PHYS 452: Quantum Mechanics II (Spring 2015)
Homework #5, due Thursday March 19, in class

1. A flat quantum rotor (i.e. rotor constrained in xy plane) that has moment of inertia I and dipole moment d (in xy plane) is placed in a uniform electric field

$$\mathcal{E}(t) = \begin{cases} \mathcal{E}_0 e^{-t/\tau}, & t \geq 0 \\ 0, & t < 0 \end{cases}$$

where $\mathcal{E}_0$ and τ are some constants. Before the field gets turned on, the rotator is in a state with a definite projection of the angular momentum, m. What are the probabilities of various values of the angular momentum and energies at $t = +\infty$? Under what conditions the results you obtained are applicable?

2. Find the probability of the hydrogen atom to have made a transition from the ground to the $2s$ and $2p$ states when it is placed in a uniform electric field with the same pulse profile as in the previous problem. How small $\mathcal{E}_0$ should be for the calculations to be valid?

3. Consider a quantum harmonic oscillator, initially in the ground state. It is subject to the time-dependent perturbation in the form

$$H'(x,t) = -e\mathcal{E}x \exp(-t^2/\tau^2)$$

which is the same as was in the example at the end of lecture #16. Here, e is the elementary charge, $\mathcal{E}$ is the magnitude of the uniform electric field (we assume it to be small), and τ is a constant that defines the pulse duration. Find the probability of transition from the ground state, $|0\rangle$, to the *second* excited state, $|2\rangle$, at $t = +\infty$. Note that this problem demands consideration of the second order of the perturbation theory.

4. Problem 9.7 in Griffiths.

Found an error or need a clarification? Email the instructor at sergiy.bubin@nu.edu.kz