COURSE INFORMATION AND PROBLEM SET 1

Physics 215C- Quantum Mechanics, SPRING 2008

Course Website: http://leopard.physics.ucdavis.edu/rts/p215C/physics215C.html

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Office Hours: Mo, 1:00-2:00 pm.

Text: *Principles of Quantum Mechanics*, R. Shankar.

Grading:

5–6 Homework Sets due weekly: 60%.

Midterm Exam, Monday May 5, in class: 15%.

Final Exam, Thursday, June 12, 1:00-3:00 pm: 25%.

Problem Set 1 (Due Wednesday, April 9.)

1. A hydrogen atom is placed in a spatially uniform, time–dependent electric field,
$$\mathcal{E}(t) = \frac{B\tau}{e\sqrt{\pi}}\ \frac{1}{t^2+\tau^2},$$
where B and τ are constants. If at $t=-\infty$ the atom is in its ground state, calculate the probability that it will be in a $2p$ state at $t=+\infty$.

2. [UCSB Qualifying Exam, Winter, 1983] A system with unperturbed eigenstates $\phi_n(\vec{x})$ and energies E_n is subject to a perturbation,
$$H'(t) = \frac{A}{\sqrt{\pi}\tau}\ e^{-t^2/\tau^2},$$
where A is a time independent operator.
   a. If at $t=-\infty$ the system is in its ground state ϕ_0, show that, to first order, the probability amplitude that at $t=+\infty$ the system will be in its m–th excited state ($m \neq 0$) is,
   $$c_m(+\infty) = -i\frac{\langle m|A|0\rangle}{\hbar}e^{-\frac{\tau^2}{4\hbar^2}(E_0-E_m)^2}.$$
   b. Next consider the limit of an impulsive perturbation $\tau = 0$ and compute the probability that the system makes any transition out of its ground state.

3. Consider a $d=1$ harmonic oscillator of mass m, frequency ω_0 and charge q. Let $|\phi_n\rangle$ and $E_n = (n+\frac{1}{2})\hbar\omega_0$ be the eigenstates and eigenvalues of its Hamiltonian H_0. For $t<0$, the oscillator is in the ground state $|\phi_0\rangle$. At $t=0$ it is subjected to an electric field "pulse" of duration τ:
$$\begin{aligned} W(t) &= -q\mathcal{E}X & \quad 0 \le t \le \tau \\ W(t) &= 0 & \quad t<0 \ \text{ and } \ t>\tau. \end{aligned}$$
$\mathcal{E}$ is the field amplitude and X is the position operator. Let $\mathcal{P}_{0n}$ be the probability of finding the oscillator in the state $|\phi_n\rangle$ after the pulse.

   Calculate $\mathcal{P}_{01}$ using first-order time dependent perturbation theory. How does $\mathcal{P}_{01}$ vary with τ for fixed ω_0?