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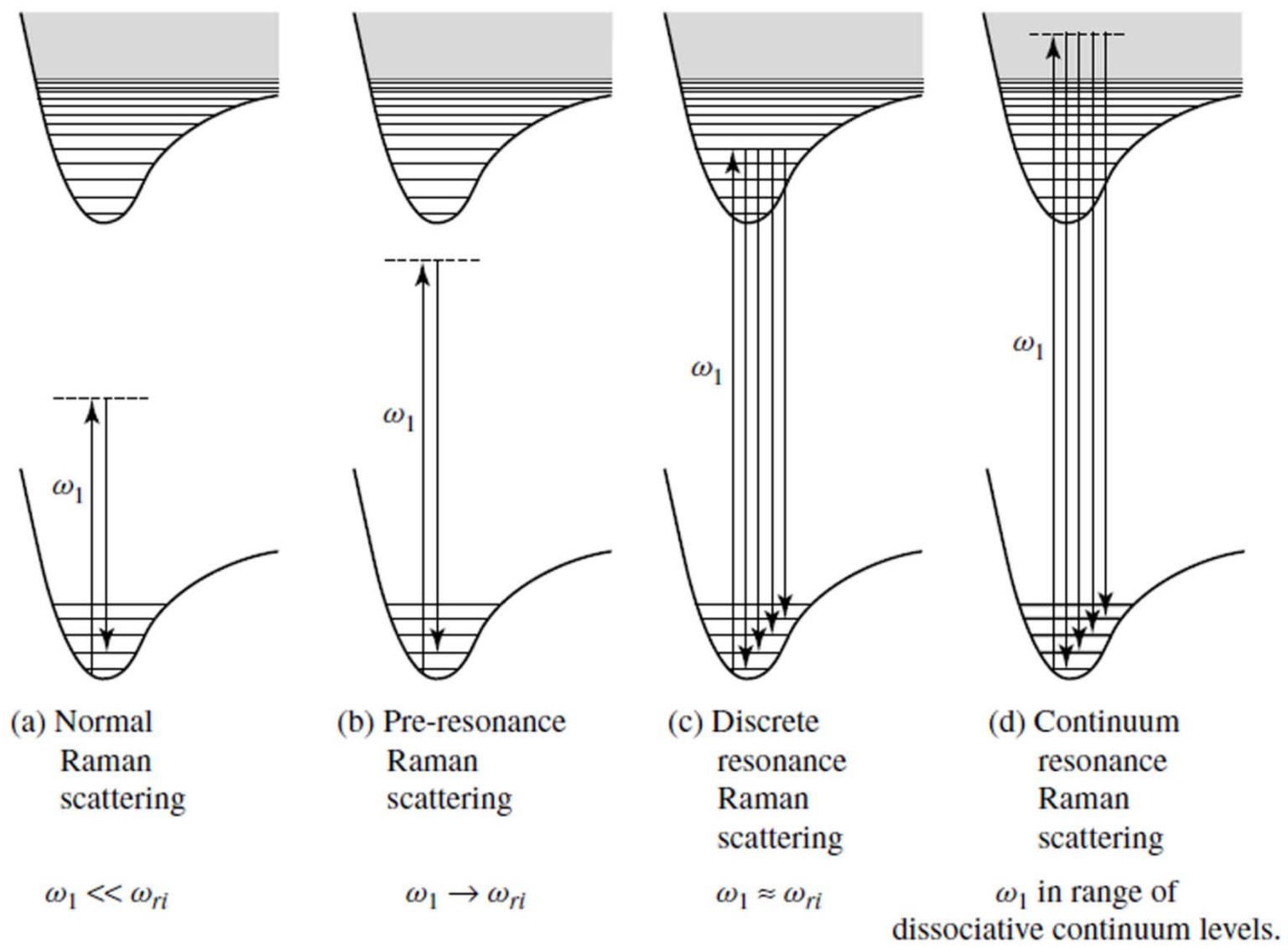
Date: 03/11/2025
Time: 10: 00 am

III/MPHYCC10 Atomic and Molecular Physics

Variants of Raman spectroscopy

- Spontaneous Raman Spectroscopy
- Fourier Transform Raman Spectroscopy
- Resonance Raman Spectroscopy
- Surface-enhanced Raman Spectroscopy(SERS)
- Stimulated Raman Spectroscopy
- coherent anti-Stokes Raman Scattering (CARS)
- Surface Enhanced CARS
- Hyper-Raman scattering
- Raman-induced Kerr spectroscopy

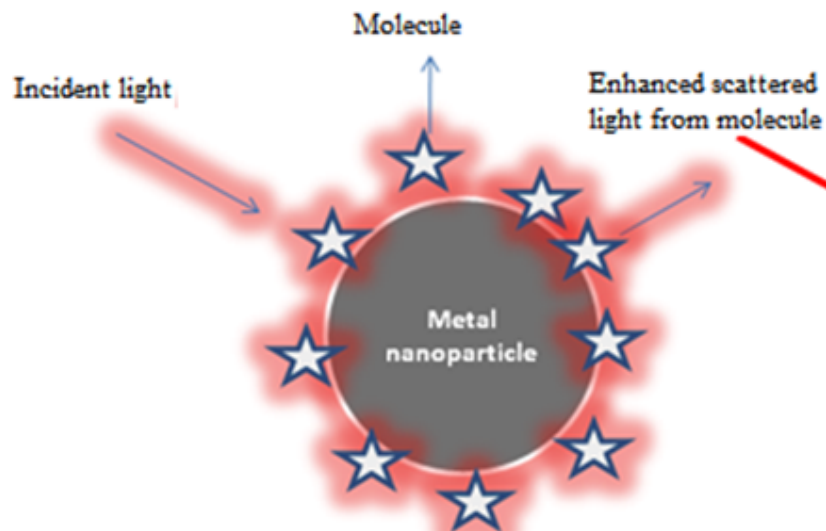
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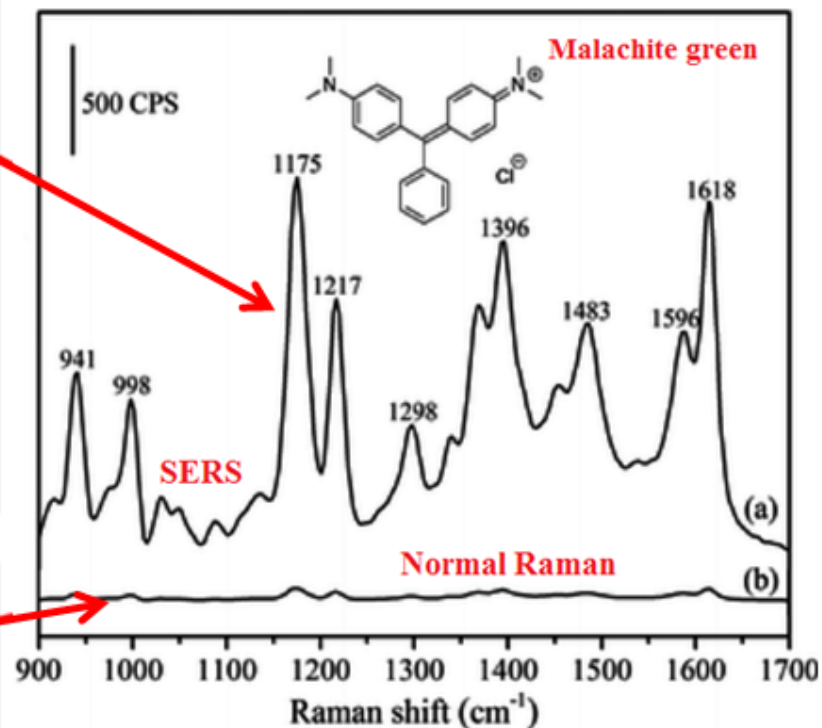
Four types of Raman scattering processes.

Surface Enhanced Raman Scattering (SERS)

Surface enhanced Raman scattering (SERS)



Raman scattering (RS)



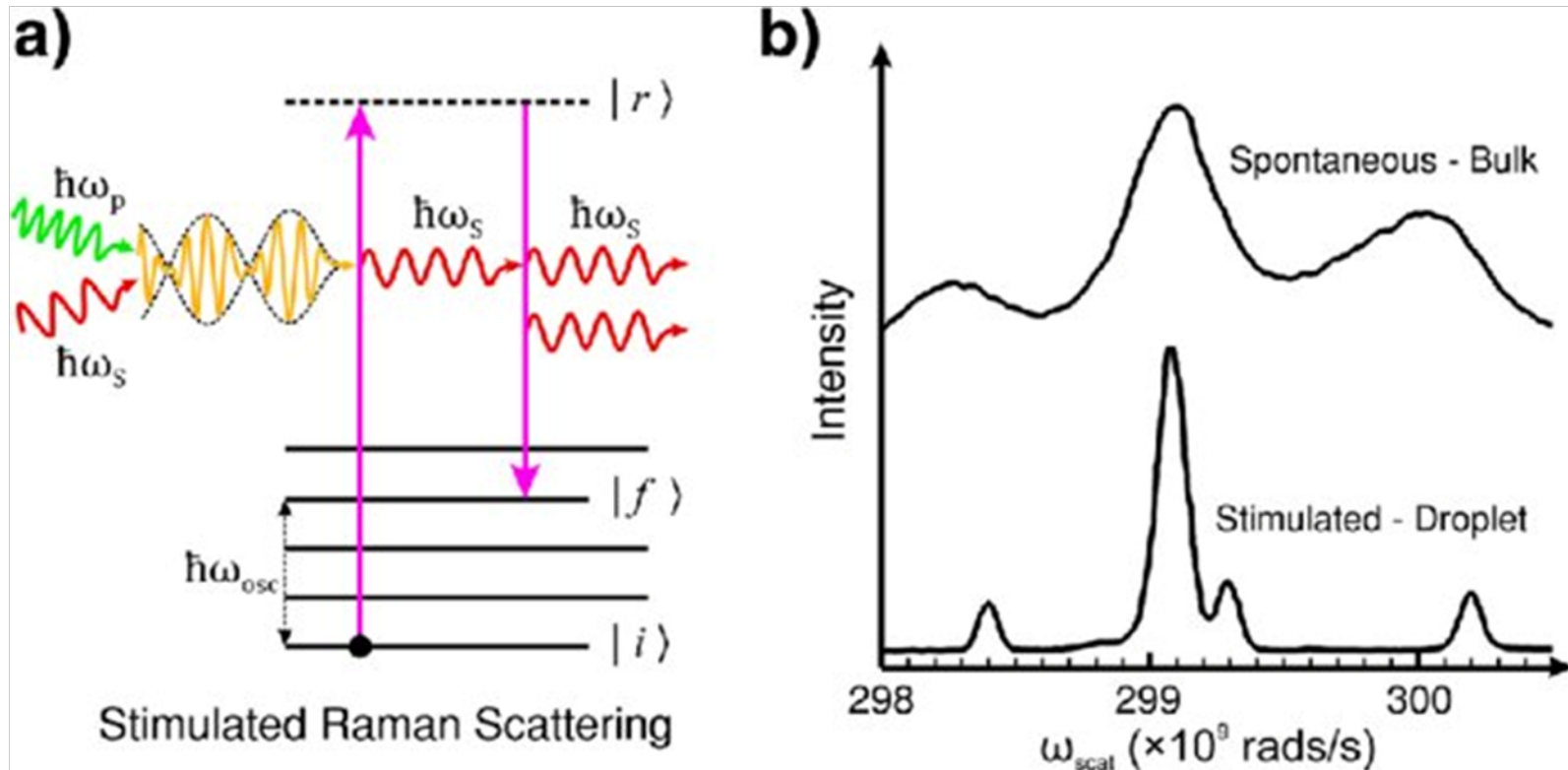
Applications of SERS

- **Determination of structure and orientation of a molecules on the metal surface.**
- **Applicable to biological, electrochemical and catalytic interfaces.**
- **Detection of biomolecules at a very low concentration**
- **Detection of environmental pollutants, radioactive materials.**
- **Used for sensing impurities in synthesized materials**

Advancements in SERS technique

- **SM-SERS**
- **Surface enhanced hyper Raman spectroscopy (SEHRS)**
- **Surface Enhanced resonance Raman spectroscopy (SERRS)**
- **Tip-enhanced Raman spectroscopy (TERS)**
- **Ultra Violet induced SERS (UV-SERS).**

Stimulated Raman Scattering

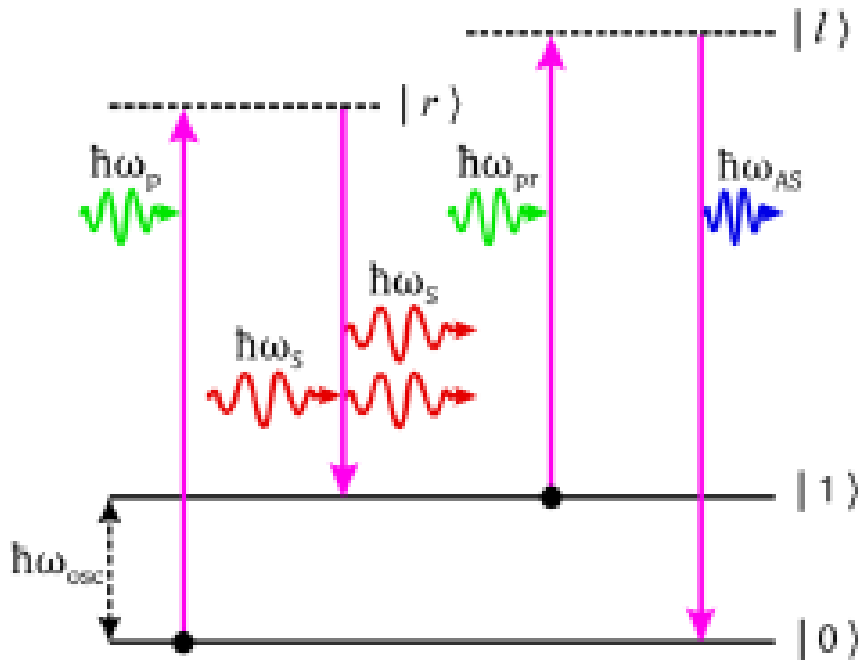


In a molecular medium, a pair of light waves can resonate with the molecular vibrational modes in such a way that energy is transferred from high frequency to low.

Line narrowing, No background interference.

Raman lasers, Optical fiber communication, imaging and diagnostics.

CARS

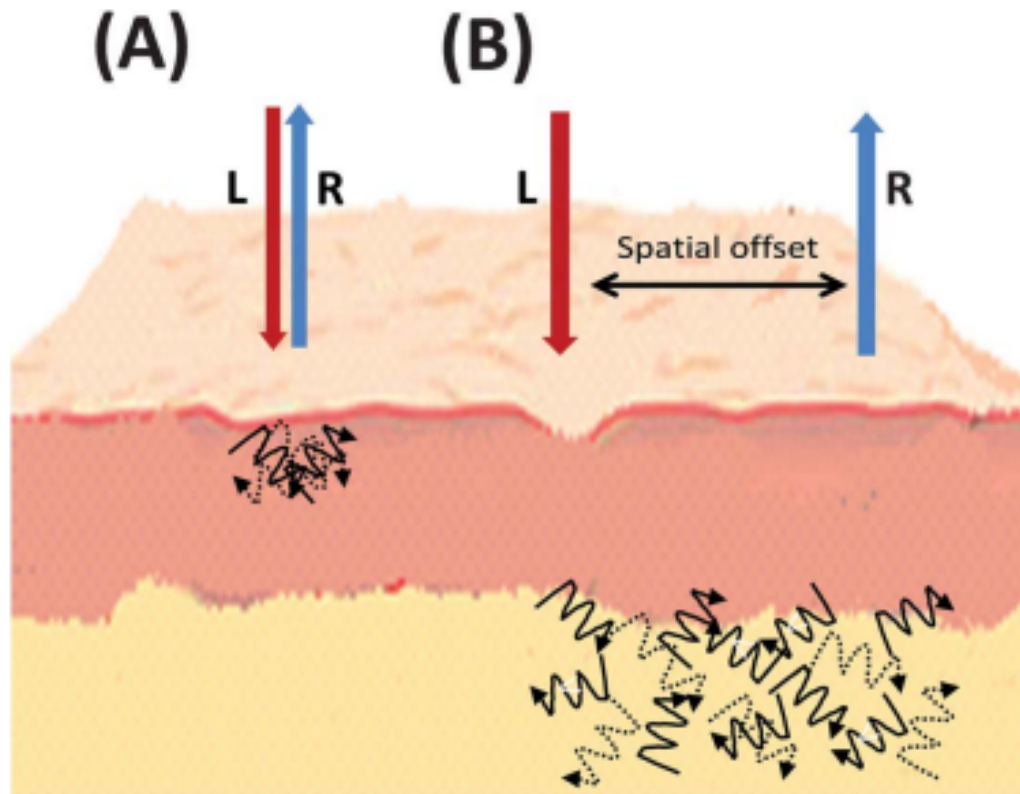


A pump beam (ω_p), a [Stokes](#) beam (ω_s) and a probe beam (ω_{pr}) interact with the sample and generate a coherent optical signal at the [anti-Stokes](#) frequency ($\omega_{pr} + \omega_p - \omega_s$). The anti-Stokes beam is resonantly enhanced when $(\omega_p - \omega_s)$ coincides with a Raman active mode. The molecule resides in a coherent [superposition](#) of states.

CARS microscopy has been applied to live-cell imaging, tracing toxic nanomaterials in biological tissues, detection of brain tumours and tracking organelle transport in living cells. CARS endoscope for in vivo imaging has been demonstrated.

CARS is used for species selective microscopy and combustion diagnostics, imaging of lipids in biological samples, to identify individual [virus](#) particles (FAST-CARS), for temperature measurements

Spatially offset Raman Scattering



Simplified graphical representation of (A) spontaneous Raman compared to (B) spatially offset Raman scattering, illustrating the spatial offset and deeper subsurface probing in skin tissue. L = laser light, R = Raman light.

Biological and Medical Applications of Spontaneous Raman Spectroscopy

- **To study hydrogen bonds**
- **Raman spectroscopy is a label-free probe**
- **Used to characterize 2D materials, transition metal dichalcogenides, phonon modes in crystals**
- **Used in chemically selective spectral imaging and drug delivery**
- **Monitoring of Metabolic activity of body**
- **To know detailed information about the molecular composition and concentration various species**
- **Monitoring biocatalytic reaction.**
- **Can be used to identify and differentiate benign and malignant breast cancer lesions by probing their unique chemical compositions**