Physics 137B, Fall 2007

**Problem set 6**: more on methods for time-dependent problems

Assigned Friday, 12 October. Due in box Friday, 19 October.

1. For $t < 0$ a spinless particle is in the ground state of a potential “box” with $V = 0$ from $x = 0$ to $x = L$, and $V = \infty$ elsewhere. The wavefunction is

$$\psi(t) = \sqrt{\frac{2}{L}} e^{-iE_0 t/\hbar} \sin(\pi x/L). \quad (1)$$

At $t = 0$ the potential suddenly changes from the box potential to a harmonic oscillator potential centered on $x = L/2$: now the Hamiltonian is

$$H = \frac{p^2}{2m} + k(x - L/2)^2/2. \quad (2)$$

For time $t > 0$, find using the sudden approximation (a) the probability that the particle is in the ground state, and (b) the probability that the particle is in the first excited state. Is either of these nonzero? You may leave any nonzero answer in the form of an integral.

2. Bransden 9.4. The point of this problem is to make you work through the example of a two-level system with constant perturbation using our equations for the time dependence of the $c$ coefficients, rather than by solving the two-level Hamiltonian and using the sudden approximation.


4. Put numbers into the Golden Rule,

$$W_{ba} = \frac{2\pi}{\hbar} |H'_{ba}|^2 \rho_b(E), \quad (3)$$

to find the rate of a process in units of $(\text{seconds})^{-1}$ with matrix element $|H'_{ba}|^2 = (1 \text{ eV})^2$ and density of states $\rho_b(E) = (1 \text{ eV})^{-1}$. Suppose that this process describes a decay from state $a$ to state $b$, and state $b$ is stable. If originally a very large number $N$ atoms are in state $a$, at what time will only one percent ($N/100$) of the atoms still be left in state $a$?