Schrodinger Time Evol.

$$i\hbar \underbrace{\frac{d}{dt}}_{\text{time evolution}} |\psi(t)\rangle = \underbrace{H(t)}_{\text{energy as QM system}} |\psi(t)\rangle$$

eigenstates of $H(t)$

$$H(t)|E_n\rangle = E_n |E_n\rangle$$

↑ states ↑ values

$H(t) = H$ no time dep.

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

expansion in energy basis

in general

$$\boxed{|\psi(t)\rangle = \sum_n c_n e^{-iE_n t/\hbar} |E_n\rangle}$$

$$\langle E_m | E_n \rangle = \delta_{nm}$$

Solve Energy Eigenvalue

$$\hat{H} \doteq \begin{pmatrix} 2 & 3 & 2 \\ 2 & 1 & 2 \\ 2 & 3 & 2 \end{pmatrix}$$

$$\det(\hat{H} - I\lambda) = 0$$

$$\lambda = \left\{ \text{energy eigenvalues} \right.$$

Activity

$$\boxed{H \doteq \hbar\omega_0 \begin{pmatrix} 2 & 0 & 1/2 \\ 0 & 1 & 0 \\ 1/2 & 0 & 2 \end{pmatrix}}$$ $|a\rangle, |b\rangle, |c\rangle$

a) not diagonal → not in basis

b) $\lambda = \hbar\omega_0$ $\quad H_{2i} = H_{i2} = 0$

$\uparrow \Leftarrow \langle 2 | H | i \rangle = 0$

$$|E_{\hbar\omega_0}\rangle \doteq \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$$

c) explicit calc.

d) $$\lambda = \begin{cases} E + \Delta E \\ E - \Delta E \end{cases}$$

$$\det(H - 1\lambda) = 0$$

$$(1-\lambda)\ \underbrace{\text{quadratic in } \lambda}_{\text{roots}}$$

$$\underline{\underline{E = 2}} \qquad \underline{\underline{\Delta E = \pm 1/2}}$$

$$|E_{3/2\,\hbar\omega_0}\rangle \doteq \frac{1}{\sqrt{2}} \underline{\begin{pmatrix} 1 \\ 0 \\ -1 \end{pmatrix}} \quad \text{antisym}$$

$$|E_{5/2\,\hbar\omega_0}\rangle \doteq \frac{1}{\sqrt{2}} \underline{\begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix}} \quad \text{sym}$$

$$\lambda = \begin{cases} \hbar\omega_0 & \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} \\ \frac{3}{2}\hbar\omega_0 & \begin{pmatrix} 1/\sqrt{2} \\ 0 \\ -1/\sqrt{2} \end{pmatrix} \\ \frac{5}{2}\hbar\omega_0 & \begin{pmatrix} 1/\sqrt{2} \\ 0 \\ 1/\sqrt{2} \end{pmatrix} \end{cases}$$

$$H = \begin{bmatrix} a & & 0 \\ & b & \\ 0 & & c \end{bmatrix}$$

$$H = \begin{bmatrix} a & 0 & d \\ 0 & b & 0 \\ d & 0 & a \end{bmatrix}$$

$$H = \begin{bmatrix} a & e & d \\ e & b & e \\ d & e & a \end{bmatrix}$$

Value of energy basis

$\Rightarrow$ spectrum observe in exp.
lab, astrophysical obs,
collision, etc.

$$\underbrace{i\hbar \frac{d}{dt}|\psi(t)\rangle = H}_{\text{time evol.}}|\psi(t)\rangle$$

time evol.

postulate 6.

H ← energy operator

$$H(t) = H$$

$$|\psi(t)\rangle = \sum_n c_n e^{-iE_n t/\hbar} |E_n\rangle$$

$$|\psi(t)\rangle = c_1 e^{-i\omega_0 t}|E_1\rangle + c_2 e^{-i\frac{3}{2}\omega_0 t}|E_2\rangle + c_3 e^{-i\frac{5}{2}\omega_0 t}|E_3\rangle$$

$$|E_1\rangle \doteq \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} \quad |E_2\rangle \doteq \begin{pmatrix} 1/\sqrt{2} \\ 0 \\ -1/\sqrt{2} \end{pmatrix}$$

$$|E_3\rangle \doteq \begin{pmatrix} 1/\sqrt{2} \\ 0 \\ 1/\sqrt{2} \end{pmatrix}$$

Probability measure E_3?

$$|\langle E_3 | \psi(t) \rangle|^2 = |c_3|^2$$

$$\langle E_m | E_n \rangle$$

Energy states are stationary states.