Phys 402
Fall 2022
Homework 4
Due Wednesday, 28 September @ 10 AM as a PDF upload to ELMS

1. Starting with the definition of $J^2 = (\vec{L} + \vec{S}) \cdot (\vec{L} + \vec{S})$, show through explicit calculation that it can be written as $J^2 = L^2 + S^2 + 2L_zS_z + L_+S_- + L_-S_+$, utilizing the raising and lowering operators $L_\pm = L_x \pm iL_y$, and $S_\pm = S_x \pm iS_y$.

2. Griffiths and Schroeter *Quantum Mechanics*, 3rd Ed., Problem 4.38 (Combining spin-1/2 particles into composite particles)

3. Griffiths and Schroeter *Quantum Mechanics*, 3rd Ed., Problem 4.40 (More C-G!)

4. Griffiths and Schroeter *Quantum Mechanics*, 3rd Ed., Problem 7.4 (General two-level system perturbation theory)

5. Griffiths and Schroeter *Quantum Mechanics*, 3rd Ed., Problem 7.21 (Splitting of the Balmer Hα line due to spin-orbit interaction)

6. Griffiths and Schroeter *Quantum Mechanics*, 3rd Ed., Problem 7.42 (Using the Feynman-Hellmann theorem to find $\langle\frac{1}{r}\rangle$ and $\langle\frac{1}{r^2}\rangle$ for Hydrogen)

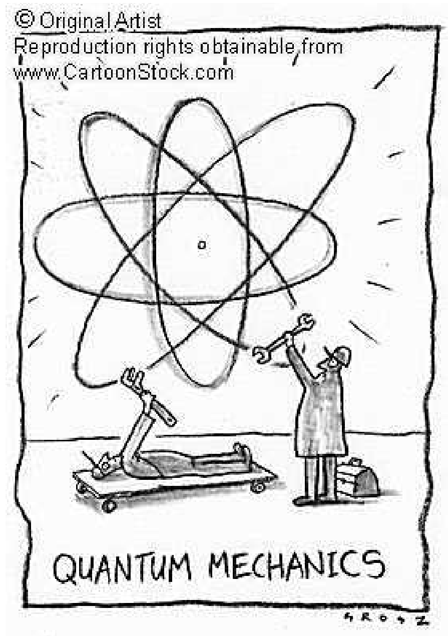
7. Griffiths and Schroeter *Quantum Mechanics*, 3rd Ed., Problem 7.45 (Stark Effect degenerate perturbation theory.) For part (b), don't do any of the integrals, just use this result for the W-matrix (i.e. the perturbing Hamiltonian matrix elements between the degenerate eigenstates):

$$\bar{\bar{W}} = \begin{pmatrix} 0 & 0 & -3eaE_{ext} & 0 \\ 0 & 0 & 0 & 0 \\ -3eaE_{ext} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix},$$

where the rows and columns are in the order of $|200\rangle, |211\rangle, |210\rangle, |21-1\rangle$. For part (c), you DO NOT need to calculate the electric dipole moments of the states!

EXTRA CREDIT

4. Griffiths and Schroeter *Quantum Mechanics*, 3rd Ed., Problem 7.48 (Crystal field splitting)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