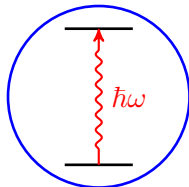


Lamb-Dicke regime/approximation

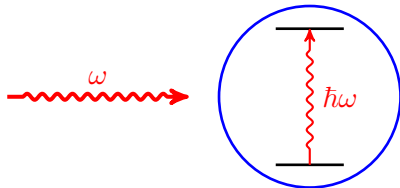
Yichao Yu

Journal Club

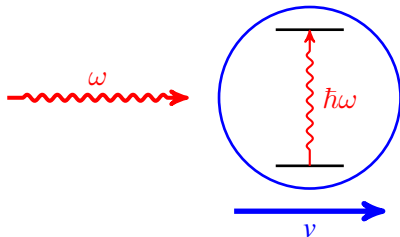
Doppler effect



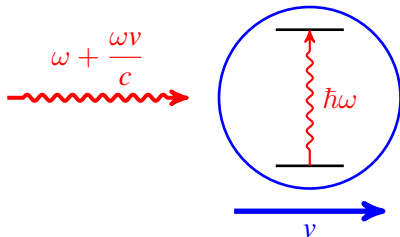
Doppler effect



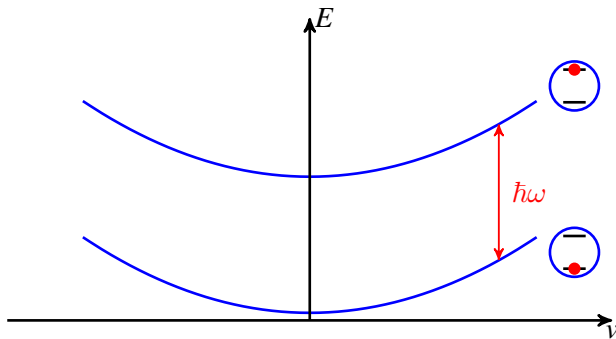
Doppler effect



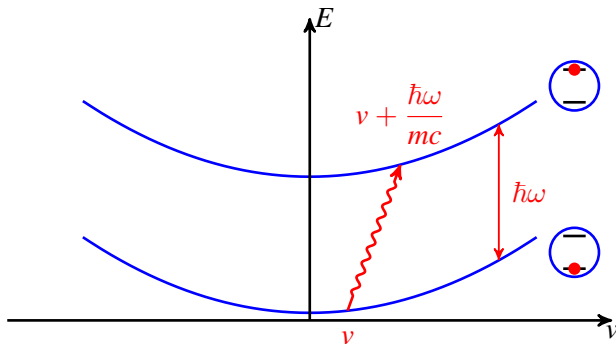
Doppler effect



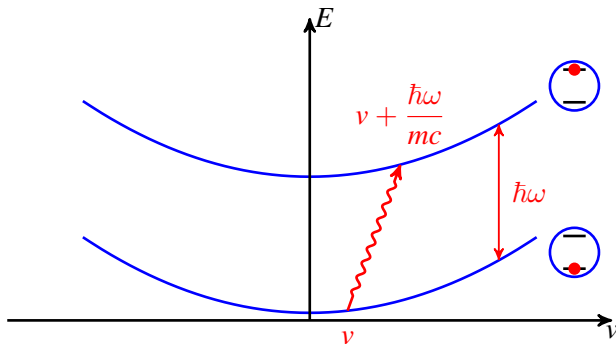
Doppler effect



Doppler effect

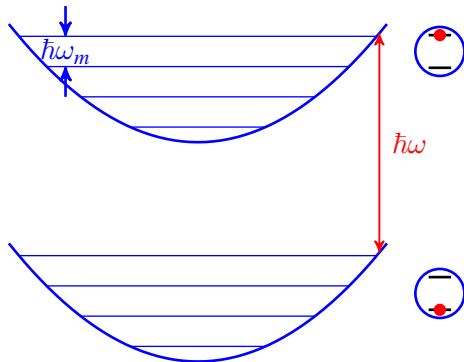


Doppler effect

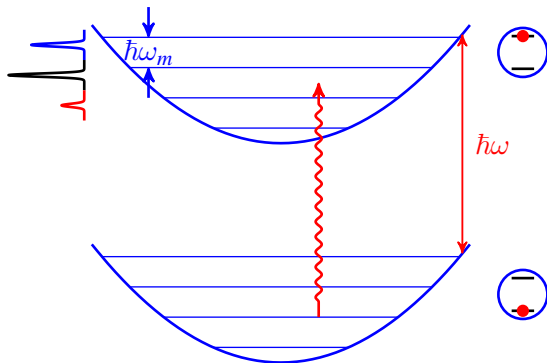


$$\omega + \frac{m}{2\hbar} \left(v + \frac{\hbar\omega}{mc} \right)^2 - \frac{mv^2}{2\hbar} = \omega + \frac{\omega v}{c} + \frac{\hbar\omega^2}{2mc^2}$$

Sideband

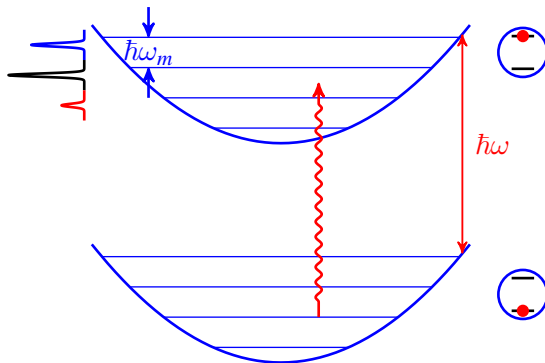


Sideband



Frequency: $\omega + n\omega_m$

Sideband



Frequency: $\omega + n\omega_m$

Strength: $\langle n | e^{ik\hat{x}} | n + \Delta n \rangle$

Lamb-Dicke parameter

$$\langle n | e^{ik\hat{x}} | n + \Delta n \rangle$$

Lamb-Dicke parameter

$$\langle n | e^{ik\hat{x}} | n + \Delta n \rangle$$

$$\hat{x} = \sqrt{\frac{\hbar}{2m\omega}} (a + a^\dagger) = z_0 (a + a^\dagger)$$

Lamb-Dicke parameter

$$\langle n | e^{ik\hat{x}} | n + \Delta n \rangle$$

$$\hat{x} = \sqrt{\frac{\hbar}{2m\omega}} (a + a^\dagger) = z_0 (a + a^\dagger)$$

$$k\hat{x} = \eta (a + a^\dagger)$$

$$\eta \equiv kz_0 = k\sqrt{\frac{\hbar}{2m\omega}}$$

Lamb-Dicke parameter

$$\langle n | e^{ik\hat{x}} | n + \Delta n \rangle$$

$$\hat{x} = \sqrt{\frac{\hbar}{2m\omega}} (a + a^\dagger) = z_0 (a + a^\dagger)$$

$$k\hat{x} = \eta (a + a^\dagger)$$

$$\eta \equiv kz_0 = k\sqrt{\frac{\hbar}{2m\omega}}$$

$$\eta = \frac{2\pi z_0}{\lambda}$$

$$\eta = \sqrt{\frac{\omega_R}{\omega_m}}$$

Lamb-Dicke parameter

$$\begin{aligned} & \langle n | e^{ik\hat{x}} | n + \Delta n \rangle \\ &= e^{-\eta^2/2} \eta^{\Delta n} \sqrt{\frac{n_-!}{n_+!}} L_{n_-}^{\Delta n}(\eta^2) \end{aligned}$$