# Phys 402
# Fall 2022
# Homework 5
# Due Wednesday, 5 October @ 10 AM as a PDF upload to ELMS

**1**. Griffiths and Schroeter *Quantum Mechanics*, 3rd Ed., Problem 7.52 (Degenerate perturbation theory for a two-dimensional charged harmonic oscillator in a magnetic field. *Hint: To solve the TISE try separation of variables:* $\psi(x,y) = X(x)Y(y)$. *Also, make use of Section 7.2.1 – Two-fold Degeneracy, starting on page 286 of Griffiths.*)

**2**. Estimate the size of the internal magnetic field in the Hydrogen atom. Start with Griffiths Eq. [7.60] and use the Bohr radius $a$ as an estimate of $r$, and $\hbar$ as an estimate for $|\vec{L}|$. Express your answer in Tesla and compare to the earth's magnetic field which is about 50 μT.

**3**. Griffiths and Schroeter *Quantum Mechanics*, 3rd Ed., Problem 7.24 (*Weak* Zeeman splitting for the H-atom n = 2 states)

**4**. Griffiths and Schroeter *Quantum Mechanics*, 3rd Ed., Problem 7.27 (*Strong* Zeeman effect for the H-atom n = 2 states)

**5**. Griffiths and Schroeter *Quantum Mechanics*, 3rd Ed., Problem 7.47 (Hyperfine splitting in Deuterium)

**6**. Consider the Schrodinger equation for the un-perturbed Helium atom, which is that of the two electrons independently orbiting the same nucleus:

$$\mathrm{H}^0 = -\frac{\hbar^2}{2m}\nabla_1^2 + \frac{(-e)(+2e)}{4\pi\varepsilon_0 r_1} - \frac{\hbar^2}{2m}\nabla_2^2 + \frac{(-e)(+2e)}{4\pi\varepsilon_0 r_2},$$

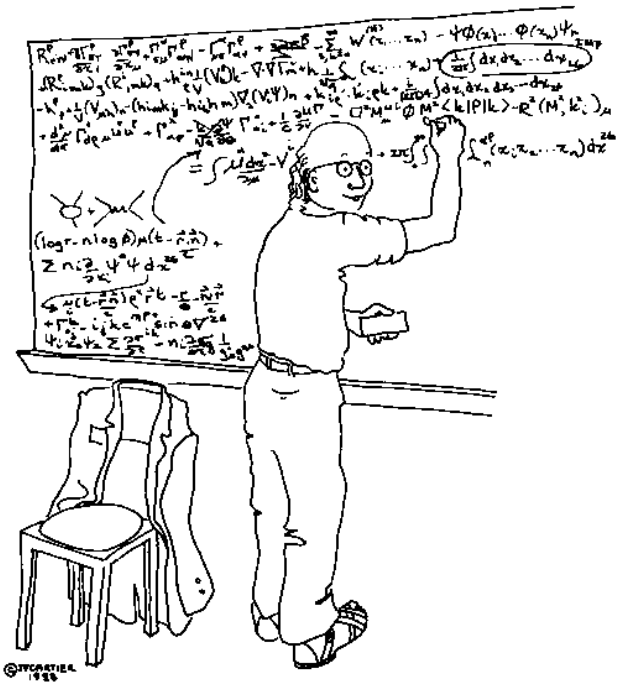
where the Laplacian operators only operate on the spherical coordinates of either electron 1 or electron 2. Note that the electrons are identical, they have exactly the same mass and charge. The solution to the un-perturbed Schrödinger equation is a wavefunction that depends on 6 coordinates:

$$\mathrm{H}^0\Psi^0 = E_T\Psi^0$$

where $\Psi^0 = \Psi^0(r_1,\theta_1,\phi_1,r_2,\theta_2,\phi_2)$. To proceed, we try an ansatz which we believe will lead to separation of variables as $\Psi^0(r_1,\theta_1,\phi_1,r_2,\theta_2,\phi_2) = \psi_a(1)\psi_b(2)$ where "1" and "2" represent all of the coordinates of electrons 1 and 2, respectively, and "$a$" and "$b$" are different lists of quantum numbers, in general. Show that this leads to two Schrodinger equations, one for each electron, with the constraint that $E_T = E_a + E_b$.

EXTRA CREDIT

**5**. Griffiths and Schroeter *Quantum Mechanics*, 3rd Ed., Problem 5.35 (Degeneracy pressure in white dwarfs)



*"At this point we notice that this equation is beautifully simplified if we assume that space–time has 92 dimensions."*