Paul Avery
PHZ4390
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Bonus Question 2

Due Friday, Sep. 13

1. (4 pts) Consider a single electron of mass m_e and charge *e* circling a nucleus of charge +*Ze*. Using the Coulomb force $\left(F = Ze^2 / 4\pi\varepsilon_0 r^2\right)$ and angular momentum quantization $\left(pr = n\hbar\right)$, derive the Bohr model equations for the orbital radii r_n, velocities v_n and energy levels E_n in terms of only *n*, $m_e c^2$, *Z*, α, $\hbar$ and *c*. Remember the definition of α in terms of *e* and the other constants. Energies are always measured relative to the total energy at infinity.
2. (1 pt) Evaluate the ground state radius (fm), velocity (units of *c*), and energy (keV) for U^{91+}, i.e. Uranium for which all electrons but one have been stripped.
3. (4 pts) Calculate r_n, v_n and E_n as in (1) but this time use the relativistic formulas for momentum and kinetic energy (be careful to use the correct relativistic formula for centripetal force). Note that the expressions r_n, v_n and E_n simplify algebraically if you spend some time on the expressions. When will this derivation break down?
4. (1 pt) Evaluate the ground state radius (fm), velocity (units of *c*), and energy (keV) for U^{91+}. By how much did the ground state energy change (keV)?