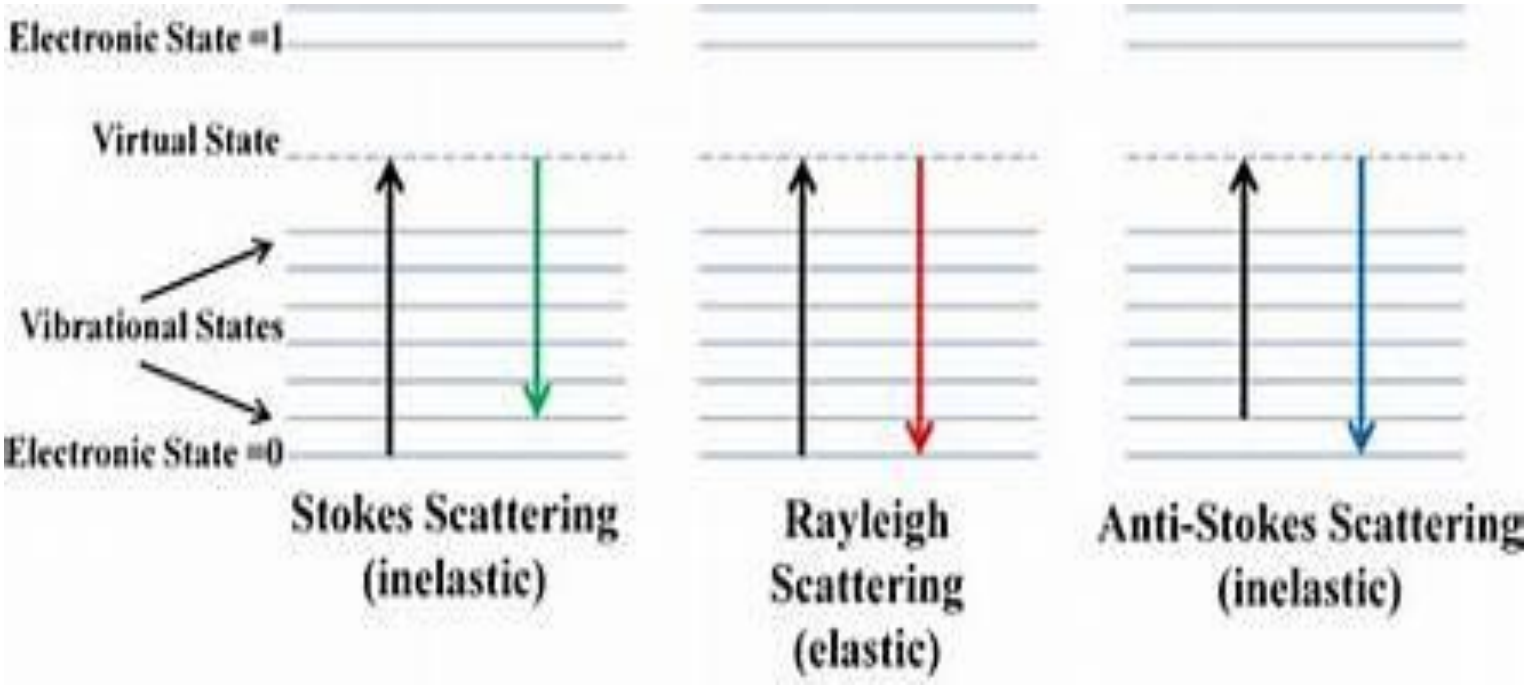
The principle behind Raman spectroscopy is that the monochromatic radiation is passed through the sample such that the radiation may get reflected, absorbed, or scattered. The scattered photons have a frequency which is different from the incident photon as the vibration and rotational property varies.

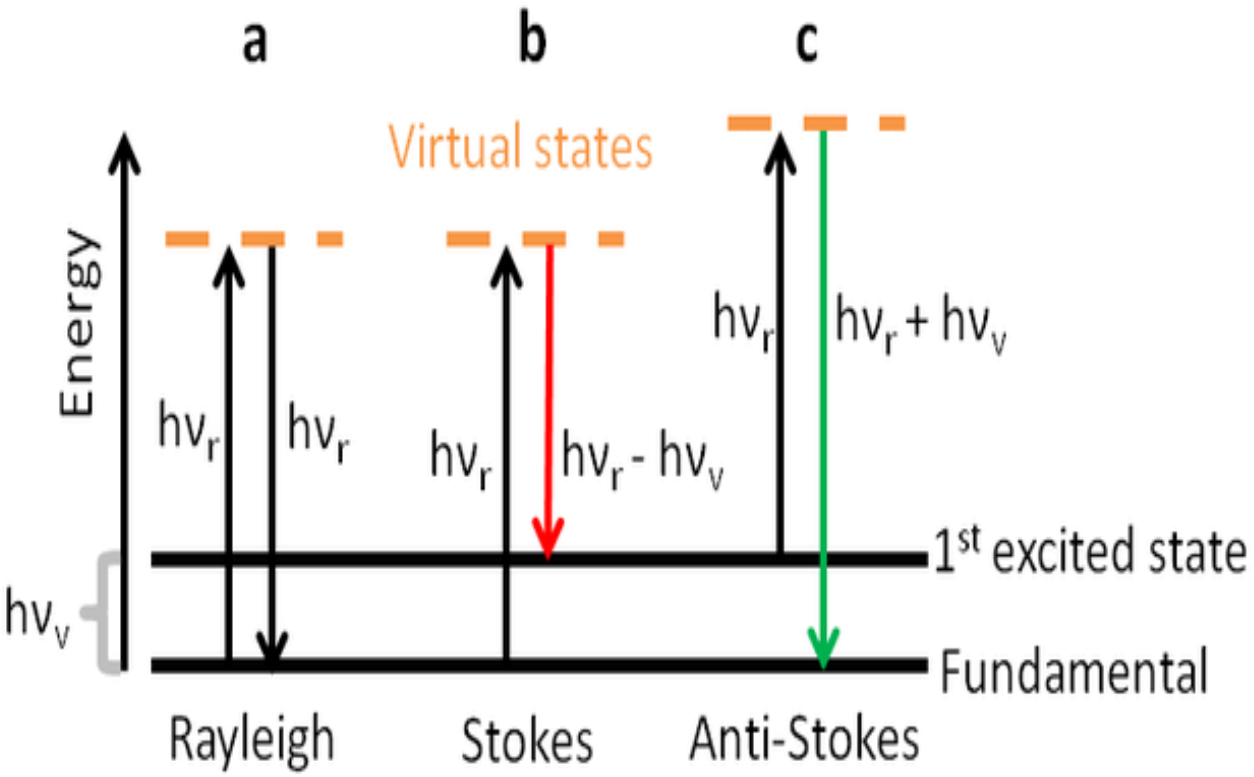
The difference between the incident photon and the scattered photon is known as the **Raman shift**. When the energy associated with the scattered photons is less than the energy of an incident photon, the scattering is known as **Stokes scattering.** When the energy of the scattered photons is more than the incident photon, the scattering is known as **anti-Stokes scattering.**

PRINCIPLE

- When monochromatic radiation is incident upon a sample then this light will interact with the sample in some fashion. It may be reflected, absorbed or scattered in some manner. It is the scattering of the radiation that occurs which gives information about molecular structure
- Raman is based on scattering. The sample is irradiated with a coherent source, typically a laser. Most of the radiation is elastically scattered (called the Rayleigh scatter).
- A small portion is inelastically scattered (Raman scatter, composed of Stokes and anti-Stokes portions). This latter portion is what we are particularly interested in because it contains the information in which we are interested.

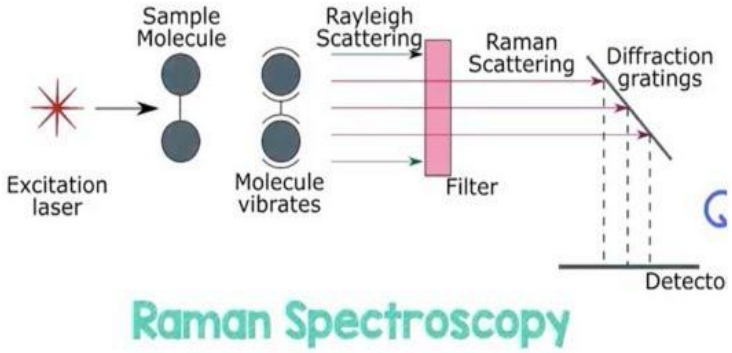

Energy
Virtual energy state
Inelastically scattered photon (λ_s)
Incident photon (λ_e)
Final
Initial
Stokes Raman scattering
Inelastically scattered photon (λ_s)
Incident photon (λ_e)
Initial
Final
Vibrational energy levels
Anti-Stokes Raman scattering

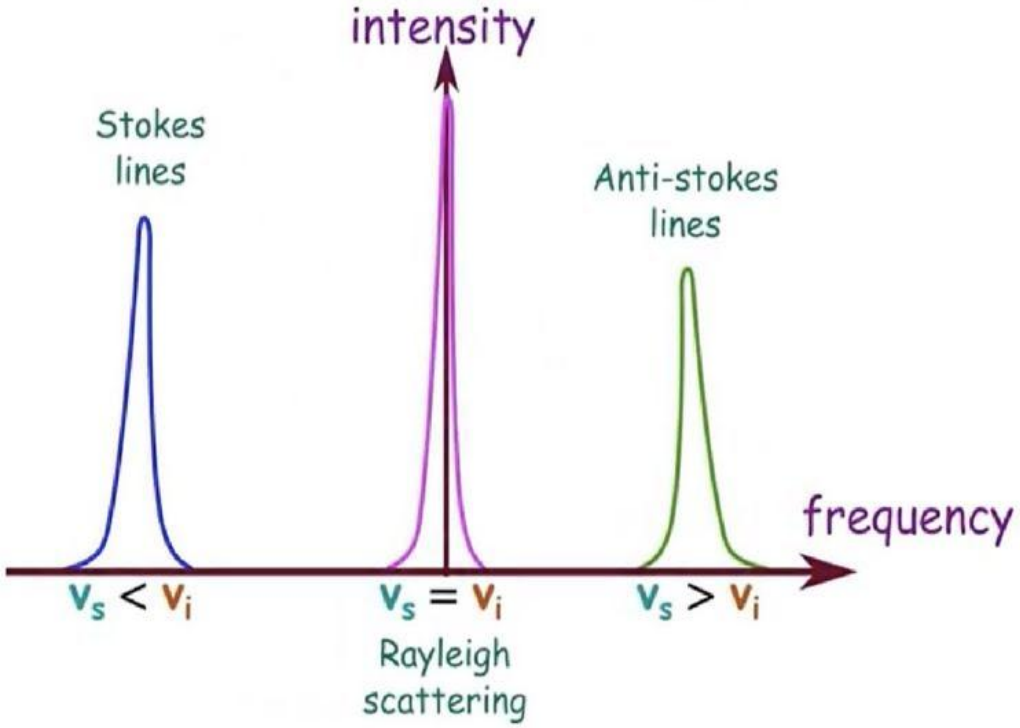

Electronic State =1
Virtual State
Vibrational States
Electronic State =0
Stokes Scattering
(inelastic)
Rayleigh
Scattering
(elastic)
Anti-Stokes Scattering
(inelastic)


a
b
c
Virtual states
Energy
hν_r
hν_r
hν_r
hν_r - hν_v
hν_r
hν_r + hν_v
hν_v
1st excited state
Fundamental
Rayleigh
Stokes
Anti-Stokes

Raman Spectroscopy

Basics and Principles





What Is Raman Spectrometer?

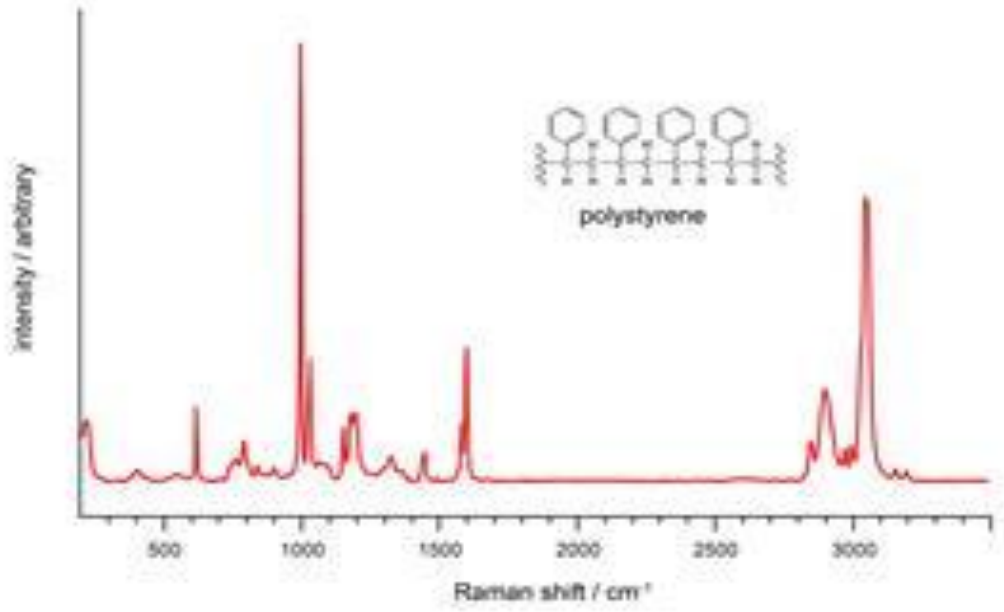
Raman spectrometer is an instrument that consists of one or more single-colored light sources and lenses and filters to focus the light and to differentiate the reflected and scattered light respectively.

A prism is used for splitting the light into their components which has a detector to detect the weak light. Later the spectrum is obtained on the monitor to analyze the information.

What Is Raman Spectra?

To analyse the Raman effect, the wavelength of the scattered photon is converted to wavenumber. These wavenumbers are plotted on the x-y plane.

The wavenumbers are taken along the x-axis and the Raman intensity is taken on the y-axis. The difference between the wavenumbers and the intensity is known as the Raman spectrum.



Raman Spectrum of Polystrene

We graphically depict the results of our measurements as Raman spectra. We plot the intensity of the scattered light (y-axis) for each energy (frequency) of light (x-axis). The frequency is traditionally measured in a unit called the wavenumber (number of waves per cm, cm^{-1}).

We plot the x-axis frequencies or wave number relative to that of the laser as it is the shift in energy of the light that is of particular interest