University of Hamburg, Department of Physics

Nonlinear Optics

Kärtner/Mücke, WiSe 2017/2018

Problem Set 6

Issued: 30.11.17 Due : 7.12.17

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).

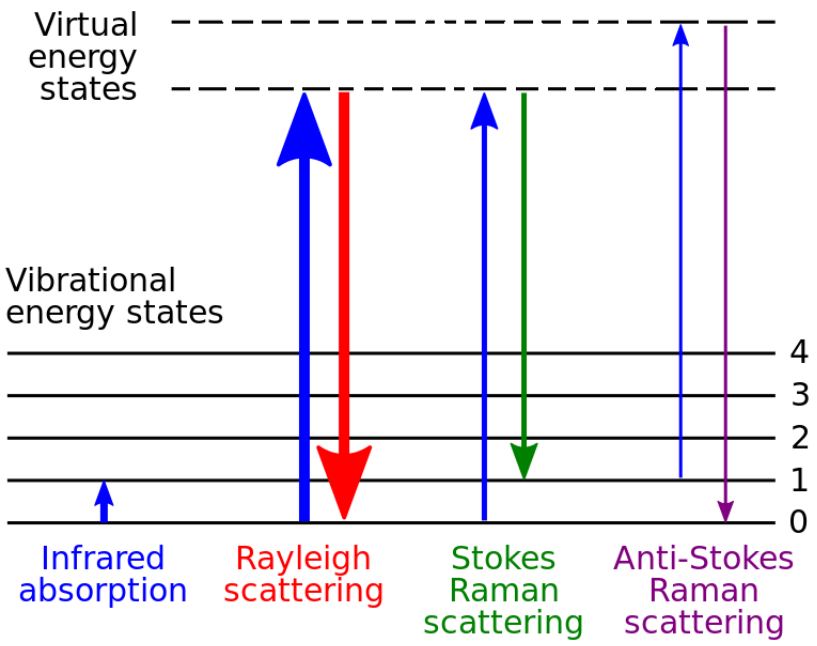

Figure 1: Graphic explanation of SRS. [1]

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 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 and the signal ω_s.

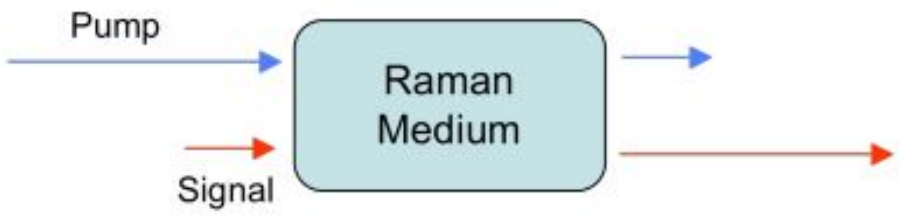

Figure 2: Graphic explanation of SRS. [2]

NOTE: for the signal, there are two effects. One is related to the stimulated Raman effect $\chi_R^{(3)}$, the other is related to 4-wave-mixing $\chi_F^{(3)}$.

2. Show that the stimulated raman effect doesn't need to be phase matched but the 4-wave-mixing needs to be phase matched.

3. By assuming that on the non-phase-matched condition (the 4-wave-mixing effect is small, so that could be neglected) and the pump is undepleted (field of the pump is constant), solve the wave equation of the signal.

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].