Physics 25 Problem Set 8

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due Wednesday, May 28

Please make your work neat, clear, and easy to follow. It is hard to grade sloppy work accurately. Generally, make a clear diagram, and label quantities. Derive symbolic answers, and then plug in numbers after a symbolic answer is available.

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1. Let's consider a Bohr theory for the deuteron. Suppose the force between the neutron and proton is $-F_0$ for $r_0 \le r \le r_0 + \Delta r$, and zero for all other distances r between the neutron and proton.
   (a) Make a plot of the force $F(r)$ and the potential energy derived from it, $V(r)$, where $V(r) \to 0$ as $r \to \infty$.
   (b) Suppose the angular momentum between the neutron and proton is exactly $\hbar$; find an expression relating F_0 to distance between the neutron and proton, r_1.
   (c) Suppose $r_1 = r_0 = 1 \times 10^{-13}\,\mathrm{cm}$, which is also called 1 fm, where fm stands for fermi or femtometer. Take $m_n c^2 = m_p c^2 = 940\,\mathrm{MeV}$, or million electron volts. Deduce a numerical value for F_0. It is very useful to know that $\hbar c = 197\,\mathrm{MeV}{\times}\mathrm{fm}$.
   (d) Evaluate the speed of the neutron (or proton) in the Bohr orbit, relative to the speed of light.
   (e) In the 'first Bohr orbit' it still must be that the total energy (sum of kinetic and potential energy) is *negative*, to achieve a bound state. This puts a constraint on Δr; find and evaluate that constraint.
   (f) For the numbers in this problem, numerically evaluate the potential energy near $r = 0$, and compare your result with page 95 of the text.
2. Consider the photon emitted when a hydrogen atom goes from the $n = 100$ Bohr orbit to the $n = 1$ Bohr orbit. Derive an expression for the ratio of the wavelength of the photon to the Bohr radius, and evaluate numerically.ı
3. Anderson, 2-13
4. Anderson, 2-15
5. Anderson, 2-18
6. Anderson, 2-21
