Stimulated Raman Scattering

(b)

Ole Krarup, https://www.linkedin.com/in/olekrarup/
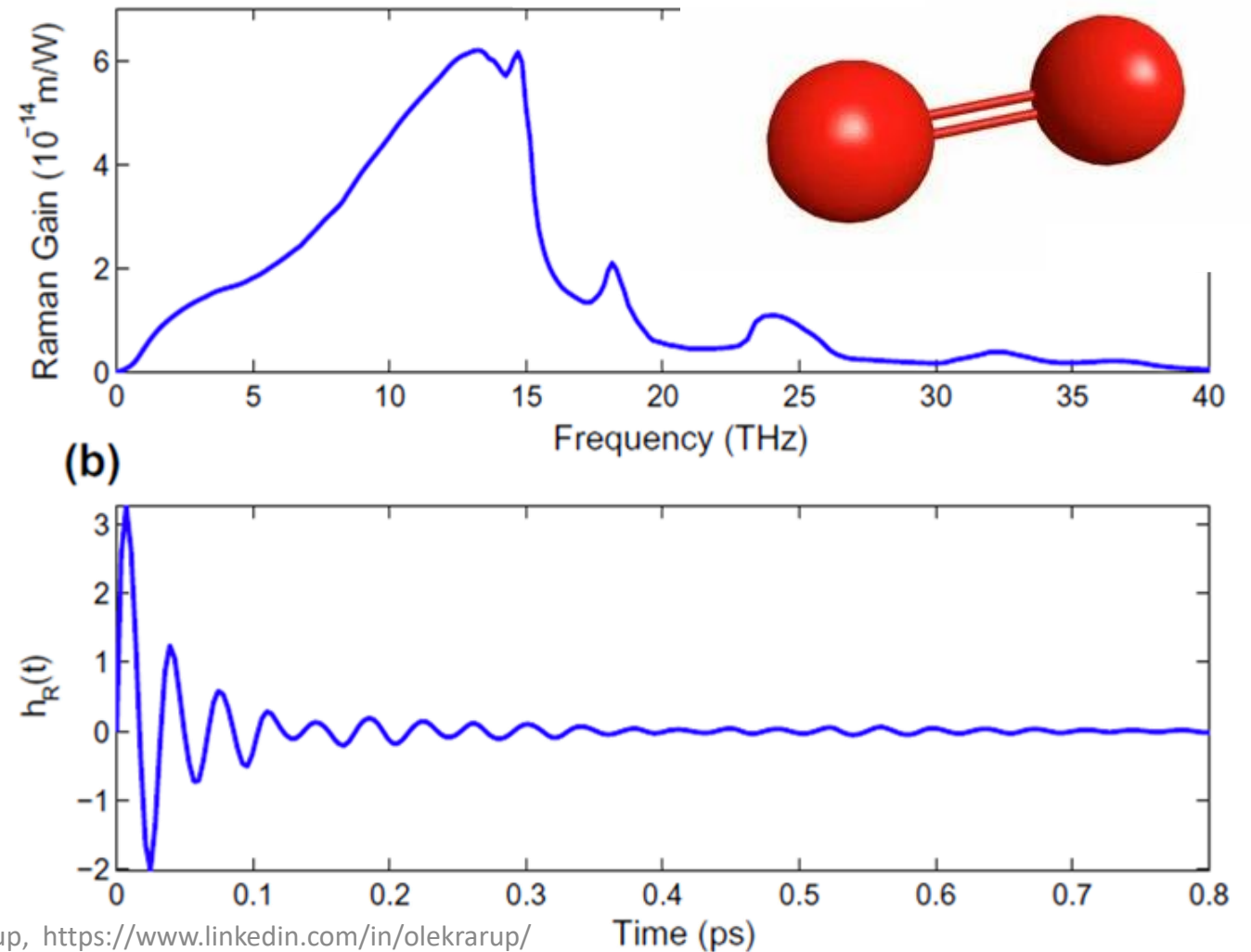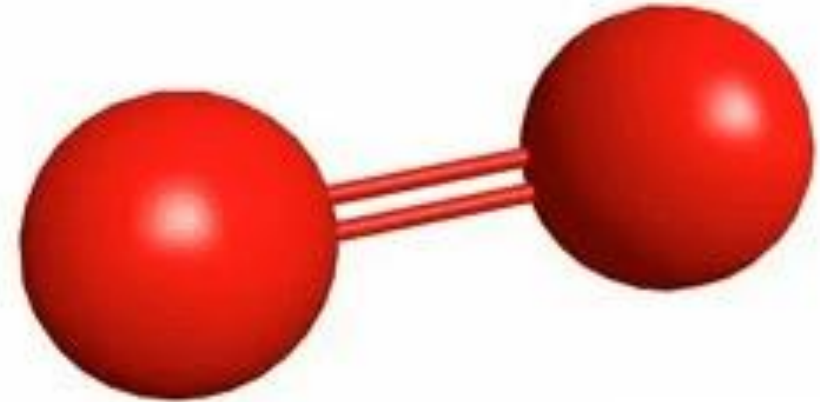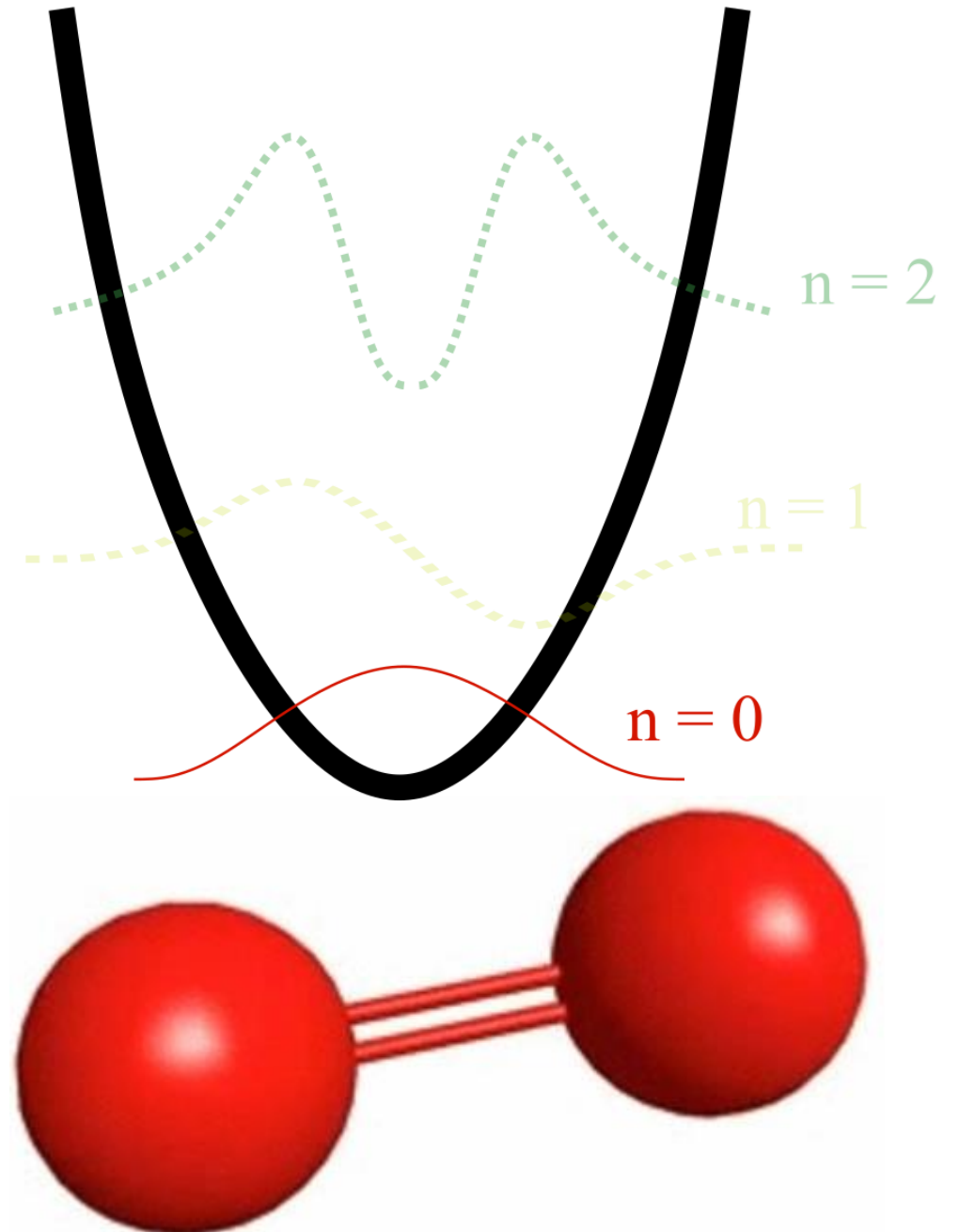
Outline

- Basic physics of Raman scattering

- Applications to silica fibers

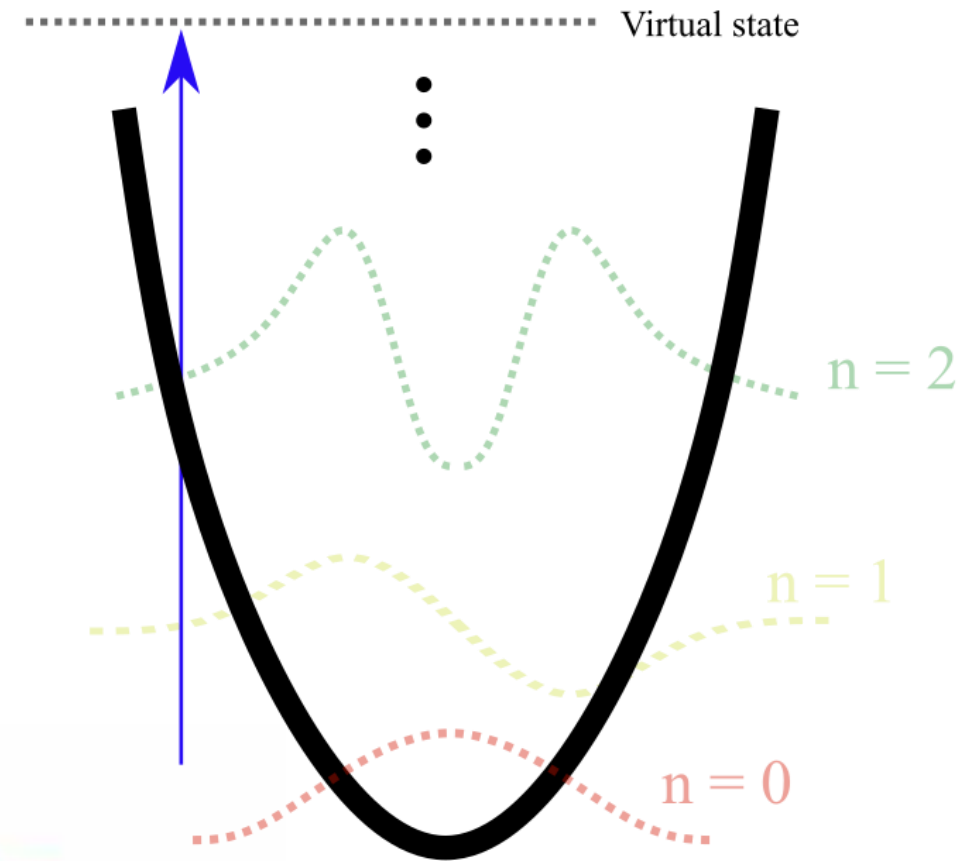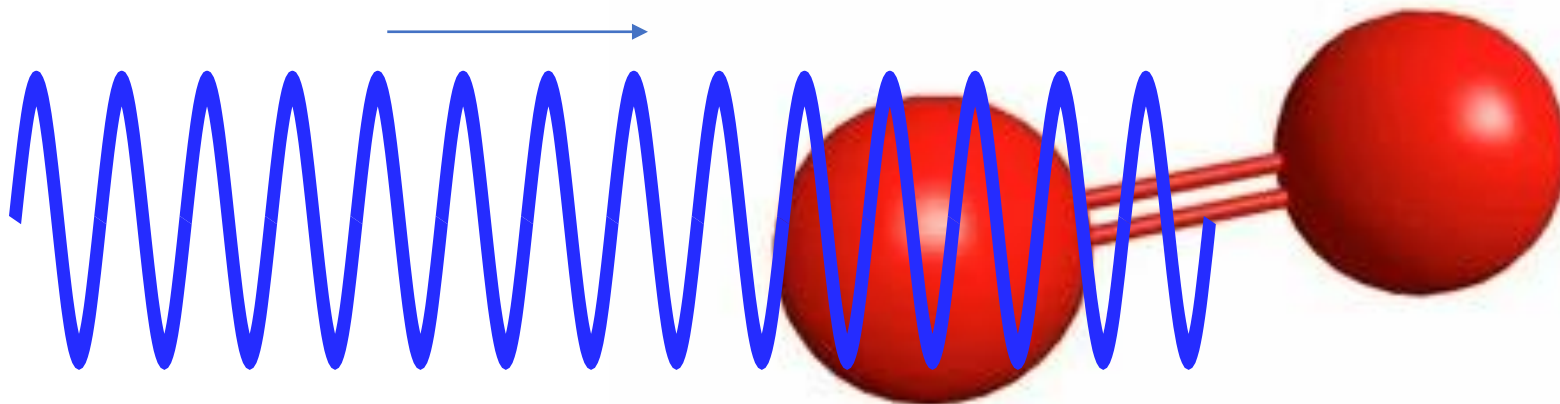- Designing a "Raman amplifier"

- Numerical simulation in python!

H_2 molecule

- Initially, a H_2 molecule is in its vibrational ground state
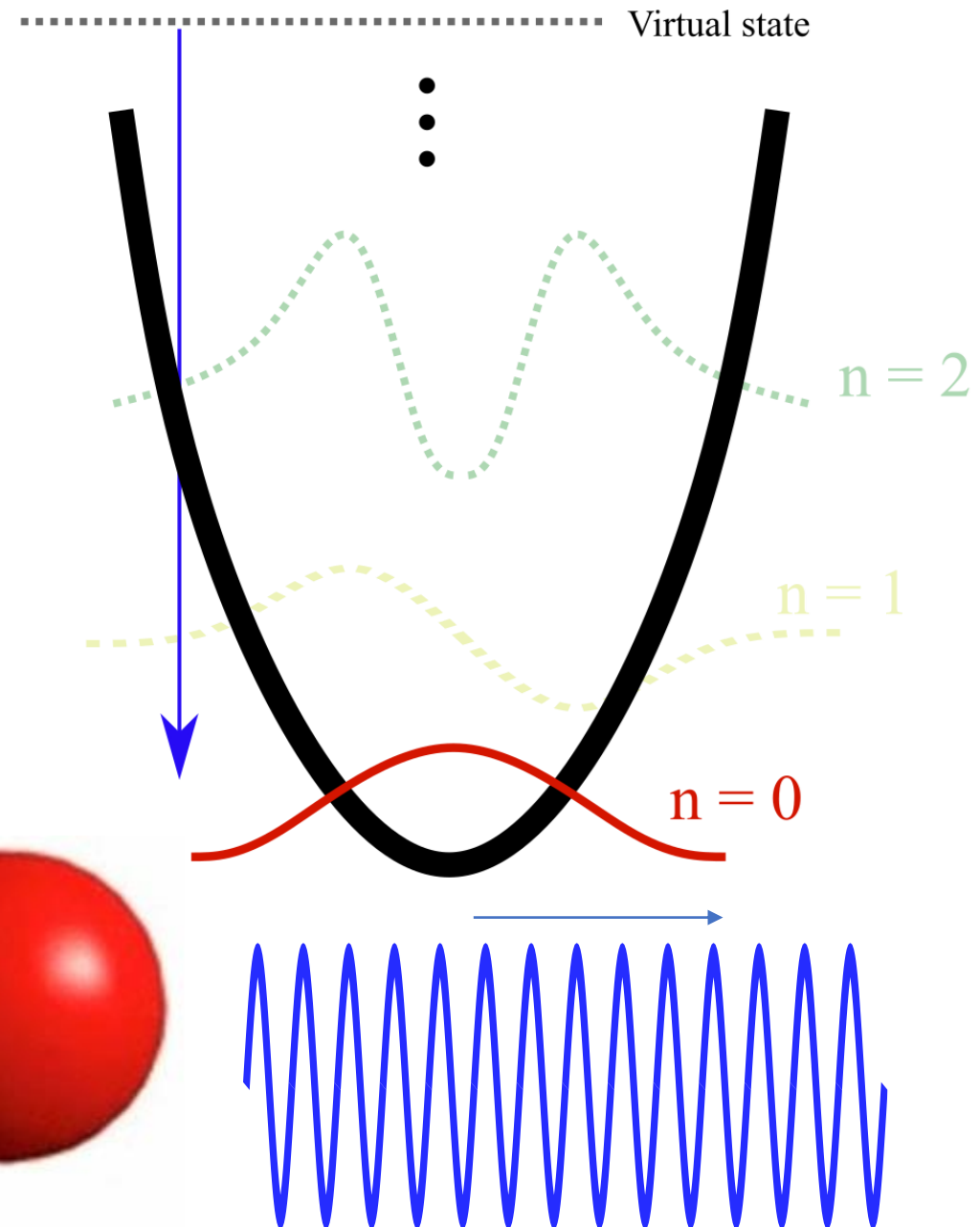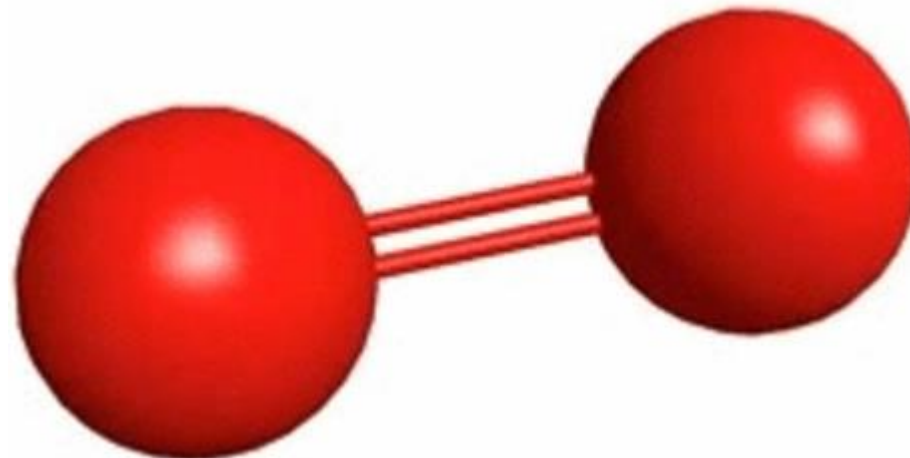
n = 2

n = 1

n = 0

Photon + H_2 molecule

- The oscillating electric field of the light "shakes" the electrons in the bond.

- A virtual state is occupied temporarily.

Virtual state

$n = 2$

$n = 1$

$n = 0$

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!)

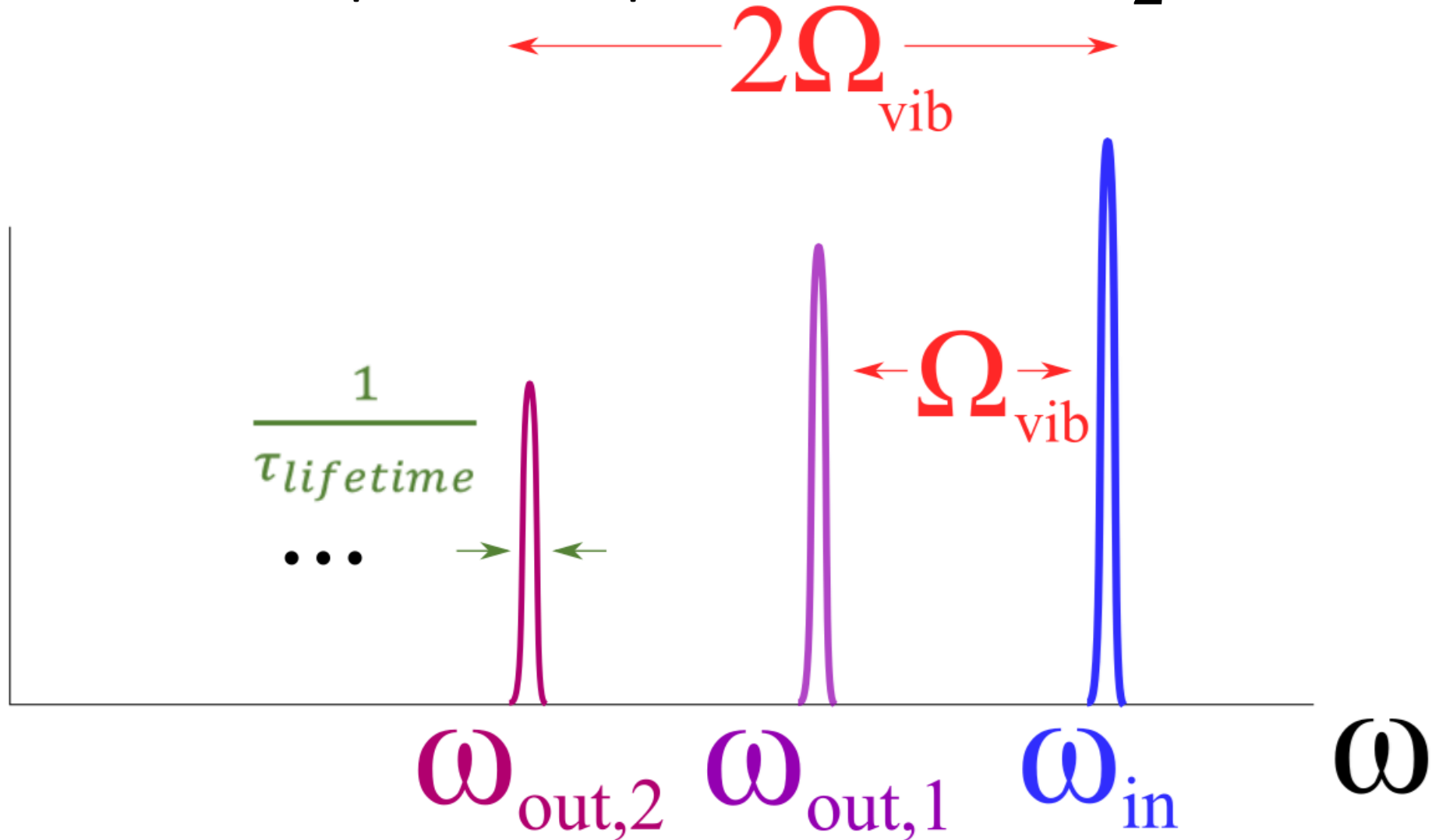Virtual state

$n = 2$

$n = 1$

$n = 0$

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>
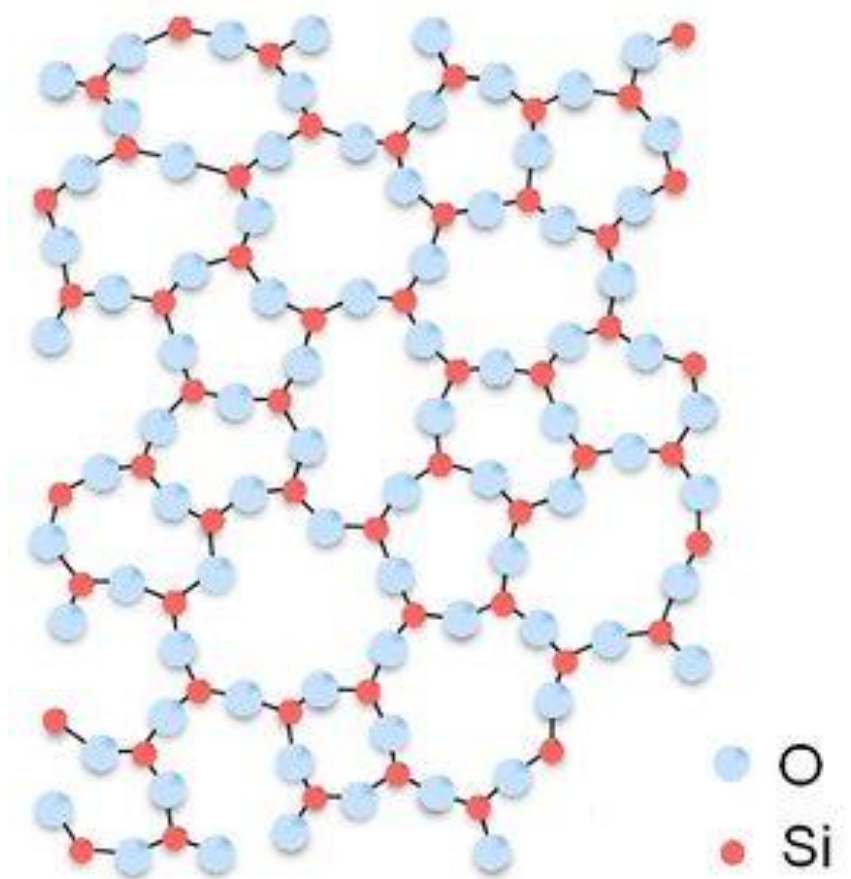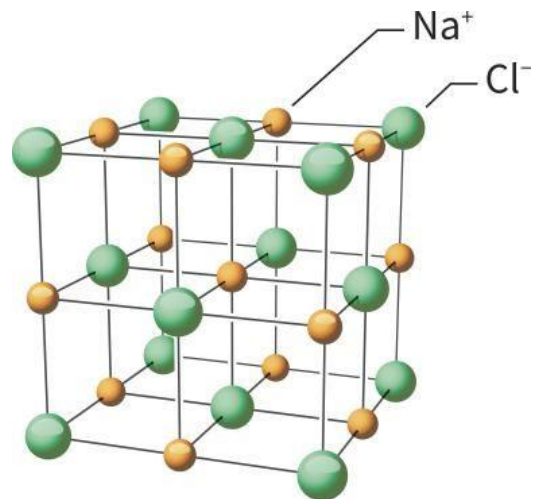
- $\omega_{out} = \omega_{in} - \Omega_{vib}$

Virtual state

$n = 2$

$n = 1$

$n = 0$
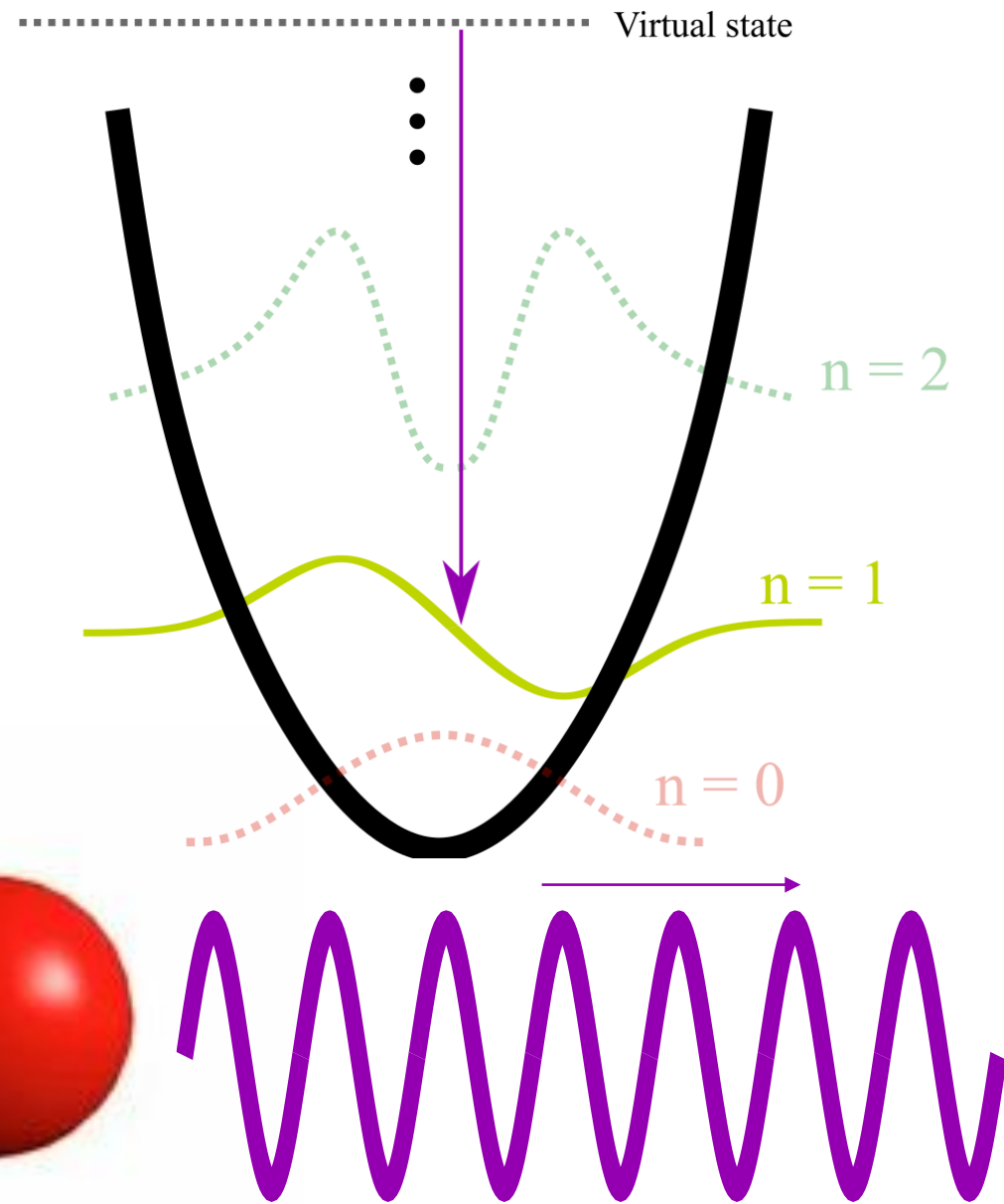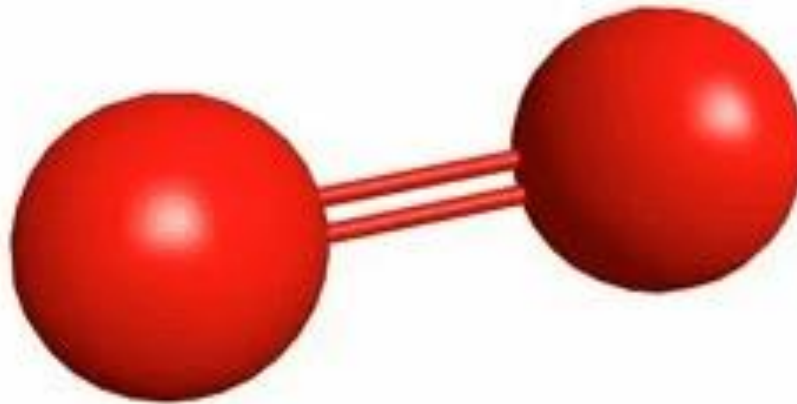
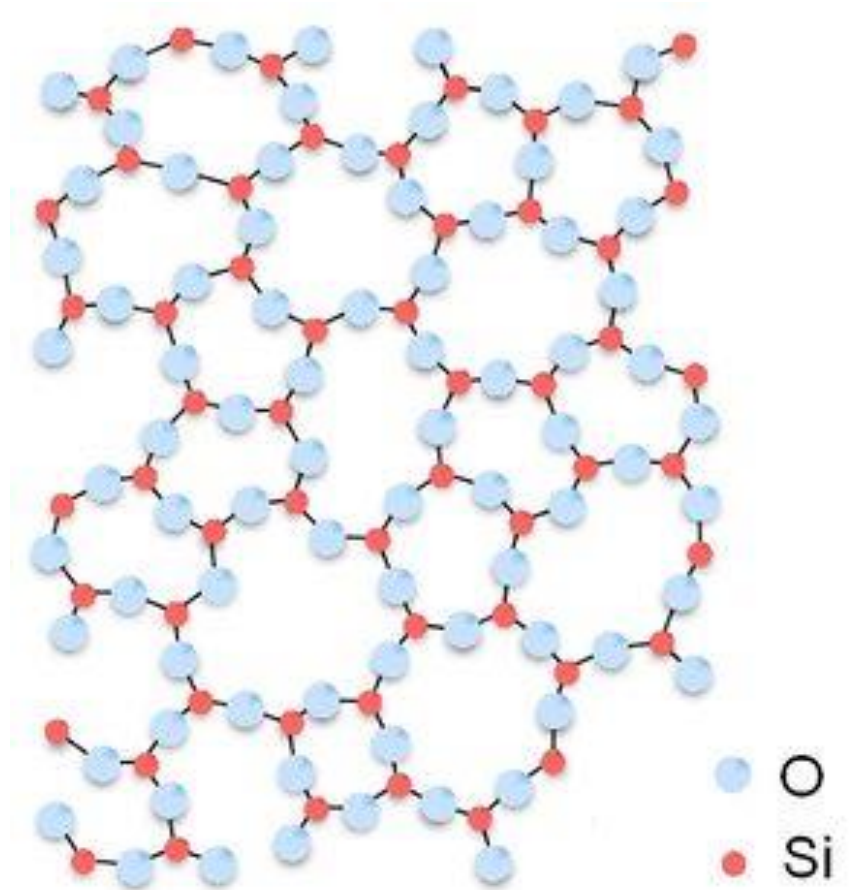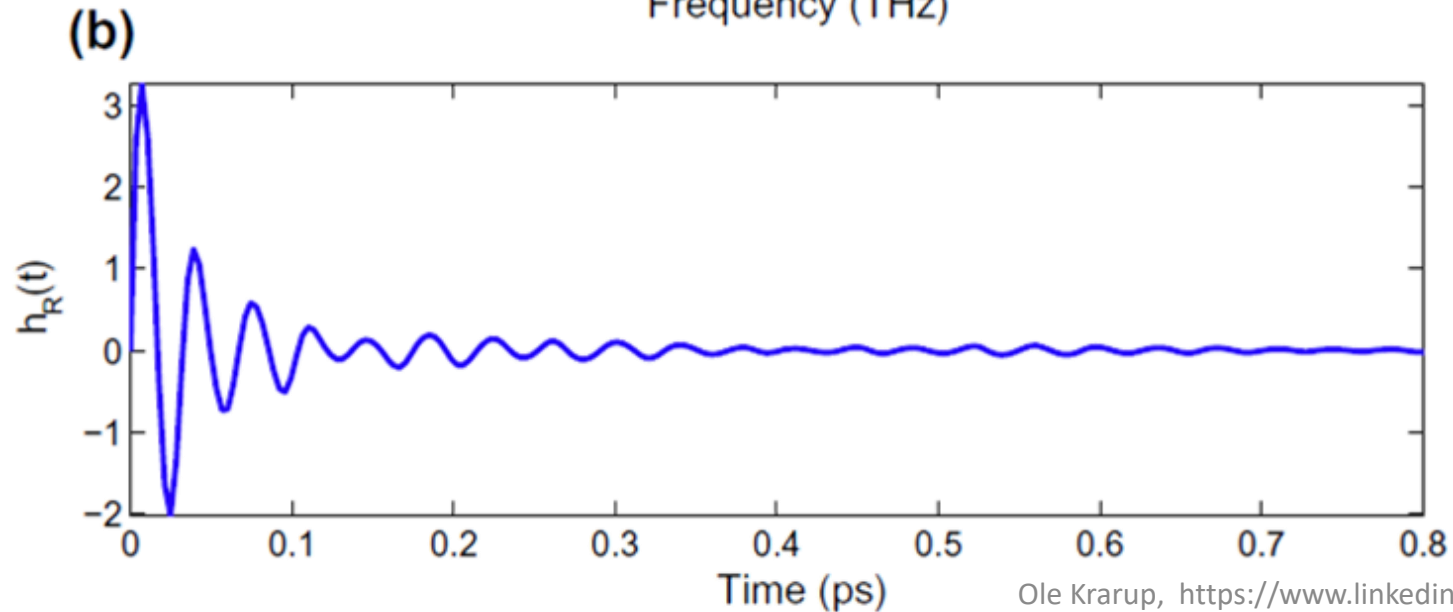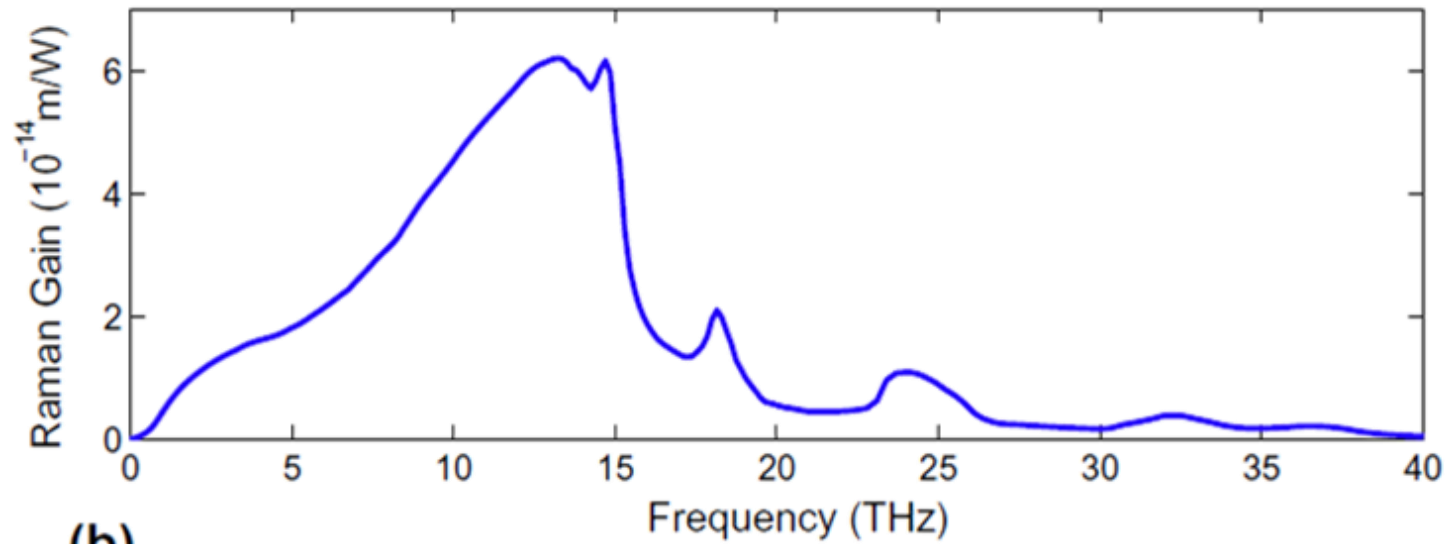# Possible output frequencies for H_2

What about silica (SiO_2) ?

- Amorphous crystal structure. ⟶

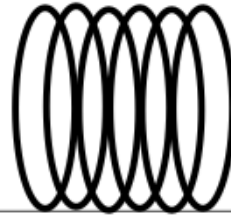- Therefore, many possible vibration states with different frequencies and lifetimes!
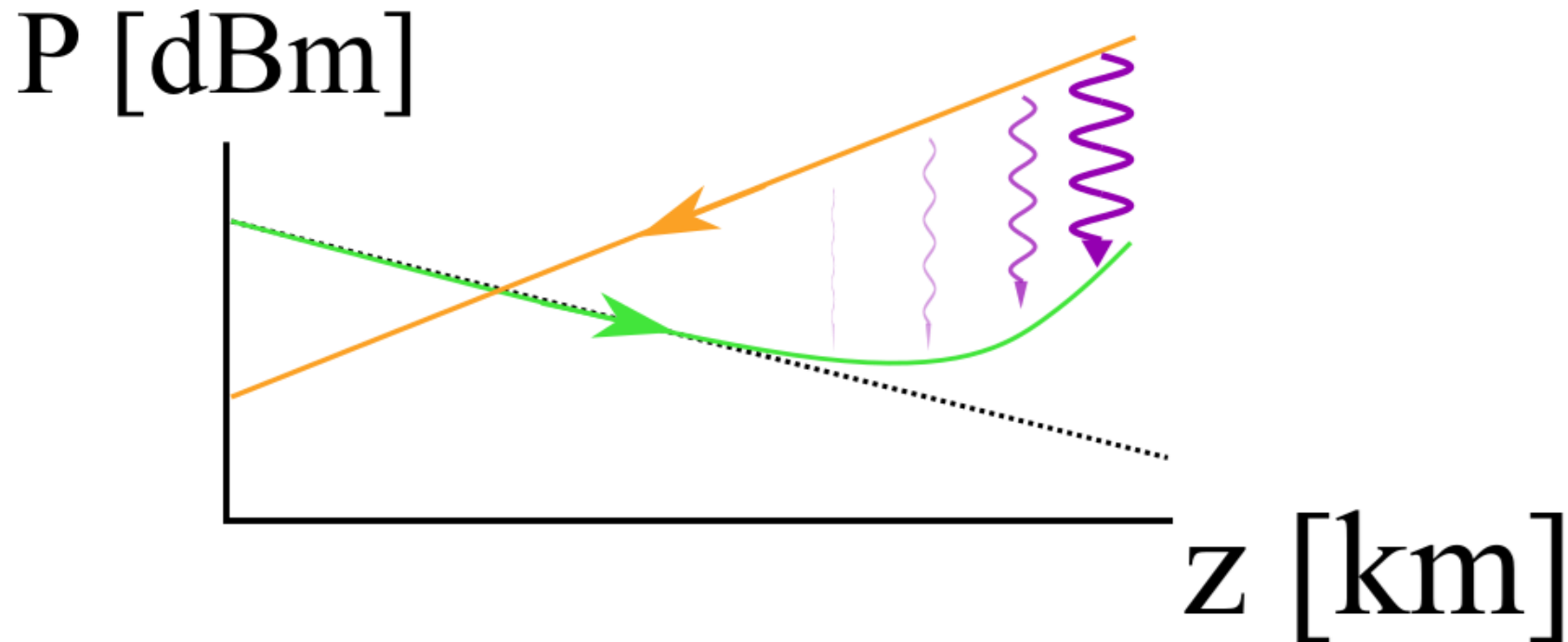

O
Si

Silica vibration in time and freq. domains

Raman amplifiers!

Communication channel going in forward direction

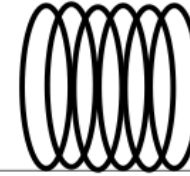Pump 13THz above going backwards into the fiber end

P [dBm]

z [km]

Coupled ODE

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

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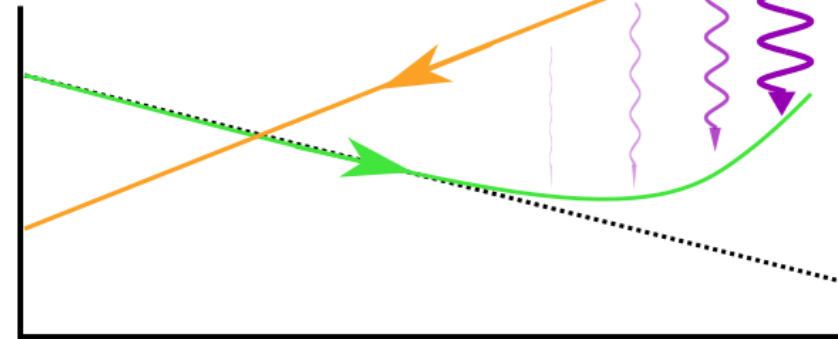
$$g_{p,s} = -g_{s,p}$$

Communication channel going in forward direction

Pump 13THz above going backwards into the fiber end

P [dBm]

z [km]