University of Hamburg, Department of Physics

Nonlinear Optics

Kärtner/Mücke, WiSe 2019/2020

Problem Set 7

Issued: 06.12.2019 Due : 13.12.2019

Stimulated Raman effect

Stimulated Raman scattering (SRS) is an effective method to detect the oscillation of molecules and Raman spectroscopy is commonly used to provide a 'fingerprint' to identify the molecules. [1] In a solid, the interaction between light and lattice vibrations (phonons) takes place via absorption or emission of a photon, leading to an Anti-Stokes or Stokes shift of the photon as shown in figure (1).

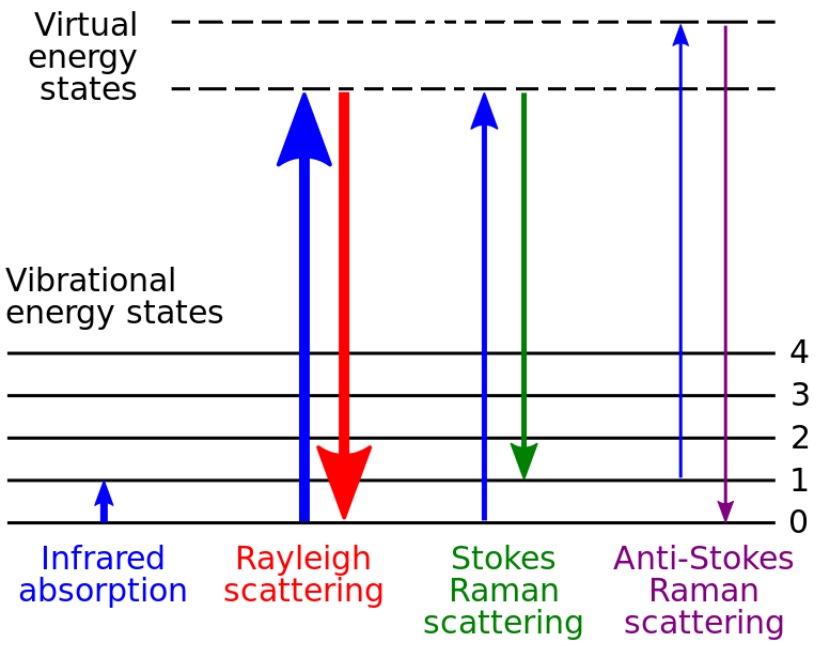

Figure 1: Graphic explanation of SRS. [1]

The frequency of the stokes line $\omega_s = \omega - \Omega$, and the anti-stokes line $\omega_{as} = \omega + \Omega$, where Ω is the oscillation frequency of the phonons.

1. Assuming pump ω_p and signal ω_s (ω_v is the frequency of the stokes line) pass through a Raman active medium as shown in figure (2). If we only consider the third

order nonlinear effect ($\chi^{(3)}$), write down the coupled wave equation of the pump ω_p and the signal ω_s.

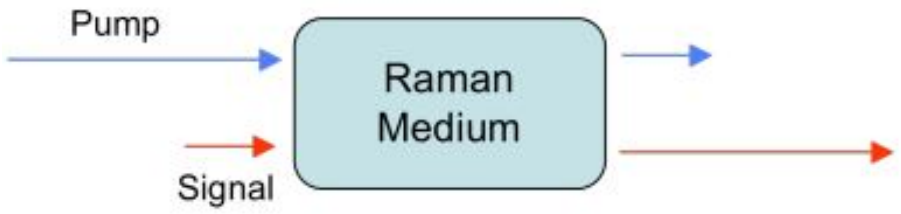

Figure 2: Graphic explanation of SRS. [2]

2. Show that the stimulated Raman effect doesn't need to be phase matched.

3. By assuming that the pump is undepleted (field of the pump is constant), solve the wave equation of the signal with l_0 the effective length of the nonlinear crystal and E_0 the initial condition for E_s.

References

[1] Wikipedia, "Raman spectroscopy — wikipedia, the free encyclopedia." https://en.wikipedia.org/w/index.php?title=Raman_spectroscopy&oldid=747734915, 2016. [Online; accessed 18-November-2016].

[2] C. T. A. Brown, "Lecture 6: χ^3 -based raman phenomena." http://www.st-andrews.ac.uk/~ctab/PH4027/NLO-Lecture6-Notes.pdf. [Online; accessed 18-November-2016, University of St Andrews].