PHYS 452: Quantum Mechanics II (Spring 2015)
Homework #6, due Tuesday April 14, in class

1. Consider an attractive delta-function potential, $V(x) = -\alpha\delta(x)$. As we know from the first semester it allows for a single bound state that has energy $E_{\text{bound}} = -\frac{m\alpha^2}{2\hbar^2}$, where m is the mass of the particle. Now using Fermi's golden rule consider the rates of transition from this bound state to excited state in the continuum.

   (a) Find the eigenfunctions belonging to the continuous spectrum.

   (b) Determine which transitions will be allowed.

   (c) Compute the density of states as a function of E.

   (d) Find what transition is going to occur more rapidly and by how much: to the one whose energy is $E = |E_{\text{bound}}|$ or the one corresponding to $E = 2|E_{\text{bound}}|$. In both cases the initial state, $|i\rangle$, is the bound state.

2. Problem 11.4 in Griffiths.

3. Problem 11.6 in Griffiths.

4. Using the first Born approximation compute the scattering amplitude of the following attractive potentials:

   (a) $V(r) = -\alpha\frac{e^{-\mu r}}{r}$

   (b) $V(r) = -\frac{\alpha}{r}$

   where α and μ are positive constans. Note that in the second case we can just use the first result and take the limit $\mu \to 0$ (in fact, direct evaluation without this trick might be problematic). In the case of the pure Coulomb potential compare your expression for the differential cross section, $\frac{d\sigma}{d\Omega}$, with the classical result, $\frac{d\sigma}{d\Omega} = \frac{\alpha^2}{16E^2\sin^4(\theta/2)}$

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