PHY-851 QUANTUM MECHANICS I

Homework 1, 30 points

September 3 - 10, 2003

Introduction. Reading: *Messiah*, Chapter 1.

1. /6/ Consider a two-step process. A photon with the wave length 0.02 nm underwent Compton scattering by an angle of 120° off an electron at rest. The scattered photon knocked out the deepest bound electron from a molibdenum atom. Evaluate the kinetic energy of the photoelectron emitted at the second step.

2. /10/ For the lowest electron orbit in the hydrogen atom

   a. estimate magnitude of the electric field of the nucleus at the orbit (in V/cm);

   b. estimate magnitude of the magnetic field created at the nucleus by the orbital motion of the electron (in Tesla);

   c. compare the Coulomb and gravitational forces between the electron and the proton.

   In all cases give the numbers!

3. /6/ *Messiah*, Problem 6, p. 44.

4. /8/ *a*. Consider the *semiclassical* transitions between the levels n and n' in the Bohr theory of the hydrogen atom, assuming $n, n' \gg 1$ and $\Delta n = |n - n'|/n \ll 1$. Show that the *correspondence principle* holds, namely that the quantum radiation frequencies coincide with those predicted for a classical particle with a revolution frequency for the relevant orbits (the last part of Problem 7, *Messiah*, p. 44).

   b. Prove that this correspondence is fulfilled for any potential well, where the periodic motion of a particle is quantized in accordance with the Bohr quantization rule,

   $$\oint p\,dx = 2\pi n\hbar. \tag{1}$$

   /Consider the momentum p along the classical orbit as a function of x and energy E_n, which is a continuous function of n, and take a derivative with respect to n./