

Ammonia (ctd.)

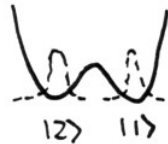
Better explanation for why $A \sim \frac{1}{\text{coupling strength}}$:

$|2\rangle$ is almost an energy eigenstate

$\Rightarrow \hat{H}|2\rangle \simeq E_0|2\rangle$

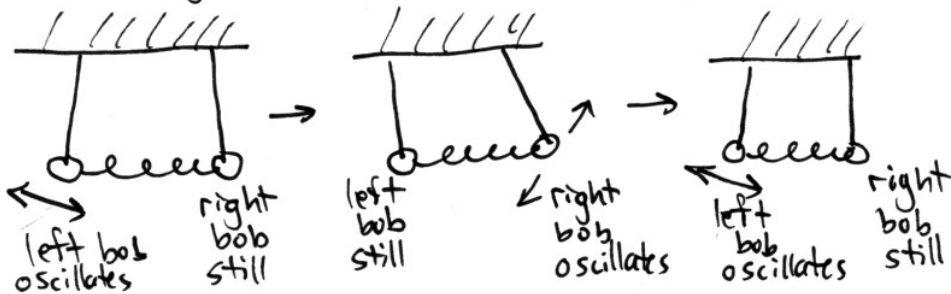
$\Rightarrow -A = \langle 1|\hat{H}|2\rangle \simeq E_0 \underbrace{\langle 1|2\rangle}_{\sim \frac{1}{\text{coupling strength}}}$

\rightarrow If we start the system in $|1\rangle$, which is an equal superposition of the energy eigenstates, then it oscillates to $|2\rangle$, back to $|1\rangle$, etc. with period $\frac{\hbar\pi}{A}$.



The same thing happens for any double-well potential.

This is analogous to the behavior of a coupled oscillator:



Energy-time uncertainty relation

Townsend shows $\Delta E \Delta t \geq \hbar/2$, where $\Delta t \equiv$ time for the state to change significantly. But, can also interpret Δt as the time used to measure E , and ΔE as the measurement uncertainty \Rightarrow can violate cons. of energy, so long as you're quick about it!

Time evolution of expectation values for energy eigenstates

\rightarrow For an energy eigenstate, $\langle A \rangle_t = \langle A \rangle_{t=0}$ for any observable $\hat{A} \Rightarrow$ "nothing ever changes in an energy eigenstate".

Connecting (again) to the wavefunction

$|\psi\rangle = \sum c_n |E_n\rangle$

$c_n = \langle E_n | \psi \rangle \quad \hat{I} = \sum |a_i\rangle \langle a_i|$
any complete basis

$\Rightarrow c_n = \int_{-\infty}^{\infty} \langle E_n | x \rangle \langle x | \psi \rangle dx = \int_{-\infty}^{\infty} \psi_n^* \psi dx$
 $\langle x | E_n \rangle^* = \psi_n(x)$

