# Physics 213a-2011 Class 18 Monday 10-17-11 Summary

## non-zero initial velocities

$$|z(t)\rangle = \begin{pmatrix} z_1(t) \\ z_2(t) \end{pmatrix} = C_p e^{i\omega_p t}|e_p\rangle + C_b e^{i\omega_b t}|e_p\rangle$$

$$\dashrightarrow \quad \mathrm{Re}\, C_p = \langle e_p | x_0 \rangle \qquad \mathrm{Re}\, C_b = \langle e_b | x_0 \rangle$$

$$\mathrm{Im}\, C_p = -\frac{\langle e_p | \dot{x}_0 \rangle}{\omega_p} \qquad \mathrm{Im}\, C_b = -\frac{\langle e_b | \dot{x}_0 \rangle}{\omega_b}$$

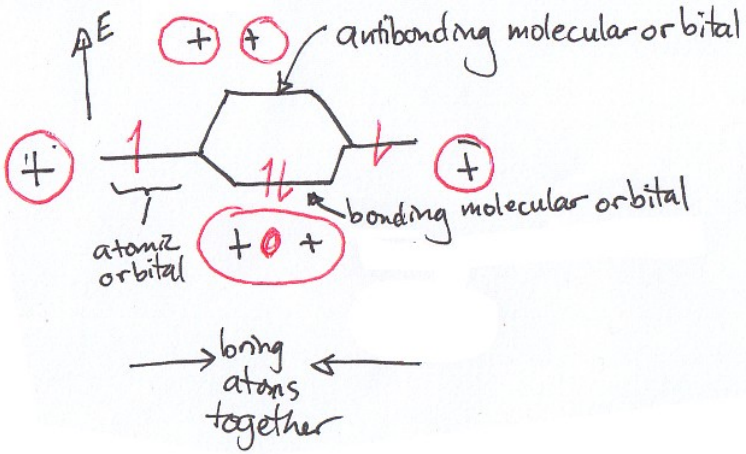
$$\Rightarrow x_1(t) = \frac{A_p}{\sqrt{2}} \cos(\omega_p t + \varphi_p) + \frac{A_b}{\sqrt{2}} \cos(\omega_b t + \varphi_b)$$

$$x_2(t) = \frac{A_b}{\sqrt{2}} \cos(\omega_b t + \varphi_b) - \frac{A_b}{\sqrt{2}} \cos(\omega_b t + \varphi_b)$$

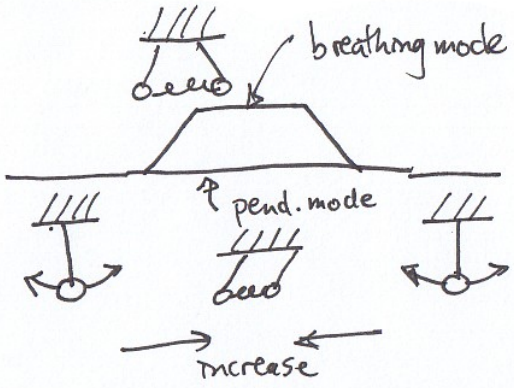
where $A_p = \sqrt{(\mathrm{Re}\, C_p)^2 + (\mathrm{Im}\, C_p)^2}$

$$\varphi_p = \tan^{-1} \frac{\mathrm{Im}\, C_p}{\mathrm{Re}\, C_p} + \begin{cases} 0 & \text{If } \mathrm{Re}\, C_p > 0 \\ \pi & \text{If } \mathrm{Re}\, C_p < 0 \end{cases}$$

## Analogy with molecular orbitals




analogous to




$$\omega_p = \sqrt{g/\ell} \qquad \omega_b = \sqrt{g/\ell + 2k/m}$$

** Quite generally, when the strength of the interaction increases, the difference in the frequencies (or energies) of the normal modes increases. **