The Proton and its Quarks Rotations and Energies

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Abstract In a proton with rest mass m_{p}, the two **u** quarks charged with $\frac{2}{3}e^{+}$, $\frac{2}{3}e^{+}$, and one **d** quark charged with $\frac{1}{3}e^{-}$, encircle the proton's harmonically at Compton radius $r_p = \frac{\hbar}{m_p c}$,

at speed $v_p = \frac{\sqrt{3}}{2}c$, and at frequency $f_p = \frac{\sqrt{3}}{2}\frac{m_p c^2}{h}$.

The proton's Rotational Energy is $\frac{1}{2}I_p\omega_p^2 = \frac{3}{4}m_p c^2$

The quarks harmonic motion explains the proton's diffraction.

The **u** quark rotational energy is 1.8MeV. The **d** quark is 7MeV.

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Contents

1.

The Quarks in a Proton with Compton Radius

We have shown that a proton with rest mass m_p, and Compton radius $r_p = \dfrac{\hbar}{m_p c}$, rotates at speed $v_p = \dfrac{\sqrt{3}}{2}c$, at Frequency

$$f_p = \frac{\sqrt{3}}{2}\frac{m_p c^2}{h}.$$

A spinning proton experiences centrifugal force that resists the circular motion.

The proton cannot be one particle charged with e^+ revolving about a center at distance r_p, because the centrifugal force on the encircling particle due to its resistance to move in circular motion has to be balanced by an attraction to the center.

Fractional charges of $\dfrac{1}{3}e$ have been observed. But three particles each with charge $+\dfrac{1}{3}e$ will be electrically repulsed from each other, and experience centrifugal forces that will push them away from the center.

To supply the centripetal forces that will keep three particles rotating about the center, they have to carry opposite charges, such as

$$\frac{2}{3}e^{+},\ \frac{2}{3}e^{+},\ \frac{1}{3}e^{-}.$$

Similarly, For a proton with a Compton radius, the Revolution Velocity is $v_p = \frac{\sqrt{3}}{2}c$, and the revolution frequency is $f_p = \frac{\sqrt{3}}{2}\frac{m_p c^2}{h}$

Two **u** quarks have charge $\frac{2}{3}e^{+}$, and one **d** quark has charge $\frac{1}{3}e^{-}$.

2.

Quarks

In 1928, J. J. Thomson presented in [Thomson,p.33], experimental evidence that the electron is a composite particle.

> "*...the properties of the electron recently discovered lead to the view that the electron...has itself a structure, being made up of smaller parts which carry charges of electricity*."

Later, Millikan presented in [Millikan, p. 161] evidence from his experiments for the existence of Subelectrons.

> "*...Ehrenhaft and Zerner even analyze our report on oil droplets and find that these also show in certain instances indications of **sub-electrons**, for they yield in these observers' hands too low values of e, whether computed from the Brownian movement or from the law of fall*."

The existence of fractional charges, and sub-electrons, is now well-established. For instance, [Wagoner, pp. 541-5].

The suggestion that the proton, and the neutron are composed of quarks is compatible with the electron being made of subelectrons.

The evidence for quarks had to leads to a planetary model for the proton. To balance the electric forces on them, the quarks must be moving in a closed orbit.

3.

Quarks' Orbits

The proton rotation produces the centrifugal forces of repulsion that balance the centripetal forces of attraction.

3.1 Closed Orbit

To stay within the proton's boundaries,

the quarks should have a closed orbit.

3.2 Central Force

By [Routh, p. 274], a closed orbit results from a central force that is proportional to the inverse square of the distance,(such as the Coulomb electric force) or directly to the distance(such as the centripetal force).

Quarks charges supply

the electromagnetic attractive force that close the orbit.

3.3 Orbit Stability

By [Routh, p.280] Central Force orbits are stable. That is, they are bounded in a ring between two circles. The stability of the proton indicates such orbits.

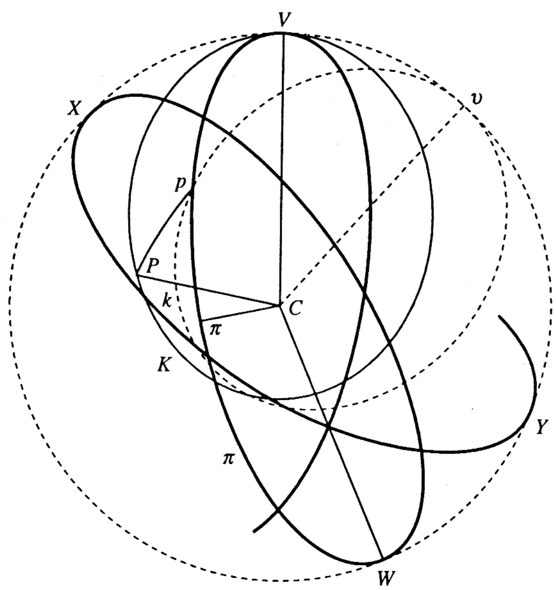
3.4 Planar Motion

Since the electric force is an inverse-squared-law force,

Quarkss' orbits will be in the same plane,

and not on a sphere

The plane of motion of the particle turns around on a sphere <u>only under a non-inverse squared law force.</u>



[Chandrasekhar, p. 195].

3.5 Proton Diffraction

The harmonic motion of quarks within the proton supports Proton diffraction.

Else, the diffraction of protons is unexplained, and the proton remains misunderstood as to whether it is a wave or a particle.

4.

The Proton's Structure

4.1 The Charges of the Quarks

A choice of

Three particles with charge $\frac{1}{3}e^{+}$,

will repel each other, and be repelled from the center by the centrifugal forces on them.

Therefore, we assume,

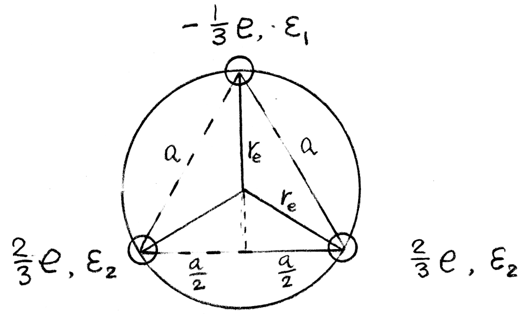
Two **u** with charge $\frac{2}{3}e^{+}$,

and

One $\mathbf{d}_{\mathrm{e}}$ with charge $\frac{1}{3}e^{+}$.

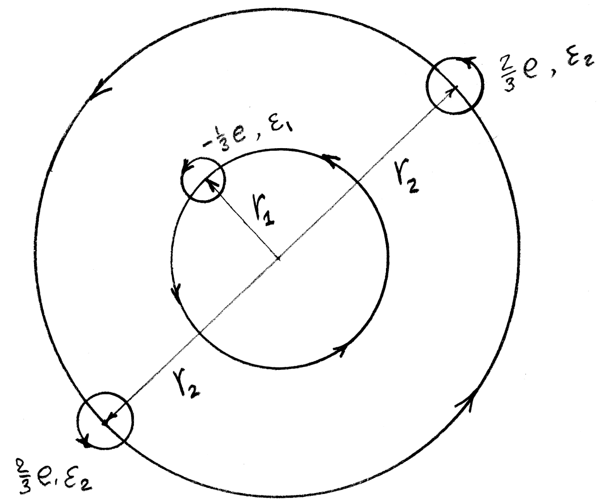
4.2 The Location of the Quarks

If the quarks were at vertices of an equilateral triangle, the repulsion will break up the proton.



Perhaps, the $\dfrac{2}{3}e^{+}$ are at distance $2r_u$, with orbit radius r_u.

And the $\frac{1}{3}e^{-}$ orbits at smaller radius r_d,



The proton Compton radius, r_p, is between the two rings,

$$r_1 < r_p < r_2,$$

5.

Quarks' Masses

By [PDG-2016],

Each of the **u** quarks with $+\frac{2}{3}e$ has energy $m_{\mathrm{u}}c^2 \sim 2.2$ MeV

$$\text{Then,}\quad \frac{m_u}{m_{\mathrm{p}}} \approx \frac{2.2\text{MeV}}{938\text{MeV}} \Rightarrow \quad m_u \sim \frac{1}{400} m_{\mathrm{p}}$$

The **d** quark with $-\frac{1}{3}e$ has energy $m_d c^2 \sim 4.7$ MeV.

$$\text{Then,}\quad \frac{m_{\mathrm{d}}c^2}{m_{\mathrm{p}}c^2} \approx \frac{4.7\text{MeV}}{938\text{MeV}} \Rightarrow \quad m_{\mathrm{d}} \sim \frac{1}{200} m_{\mathrm{p}}$$

6.

The Mass and the Rotational Energy of the Spinning Proton

6.1 The Relativistic Mass of the Spinning Proton is $\boxed{2m_{\mathrm{p}}}$

Proof: The proton rotational speed is the relativistic, $v_p = \dfrac{\sqrt{3}}{2}c$

and the mass is the relativistic,

$$\frac{m_p}{\sqrt{1-\dfrac{v_p^2}{c^2}}} = \frac{m_p}{\sqrt{1-\dfrac{1}{c^2}\dfrac{3}{4}c^2}} = 2m_p.$$

6.2 The Rotational Energy of the Proton is $\boxed{\dfrac{3}{4}m_p c^2}$

Proof: The spin angular moment of the rotating proton is $I_{\mathrm{p}}\omega_{\mathrm{p}} = 2m_{\mathrm{p}}v_{\mathrm{p}}r_{\mathrm{p}}$. Therefore, the rotational energy is

$$\frac{1}{2}(I_p\omega_{\mathrm{p}})\omega_{\mathrm{e}} = \frac{1}{2}(2m_{\mathrm{p}}v_p r_{\mathrm{p}})\omega_{\mathrm{p}} = m_{\mathrm{p}}v_p^2 = m_{\mathrm{p}}\frac{3}{4}c^2 = \frac{3}{4}m_{\mathrm{p}}c^2$$

6.3 The Non-Rotational, Electric, Magnetic, Energies of the Proton are $\boxed{\dfrac{1}{4}m_p c^2}$

7.

The Quarks Relativistic Mass and Rotational Energies

6.1 Relativistic Mass of the Spinning u is $\boxed{2m_u \sim \frac{1}{200} m_p}$

Relativistic Mass of the Spinning d is $\boxed{2m_d \sim \frac{1}{100} m_p}$

<u>Proof</u>: **u** rotational speed is $v_u = \frac{\sqrt{3}}{2} c$ and its relativistic mass is

$$\frac{m_u}{\sqrt{1 - \frac{v_u^2}{c^2}}} = \frac{m_u}{\sqrt{1 - \frac{1}{c^2}\frac{3}{4}c^2}} = 2m_u \sim \frac{1}{200} m_p \sim 10^{-29}\text{kg}.$$

d rotational speed is $v_d = \frac{\sqrt{3}}{2} c$ and its relativistic mass is

$$\frac{m_d}{\sqrt{1 - \frac{v_d^2}{c^2}}} = \frac{m_d}{\sqrt{1 - \frac{1}{c^2}\frac{3}{4}c^2}} = 2m_d \sim \frac{1}{100} m_p \sim 2 \times 10^{-29}\text{kg}.$$

6.2 The Rotational Energy of u is $\boxed{\sim 1.8\text{MeV}}$

The Rotational Energy of d is $\boxed{\sim 7\text{MeV}}$

Proof: The relativistic spin angular moment of **u** is

$$I_u \omega_u = 2m_u v_u r_u .$$

Therefore, the relativistic rotational energy is

$$\begin{aligned}\frac{1}{2}(I_u\omega_u)\omega_u &= \frac{1}{2}(2m_u v_u r_u)\omega_u \\ &= m_u v_u^2 \\ &= m_u \frac{3}{4}c^2 \\ &\sim \frac{1}{400} m_{\mathrm{p}} \frac{3}{4} c^2 \\ &\sim \frac{3}{1600} 938\mathrm{MeV} \\ &\sim 1.8\mathrm{MeV} . \square\end{aligned}$$

The relativistic spin angular momentum of **d** is

$$I_d \omega_d = 2m_d v_d r_d .$$

Therefore, the relativistic rotational energy is

$$\begin{aligned}\frac{1}{2}(I_d\omega_d)\omega_d &= \frac{1}{2}(2m_d v_d r_d)\omega_d \\ &= m_d v_d^2 \\ &= m_d \frac{3}{4}c^2 \\ &\sim \frac{3}{400} m_{\mathrm{p}} c^2 \\ &\sim 7\mathrm{MeV} . \square\end{aligned}$$

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