231B: Angular momentum and hydrogenic atoms

Quiz 2', Winter 2020
(Dated: February 2, 2020)

1. Find $\langle 2|p|1\rangle$ for a harmonic oscillator.

   $i\sqrt{\omega}$

2. For a particle on a ring of radius 2, write down a normalized first excited state wavefunction.

   $\frac{e^{i\phi}}{\sqrt{2\pi}}$

3. What is the eigenvalue of L^2 of $Y_2^{-1}(\theta,\phi)$?

   6

4. Repeat previous problem for L_z.

   $-\hbar$

5. What is $[L_y^2 + L_x^2, L_z]$?

   0

6. What is $\langle 2,1|L_x|2,2\rangle$?

   1

7. What is the transition frequency between the ground and second excited states in He^+?

   3/2 Hartree

8. The usual sequence of atomic orbitals is s, p, d, and f. If the next set is g orbitals, what is the degeneracy of the first hydrogenic level that has g-orbitals?

   Degeneracy of 0

9. Knowing $E_0 = -Z^2/2$ for the hydrogenic atom, deduce T_0, the expectation value of the kinetic energy.

   $\frac{Z^2}{2}$

10. If $\hat{H} = \hat{T} + \lambda\hat{V}$, and $E(\lambda) = 2\lambda^2$, what is $\langle V\rangle$ at $\lambda = 1$?

    V = 4