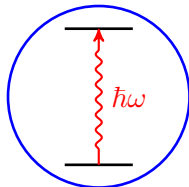# Lamb-Dicke regime/approximation
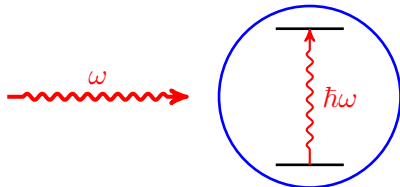
Yichao Yu

Journal Club
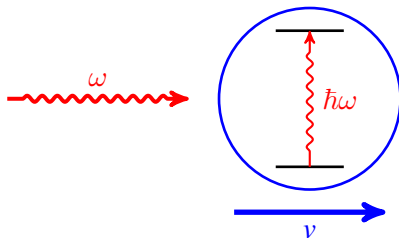
Doppler effect
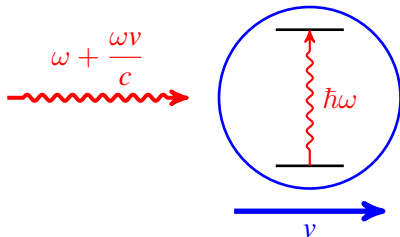
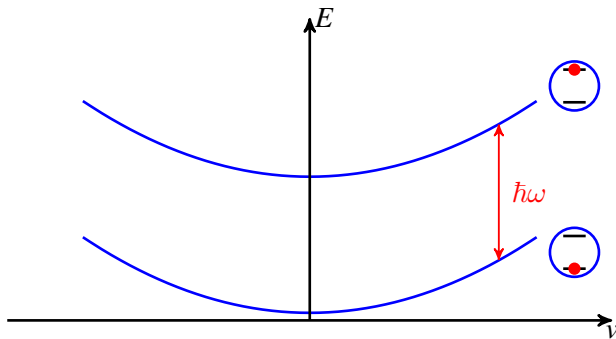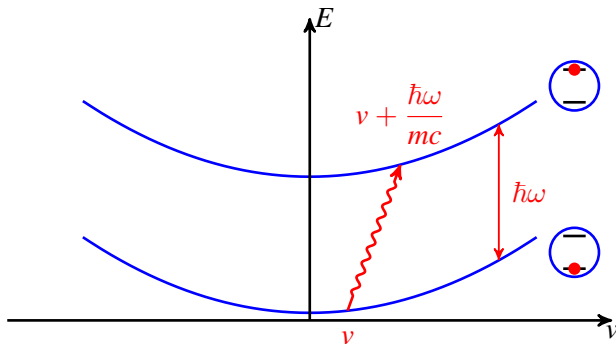# Doppler effect

Doppler effect
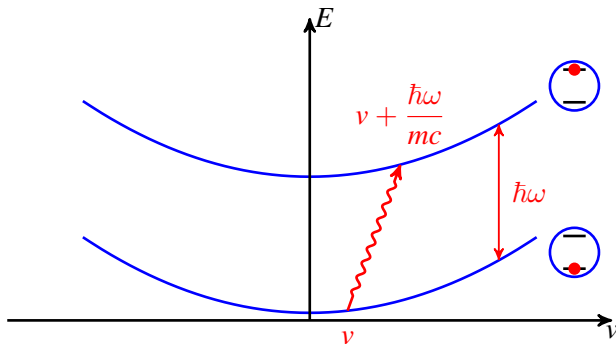
Doppler effect

Doppler effect

Doppler effect

Doppler effect
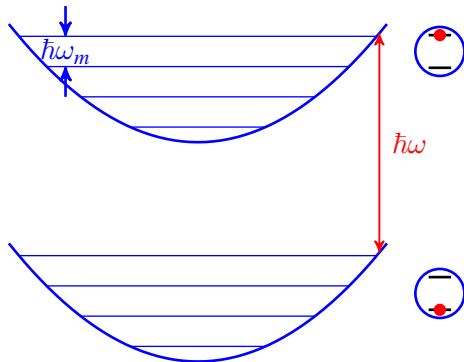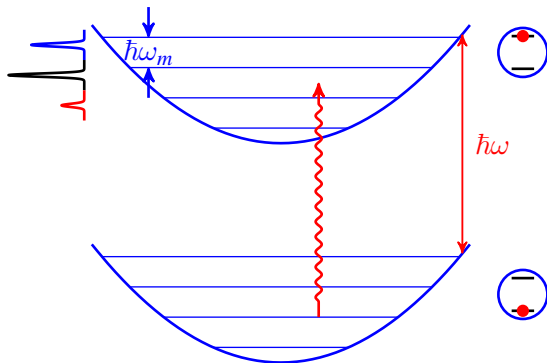

$$\omega + \frac{m}{2\hbar}\left(v + \frac{\hbar\omega}{mc}\right)^2 - \frac{mv^2}{2\hbar} = \omega + \frac{\omega v}{c} + \frac{\hbar\omega^2}{2mc^2}$$

Sideband

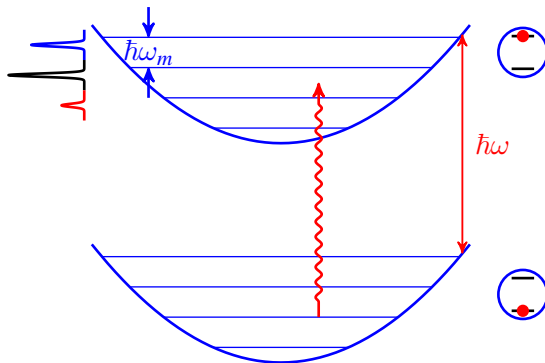## Sideband

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

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

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

Lamb-Dicke parameter

$$\langle n|\mathrm{e}^{\mathrm{i}k\hat{x}}|n + \Delta n\rangle$$

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

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

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

Lamb-Dicke parameter

$$\langle n|\mathrm{e}^{\mathrm{i}k\hat{x}}|n + \Delta n\rangle$$

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

$$k\hat{x} = \eta\Big(a + a^{\dagger}\Big) \qquad\qquad \eta = \sqrt{\frac{\omega_R}{\omega_m}}$$

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

Lamb-Dicke parameter

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