Homework # 1; due Thursday, Sept. 9

Reading: Chapters 1,2 of Griffiths, Wikipedia.

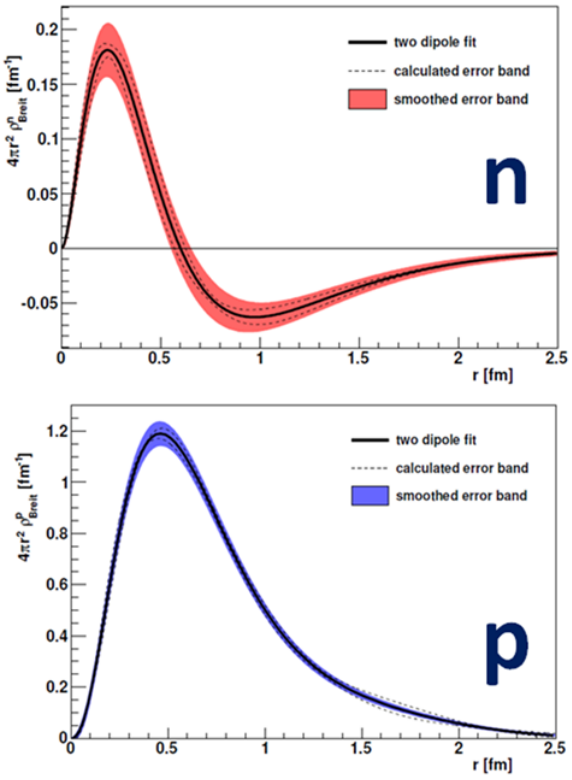
1. This problem illustrates some typical and rather instructive estimates that working physicists cover their lunch-time napkins with.
   (a) Estimate the number of atoms contained in the Earth.
   (b) The angular momentum of an atom or a molecule, if it is nonzero, is on the order of $\hbar$. Estimate the angular momentum of the Earth's rotation per atom in the units of $\hbar$.

2. What is the physical meaning of the Planck mass and Planck length scale? Derive analytical expressions for these quantities, and obtain approximate numerical values in grams, eV/c^2, and centimeters.

3. Griffiths, Prob. 1.1. Consider first the case of a nonrelativistic particle. Does the answer change if the particle is relativistic?

4. Griffiths, Prob. 1.2 and 1.3.

5. The *nucleons*, the neutron and the proton are finite-sized particles, so it is perfectly legitimate to inquire about the distribution of the charge within them. A reasonable quantity that tells us how much charge there is at a radius r from the center of the nucleon is $4\pi r^2\rho/e$, where the $4\pi r^2$ comes from the volume of a spherical shell of radius r and a fixed thickness dr, ρ is the electric-charge density, and e is the proton charge. These distributions for the proton and the neutron are sketched in the figure.



In the case of the neutron, we see that it qualitatively resembles an atom: there is a positive core, and a negative halo, while the whole system is neutral. In contrast to an atom, where the positive core (the nucleus) is several orders of magnitude more compact then the atom, the core is relatively larger for the neutron.

Give a qualitative explanation for the excess of negative charge at the periphery of the neutron.

Hint: Consider the quark composition of the nucleons and the concept of virtual mesons.