Physics 125b

Problem Set 3, Due Wednesday Jan. 31, 2018

Problem 1

A particle of mass m moves in one dimension and has the Hamiltonian,

$$H(t) = \frac{p^2}{2m} + \frac{1}{2}m\omega(t)^2x^2 \tag{1}$$

where

$$\omega(t)^2 = \omega_0^2\left[1 + \varepsilon\sin\left(\frac{\pi t}{T}\right)\right]. \tag{2}$$

The dimensionless parameter $|\varepsilon| \ll 1$. Assume that at the initial time $t = 0$ the particle is in the groundstate of $H(0)$. Derive an expression for the probability that at the later time T the particle is in an excited energy eigenstate of $H(T)$. Use first order time dependent perturbation theory.

Problem 2

Consider a particle with charge q and mass m in the ground state of the spherically symmetric potential

$$V(r) = \frac{1}{2}m\omega^2(r^2 - r_0^2) \text{ for } r < r_0 \text{ and } V(r) = 0 \text{ for } r > r_0.$$

Derive and expression for the probability that an incident electromagnetic wave $\vec{A}(\vec{r}, t) = \vec{A}_0\cos(\vec{k}\cdot\vec{r} - \omega t)$ pops the particle out of the potential well. Approximate the ground state as the harmonic oscillator ground state and then make the same assumptions and approximations as when we discussed the ionization of the hydrogen atom by an incident electromagnetic wave in class.