QM Ch 3-4 - Tues 10 Apr 2007 - E/Z
Physical Systems - Spring

3 Particle-wave duality: every photon is a wave that interferes with itself. (117)

Measurement ruins double-slit interference:
To detect x, need light of short $\lambda$ = high $p$ $\rightarrow$ changes $p$
State of given $p$ has well-defined $\lambda$ $\therefore$ spread out in $x$

4. Matrix elements in x basis of $X$ and $P$ operators: $\langle x|X|x'\rangle = x\,\delta(x-x')$
120 $\langle x|P|x'\rangle = -i\hbar\,\delta'(x-x')$
66 $= -i\hbar\,\delta(x-x')\frac{\partial}{\partial x}$
64 $\langle f|g\rangle = \int_{-\infty}^{\infty} f(x)\,g(x)\,dx$

Probability of measuring $\omega_i$ in state $\psi$ (normalized) is
(4.2.2) $P(\omega_i) = |\langle \omega_i|\psi\rangle|^2$ where $|\omega_i\rangle$ = eigenstate

123 If state in a superposition $|\psi\rangle = \alpha|\omega_1\rangle + \beta|\omega_2\rangle$
Then $P(\omega_1) = \alpha^2$ and $P(\omega_2) = \beta^2$

127 Components of $|\psi\rangle$ in the $X$ basis are $\psi(x) = \langle x|\psi\rangle$
126 Expansion $|\psi\rangle$ in the $|\omega\rangle$ basis: $|\psi\rangle = \int |\omega\rangle\langle\omega|\psi\rangle\,d\omega$
141 $\langle x|\psi\rangle = \psi(x)$ $\rightarrow$ $|\psi\rangle = \int |x\rangle \psi(x)\,dx$
133 Expectation value of $\Omega$ measurement: $\langle\Omega\rangle = \langle\psi|\Omega|\psi\rangle$

134 Uncertainty $\Delta\Omega = \left[\langle\Omega^2\rangle - \langle\Omega\rangle^2\right]^{1/2}$ = average fluctuation about the mean $\langle\Omega\rangle$

# QM Ch 4 - notes continued

p.137 If $[\Omega, \Lambda] \equiv (\Omega\Lambda - \Lambda\Omega) = 0$ then $\Omega$ and $\Lambda$ are INCOMPATIBLE and cannot both be measured at once. There exist no simultaneous eigenkets for incompatible operators.

p.144 Ex: $[X, P] = i\hbar \therefore \Delta X \Delta P \geq \hbar/2$

127, 142 $\langle x | \psi \rangle = \psi(x)$ = components of $|\psi\rangle$ in $\bar{X}$ basis

$\langle x | \bar{X} | \psi \rangle = x\,\psi(x)$

$\langle \bar{X} \rangle = \langle \psi | \bar{X} | \psi \rangle = \int \langle \psi | x \rangle \langle x | \bar{X} | \psi \rangle \, dx = \int \psi^*(x)\, x\, \psi(x)\, dx$

143 $\langle x | P | \psi \rangle = -i\hbar \frac{\partial \psi}{\partial x}$ = momentum operator on $\psi$ in x basis

157 $P^2/2m$ = momentum operator in p basis

$x$ = position operator in x basis

157 $i\hbar\, \partial/\partial p$ = " " in p basis

144 $\langle x | p \rangle = \psi_p(x)$

$\langle p | \psi \rangle$ = components of $|\psi\rangle$ in p basis

151 Schrödinger Equation $H|\psi(t)\rangle = i\hbar \frac{\partial}{\partial t} |\psi(t)\rangle$

where $H = \frac{P^2}{2m} + V(x)$ = Hamiltonian operator

152 $|\psi(t)\rangle = U(t)\,|\psi(0)\rangle$ where propagator $U(t) = e^{-iEt/\hbar}$

153 Normal modes = stationary states $|E(t)\rangle = |E\rangle e^{-iEt/\hbar}$

$H|E\rangle = E|E\rangle \rightarrow P(\omega, t) = P(\omega, 0)$: TIME-INDEPENDENT