1 Eigenvalues for Different Systems

(2, 4 pts)

(a) Fill in the following table with the appropriate eigenvalues for each operator for each system.

	$\vert m\rangle$ particle on a ring	$\vert \ell, m\rangle$ particle on a sphere	$\vert n, \ell, m\rangle$ Hydrogen atom
L_z			
L^2			
H			

(b) Write the Hamiltonian for each of the following systems explicitly in the position representation (i.e., differential operators).

	$\vert m\rangle$ particle on a ring	$\vert \ell, m\rangle$ particle on a sphere	$\vert n, \ell, m\rangle$ Hydrogen atom
H			

2 Hydrogen Atom Representation Matching

(10 pts) The last page contains 5 different representations for 3 different Hydrogen states. There are wave functions (orbitals) of the hydrogen atom plots, Radial Function Probability Density Plots, Spherical Harmonic Plots, Wavefunctions, and Kets. Your task is match all of the different representations of each state. (You should have 3 groups, each with 5 letters). Please give some short reasoning on how each piece is connected to at least one other piece in the group.

3 SP not Hybrid

(2, 2, 2, 2, 4 pts)

A hydrogen atom is initially in the state $|\Psi(t=0)\rangle = \frac{1}{\sqrt{2}}\left(|1,0,0\rangle + |2,1,0\rangle\right)$.

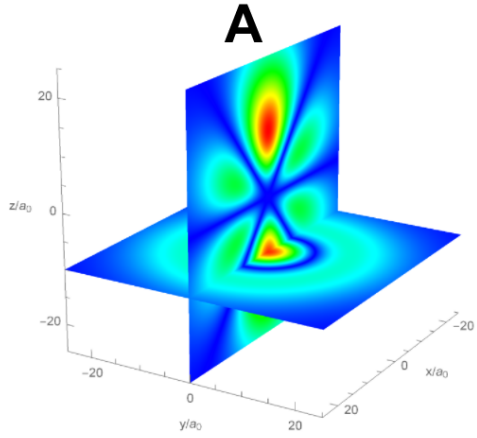
(a) If you measure the energy of this state, what possible values could you obtain?

(b) What is $|\Psi(t)\rangle$, where $t > 0$?

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

(d) Write $|\Psi(t)\rangle$ in wave function notation.

A



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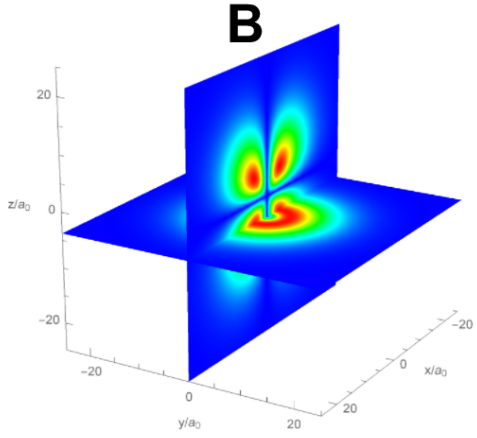

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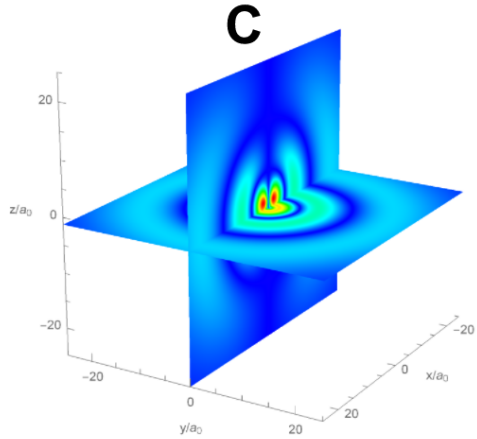

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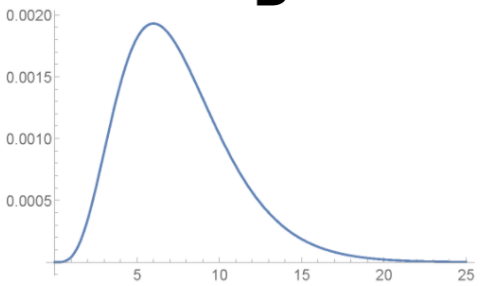

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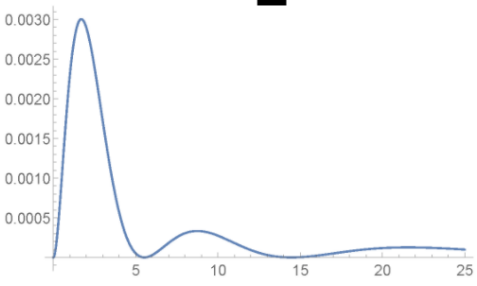

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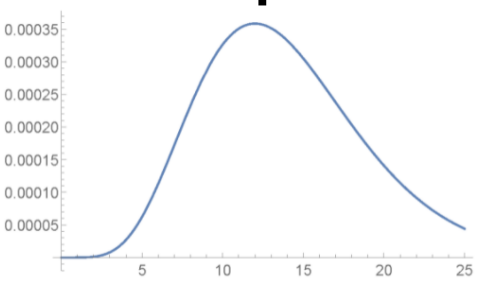
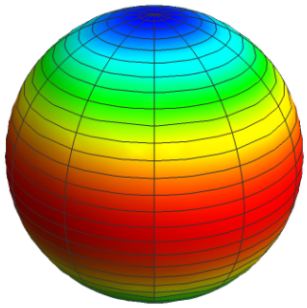
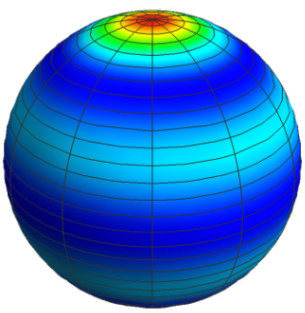


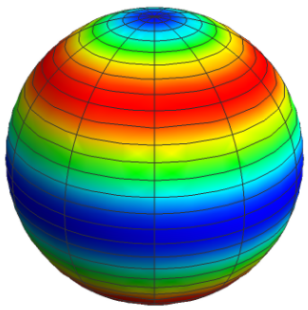
G



H



I



J $\left(\frac{2\sqrt{2}}{81\sqrt{15a_o^7}}\ r^2 e^{\frac{-r}{3a_o}}\right)\left(\sqrt{\frac{15}{8\pi}}\sin\theta\cos\theta e^{-i\phi}\right)$

K $\left(\frac{1}{768\sqrt{35a_o^9}}\ r^3 e^{\frac{-r}{4a_o}}\right)\left(\sqrt{\frac{7}{16\pi}}\left(5\cos^3\theta-3\cos\theta\right)\right)$

L $\left(\frac{\sqrt{5}}{16\sqrt{3a_o^5}}\left(r-\frac{r^2}{4a_o}+\frac{r^3}{80a_o^2}\right)e^{\frac{-r}{4a_o}}\right)\left(-\sqrt{\frac{3}{8\pi}}\sin\theta e^{i\phi}\right)$

M $|4\ 1\ 1\rangle$

N $|3\ 2\ -1\rangle$

O $|4\ 3\ 0\rangle$