Quantum Mechanics II - Module 5

Hydrogen Atom

Assume that ψ_{nlm} denotes an eigenfunction of the hydrogen atom with principal quantum number n, and angular momentum quantum numbers l and m. Let the hydrogen atom be in a state described by the wave function

$$\psi(\mathbf{r}) = C \left(4\psi_{100}(\mathbf{r}) + 3\psi_{211}(\mathbf{r}) - 4\psi_{210}(\mathbf{r}) + \sqrt{10}\psi_{21-1}(\mathbf{r}) \right).$$

- 1. Find a normalization constant C.
- 2. What is the expectation value of the energy?
- 3. What is the expectation value of L^2 ?
- 4. What is the expectation value of L_z ?
- 5. Write down $\psi(\mathbf{r}, t)$ at some later time t.

Expansion in Terms of Angular Momentum Eigenstates

At a given instant in time the angular wavefunction of a system is given by

$$Y(\theta, \phi) = \sqrt{\frac{3}{4\pi}} \sin \theta \sin \phi.$$

- 1. What possible values of L_z will be found in a measurement, and with what probabilities will they occur?
- 2. What is $\langle L_z \rangle$ for this state?
- 3. What is $\langle L^2 \rangle$ for this state?