

Modern Physics

Tutorial 10
Quantum Mechanics and Nuclear Physics
LUMS School of Science and Engineering

November 21, 2012

1 3-D Harmonic Oscillator

Consider an anisotropic three-dimensional harmonic oscillator potential

$$V(x, y, z) = \frac{1}{2}m(\omega_x x^2 + \omega_y y^2 + \omega_z z^2). \quad (1)$$

- Write the Hamiltonian operator of the system.
- Evaluate the energy levels in terms of ω_x , ω_y , and ω_z .
- Find the three lowest levels for the case $\omega_x = \omega_y = \omega_z$, and determine the degeneracy of each level.
- Find the three lowest levels for the case $\omega_x = \omega_y = \frac{2}{3}\omega_z$, and determine the degeneracy of each level.

2 Three Independent Harmonic Oscillator

Consider the system of three independent harmonic oscillator each of mass m with angular frequency ω_1 , ω_2 , ω_3 .

- Write the Hamiltonian operator of the system.
- Evaluate the energy levels in terms of ω_1 , ω_2 , and ω_3 .
- Find the three lowest levels for the case $\omega_1 = \omega_2 = \omega_3$, and determine the degeneracy of each level.
- Find the three lowest levels for the case $\omega_1 = \omega_2 = \frac{2}{3}\omega_3$, and determine the degeneracy of each level.

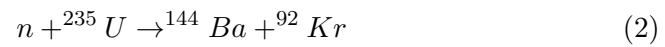
3 Pauli Exclusion Principle

Consider a system of eight identical particles in a cubical box of length L . Find the lowest energy of the system if

- a) particles are electrons,
- b) particles have equal to that of the mass of electron but they are not fermions.

4 Binding Energy

Consider the fission reaction



Given that the masses of the isotopes ${}^{235}\text{U}$, ${}^{144}\text{Ba}$, ${}^{92}\text{Kr}$ are 235.04394u, 143.92285u, 91.92627u, respectively, calculate the energy released in this reaction.