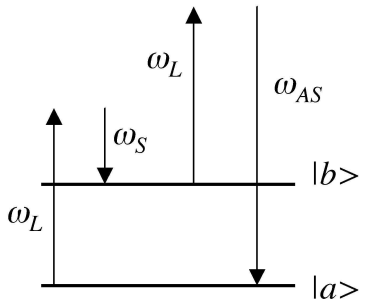
Nonlinear Electromagnetism
TD n°9
Stokes - Anti-Stokes coupling in stimulated Raman scattering

We are investigating the amplification of an infrared beam (frequency ω_S) through stimulated Raman scattering with a pump beam (frequency ω_L) and an Anti-Stokes beam (frequency ω_{AS}). All involved frequencies are assumed much smaller than the electronic transition frequencies of the medium, which are the only one-photon allowed transitions. All considered waves are traveling in the same direction and have the same linear polarisation. The one-photon forbidden transitions $a \rightarrow b$ and $b \rightarrow a$, are resonantly excited with two photons : $\omega_L - \omega_S = \omega_{AS} - \omega_L = \omega_{ba}$.



1. Write the wave equation for the amplitudes A_{AS} et A_S, assuming that the pump is undepleted ($A_L(z) = Cst$).
2. Give the expression of the third order effective susceptibility $\chi^{(3)}_{eff}$ involved in these equations.
3. Write the wave equation of the amplitude A_S as a function of the Raman amplification coefficients of the Anti-Stokes and Stokes waves g_{AS} et g_S and of $\Delta k = 2k_L - k_{AS} - k_S$. Show that $A_S(z)$ is of the form :

$$A_S(z) = ae^{r_1 z} + be^{r_2 z}.$$

4. Calculate the coefficients r_1 and r_2 and the gain that can be obtained on the Stokes wave intensity and investigate the limiting case where $\Delta k \gg g_{AS} - g_S$ and $\Delta k \ll g_{AS} - g_S$