1. Calculate the degeneracy (i.e. the number of levels which have this energy) of the hydrogen-like (H-like) ion level with energy (in atomic units)

\[ E_n = -\frac{Z^2}{2n^2}. \]

2. Prove that the transformation of the spherical harmonics \( Y_{lm}(\theta, \phi) \) under the parity operator \( P \) is given by \( P(Y_{lm}(\theta, \phi)) = (-1)^l Y_{lm}(\theta, \phi) \).

3. The tritium atom which is in its ground state suddenly decays to helium which is then ionized as the electron from the decay leaves the atom without disturbing the interbound electron. Thus, He\(^+\) ion is left. What is the probability to find this He\(^+\) ion in the 2s state? What nuclear decay occurred?

**Hint:** If the state wave function \( \psi(r) \) is in superposition of basis set states \( u_k(r) \)

\[ \psi(r) = \sum_k c_k u_k(r) \]

the coefficients \( c_k \) are given by

\[ c_k = \int d^3r u_k^* \psi(r). \]

The hydrogenic wave functions are given in “Lectures on Atomic Physics”.

4. Calculate transition energy between \( n=1 \) and \( n=2 \) states of muonium and the corresponding wavelength of the transition. Express wavelength in nm or Å.

5. What is the probability of finding electron in H-like potassium (\(^{41}\)K) inside the nucleus? The electron is in the ground state (1s). The nuclear radius can be estimated from the formula \( R=1.2A^{1/3} \) fm.

6. In problem 5, consider system with muon instead of electron, i.e. (\( \Lambda\mu \)) where \( \Lambda \) is \(^{41}\)K nucleus. What is the probability to find muon inside the nucleus?

7. Calculate \([H, P]\), where \( P \) is a parity operator and \( H \) is a Hamiltonian for spherically symmetric potential. What physical law is a consequence of the result? Why?