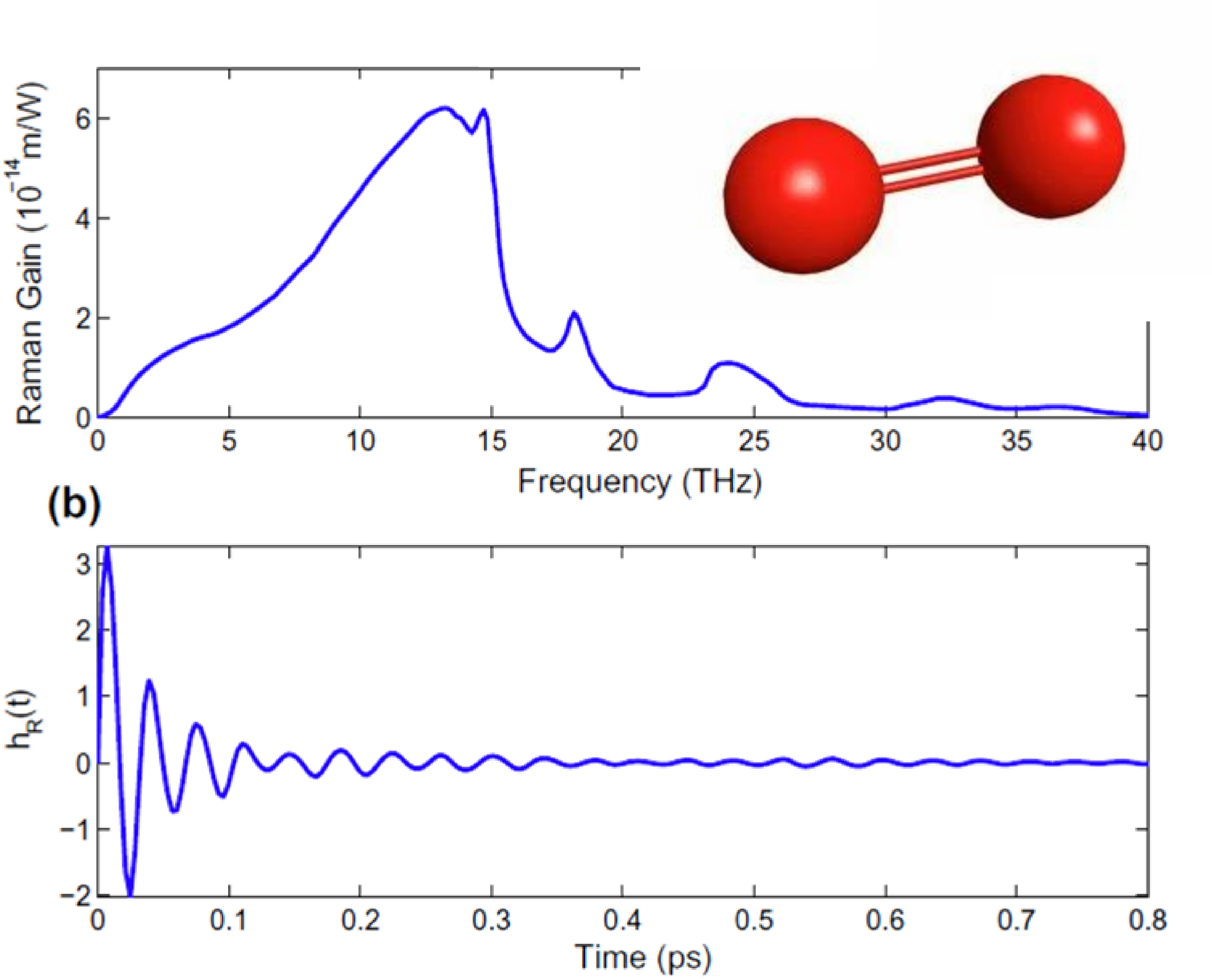
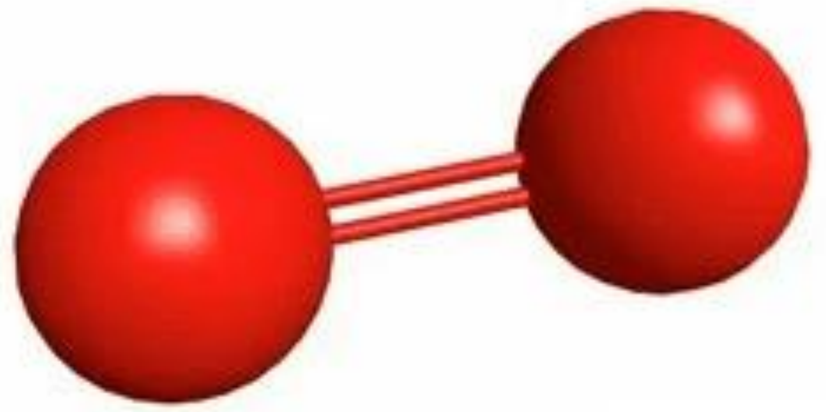
Stimulated Raman Scattering



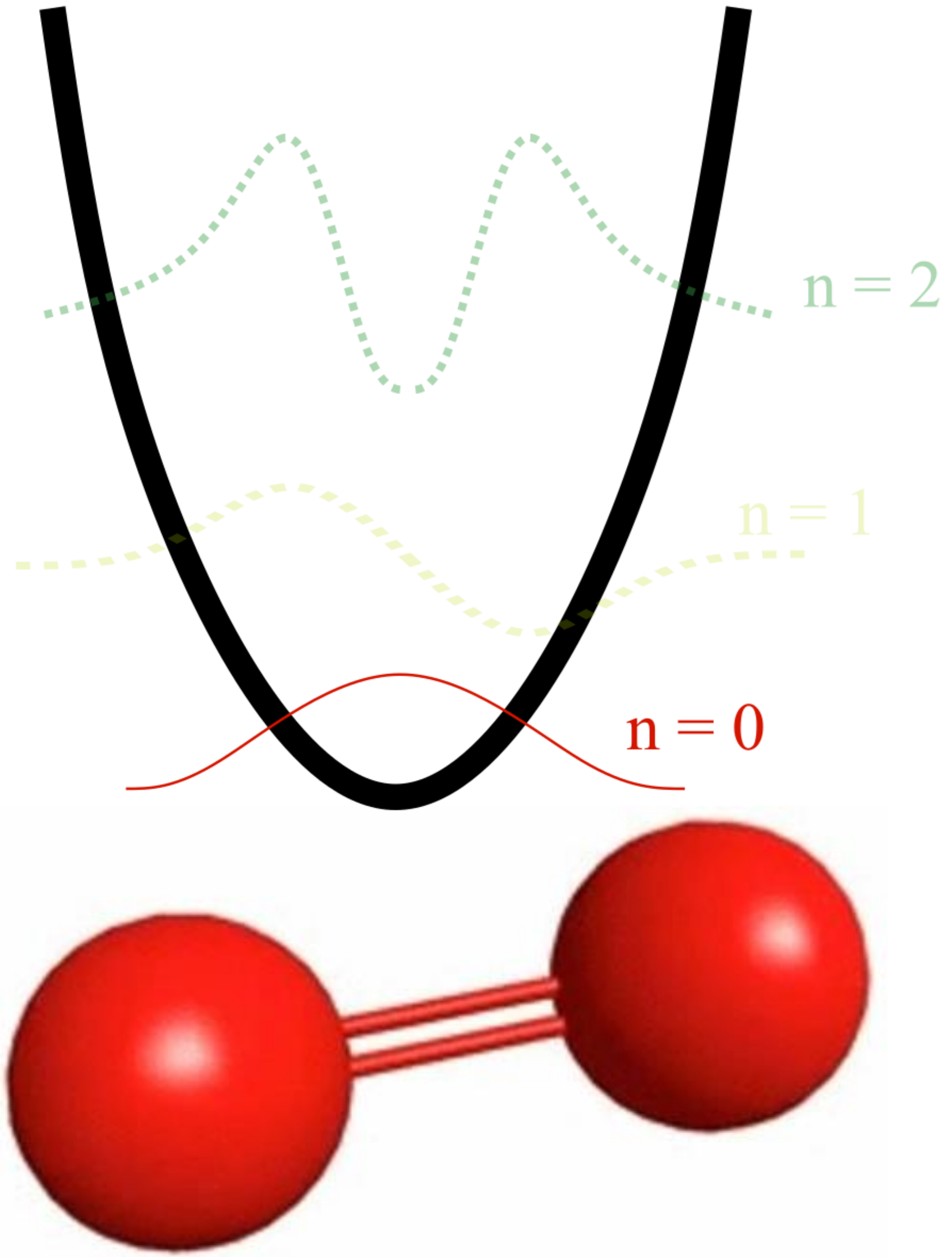
Outline

- Basic physics of Raman scattering
- Applications to silica fibers
- Designing a "Raman amplifier"
- Numerical simulation in python!



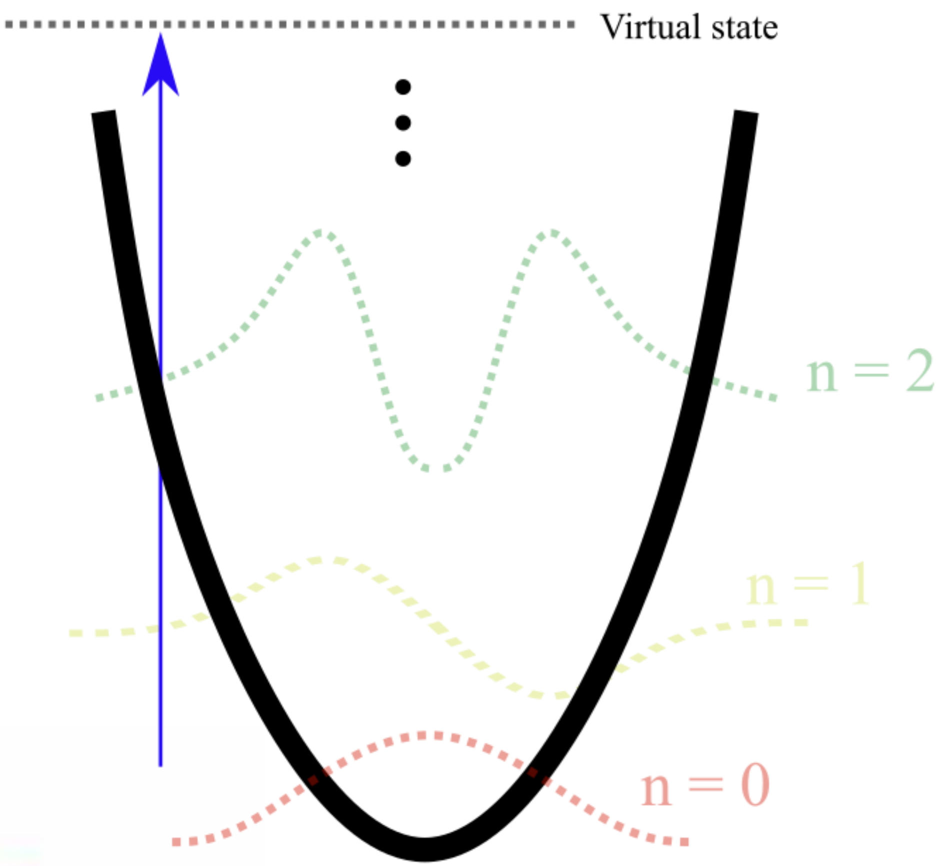
H_2 molecule

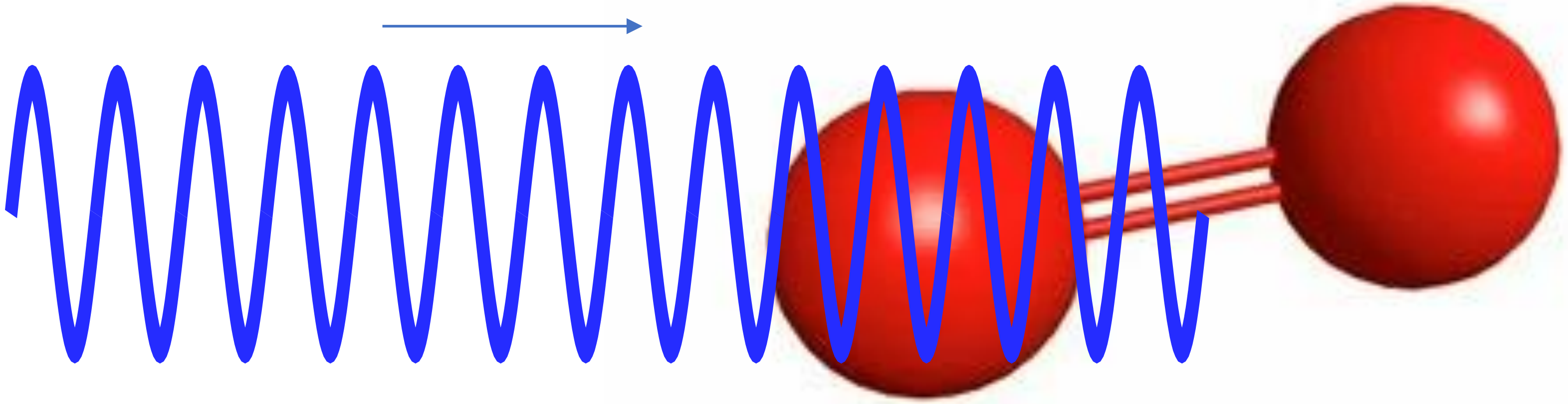
- Initially, a H_2 molecule is in its vibrational ground state



Photon + H_2 molecule

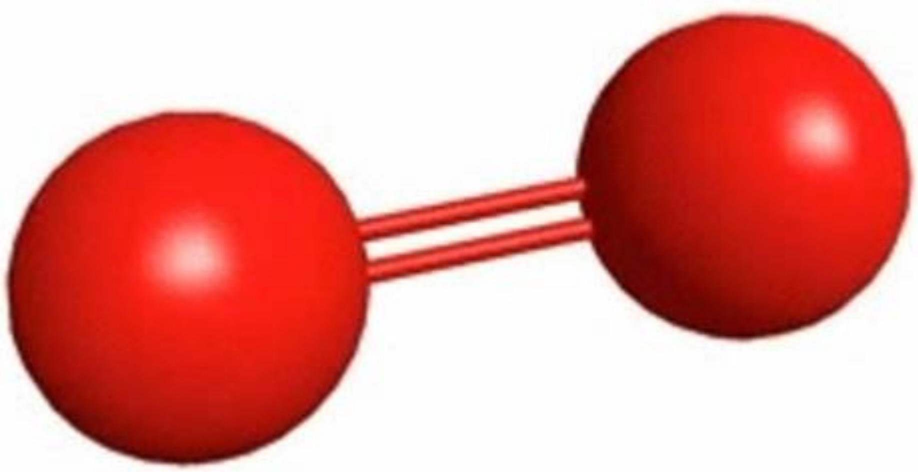
- The oscillating electric field of the light "shakes" the electrons in the bond.
- A virtual state is occupied temporarily.

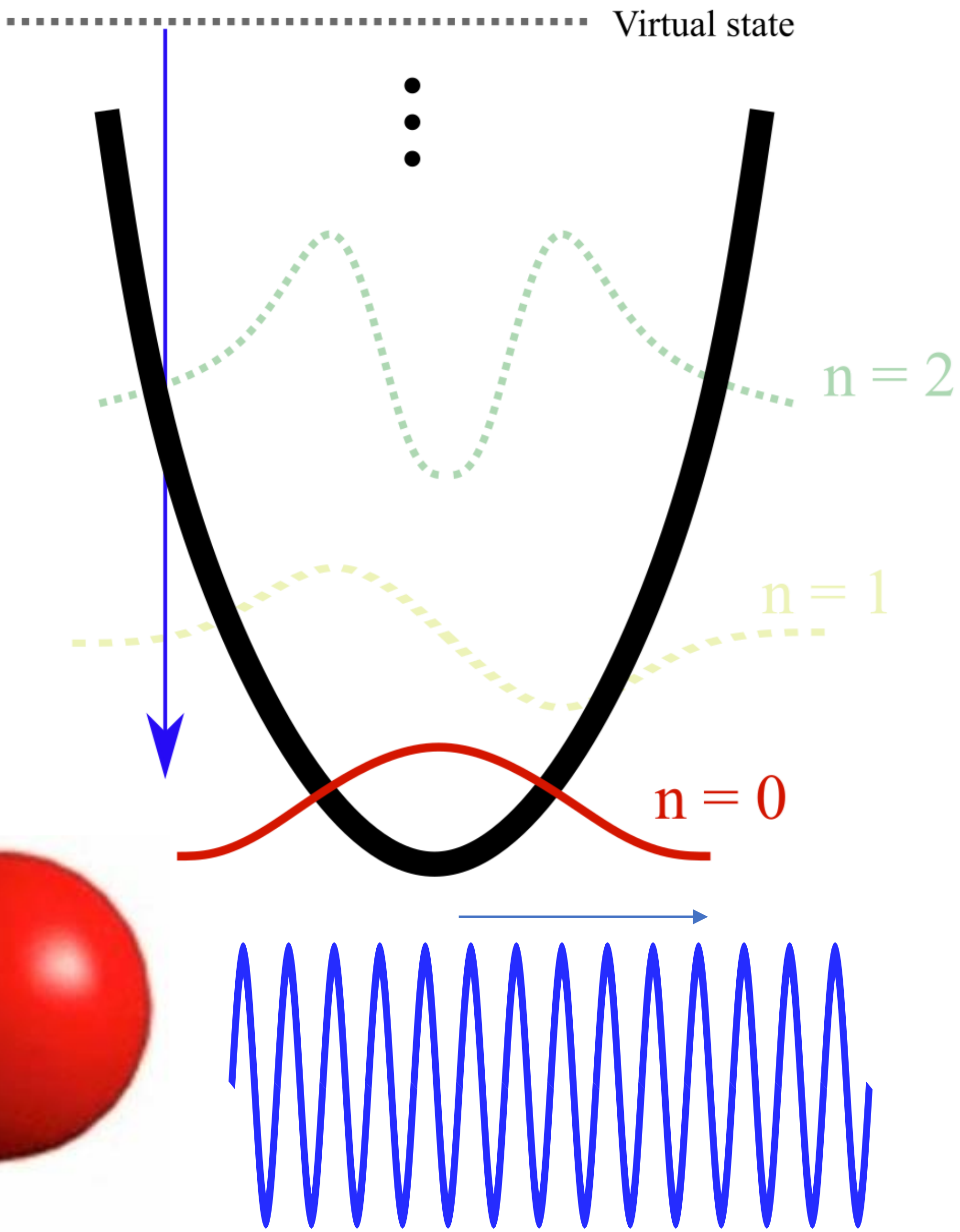




Photon + H_2 molecule

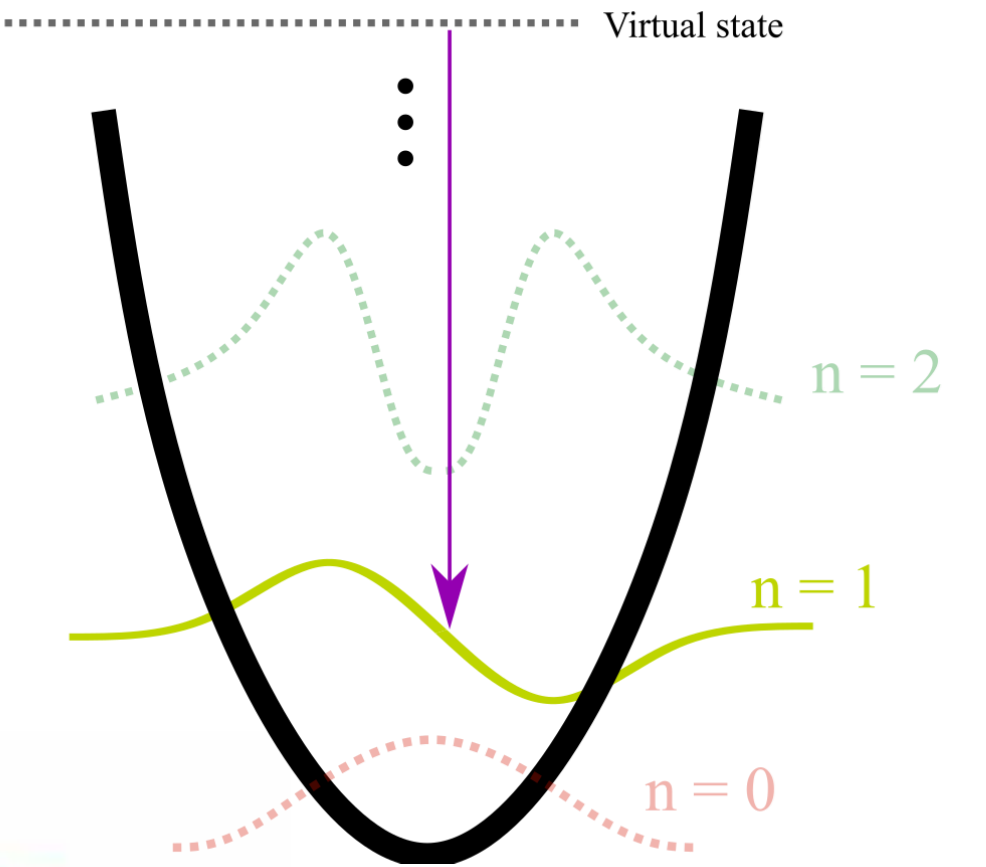
- The virtual state can emit a photon with the same frequency and leave the H_2 in its original ground state (boring!)

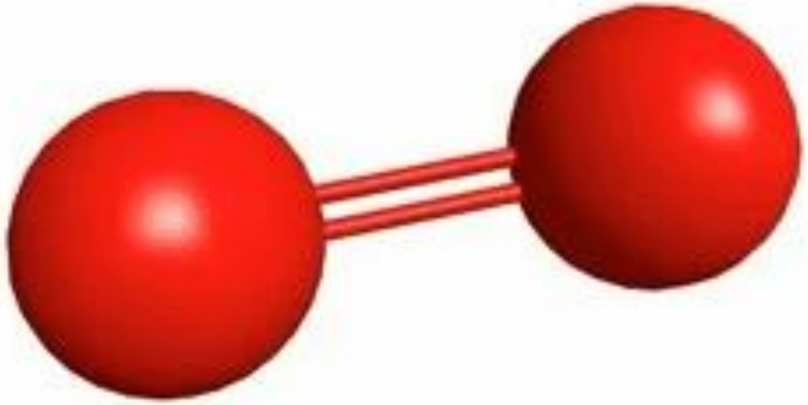


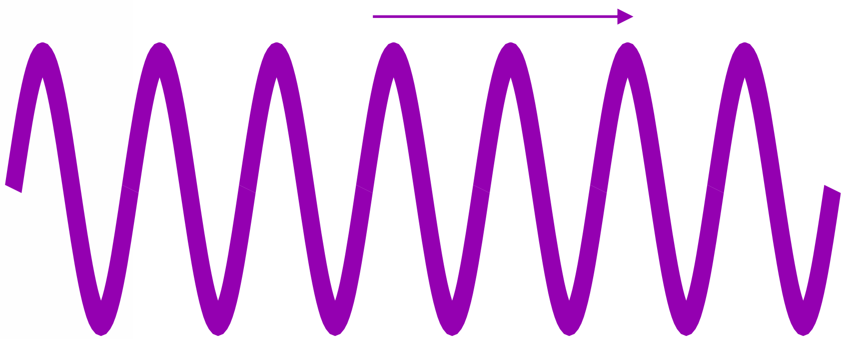


Photon + H_2 molecule

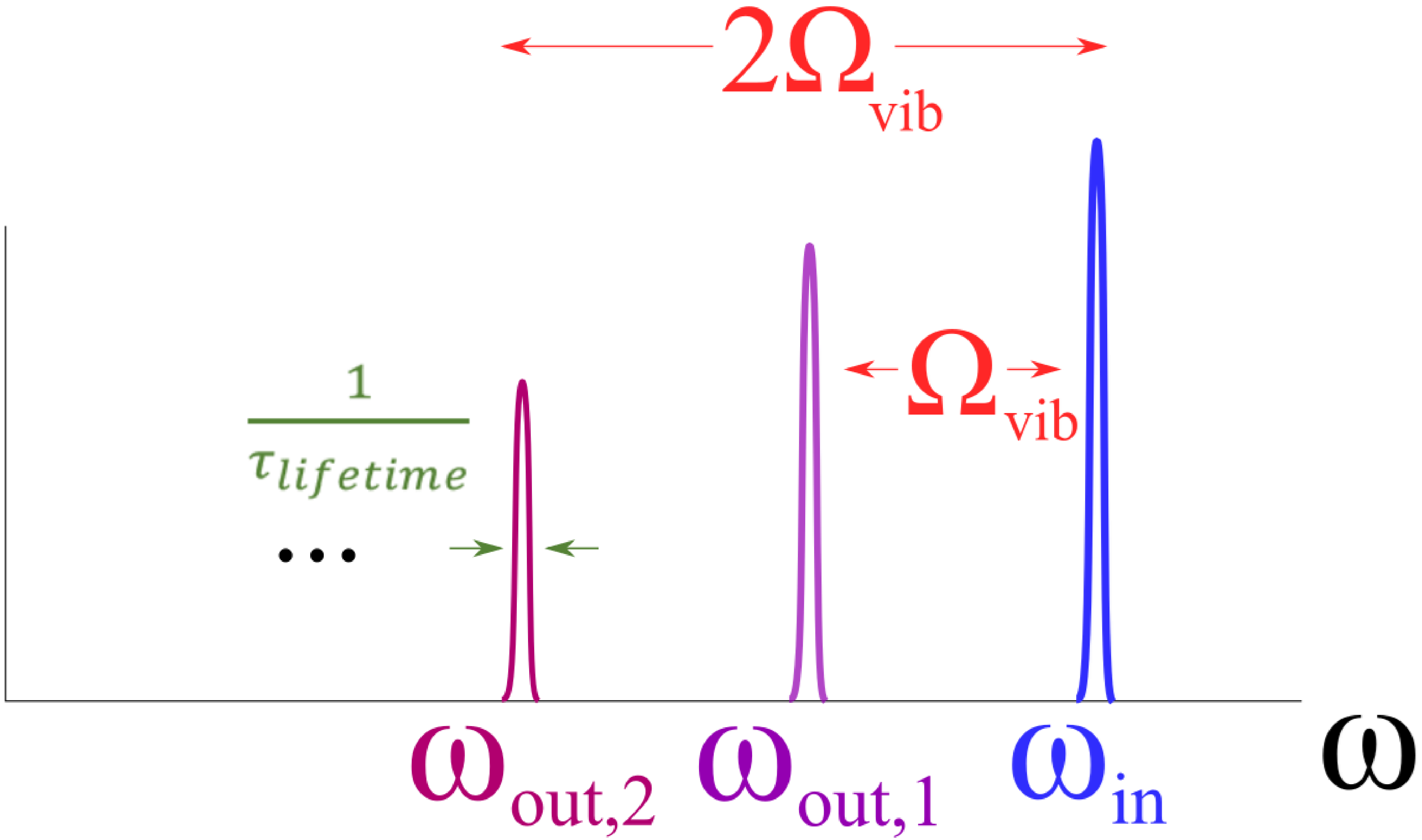
- Alternatively, the virtual state can relax to a mechanically excited H_2 molecule and a photon with <u>less</u> energy (lower frequency).
- This is <u>Raman Scattering!</u>
- $\omega_{out} = \omega_{in} - \Omega_{vib}$







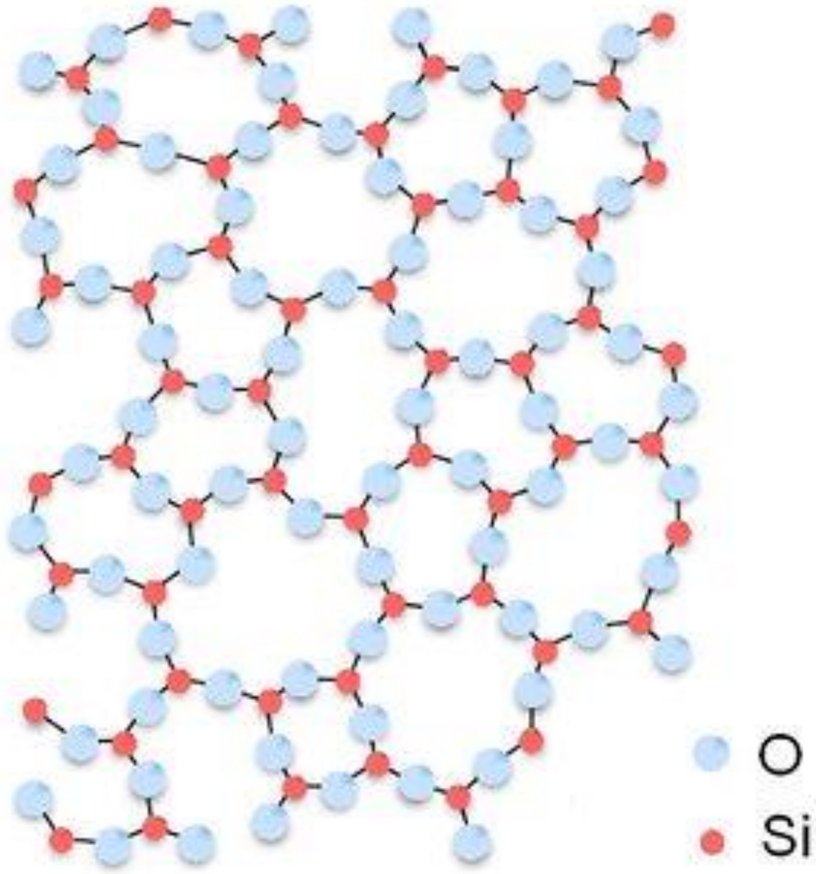
Possible output frequencies for H_2

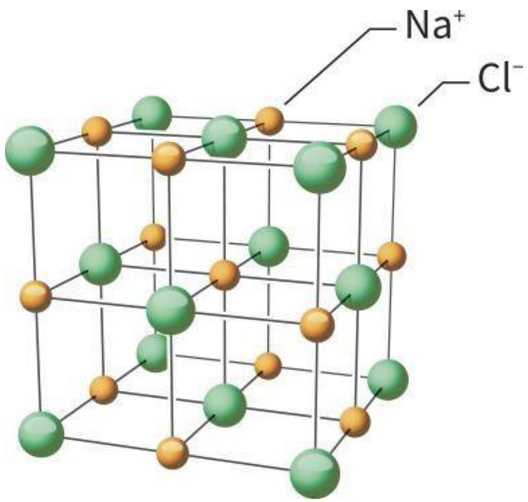


What about silica (SiO_2) ?

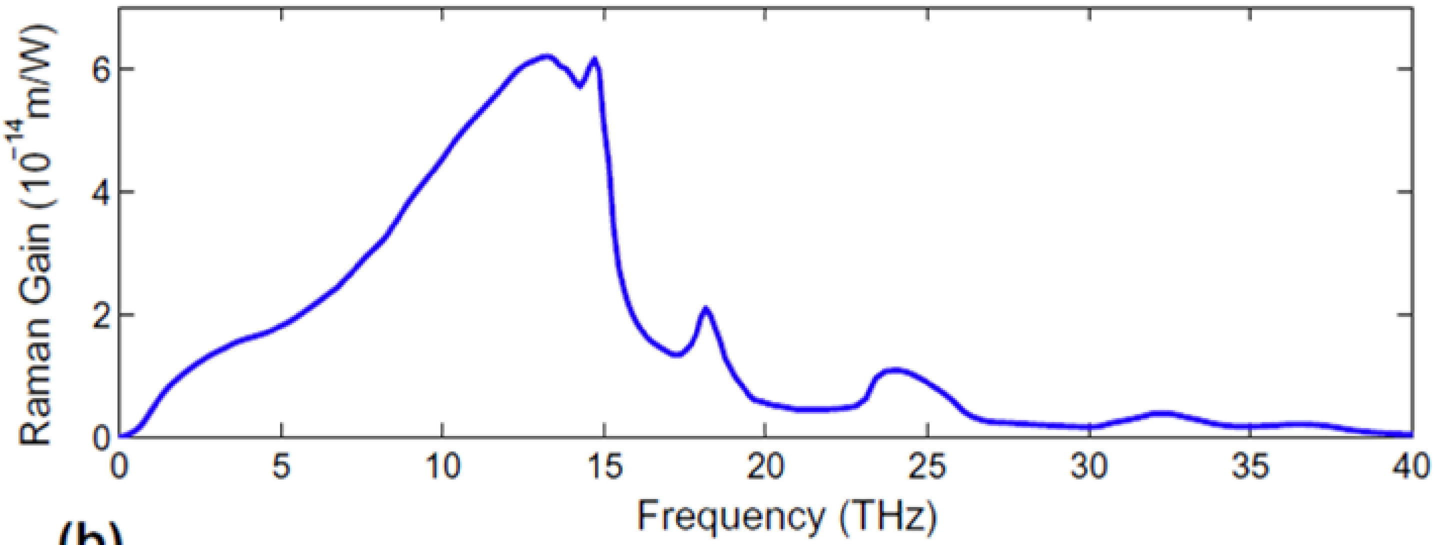
- Amorphous crystal structure.

- Therefore, many possible vibration states with different frequencies and lifetimes!

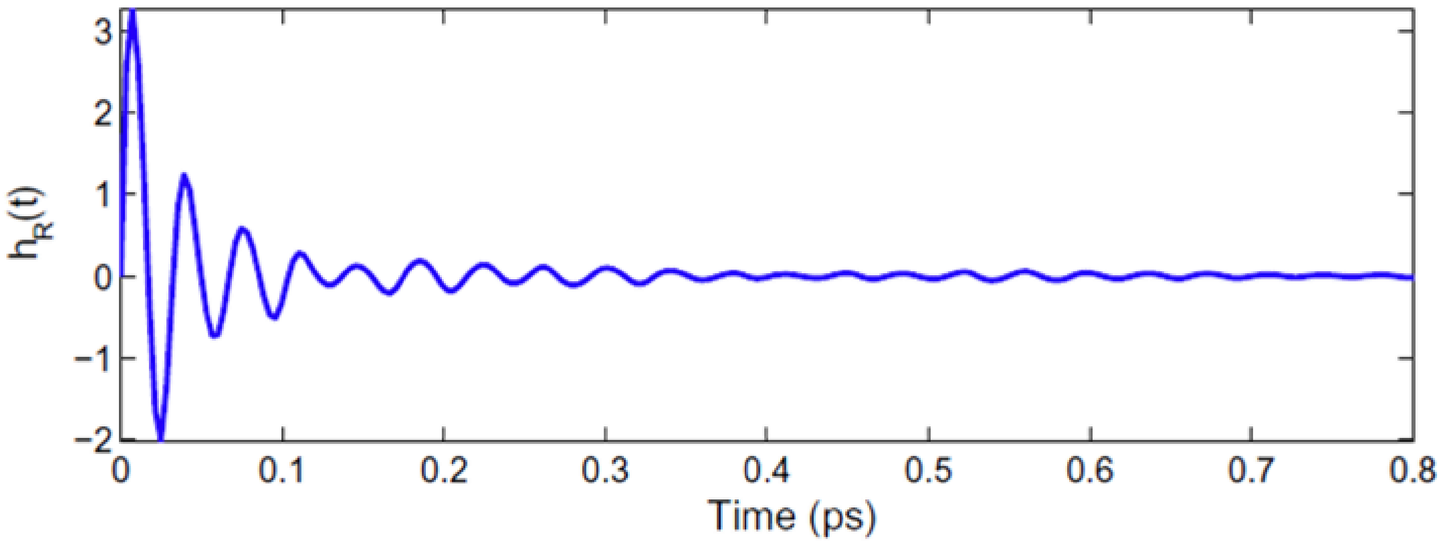


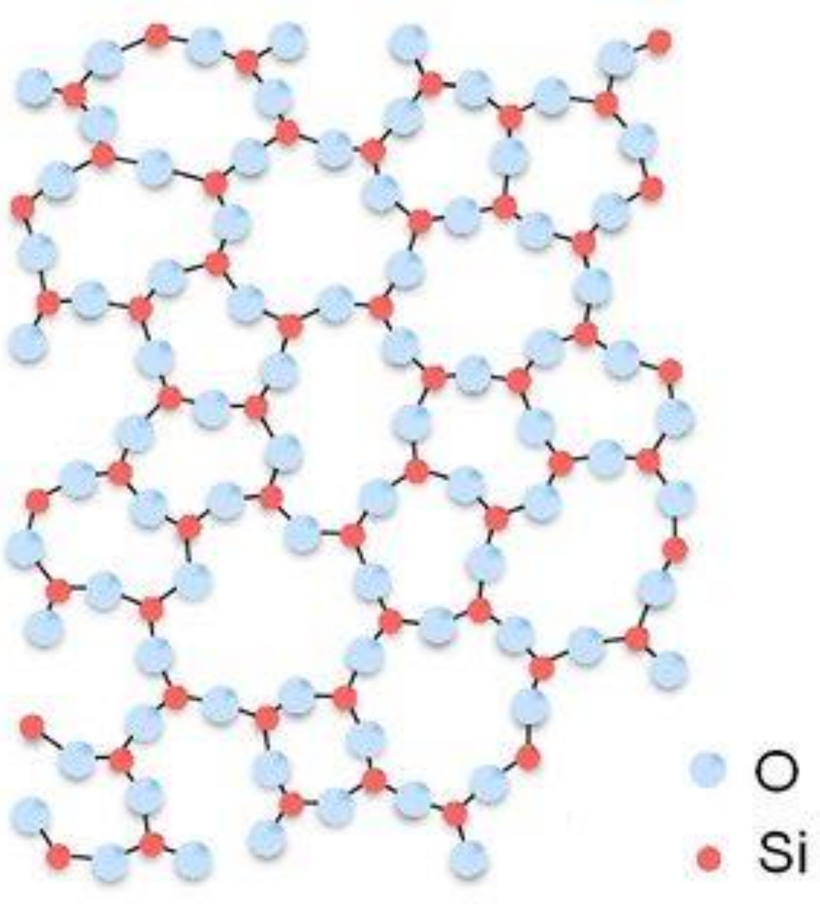


Silica vibration in time and freq. domains

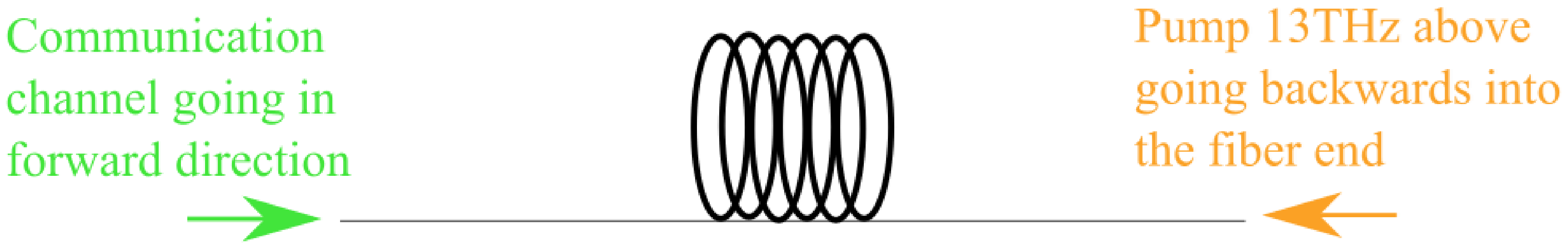


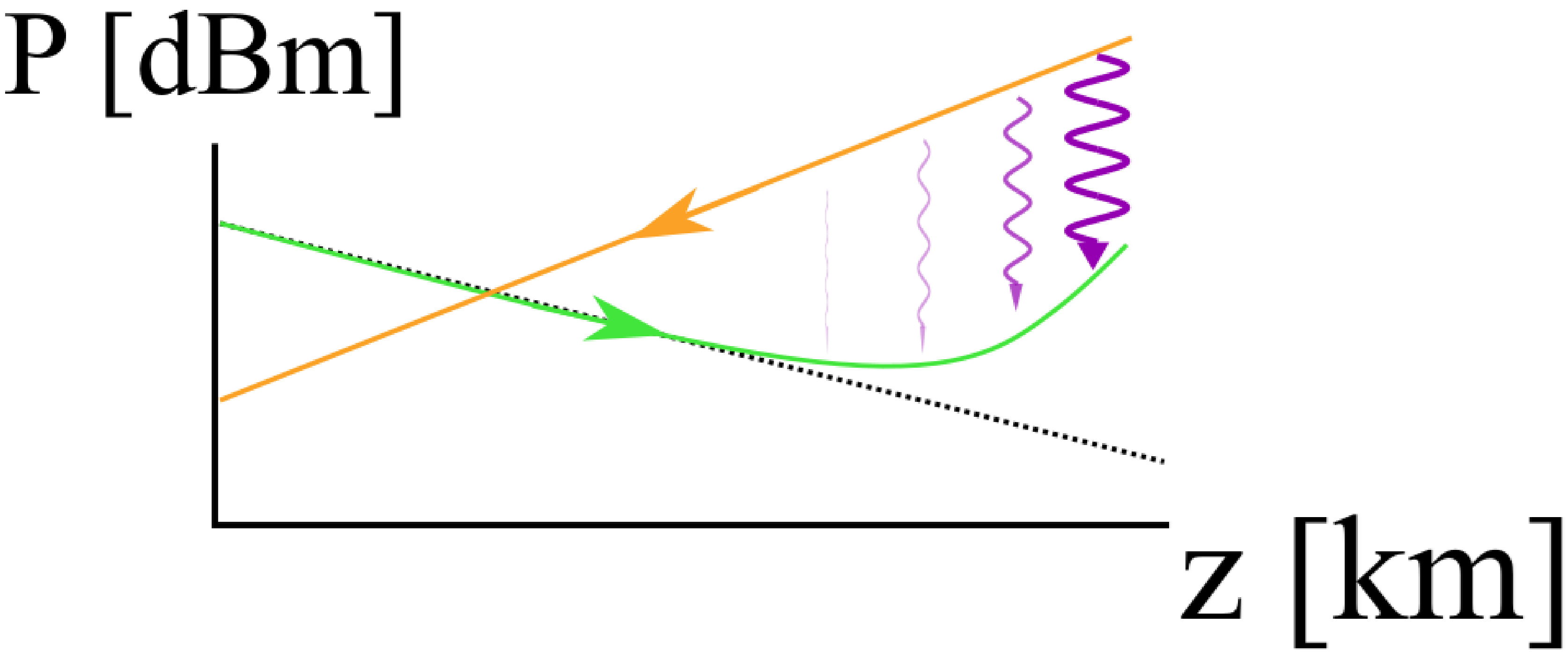
(b)





Raman amplifiers!





Coupled ODE

$$\frac{dI_s}{dz} = (g_{s,p} I_p - \alpha_s) I_s$$

$$\frac{dI_p}{dz} = \left(\frac{\omega_p}{\omega_s} g_{p,s} I_s - \alpha_p\right) I_p$$

$$g_{p,s} = -g_{s,p}$$