Proton's Spin and Radius

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Abstract The proton's Spin is a negligible fraction of $\hbar$.

We present a ring model for the proton to approximate its spin, and its radius

We assume that the Subprotons, the quarks, move along a circle of radius r_{p} at light speed c, $\frac{c}{2\pi r_{\mathrm{p}}} = \nu_{\mathrm{p}}$ times per second. This associates with the proton a wave of length $\lambda_{\mathrm{p}} = 2\pi r_{\mathrm{p}}$.

The proton's frequency, mass, and energy are inversely proportional to its radius.

$$\nu_{\mathrm{p}} = \frac{c}{2\pi r_{\mathrm{p}}},$$

$$m_{\mathrm{p}} \sim (1+\tfrac{1}{\pi})\tfrac{4}{27}10^{-7}e^2\frac{1}{r_{\mathrm{p}}},$$

$$m_{\mathrm{p}}c^2 \sim (1+\tfrac{1}{\pi})\tfrac{4}{27}10^{-7}e^2c^2\frac{1}{r_{\mathrm{p}}}.$$

The approximate proton's radius is

$$r_{\mathrm{p}} \sim (1+\tfrac{1}{\pi})\tfrac{4}{27}10^{-7}\frac{e^2}{m_{\mathrm{p}}} \sim 3\times 10^{-19}\,\mathrm{m}.$$

The proton's Radius-Energy Relation suggests that a heavier positively charged Baryon made of three quarks, is a proton with

a smaller radius.

The quarks' harmonic motion explains proton's diffraction.

The Proton's Spin is $\sim 10^{-5}\hbar$

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Contents

Proton's Spin is not $\frac{1}{2}\hbar$

The postulate that the proton's spin is $\frac{1}{2}\hbar$, appears in textbooks, as a fact well-established by a theory that no one knows its details, and well-confirmed in experiments that never took place.

Some authors believe that Dirac's Equation for the proton's wave function ψ implies that the proton spin is $\frac{1}{2}\hbar$. But any $\text{constant} \times \psi$ solves the Dirac equation, and the normalization means, $\int \left|\text{constant} \times \psi\right| = 1$.

Many authors believe that it follows from Quantum Field Theory. But that theory uses the Atomic system units where $\hbar = 1$. Hence it may at most indicate orientation of revolution.

In fact, monographs about quarks such as [Efimov], [Ripka], [Klinkhamer], and [Kokkedee] avoid nucleon's spin, while monographs such as [Roberts], and [Troshin] that mention spin, avoid its value.

Moreover, this postulate violates special Relativity.

0.1 *Postulating the Proton's Spin to be $\frac{1}{2}\hbar$ requires revolution at speeds greater than light speed, violating Special Relativity.*

<u>Proof</u>: A rigid Spherical proton with mass m_{p} and radius r_{p}, that spins at speed v_s has moment of inertia $\frac{2}{5}m_{\mathrm{p}}r_{\mathrm{p}}^2$, and Spin Angular Momentum

$$I\omega = (\tfrac{2}{5}m_{\mathrm{p}}r_{\mathrm{p}}^2)(\frac{v_s}{r_{\mathrm{p}}}) = \tfrac{2}{5}m_{\mathrm{p}}r_{\mathrm{p}}v_s,$$

Postulating that the Spin is $\frac{1}{2}\hbar$,

$$\tfrac{2}{5}m_{\mathrm{p}}r_{\mathrm{p}}v_s = \tfrac{1}{2}\hbar,$$

$$v_s = \tfrac{5}{4}\frac{\hbar}{m_{\mathrm{p}}r_{\mathrm{p}}}$$

$$= \tfrac{5}{4}\frac{m_{\mathrm{e}}v_B r_B}{m_{\mathrm{p}}r_{\mathrm{p}}},$$

$$= \tfrac{5}{4}\frac{m_{\mathrm{e}}}{m_{\mathrm{p}}}\frac{\alpha c r_B}{r_{\mathrm{p}}}, \text{ where } \alpha \approx \tfrac{1}{137}, \ \tfrac{m_{\mathrm{e}}}{m_{\mathrm{p}}} \approx \tfrac{1}{1836}$$

Using $r_B \sim 5\cdot 10^{-11}\mathrm{m}$, and $r_{\mathrm{p}} \sim 3\times 10^{-19}\mathrm{m}$, (obtained here)

$$v_{\mathrm{spin}} \sim \tfrac{5}{4}\tfrac{1}{137}\tfrac{1}{1836}\tfrac{5\cdot 10^{-11}}{3\times 10^{-19}}c$$

$$\sim 828c \gg c. \square$$

The arbitrary postulate that the proton has spin $\frac{1}{2}\hbar$ has to avoided.

We will approximate the proton's Spin from the orbital angular momentum of the subprotons.

1.

Evidence for Subprotons

In the 1960's, high energy experiments indicated that the nucleons are composite particles. The Subparticles were proposed under the names Partons, Quarks, Aces,… to guarantee the exclusive rights of the proposer.

The theory created to establish the existence of Subprotons uses mathematical symbols, but its inaccuracies, and inconsistencies, prevent us from any serious critique of it.

In particular, monographs about the Subprotons do not suggest an elementary model for the structure of the proton, and without such model we cannot approximate the spin, and the radius of the proton.

The evidence for Subprotons had to lead to a planetary model for the proton. Just to balance the electric forces on them, the Subprotons must be moving, and since they are not going anywhere, the motion is in a closed orbit.

2.

Diffraction and De Broglie Wave

Diffraction of protons had to suggest harmonic motion of Subprotons within the proton. That harmonic motion manifests itself in a physical wave.

Without the subprotons circulating within the boundaries of the proton, the diffraction of protons remains a mystery.

De Broglie wave is based on the speculation that like the photon ϕ which is a particle with speed c, and wavelength

$$\lambda_\phi = \frac{c}{\nu_\phi} = \frac{hc}{h\nu_\phi} = \frac{hc}{m_\phi c^2} = \frac{h}{m_\phi c},$$

any particle p with speed v_p, has an associated longitudinal wavelength

$$\lambda_p = \frac{h}{m_p v_p}.$$

The diffraction of protons, that must be due to harmonic motion of their subprotons, was attributed to a wiggling proton.

Since it is impossible to visualize an proton wiggling along it path, a property called wave particle duality was invented.

Even De Broglie realized that his wave represents the uncertainty in the particle location, [Dan1], [de Broglie].

Thus, the denial of an elementary proton model, eliminated the wave that underlies the harmonic motion of the subprotons, and the proton remained a puzzle as to whether it is a wave or a particle.

3.

Subprotons' Motion

The Spin suggests a harmonic motion of the subprotons.

Then, the centripetal forces of repulsion will balance the Lorentz magnetic and electric forces of attraction, to yield a stable structure.

3.1 Closed Orbit

To stay within the proton boundaries,

the subprotons 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).

Subprotons charges supply

the electromagnetic force to 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.

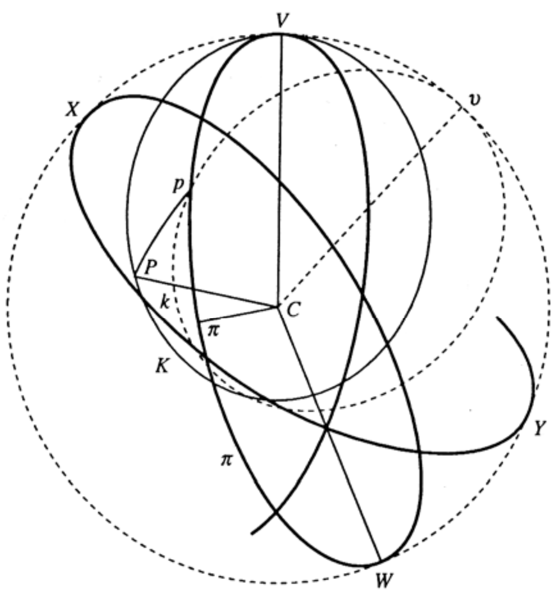
3.4 Planar Motion

Since the electric force is inverse squared law force,

Subprotons' orbits will be in the same plane,

and not on a sphere

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



[Chandrasekhar, p. 195].

3.5 Subprotons' Speed

In [Dan4], we assumed that the subelectrons circulated the electron's center at light speed. Since the proton and the electron mirror each other, we'll assume that

the Subprotons move along a circle of radius r_{p}*, at light speed* c*,*

$$\nu_{\text{p}} = \frac{c}{2\pi r_{\text{p}}} \text{ times per second.}$$

The Subprotons tangential speed in their circular path is c

Thus, the proton has an associated wave of length $\lambda_{\text{p}} = 2\pi r_{\text{p}}$, which explains protons' diffraction.

3.6 Only one Energy State; No assumption of Gluons

Moving at light speed, the Subprotons are charged radiation particles. We will assume that the proton has only one energy state, the quarks have specific orbits, in which they do not radiate. The quarks do not exchange gluons. The QFT assumption of gluons has no experimental basis, and is not necessary in our Current-Ring Model for the proton.

4.

The Proton Structure

4.1 The Charges and Masses of the Subprotons

The d subproton has $\frac{1}{3}e$ charge and its mass m_d is between

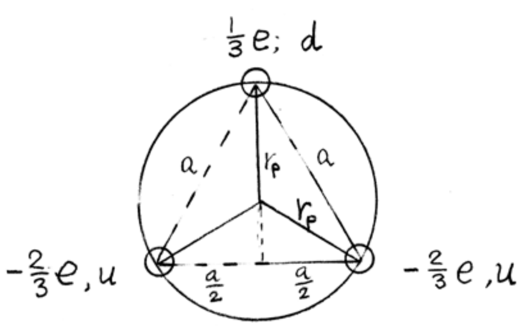
$$4.1 \quad \text{and} \quad 5.8 \quad \text{MeV},$$ an average of $4.95\ \text{MeV}$, [PDG]

Each of the u subprotons has $-\frac{2}{3}e$ charge and mass m_u between

$$0.35 \quad \text{and} \quad 0.6 \quad m_d,$$ an average of $0.475 \quad m_d$, [PDG]

4.2 The Location of the Subprotons

The symmetric location of the subprotons at the vertices of an equilateral triangle will result in greater repulsion, and no proton.

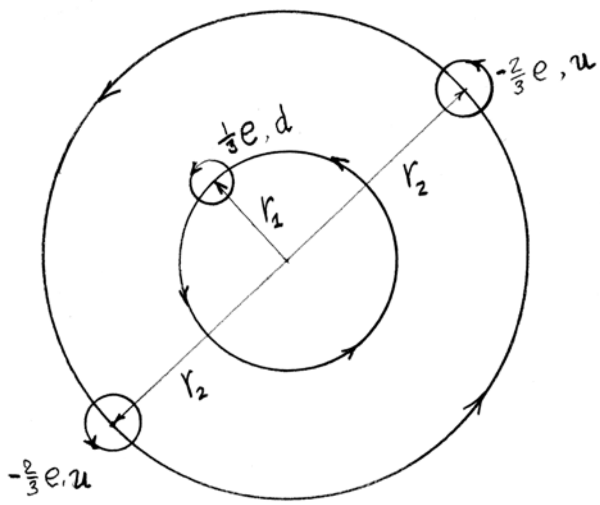


In fact, the planetary model will not allow all three subprotons to be on the same circle.

To simplify the discussion, we will let the two u subprotons share the same orbit.

To temper the effect of the repulsion between the two positively charged u subprotons, the distance between them has to be larger then the distance of either one of them from the d Subproton.

Therefore, the orbit of the d Subproton will have a smaller radius. This means two current rings. One with radius r_1, and one with radius r_2,



Since the correct model is made of at least two current rings, the proton has no radius. What we mean by the proton radius, r_{p}, is a number between the two ring radii,

$$r_1 < r_{\text{p}} < r_2,$$

the order of the size of the two rings.

Indeed, each Subproton has its own radius approximated by r_{p}.

5.

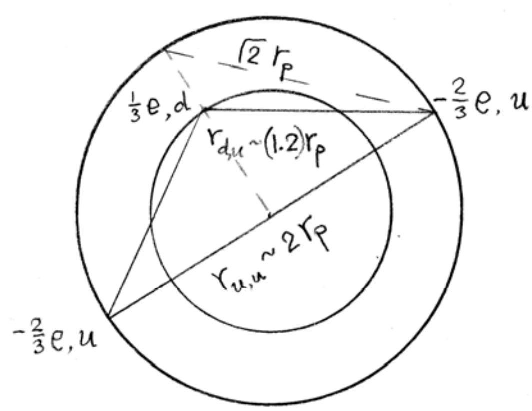
Binding Electric Energy

5.1 The Proton's Binding Electric Energy

$$U_{electric} \sim -\frac{1}{27\pi\varepsilon_0}\frac{e^2}{r_{\mathrm{p}}}$$

$$= -\frac{4}{27}10^{-7}c^2\frac{e^2}{r_{\mathrm{p}}}$$

<u>*Proof*</u>: $$U_{electric} = \frac{1}{4\pi\varepsilon_0}\left\{\frac{(-\frac{2}{3}e)(-\frac{2}{3}e)}{r_{u,u}} + 2\frac{(\frac{1}{3}e)(-\frac{2}{3}e)}{r_{d,u}}\right\}$$



where

$$r_{\mathrm{p}} < r_{d,u} < r_{\mathrm{p}}\sqrt{2} \sim 1.4 r_{\mathrm{p}}.$$

Approximating

$$r_{d,u} \sim (1.2) r_{\mathrm{p}},$$

$$r_{u,u} \sim 2r_{\mathrm{p}},$$

we have

$$U_{electric} \sim \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r_{\mathrm{p}}}\left\{\frac{\frac{4}{9}}{2} - 2\frac{\frac{2}{9}}{(1.2)}\right\}$$

$$\sim -\frac{1}{27\pi\varepsilon_0}\frac{e^2}{r_{\mathrm{p}}}$$

$$= -\frac{4}{27}10^{-7}c^2\frac{e^2}{r_{\mathrm{p}}}.$$

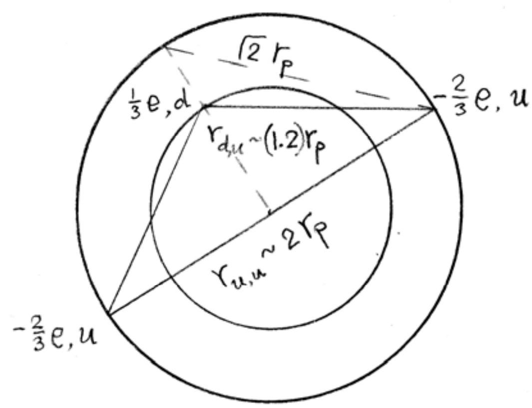
6.

Binding Magnetic Energy

6.1 Repulsion Magnetic Energy between the u quarks

$$\frac{2}{9\pi}\frac{1}{10^7}\frac{e^2}{r_{\text{p}}}c^2$$

Proof:



The u quark with $-\frac{2}{3}e$ charge generates the current

$$-\tfrac{2}{3}e\nu_{\text{p}} = -\tfrac{2}{3}e\frac{c}{2\pi r_{\text{p}}} = -\frac{ec}{3\pi r_{\text{p}}},$$

which at distance $2r_{\text{p}}$, has the magnetic field

$$\mu_0\frac{1}{2\pi(2r_{\text{p}})}\left(-\frac{ec}{3\pi r_{\text{p}}}\right) = -\frac{1}{3\pi}\frac{\mu_0}{4\pi}\frac{ec}{{r_{\text{p}}}^2}.$$

That field applies to the other u quark, the Lorentz force,

$$(-\tfrac{2}{3}e)c(-\frac{1}{3\pi}\frac{\mu_0}{4\pi}\frac{ec}{r_e^{\,2}}) = \frac{2}{9\pi}\frac{\mu_0}{4\pi}\frac{e^2}{r_e^{\,2}}c^2.$$

Multiplying the force by r_e, the magnetic repulsion energy is approximately

$$\frac{2}{9\pi}\frac{\mu_0}{4\pi}\frac{e^2}{r_e}c^2 = \frac{2}{9\pi}\frac{1}{10^7}\frac{e^2}{r_e}c^2.$$

6.2 Attractive Magnetic Energy between d and u quarks

$$-\frac{10}{27\pi}\frac{1}{10^7}\frac{e^2}{r_p}c^2$$

Proof: Each u quark generates the current

$$-\tfrac{2}{3}e\nu_p = -\tfrac{2}{3}e\frac{c}{2\pi r_p} = -\frac{ec}{3\pi r_p},$$

which at distance $1.2r_p$, has the magnetic field

$$\mu_0\frac{1}{2\pi(\frac{6}{5}r_p)}(-\frac{ec}{3\pi r_p}) = -\frac{5}{9\pi}\frac{\mu_0}{4\pi}\frac{ec}{r_p^2}.$$

That field applies to the charge d quark, the Lorentz force,

$$(\tfrac{1}{3}e)c(\frac{5}{9\pi}\frac{\mu_0}{4\pi}\frac{ec}{r_p^2}) = -\frac{5}{27\pi}\frac{\mu_0}{4\pi}\frac{e^2}{r_p^{\,2}}c^2.$$

Multiplying the force by r_p, the magnetic attraction energy between each u quark, and the d quark is approximately

$$-\frac{5}{27\pi}\frac{\mu_0}{4\pi}\frac{e^2}{r_{\mathrm{p}}}c^2 = -\frac{5}{27\pi}\frac{1}{10^7}\frac{e^2}{r_{\mathrm{p}}}c^2.$$

Thus, the magnetic attraction energy is approximately

$$-\frac{10}{27\pi}\frac{1}{10^7}\frac{e^2}{r_{\mathrm{p}}}c^2$$

6.3 The Proton's Binding Magnetic Energy

$$U_{magnetic} \sim -\frac{4}{27\pi}\frac{1}{10^7}\frac{e^2}{r_{\mathrm{p}}}c^2$$

Proof: The sum of 6.1, and 6.2.

7.

Proton's Rotation Energy

7.1 The Proton's Rotation Energy is negligible

$$U_{\text{rotational}} = (\tfrac{1}{2}m_{\text{d}} + m_{\text{u}})c^2 \sim \frac{1}{200}m_{\text{p}}c^2$$

<u>*Proof*</u>: The d quark with $\frac{1}{3}e$ and mass m_{d} has rotation energy

$$\tfrac{1}{2}m_{\text{d}}{r_{\text{p}}}^2{\omega_{\text{p}}}^2 = \tfrac{1}{2}m_{\text{d}}c^2.$$

The u quarks with $-\frac{2}{3}e$ and masses m_{u} have rotation energy

$$2\tfrac{1}{2}m_{\text{u}}{r_{\text{p}}}^2{\omega_{\text{p}}}^2 = m_{\text{u}}c^2.$$

The rotation energy of the proton is

$$(\tfrac{1}{2}m_{\text{d}} + m_{\text{u}})c^2 \sim (\frac{1}{400} + \frac{1}{400})m_{\text{p}}c^2 = \frac{1}{200}m_{\text{p}}c^2$$

8.

Proton's Energy and radius

8.1 The Proton's Energy

$$\boxed{m_{\mathrm{p}} c^2 \sim (1+\tfrac{1}{\pi})\tfrac{4}{27} 10^{-7} e^2 \frac{1}{r_{\mathrm{p}}} c^2}$$

<u>*Proof*</u>:

$$m_{\mathrm{p}} c^2 = \underbrace{U_{\text{electric}}}_{\sim \frac{4}{27} 10^{-7} c^2 \frac{e^2}{r_{\mathrm{p}}}} + \underbrace{U_{\text{magnetic}}}_{\sim \frac{1}{\pi}\frac{4}{27} 10^{-7} c^2 \frac{1}{r_{\mathrm{p}}} e^2} + \underbrace{U_{\text{rotational}}}_{\sim \frac{1}{200} m_{\mathrm{p}} c^2}$$

8.2 The Proton's Mass

$$\boxed{m_{\mathrm{p}} \sim (1+\tfrac{1}{\pi})\tfrac{4}{27} 10^{-7} e^2 \frac{1}{r_{\mathrm{p}}}}$$

8.3 The Proton's Radius

$$\boxed{r_{\mathrm{p}} \sim (1+\tfrac{1}{\pi})\tfrac{4}{27} 10^{-7} e^2 \frac{1}{m_{\mathrm{p}}}}$$

Substituting

$$e = -1.60217733 \times 10^{-19} \mathrm{C},$$

$$m_{\mathrm{p}} = 1.6726231 \times 10^{-27} \mathrm{Kg},$$

$$\boxed{r_{\mathrm{p}} \sim 2.99734552 \times 10^{-19} \mathrm{m}}.$$

9.

Proton Radius-Energy Relation

9.1 *Proton's Frequency, Mass, Energy are proportional to* $\frac{1}{r_{\text{p}}}$

$$\nu_{\text{p}} = \frac{c}{2\pi}\frac{1}{r_{\text{p}}},$$

$$m_{\text{p}} \sim (1+\tfrac{1}{\pi})\tfrac{4}{27}10^{-7}e^2\frac{1}{r_{\text{p}}}.$$

$$\boxed{m_{\text{p}}c^2 \sim (1+\tfrac{1}{\pi})\tfrac{4}{27}\frac{1}{10^7}e^2c^2\frac{1}{r_{\text{p}}}}$$, *the proton's Radius-Energy Relation.*

The Proton Radius-Energy Relation suggests that a heavier positively charged Baryon made of three quarks, is a proton with a smaller radius.

10.

Proton Spin

10.1 Proton Spin by Quarks' Orbital Angular Momentum

$$m_d c r_p + 2 m_u c r_p \sim 1.42558517 \times 10^{-5} \hbar$$

Proof: $m_d c r_p + 2 m_u c r_p = (m_d + 2 m_u) c r_p$

$$\sim \tfrac{1}{100} m_p c r_p$$

Since $m_p \sim (1 + \tfrac{1}{\pi}) \tfrac{4}{27} \tfrac{\mu_0}{4\pi} e^2 \dfrac{1}{r_p}$,

$$\sim \tfrac{1}{100}(1 + \tfrac{1}{\pi}) \tfrac{4}{27} \tfrac{\mu_0}{4\pi} e^2 c$$

Substituting $e^2 \mu_0 c = 2h\alpha$, where $\alpha \approx \tfrac{1}{137}$,

$$= \tfrac{1}{100}(1 + \tfrac{1}{\pi}) \tfrac{4}{27} \tfrac{1}{4\pi} 2\alpha h$$

$$= \tfrac{1}{100}(1 + \tfrac{1}{\pi}) \tfrac{4}{27} \alpha \hbar$$

$$\approx \tfrac{1}{100}(1 + \tfrac{1}{\pi}) \tfrac{4}{27} \tfrac{1}{137} \hbar$$

$$\approx 1.42558517 \times 10^{-5} \hbar$$

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