**Central Forces Homework 10**

*Due 6/9/17, 4 pm*

**For every problem**, before you start the problem, make a brief statement of the form that a correct solution should have, clearly indicating what quantities you need to solve for. This statement will be graded.

**PRACTICE:**

1. (McIntyre 8.6) Calculate the probability that the electron is measured to be within one Bohr radius of the nucleus for the $n = 2$ states of hydrogen. Discuss the differences between the results for the $l = 0$ and $l = 1$ states.

2. Consider the initial state $\frac{1}{\sqrt{2}}(|1, 0, 0\rangle + |2, 1, 0\rangle)$. Note, this is **not** an *sp* hybrid orbital such as occurs in chemistry in the study of molecular bonding.

   (a) If you measure the energy of this state, what possible values could you obtain?

   (b) What is this state as a function of time?

   (c) Calculate the expectation value $\langle \hat{L}^2 \rangle$ in this state, as a function of time. Did you expect this answer? Comment.

   (d) Write the time-dependent state in wave function notation.

   (e) Calculate the expectation value $\langle \hat{z} \rangle$ as a function of time. Do you expect this answer?

3. Complete the attached table for the hydrogen atom.

**REQUIRED:**

4. McIntyre 8.14

5. (McIntyre 8.7) Calculate the probability that the electron is measured to be in the classically forbidden region for the $n = 2$ states of hydrogen. Discuss the differences between the results for the $l = -1$ and $l = 1$ states.

# Hydrogen Atom

| | **Ket Representation** | **Wave Function Representation** | **Matrix Representation** |
|---|---|---|---|
| Hamiltonian | | | |
| Eigenvalues of Hamiltonian | | | |
| Normalized Eigenstates of Hamiltonian | | | |
| Coefficient of the energy eigenstate with quantum numbers $n, \ell, m$ | | | |
| Probability of measuring $E_n$ | | | |

# Hydrogen Atom

| | **Ket Representation** | **Wave Function Representation** | **Matrix Representation** |
|---|---|---|---|
| Operator for square of the angular momentum | | | |
| Eigenvalues of $L^2$ | | | |
| Normalized Eigenstates of $L^2$ | | | |
| Coefficient of the eigenstates of $L^2$ with quantum numbers $n, \ell, m$ | | | |
| Probability of measuring $\hbar^2 \ell(\ell+1)$ for the square of the angular momentum | | | |

# Hydrogen Atom

| | **Ket Representation** | **Wave Function Representation** | **Matrix Representation** |
|---|---|---|---|
| Operator for z-component of angular momentum | | | |
| Eigenvalues of $L_z$ | | | |
| Normalized Eigenstates of $L_z$ | | | |
| Coefficient of $m^{th}$ eigenstates of $L_z$ | | | |
| Probability of measuring $m\hbar$ for $z$-component of angular momentum | | | |