Quantum Mechanics Assignment

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October 2020

1. Normalize the function $R_{21}(r) = \frac{C_0}{4a^2} r e^{\frac{-r}{2a}}$ and construct the wavefunction $\psi_{211}, \psi_{210}, \psi_{21-1}$

2. Find the $\langle$r$\rangle$ and $\langle r^2 \rangle$ for an electron in the ground state of hydrogen.Express your answers in terms of the Bohr radius.

3. A hydrogen atom at $t = 0$ is in the following linear combination of stationary states n=2, l=1, m=1 and n=2, l=1, m=-1:
   $\psi(r, 0) = \frac{1}{\sqrt{2}}(\psi_{211} + \psi_{21-1})$. Construct $\psi(r, t)$. Find the expectation value of the potential energy $\langle V \rangle$.

4. Prove the following commutator relations.
   (1) $[L_z, x] = i\hbar y$,
   (2) $[L_z, p_x] = i\hbar p_y$,
   (3) $[L_z, p_y] = -i\hbar p_x$

5. Show that the Pauli spin matrices satisfy the product rule,
   $\sigma_j \sigma_k = \delta_{jk} + i \sum \epsilon_{jkl} \sigma_l$ (The summation is over l).

6. An electron is in a spin state $\chi = A \begin{pmatrix} 3i \\ 4 \end{pmatrix}$.

   1) determine the normalization constant A.
   2) Find the expectation value of $S_x, S_y, and S_z$.

7. Refer to example 4.3 of Griffiths and compute problem 4.32.

8. An electron is at rest in an oscillating magnetic field $\mathbf{B} = B_0 cos(\omega t)\hat{k}$, where B_0 and ω are constants.

   (i) Fine the hamiltonian of the system.
   (ii) Find the probablity of getting $-\hbar/2$, if you measure S_x.

9. With the given function, $Y_2^1(\theta, \phi) = -\sqrt{\frac{15}{8\pi}} \sin\theta \cos\theta e^{i\phi}$. Find $Y_2^2(\theta, \phi)$ and the normalization constant.

10. Solve Ques. 4.21 part (b) from griffiths book.
11. Problem 4.24, both the parts from griffiths book.
12. Solve Ques,4.9 from griffiths book.