661, Spring 2016, Homework II, (3 problems)

Problem 1

Using the National Nuclear Data Center webpage find six different isotopes of Thorium that decay by emitting alpha radiation. Consider their mean-life $\tau_{1/2}$ and the energy E_α of the corresponding α–particle. Plot $\ln(\tau_{1/2})$ as a function of $\frac{1}{\sqrt{E_\alpha}}$. Compare with the prediction from WKB.

Problem 2

Consider the $|nlm\rangle$ states of the hydrogen atom, ignoring the spin. Which of the following matrix elements vanish due to **parity**, **total angular momentum** and $\mathbf{L_z}$ selection rules? Explain the arguments you use.

Matrix Element	Π	L^2	L_z
$\langle n', \ell = 1, m = 0 \vert\ z\ \vert n, \ell = 2, m = 0\rangle$			
$\langle n', \ell = 1, m = 0 \vert\ zy^2\ \vert n, \ell = 2, m = 1\rangle$			
$\langle n', \ell = 4, m = 0 \vert\ p_z x\ \vert n, \ell = 0, m = 0\rangle$			
$\langle n', \ell = 3, m = 0 \vert\ p_x^2\ \vert n, \ell = 0, m = 0\rangle$			
$\langle n', \ell = 2, m = 1 \vert\ x p_y\ \vert n, \ell = 1, m = 0\rangle$			

Problem 3

Stark effect.

Consider a hydrogen atom in an electric field such that there is an extra potential energy

$$V = ez|\vec{E}|$$

In the previous homework you studied the polarization induced on the ground state by such an electric field. In this problem, consider instead the second energy level (states $2s, 2p$, four states in total). Show that, in this case, there is a first order correction to the energy. Compute the spectrum at this order and the polarization of each eigenstate of energy. Does the atom have a finite polarization for very small $\vec{E} \to 0$?. How does that compare with the situation for the ground state?