Modern Physics

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

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1 3-D Harmonic Oscillator

Consider an anisotropic three-dimensional harmonic oscilator potential

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

a) Write the Hamiltonian operator of the system.

b) Evaluate the energy levels in terms of ω_x, ω_y, and ω_z.

c) Find the three lowest levels for the case $\omega_x = \omega_y = \omega_z$, and determine the degeneracy of each level.

d) 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 w_1, w_2, w_3.

a) Write the Hamiltonian operator of the system.

b) Evaluate the energy levels in terms of ω_1, ω_2, and ω_3.

c) Find the three lowest levels for the case $\omega_1 = \omega_2 = \omega_3$, and determine the degeneracy of each level.

d) 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

$$n + {}^{235}U \rightarrow {}^{144}Ba + {}^{92}Kr \tag{2}$$

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