NO.

DATE

Dirac Notation

$\Psi(x,t) = C_x(t) = \langle x | S(t) \rangle$ $\qquad C_n(t) = \langle \underline{n} | S(t) \rangle$

nth eigenfunction of $\hat{H}$

$\Phi(p,t) = C_p(t) = \langle p | S(t) \rangle$

$\Psi(x,t) = \int \Psi(y,t)\,\delta(x-y)\,dy = \int \Phi(p,t) \frac{1}{\sqrt{2\pi\hbar}} e^{\frac{ipx}{\hbar}}\,dp = \sum_n C_n e^{-\frac{iE_n t}{\hbar}} \psi_n(x)$

$\hat{Q}|\alpha\rangle = |\beta\rangle$ $\quad , \sum_n b_n |e_n\rangle = \hat{Q} \sum_n a_n |e_n\rangle = \sum_n a_n \hat{Q} |e_n\rangle$ — ①

$|\alpha\rangle = \sum_n a_n |e_n\rangle$ $\qquad a_n = \langle e_n | \alpha \rangle$

$|\beta\rangle = \sum_n b_n |e_n\rangle$ $\qquad b_n = \langle e_n | \beta \rangle$

① $\Rightarrow \langle e_m | \sum_n b_n |e_n\rangle = \sum_n a_n \underbrace{\langle e_m | \hat{Q} | e_n \rangle}_{\text{matrix representation}}, \quad b_m = \sum_n Q_{mn} a_n$

Example : Two level

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DATE / /

$|\alpha\rangle\langle\alpha|$ is an operator projection operator $\hat{P}$

$|\alpha\rangle\langle\alpha|\beta\rangle = \underline{\langle\alpha|\beta\rangle|\alpha\rangle}$
vector

$|e_n\rangle\langle e_n|\alpha\rangle = \langle e_n\rangle\langle e_n \sum_m a_m|e_m\rangle = a_n|e_n\rangle$

$\sum_n |e_n\rangle\langle e_n|\alpha\rangle = \sum_n a_n|e_n\rangle = |\alpha\rangle \quad \because \sum_n |e_n\rangle\langle e_n| = 1 \Rightarrow$ the basis set is complete

for continuous spectram $\langle e_z|e_{z'}\rangle = \delta(z-z')$

$\int |e_z\rangle\langle e_z| dz \Rightarrow \int |e_z\rangle\langle e_z|\alpha\rangle dz = \int c_z|e_z\rangle dz = |\alpha\rangle$

$[\hat{A}, \hat{B}] = 0$ they can share the same set of eigenfunction

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