FINAL EXAMINATION

PHYSICS 6710 - ATOMIC STRUCTURE

Fall 2007 11 December 2007

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1. In most circumstances the dominant portion of the binding energy of an electron in an atom arises from the central Coulomb attraction to the nucleus and core electrons, known as the "gross energy." However, there are many additional smaller contributions to the binding energy that are treated perturbatively. Consider each of the following smaller contributions and state and explain (using conceptual semiclassical models where possible) whether or when each INCREASES or DECREASES the binding energy of the electron.

    a. Relativistic corrections to the kinetic energy (relativistic mass).
    b. Spin-orbit magnetic coupling.
    c. Dipole polarizability of the core.
    d. Quadrupole polarizablity of the core.
    e. Penetration of the inner electron core by the orbital electron.
    f. The fact that g-factor of the electron is slightly greater that 2.0.
    g. The fact that the mass of the nucleus is not infinite.

2. Consider a neutral boron atom in the configuration $1s^2 2s2p3p$.

    a. List the various spectroscopic levels that arise from the configuration.
    b. Consider the term of highest L and S. Sketch (to relative scale) the relative spacing of the fine structure levels of this term.

3. Draw an energy level diagram for the K and L shells of the hydrogen atom under each of the circumstances described below. Label each level with its appropriate quantum numbers, and indicate descriptive labels such as "gross structure," "fine structure," "Lamb shift," "Zeeman effect," etc.

    a. The free atom, with no external fields.
    b. The atom in the presence of a weak magnetic field
    c. The atom in the presence of a magnetic field commensurate with internal fields.
    d. Describe, but do not draw, the behavior in the presence of a gigantic magnetic field.

4. The lifetime of the 3p level of the neutral sodium atom, which decays to ground by the 3s-3p "Na-D" line at 5892 Å is 16.5 ns. For the 4p level, 1/3 of the decays branch to ground by the 3s-4p transition at 3305 Å.

   a. Compute the absorption oscillator strength of the 3s-3p transition.
   b. Using the *f*-sum rule, set a lower limit on the lifetime of the 4p level.

   The relationship between the oscillator strength and the transition probability is:

$$g_u A_{ul}(ns^{-1}) = \left[\frac{2582.68}{\lambda(A)}\right]^2 g_l f_{lu}$$

5. Describe as many physical manifestations of the quantity "action" (ML^2/T) as you Can.