Physics 472 - 2020

Quantum Mechanics

Problem Set 2

1. Using the uncertainty relation, obtain an estimate of the minimal energy of a particle in a parabolic potential; the Hamiltonian is

$$H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2 x^2.$$

2. Use the expressions for $\partial/\partial\theta$ and $\partial/\partial\phi$ in terms of $\partial/\partial x, \partial/\partial y, \partial/\partial z$ to derive the expression for $L_\pm$. Show that $L_-(\sin\theta)^l e^{-il\phi} = 0$

3. Using the expressions for $L_\pm$ and L_z, find the operator L^2 in terms of the derivatives over θ, ϕ.

4. A thin uniform doughnut or radius R that carries a charge Q and has a mass M, rotates in its plane about its axis (you can also think of a point charge rotating along the orbit of radius R, and uniformly "smear" the charge along the orbit). The angular momentum of the doughnut is L. Find the magnetic dipole moment. Find the ratio of the magnetic dipole moment to the angular momentum (the **gyromagnetic ratio**).

Each problem is 10 pt.