Protons and Neutrons

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Introduction

The Standard Model considers protons and neutrons to be composed of U and D quarks. Since both have a magnetic moment, our unified theory requires them to be composite bodies consisting of charged particles in orbit about one another. Given that neutrons decay into a proton plus an electron, the neutron may well be a proton with an electron trapped inside it.

We start by considering the equations describing the orbital system of a hydrogen atom and progressively develop the model through logical deduction. We end up with a proton consisting of two U quarks of charge $+\frac{2}{3}e$ and mass of roughly $\frac{1}{6}\,m_p$ orbiting a D quark of charge $-\frac{1}{3}e$ and mass of roughly $\frac{2}{3}\,m_p$ on opposite sides of the same orbit. The known parameters of the proton require an attractive force many orders of magnitude greater than the electric force, so we propose that each U quark is stuck to the D quark by a single quanta of electric flux. This allows us to account for the magnetic moment and predicts a quantised angular momentum. The U quarks have a velocity of about $\frac{2}{3}$ of the speed of light. We have not done the analysis of the relativistic correction, so the above figures for the masses of the quarks are only approximate.

We find that the magnetic flux density generated by the orbiting quarks is easily strong enough to give electrons a cyclotron radius which would fit within the confines of the proton. The actual field is non uniform so we would expect a chaotic sort of not very circular spiralling motion. We are at this stage able to say that it is perfectly feasible that the neutron is a proton with an electron trapped inside it. However, the detailed study of the chaotic motion remains beyond the author.

Comparison with Atom

The basic equations for the hydrogen atom are:

$$-\frac{Z\,e^2}{4\,\pi\,\varepsilon_0\,r} \;=\; -4\,m_r\,\pi^2 r^2 \nu^2; \qquad \frac{1}{2}\,\nu\,e\,n\,\Phi_0 \;=\; \frac{1}{2}\,2m_r\,\pi^2 r^2 \nu^2$$

$$\Rightarrow \qquad r \;=\; \frac{4\,n^2 \Phi_0^2\,\varepsilon_0}{\pi\,Z\,m_r}; \qquad \nu \;=\; \frac{e\,Z^2\,m_r}{32\,n^3\,\Phi_0^3\,\varepsilon_0^2}$$

Leading to magnetic moment and angular momentum

$$\mu \;=\; I\,A \;=\; \frac{n\,e^2\;\Phi_0}{2\pi\,m_r} \qquad L \;=\; r\,m\,\mathrm{v} \;=\; \frac{n\,e\,\Phi_0}{\pi} \;=\; n\,\hbar$$

It is mathematically possible for two electrons to share the same orbit such that they are on opposite sides of the nucleus. (though nature does not seem to implement this solution) The equations are:

$$-\frac{2\,Z\,e^2}{4\,\pi\,\varepsilon_0\,r} + \frac{Z\,e^2}{4\,\pi\,\varepsilon_0\,2\,r} \;=\; -8\,m_r\,\pi^2 r^2 \nu^2; \qquad \frac{1}{2}\,\nu\,2e\,n\,\Phi_0 \;=\; 2\left(\frac{1}{2}\,2m_r\,\pi^2 r^2 \nu^2\right)$$

$$\Rightarrow \qquad r \;=\; \frac{16\,n^2 \Phi_0^2\,\varepsilon_0}{\pi\,Z\,m_r}; \qquad \nu \;=\; \frac{e\,Z^2\,m_r}{512\,n^3\,\Phi_0^3\,\varepsilon_0^2}$$

Leading to twice the magnetic moment and angular momentum corresponding to twice the number of electrons and thus obeying the same quantisation.

$$\mu = I A = \frac{n e^2 \Phi_0}{\pi m_r} \qquad L = r m \mathrm{v} = \frac{2 n e \Phi_0}{\pi} = 2 n \hbar$$

We are tempted to modify this equation to model a proton as a D quark orbited by two U quarks.

The equations are:

$$-\frac{2\left(\frac{2}{3}e\right)\left(\frac{1}{3}e\right)}{4\pi\varepsilon_0 r} + \frac{\left(\frac{2}{3}e\right)^2}{4\pi\varepsilon_0 2r} = -8\left(\tfrac{1}{3}m_p\right)\pi^2 r^2 \nu^2; \qquad \frac{1}{2}\nu\, 2\left(\frac{2}{3}e\right) n\,\Phi_0 = 2\left(\frac{1}{2}2\left(\tfrac{1}{3}m_p\right)\pi^2 r^2 \nu^2\right)$$

$$\Rightarrow \qquad r = \frac{48\, n^2 \Phi_0^2\, \varepsilon_0}{\pi m_r}; \qquad \nu = \frac{e\, m_r}{2304\, n^3\, \Phi_0^3\, \varepsilon_0^2}$$

Leading to magnetic moment and angular momentum

$$\mu = I A = \frac{4n e^2 \Phi_0}{3\pi m_r} \qquad L = r m \mathrm{v} = \frac{4n e \Phi_0}{3\pi} = \tfrac{4}{3} n \hbar$$

The only problem being that when we evaluate the radius, we get approximately 1×10^{-12} which is several orders of magnitude greater that the known size of the proton. We not also that the orbiting charge of $\frac{2}{3}e$ results in a breaking of the quantisation rule introducing thirds.

The proton

The proton is not a spherical particle, so its size is somewhat difficult to specify exactly. However, we can find the radius at which its charge is rotating by experiment. One such value, determined by McCord and Earl is 8.65×10^{-16}. We know the magnetic moment and assume from the three quark model that the orbiting charge is $2 \times \frac{2}{3}e$. It follows that:

$$\mu_p = 1.410 \times 10^{-26} = I A = \tfrac{4}{3} e\, \nu\, \pi r^2 \qquad \Rightarrow \nu = \frac{3\mu_p}{4\pi e r^2} = 2.809 \times 10^{22}$$

This gives the U quarks a velocity of just over half the speed of light:

$$\mathrm{v} = 2\pi r \nu = 1.527 \times 10^8 = 0.5093\, c$$

The problem with understanding such an orbit is that at close range, the electric force of attraction is far less than the centrifugal force.

$$F_{elec} = \frac{\left(\frac{2}{3}e\right)^2}{4\pi\varepsilon_0 r^2} - \frac{\frac{2}{3}e\,\frac{1}{3}e}{4\pi\varepsilon_0 (2r)^2} = 119.9$$

$$F_{cent} = \frac{m \mathrm{v}^2}{\sqrt{1 - \frac{\mathrm{v}^2}{c^2}}\; r} = 17{,}458 \sim 1.7\, tons$$

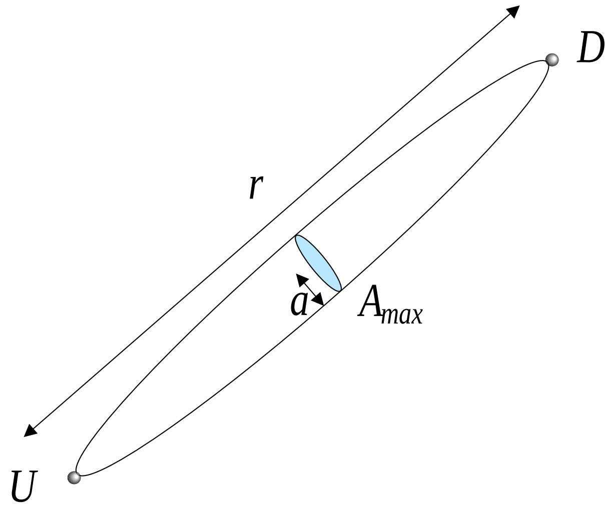
Clearly, we need something extra to provide virtually all of the required centripetal force. Our unified theory allows only energy in the form of quantised electric and magnetic flux. We therefore hypothesize the existence of an entity which we call a DUion ("dew-e-on") consisting of a quantum of electric flux with one end on the surface of the D quark and the other end on the surface of the U quark. The proton will need two of these, one for each D quark.

The U quark has a radius given by its mass $m_u = \frac{1}{3}m_p$ and its charge of $\frac{2}{3}e$.

$$r_u = \frac{\mu_0 \left(\frac{2}{3}e\right)^2}{6\pi\, m_u} = 1.364 \times 10^{-18}$$

The electric field strength at its surface and the force on the displacement charge on the end of the DUion are:

$$E = \frac{\frac{2}{3}e}{4\pi\, \varepsilon_0\, r_u^2} = 5.52 \times 10^{26} \qquad F_{contact} = \frac{\frac{2}{3}e}{4\pi\, \varepsilon_0\, r_u^2}\,\frac{e}{6} = 1.38 \times 10^{7}$$



So with a force of over a thousand tons needed to part the DUion from its quarks, they would appear to be firmly bound. But this of cause is not the force which it exerts between the quarks. While the ends of the DUion are anchored to the quarks defining their size, the body of the flux quanta is subject to two internal stresses, one attempting to increase its area of cross section in order to reduce its energy density and energy content; the other attempting to shorten it. The force it transmits is limited by A_{max} the largest area of cross section. Electric flux density over the maximum cross section is $D_{min} = \frac{\frac{1}{6}e}{A_{max}}$. According to Classical Theory, the internal stress is $\frac{1}{2\varepsilon_0} D^2$ giving a force:

$$F_{min} = \frac{1}{2\varepsilon_0}\left(\frac{\frac{1}{6}e}{A_{max}}\right)^2 A_{max} = \frac{e^2}{72\, \varepsilon_0\, A_{max}}$$

We can estimate the radius a of cross section by equating F_{min} with the centrifugal force:

$$\pi\, a^2 = \frac{e^2}{72\, \varepsilon_0\, A_{max}} \qquad \Rightarrow\; a \sim 2.7 \times 10^{-17}$$

We have not done a proper calculation because that would involve some difficult calculus, but the estimate is about $\frac{1}{16th}$ of its length which is not totally unfeasible and probably a lot more feasible than any of the alternative theories. The most interesting thing which emerges is that the DUion force obeys an inverse square law if the ratio of $a : r$ remains constant.

Let us consider the effect of a scaling by a factor k. The flux density is everywhere reduced by a factor of $\frac{1}{k^2}$ which reduces the energy density by a factor of $\frac{1}{k^4}$. Now its volume will increase by a factor of k^3, so its energy content will decrease by a factor of $\frac{1}{k}$. If its length was originally 1 and we scaled it by a factor of r, its energy content would be proportional to $\frac{1}{r}$.

Therefore we conclude that whatever the nature of the DUion, provided its geometry remains constant, its energy content and transmitted force behave in exactly the same way as the force exerted by a proton on an electron. Therefore, the Virial Theorem and the orbital mechanics within the proton are the same as those within the atom. The only adjustment we need to make to the theory is the fact that the flux of of the DUions now contributes to the magnetic intensity opposing that of the orbiting U quarks. The net current generating the magnetic field is $2\left(\frac{2}{3} - \frac{1}{6}\right)e\,\nu = e\,\nu$.

We modify the equations; dividing the first by r to change it into the force equation and then replacing the electrostatic force with a force F. Note that since the DUion force and the much weaker electric force both obey an inverse square law, no accuracy is lost. The resulting equations are:

$$-F \ = \ -8\ \left(\tfrac{1}{3}m_p\right)\ \pi^2 r\,\nu^2; \qquad \frac{1}{2}\,\nu\, e\, n\, \Phi_0 \ = \ 2\ \left(\frac{1}{2}\,2\left(\tfrac{1}{3}m_p\right)\ \pi^2 r^2 \nu^2\right)$$

$$\Rightarrow\ r \ = \ \sqrt[3]{\frac{3\,(e\,n\,\Phi_0)^2}{2\pi^2\ m_p\,F}} \qquad \nu \ = \ \sqrt[3]{\frac{3F^2}{16\pi^2\ e\ n\ \ m_p\,\Phi_0}}$$

Leading to magnetic moment and angular momentum:

$$\mu \ = \ I\,A \ = \ \frac{3n\,e^2\ \ \Phi_0}{4\pi\ m_p} \qquad L \ = \ r\,\frac{m_p}{3}\,\mathrm{v} \ = \ \frac{n\,e\,\Phi_0}{\pi} \ = \ n\,\hbar$$

And we are relieved to find that the quantisation rule for angular momentum is now obeyed. However, the magnetic moment is wrong. This leads to the conclusion that the mass of the U quark is not $\frac{1}{3}$ of the mass of the proton. If m_u is the mass of the U quark, the new equations become:

$$-F \ = \ -8\ m_u\,\pi^2 r\,\nu^2; \qquad \frac{1}{2}\,\nu\, e\, n\, \Phi_0 \ = \ 2\ \left(\frac{1}{2}\,2m_u\,\pi^2 r^2 \nu^2\right)$$

$$\Rightarrow\ r \ = \ \sqrt[3]{\frac{(e\,n\,\Phi_0)^2}{2\pi^2\ m_u\,F}} \qquad \nu \ = \ \sqrt[3]{\frac{F^2}{16\pi^2\ e\ n\ \ m_u\,\Phi_0}}$$

Leading to magnetic moment and angular momentum:

$$\mu \ = \ I\,A \ = \ \frac{n\,e^2\ \ \Phi_0}{4\pi\ m_u} \qquad L \ = \ r\,m_u\,\mathrm{v} \ = \ \frac{n\,e\,\Phi_0}{\pi} \ = \ n\,\hbar$$

We can then calculate the mass of the U quark from the known magnetic moment of the proton:

$$m_u \ = \ \frac{n\,e^2\ \ \Phi_0}{4\pi\,\mu_p} \ = \ 0.17903\,m_p$$

We thus conclude that the inertial mass of the U quark as calculated from the orbital mechanics is just over one sixth of the mass of the proton. Since this is less than half the proton mass it gives a satisfactory solution. We just need to check the orbital velocity.

$$\mathrm{v} \ = \ 2\pi\,r\,\nu \ = \ 0.6790\,c$$

Which is just over $\frac{2}{3}$ of the speed of light. This is feasible, but it also shows that none the results we calculated above are accurate because a significant correction factor is needed to take into account the relativistic increase in mass. The one exception being the angular momentum which is quantised and independent of the orbiting mass.

Since the mass of the U quark is not exactly one third of the proton mass, the neutron must consist of a proton with an electron trapped inside it.

The Neutron

We have concluded that a neutron cannot consist of a two D quarks and one U quark. We know that neutrons decay into a proton plus an electron with a half life of about 15 minutes, so the question is whether or not it is feasible for an electron to be trapped inside a proton.

The model we have proposed for the proton involves two of the entity we have called a DUion which is a quanta of electric flux linking the U quarks to the D quark. The force transmitted by the DUions is many orders of magnitude greater the electric forces due to their charge, so the addition of an electron to a proton will not have any appreciable effect on the quark orbits other than that due to magnetic coupling.

When we consider the proton as a current loop and put in the numbers, we find a current of 6,001 Amps generating a magnetic field with a flux density at the centre of the loop of 4.359×10^{12} T. These figures are beyond comprehension when one thinks about the diameter of a wire needed to carry a current of 6000 A or consider the size of an electromagnet required to generate a field of 4.359 T. So it is little wonder that no-one has ever considered the cyclotron radius of an electron trapped inside a proton.

Obviously, it will require a very considerable amount of numerical analysis to solve the real problem because there is no simple formula for the magnetic flux at points in the vicinity of a current loop other than at its centre or close to the loop. We know the field in the plane of the current loop increases in strength as we move away from the the centre, so the electron cannot describe circular motion. What we can do is take the minimum flux density and an arbitrary radius, say $\frac{1}{4}$ of the radius of the U quark orbit, and calculate the velocity of the electron.

$$\frac{m_e \mathrm{v}}{e\,B} = 2.1625 \times 10^{-16} \qquad \Rightarrow \mathrm{v} = 0.5530\,c$$

Which is of the order of half the speed of light. Bearing in mind the fact that the U quarks have a velocity of the order of $\frac{2}{3}$ of the speed of light, it is not difficult to see the possibility of a phase locked motion of the electron chasing one of the U quarks, but never catching it because as it gets closer, it meets increasing flux density tightening its orbit.

Conclusion

We have a classical theory of the structure of protons and neutrons. We have established that it is feasible, but it still remains to do some very difficult numerical analysis to work out the fine detail.

We need to add the relativistic corrections to the proton model.

We also need to model the chaotic motion of an electron trapped inside a proton to see if we can account for the magnetic moment of the neutron and its half life. This may involve many years of work.