Piazza!

weekly psets — due Friday midnight :)

Midterm	20%	→ maybe takehome?
Final	40%	→ " "
Psets	40%	

no discussion section
same TAs :)

Phys 234 & 234

① Postulates of QM, 2 state systems, entangled states (EPR)
→ go straight into it

② Schrödinger eqⁿ w/time, 1-D potentials

③ Sch eqⁿ in 3-D, Rotational invariance, spin & statistics, atomic structure

④ Approximation methods (perturbation theory)

Revisit w/new examples & sophistication

This course:

① 2-state systems (spin ½, Stern-Gerlach device)
entanglement (Bob + Alice + Chris +...) w/density matrices
GHZ state (extension of Bell's thm)
use entanglement to correct quantum errors

② 1-D systems (periodic potentials, band structure of solids)

③ QM + classical E & M — levitating frog!
$\vec{B} = \vec{\nabla} \times \vec{A}$ $\quad \vec{A} \to \vec{A} + \vec{\nabla}\Lambda$ → wtf? gauge invariance

④ Perturbation theory (maybe some time-dependence)

Two State Systems

Hilbert Space: $\mathcal{H} = \mathbb{C}^2$, 2-D orthonormal basis

$|+\rangle, |-\rangle$ $\quad \langle +|+\rangle = 1 = \langle -|-\rangle$
$|\uparrow\rangle, |\downarrow\rangle$ $\quad \langle +|-\rangle = 0$
$|0\rangle, |1\rangle$

$|\psi\rangle = \alpha|+\rangle + \beta|-\rangle \qquad \alpha, \beta \in \mathbb{C}$

$\langle\psi|\psi\rangle = 1 = \alpha^2 + \beta^2$
$= \alpha_1^2 + \alpha_2^2 + \beta_1^2 + \beta_2^2 = 1$

$\alpha = \alpha_1 + i\alpha_2$ (Real, imaginary)
$\beta = \beta_1 + i\beta_2$

eq^n for 3-sphere S^3

physical states described by rays, not vectors, in $\mathcal{H}$

$|\psi\rangle \cong e^{i\phi}|\psi\rangle \qquad \phi \in \mathbb{R}$

$|\psi\rangle = a|+\rangle + \beta|-\rangle$, $a \in \mathbb{R}$

$a^2 + \beta_1^2 + \beta_2^2 = 1$

S^2 Bloch Sphere

Postulates ... again

① State of QM system is described by ray $|\psi\rangle$ in Hilbert space

② Physical observables correspond to Hermitian operators $\mathcal{O}$

A measurement of $\mathcal{O}$ gives 1 of its eigenvalues λ_i w/prob. $|\langle\lambda_i|\psi\rangle|^2$

where $|\lambda_i\rangle$ is eigenstate w/eigenvalue λ_i: $\mathcal{O}|\lambda_i\rangle = \lambda_i|\lambda_i\rangle$

③ Immediately after measurement, system is in state $|\lambda_i\rangle$

④ States evolve w/time according to ... $i\hbar \frac{\partial}{\partial t}|\psi(t)\rangle = H|\psi(t)\rangle$ (Hamiltonian)

problems: measurement in ② isn't well defined

interaction w/classical system that is correlated but fr, classical is limit of QM

what about the measurer???

eigenstates in ② assumed as non-degenerate

talked about in last quarter

maybe don't know actual QM state

assign classical probabilities

④ says there are time evolutions but ⑤ talks about time as well