Homework Set #1

Due Date: Before class Friday January 25th

1) You   *(2 points)*

   (a) What is your major/minor ?

   (b) When do you plan on graduating?

   (c) What do you want to do after graduation ? (eg: grad school ? if so, what subject ? if not, what industry?)

   (d) What do you most want to get out of this course ?

2) Solid State Physics   *(5 points)*

   (a) Assume a solid is composed of closely packed atoms. What is the spacing between atoms? Express your result in terms of α, α_G, m_{proton}, and m_{electron}.

   (b) If you wanted to study the crystal structure of a solid material with $Z \sim 10$ using light, what wavelength of photons would you need ? Express your result in terms of α, α_G, m_{proton}, and m_{electron}.

   (c) Where in the spectrum of EM radiation do these photons lie?

3) Strength of Gravity on Earth   *(5 points)*

   (a) Calculate the local strength of gravity g_{local} in terms of α, α_G, m_{proton}, and m_{electron}.

   (b) What is your estimated value in mks units ?

   (c) How does this compare with the well-known value of 9.8 m/s^2 ?

4) Neutron Stars   *(5 points)*

   (a) Estimate the radius, mass, and speed of sound for neutron stars in terms of α, α_G, m_{proton}, and m_{electron}. (Assume: A neutron star is a solid made of neutrons and $m_{\text{proton}} \sim m_{\text{neutron}}$)

   (b) What are you estimated values in mks units ?

   (c) Compare your estimates to actual values for Neutron Stars quoted online.

   (d) Look up m_{neutron}. How does this compare with the assumption of $m_{\text{proton}} \sim m_{\text{neutron}}$?

5) 2D Rotations   *(3 points)*

(a) Show that $R(\Theta) = e^{I\Theta} = cos(\Theta) + I sin(\Theta)$ where, $I = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$

6) 3D Rotations   *(5 points)*

(a) Work out the "algebra" of the generators of 3D rotations J_i.

Where $J_3 = \begin{bmatrix} 0 & -i & 0 \\ i & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$,
$\qquad\qquad J_2 = \begin{bmatrix} 0 & 0 & -i \\ 0 & 0 & 0 \\ i & 0 & 0 \end{bmatrix}$
$\qquad\qquad J_1 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -i \\ 0 & i & 0 \end{bmatrix}$

(These generators different from the T's derived in class by a factor of i)
Working out the algebra means calculating the commutation relations $[J_i, J_j]$.

(b) Let M be a traceless 2×2 hermitian matrix and U be a 2×2 hermitian matrix with determinant = 1. Show that $M' = U^\dagger M U$ is also traceless and hermitian and that is has the same determinant as M.