The Neutron Lifetime

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We have developed an alternative to the standard model of particle physics. In our model, the mass of an elementary particle, like its charge, is an intrinsic property of the particle determined by its internal structure and internal kinematics. There is no Higgs mechanism.

In this paper we briefly review the current status of our model including the main results of calculations that we have reported previously [1-5]. We then turn our attention to particle stability. We note a possible reason for the stability of the proton and the electron and, as a further application of our approach, we present a calculation of the neutron lifetime.

Overview

Experiments have demonstrated that protons and neutrons contain point-like charged scattering centres known as partons [6]. The parton charge has not been measured. Experiments have also determined the distribution of charge on the interior of protons and neutrons [7]. The positive charge of the proton is located at an average distance of ~ 0.4 fm from the proton centre (see figure 1). The neutron structure, shown in figure 2, indicates positive charge at a mean distance of ~ 0.3 fm and an equal quantity of negative charge at a mean distance of ~ 0.9 fm from the centre.

We use the measured internal charge distribution to determine the mean locations of the partons. The only point-like particles that have been shown to exist in nature are electrons and positrons. Therefore, we assume that the partons, of which protons and neutrons are composed, are electrons and positrons. In addition, the neutron incorporates a neutrino as a neutral parton. Partons are not quarks and gluons. All the experimental data that we are aware of are consistent with this proposition. We use a semi-classical technique to derive simple expressions for proton and neutron properties and all of our derived quantities are in good agreement with data.

If we adopt the conventional assumption that the partons are quarks and gluons, we encounter a problem because quark masses are unknown. In addition, if we assume "reasonable" quark masses [8], the quark charges give results that disagree with data. The

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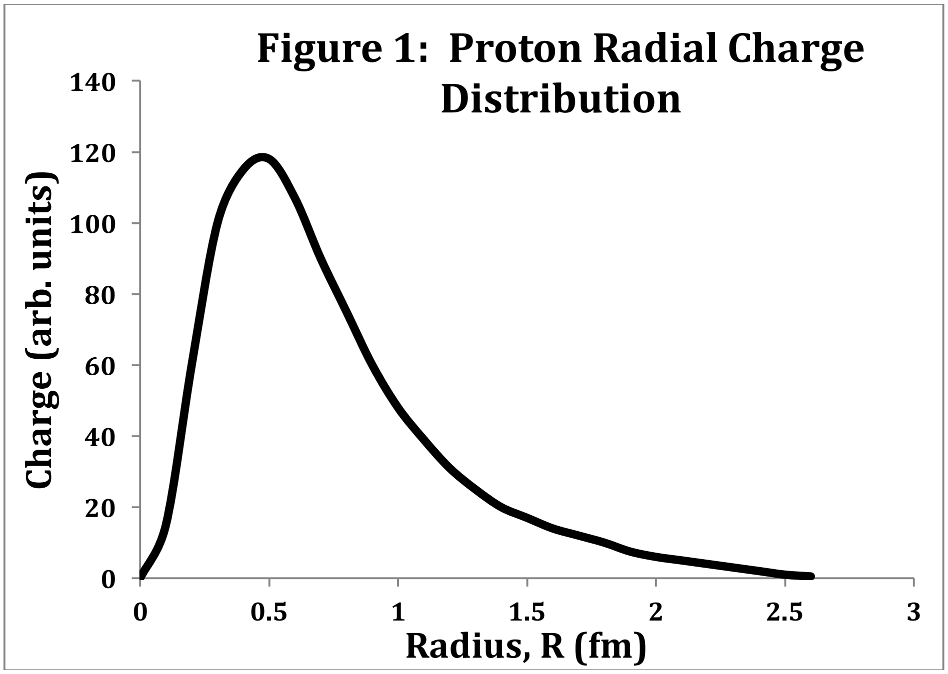
electron and positron interpretation is more natural, allows calculations and gives better agreement with experimental results.

The forces that determine and maintain the orbital structure are assumed to be gravity (acting on the parton mass and energy) and electrostatics (acting on charge). The only unpalatable feature of our model is the very large gravitation parameter inside proton, neutron and electron.

Our model is also able to make several testable predictions. A summary of the calculations and results is given in an earlier paper [1]. More details of the model and its development, including attempts to formulate parton equations-of-motion and hence estimates of the short-distance gravitation parameter, are given elsewhere [2-5].

Proton Structure

In our model, the proton is assumed to be composed of two positrons and an electron in an orbital structure similar to that of a simple atom. The mean radii of the orbits are obtained from a fit to the experimentally determined internal charge distribution shown in figure 1.



A Bohr quantum condition is applied to each orbit to calculate the energy and the proton mass is given by the relativistic effective mass of the constituents. The proton magnetic moment is the sum of the constituent magnetic moments plus orbital current loops. The antiproton is not antimatter; it is simply a negative proton composed of two electrons and a positron. This approach permits us to derive properties of the proton that are consistent with its internal charge structure and that are in good agreement with measurements. It also explains in a natural manner why protons, antiprotons, electrons and positrons all have exactly the same quantity of charge and spin. More details are given elsewhere [1].

Neutron Structure

The neutron is assumed to be composed of two electrons, two positrons and a neutrino in an orbital structure similar to that of the proton. As in the proton case, the radii of the orbits are obtained using a fit to the experimentally determined internal charge distribution. For both proton and neutron fits, we use Gaussian line-shapes for the individual parton charge distributions.

The two positrons and one of the electrons form a dwarf proton close to the centre of the neutron. The other electron has a larger orbital radius. The so-called antineutron is composed of the same constituents but with a negatively charged dwarf proton close to the centre and a positron at a larger radius. Again, simple assumptions and semi-classical calculations allow us to derive several expressions that give quantities in good agreement with data. These include, the neutron mass, magnetic moment, radial dimensions, spin, charge and internal charge structure. More details are given elsewhere [1].

Electron, Positron and Neutrino Mass and Charge

The electron is assumed to be a point-like fundamental particle whose mass comes from a balance of electrostatic and gravitational self-energy. To maintain the balance and to give exactly the measured value of charge to mass ratio, the ratio of gravitation to electrostatic parameters is predicted to be much larger than the macroscopic value. The proton and neutron calculations also predict a very large value for the gravitation parameter at short distances. Positrons are simply negative electrons. There is no antimatter. The neutrino is assumed to be a massless, chargeless electron-like particle and it can have either left- or right-handed helicity. At this stage in the development of the model we see no need for multiple neutrino types. Nor do we see the need for the neutrino to have charge or mass although a very small mass and charge cannot be ruled out. More details are given elsewhere [1].

Particle Stability and Gravitation

Our model assumes that gravity and electrostatic forces are responsible for the charge to mass ratio of the electron and positron and for the internal structure of the proton and the neutron and therefore for the masses and magnetic moments, etc. The proton model necessitates a short-range value for the gravitation parameter, $G_0 = 1.8 \times 10^{29}$ Nm^2/kg^2. Attempts to derive an equation-of-motion for the neutron model give similar values and so we assume that this is also the value inside the neutron. The electron self-mass model is also consistent with this value. This is forty orders of magnitude larger than the macroscopic value. Using this value we can calculate the Schwarzschild radius (R_S) of electron, proton and neutron. The electron and proton are completely contained well inside their respective R_S values and we hypothesise that this is the reason for their stability.

The neutron, on the other hand, has a neutrino outside R_S and this might be the reason it is unstable. Developing this idea further allows us to calculate the neutron lifetime.

Neutron Lifetime

Inside the neutron there is an electron at a mean distance of ~ 0.9 fm from the centre. In order for the neutron to decay this electron has to be outside R_S at ~ 6.7 fm from the centre. The fit to the internal charge distribution shows that the negative charge at ~ 0.9 fm can be reproduced using a Gaussian line-shape with mean $R_0 = 0.88$ fm and $\sigma = 0.55$ fm.

This can be used to calculate, P, the probability that the distance of the electron from the centre of the neutron is > 6.7 fm. We assume that the mean lifetime of the neutron is given by: $\tau_n = t_0/P$ where t_0 is a characteristic time given by the orbital period at 0.88 fm (= 1.8×10^{-23} s). Since $P = 1.8 \times 10^{-26}$, this gives a neutron mean lifetime of 1000 s. Any electron orbit further from the neutron centre has a larger escape probability and therefore it gives a shorter neutron lifetime. Any electron orbit closer to the neutron centre has a smaller escape probability and therefore a longer neutron lifetime. The entire exponential neutron lifetime distribution is simply a reflection of the charge distribution of the internal electron at ~ 0.9 fm.

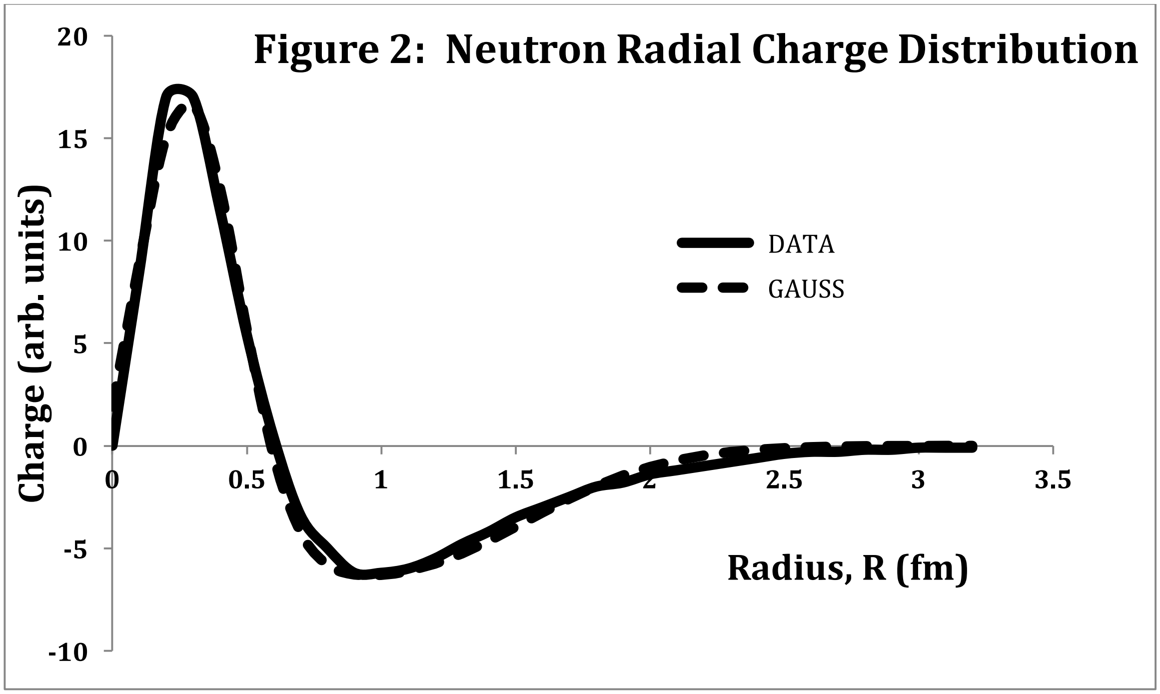


Figure 2: Neutron Radial Charge Distribution

Comments

In our model the charged partons are electrons and positrons. This new model explains many experimental observations that the standard model is unable to explain.

The electron and the positron are assumed to be point-like objects whose masses originate in a natural balance of electrostatic and gravitational self-energy. We use the measured ratio of electron mass and charge to determine the ratio of the short-distance values of the gravitation and electrostatic parameters. This ratio is much larger than the macroscopic value.

The proton and neutron are separate and different particles. The proton is assumed to be composed of two positrons and an electron and the neutron is composed of two positrons, two electrons and a neutrino. The two positrons and one of the electrons in the neutron form an off-mass-shell dwarf proton. An approach reminiscent of the Bohr description of the hydrogen atom is used to make calculations. The fields that hold the proton and neutron together are electromagnetism and gravity and the values of the gravitation and electrostatic parameters are in good agreement with those obtained from the electron mass/charge ratio.

In the proton model there is a central electron with two positrons in orbit. The orbital radii are determined by fitting to the internal charge distribution and simple calculations give the exact proton mass and the approximate magnetic moment [1, 3]. The short-distance gravitation parameter, G_0, is the only variable that has to be determined. There are an infinite number of possible positron or electron orbits that give the exact proton mass and they all give a good approximation to the proton magnetic moment. The model automatically gives the spin and charge exactly equal to the positron spin and charge.

The neutron model is very similar to the proton model and is also capable of calculating neutron mass, magnetic moment, spin, charge and internal charge distribution [1, 2]. The model also gives the neutron lifetime.

It is worth emphasizing that there is only one variable parameter in the mass and size calculations. The radial dimensions of protons and neutrons and all three masses (electron, proton and neutron) are determined by the short-distance value of the gravitation parameter. This is $G_0 = 1.8 \times 10^{29}$ Nm^2/kg^2 to be compared with the macroscopic value of $G = 6.67 \times 10^{-11}$ Nm^2/kg^2. Of course it could be a different force altogether, but the simplest assumption is that it is gravity with a very large parameter. Perhaps this is a clue leading us towards quantum gravity.

We have started with the simplest possible set of assumptions and it is quite remarkable how many elementary particle properties fall into place. Our hypothesis is very simple yet it provides some very straightforward calculations and predictions. We are not aware of any data that are in disagreement with our model. However, it is perhaps incomplete and will need further development as more experimental results are confronted.

Our model offers several advantages over the particle physics standard model. There are far fewer parameters. There are neither *ad hoc* fields nor *ad hoc* quantum numbers. The mass and charge of a particle are intrinsic properties. There is no Higgs mechanism. Quarks and gluons are mathematical entities not physical particles. The charges of proton and electron are naturally equal and opposite. There is no matter-antimatter imbalance in the universe.

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