QUANTUM MECHANICS III

PHYS 518

Problem Set # 5

Distributed: November 14, 2008

Due: November 21, 2008

1. Fermi's Golden Rule: Compute the lifetime of the hydrogen state $|nlm_l\rangle$ with saturated quantum numbers: $l = n - 1$ and $m_l = \pm l$.

2. Phases and Time Dependent Perturbation Theory: A harmonic oscillator is in its ground state for $t < 0$ and is perturbed by an electric dipole forcing term with hamiltonian $H_1(t) = -eExf(t)$, with $f(t) = 0$, $t < 0$ and $f(t) = e^{-t/\tau}$ for $t \geq 0$. For convenience, use $x = \sqrt{\frac{\hbar}{2m\omega}}(a^\dagger + a)$.

a. Compute the amplitude for the transition $|0\rangle \rightarrow |1\rangle$ to third order in TD perturbation theory. Make sure you get the phases correct.

b. Compare your answer with the correct answer, obtained by summing all terms to infinity: $c_{|n\rangle \leftarrow |0\rangle}(t \rightarrow \infty) = e^D c^n/\sqrt{n!}$ with $D = -\frac{g^2}{(\gamma + i\omega)(2\gamma)}$ and $c = \frac{-ig}{(\gamma - i\omega)}$ where $g = -eE/\sqrt{2m\hbar\omega}$.