

Dirac's Magnetic Monopoles have Huge Magnetic Charge, May be Almost Massless, But may be Detected in Neutron Decay

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Abstract Dirac claimed that if a single magnetic monopole is a moving particle with a given wave function, the size of its magnetic charge would be about $(137)/2$ times greater than the electric charge of the electron.

We show that confused by the CGS units system, Dirac multiplied the Vector Potential for a moving electron in an electromagnetic field by the speed of light in the vacuum $c \approx 3 \cdot 10^8 \text{m/sec}$, instead of dividing by c , and obtained no magnetic charge whatsoever.

Dirac could not notice his error because in the CGS units, the magnetic and the electric charges have the same unit. That unit which goes by the name of stat-Coulomb is fictional. There is no one measurement instrument that measures it.

Using the correct Vector Potential, we show that the MKS elementary magnetic charge is given by

$$\mathfrak{M} \approx 3 \cdot 10^8 \frac{137}{2} e \quad \text{Newton} \times \text{meter},$$

where $e = 1.60217733 \times 10^{-19}$ Coulomb (=Ampere \times sec) is the electron charge.

This huge magnetic charge may enable us to detect a Dirac Magnetic Monopole in an experiment.

Assuming that an elementary magnetic dipole is a pair of opposite-signs single magnetic monopoles, Dirac concluded that greater attraction due to the higher magnetic charges of the monopoles is the reason why opposite monopoles are locked in dipoles.

In fact, what is crucial is the distance between the poles in the dipole. That distance must be way smaller than the distance between poles from different dipoles. Then, when a magnet breaks, it will always break between its dipoles.

Recently, we established that the Neutron is a mini-Hydrogen Atom composed of an electron and a proton. The electron's orbit, and the proton's orbit are magnetic dipoles.

Perhaps, in a radio-active decay of the Neutron into its electron and proton, when the magnetic dipoles of the electron and the proton disintegrate, either dipole breaks down into two monopoles. The electromagnetic energy locked in either dipole splits evenly into two monopoles of opposite magnetic signs. A particle that

carries a North magnetic charge, and a particle that carries a South magnetic charge.

Perhaps, Dirac Magnetic Monopoles appear in the disintegration of a neutron into its electron and proton.

The dipole magnetic energy contained the proton's orbit equals the dipole magnetic energy contained in the electron's orbit. That energy is about

$$36\text{eV}.$$

Therefore, the magnetic energy of each pole may be about

$$18\text{eV}.$$

In comparison, the energy of the electron Neutrino is about 7eV.

By mass-energy equivalence, the mass of each particle is about

$$(3.209692764)10^{-33}\text{kg} = \frac{3.523499235}{1000}m_e,$$

where $m_e = (0.91093897)10^{-30}\text{kg}$ is the electron mass.

Perhaps, magnetic monopoles were not detected so far because they are almost massless.

If the particle carrying the magnetic monopole is a photon, its frequency is about

$$\nu_m = (8.71925892)10^{15}\text{cycles/sec},$$

where $h = (6.6260755)10^{-34}\text{Jsec}$ is Planck constant

And its wave length

$$\lambda_m \sim (3.44065938)10^{-8}\text{meter}$$

is in the Ultra-Violet range.

For the Hydrogen Atom, the magnetic dipoles of the electron, and the proton contain magnetic energy of about

$$\frac{1}{10,000} \text{ eV}$$

Therefore, the magnetic energy of each pole may be about

$$\frac{1}{20,000} \text{ eV}.$$

It is unlikely that Hydrogen monopoles may be detected.

Finally, Dirac attempts to find Schrödinger's wave function of an electron moving in the radial field of quantum magnetic monopole. That example is based on Dirac's erroneous vector potential, and is tainted with CGS stuff. Even if reworked in MKS units, we don't know its relevance to observing magnetic monopoles in experiments.

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1.

Dirac's Wave Function and Magnetic Monopoles

Dirac assumes that a moving particle carrying a single magnetic pole has a wave function

$$\begin{aligned}\psi(t, x, y, z, X) &= \underbrace{A(t, x, y, z)e^{i\gamma(t, x, y, z)}}_{\psi_1(t, x, y, z)} e^{i\beta(t, x, y, z, X)}, \\ &= \psi_1(t, x, y, z)e^{i\beta(t, x, y, z, X)}\end{aligned}$$

that depends on an unspecified variable X . But the partial derivatives of β are independent of X . That is,

$$\partial_t\beta = \partial_0\beta = \kappa_0(t, x, y, z),$$

$$\partial_x\beta = \partial_1\beta = \kappa_1(t, x, y, z),$$

$$\partial_y\beta = \partial_2\beta = \kappa_2(t, x, y, z),$$

$$\partial_z\beta = \partial_3\beta = \kappa_3(t, x, y, z),$$

And

$$\partial_{ij}\beta \text{ need not equal } \partial_{ji}\beta.$$

The phase change around a closed space-time curve α is

$$\oint_{\text{space-time cycle } \alpha} d\beta = \oint_{\alpha} \kappa_0 dt + \kappa_1 dx + \kappa_2 dy + \kappa_3 dz$$

By Stokes Theorem, the line integral equals the surface integral

$$\begin{aligned}
&= \iint_{\text{surface bounded by } \alpha} (\partial_1 \kappa_2 - \partial_2 \kappa_1) dx \wedge dy + (\partial_1 \kappa_3 - \partial_3 \kappa_1) dx \wedge dz \\
&+ \iint_{\text{surface bounded by } \alpha} (\partial_1 \kappa_0 - \partial_0 \kappa_1) dx \wedge dt + (\partial_2 \kappa_3 - \partial_3 \kappa_2) dy \wedge dz \\
&+ \iint_{\text{surface bounded by } \alpha} (\partial_2 \kappa_0 - \partial_0 \kappa_2) dy \wedge dt + (\partial_3 \kappa_0 - \partial_0 \kappa_3) dz \wedge dt
\end{aligned}$$

Differentiating ψ , for $i = 0, 1, 2, 3$ ¹

$$-i\hbar \partial_i \psi = e^{i\beta} (-i\hbar \partial_i \psi_1 + \hbar \kappa_i \psi_1)$$

That is, with respect to time,

$$-i\hbar \partial_0 \psi = e^{i\beta} (-i\hbar \partial_0 \psi_1 + \hbar \kappa_0 \psi_1)$$

and with respect to space

$$-i\hbar \nabla \psi = e^{i\beta} (-i\hbar \nabla \psi_1 + \hbar \vec{\kappa} \psi_1)$$

Therefore, if Schrödinger's wave equation for ψ has the Momentum operator P , and the Energy operator² W , then Schrödinger's wave equation for ψ_1 has the Momentum operator $P + \hbar \vec{\kappa}$, and the Energy operator $W - \hbar \kappa_0$.

Thus, if ψ satisfies Schrödinger's wave equation for a neutral particle moving in a field free space, Then ψ_1 satisfies the same

¹ Dirac denotes Planck's Constant divided by 2π by \hbar . We use the common notation \hbar

² The energy operator is usually denoted by E

equation for an electron moving in an electromagnetic field with a CGS scalar potential³

$$\phi = -\frac{\hbar}{e}\kappa_0,$$

and a CGS vector potential,

$$\vec{A} = \frac{\hbar}{ec}\vec{\kappa}.$$

Dirac used an erroneous vector potential $\vec{A} = \frac{\hbar c}{e}\vec{\kappa}$, which yields no magnetic charge whatsoever.

We first use the correct vector potential to obtain the magnetic charge. Then we show why Dirac's obtained nothing.

³ Dirac denotes the scalar potential by A_0 . We use the common notation ϕ .

2.

The Huge Elementary Magnetic Charge of a Monopole

We consider an electron moving in an electromagnetic field with a CGS scalar potential

$$\phi = -\frac{\hbar}{e}\kappa_0,$$

and a CGS vector potential,

$$\vec{A} = \frac{\hbar}{ec}\vec{\kappa}.$$

By [Woan, p.135], in the conversion from CGS to MKS, ϕ remains unchanged. But the MKS vector potential is multiplied by c .

That is, the MKS vector potential is

$$\vec{A} = \frac{\hbar}{e}\vec{\kappa}.$$

Then,

$$\nabla \times \vec{\kappa} = \frac{e}{\hbar} \underbrace{\nabla \times \vec{A}}_{\vec{B}}$$

$$\underbrace{\nabla \kappa_0}_{-\frac{e}{\hbar}\nabla\phi} - \underbrace{\partial_t \vec{\kappa}}_{\frac{e}{\hbar}\partial_t \vec{A}} = \frac{e}{\hbar} \underbrace{(-\nabla\phi - \partial_t \vec{A})}_{\vec{E}}$$

The phase change around an infinitesimal closed space-curve α is

$$\oint_{\text{infinitesimal space cycle } \alpha} d\beta.$$

If ψ vanishes along a line that passes through that cycle, then the phase-change around the cycle increases by a multiple of 2π .

Now,

$$\oint_{\alpha} d\beta = \oint_{\alpha} \kappa_1 dx + \kappa_2 dy + \kappa_3 dz$$

By Stokes Theorem, the line integral equals the surface integral

$$\begin{aligned} &= \iint_{\text{surface bounded by } \alpha} (\partial_1 \kappa_2 - \partial_2 \kappa_1) dx \wedge dy + (\partial_1 \kappa_3 - \partial_3 \kappa_1) dx \wedge dz \\ &+ \iint_{\text{surface bounded by } \alpha} (\partial_2 \kappa_3 - \partial_3 \kappa_2) dy \wedge dz \\ &= \iint_{\text{surface bounded by } \alpha} \underbrace{(\nabla \times \vec{\kappa})}_{\frac{e}{\hbar} \vec{B}} \cdot d\vec{S} \\ &= \frac{e}{\hbar} \iint_{\text{surface bounded by } \alpha} \vec{B} \cdot d\vec{S} \\ &= \frac{e}{\hbar} \times (\text{Magnetic Flux through the Surface}) \end{aligned}$$

If the surface is closed, the MKS Magnetic Flux through it is

$$\oint_{\text{closed surface } S} \vec{B} \cdot d\vec{S} = \mu_0 \times (\text{magnetic charge inside } S),$$

where $\mu_0 = \frac{4\pi}{10^7} \frac{\text{Newton}}{(\text{Ampere})^2}$ is the permeability of the vacuum.

If the ψ -vanishing line is inside an infinitesimal closed surface, its ends points are an elementary magnetic monopole with magnetic charge \mathfrak{M} , and $\frac{e}{\hbar}\mu_0\mathfrak{M}$ equals the minimal phase change 2π ,

$$\frac{e}{\hbar}\mu_0\mathfrak{M} = 2\pi.$$

Therefore, the MKS elementary magnetic charge of a Dirac magnetic monopole is

$$\begin{aligned}\mathfrak{M} &= \frac{2\pi\hbar}{\mu_0 e}, \\ &= c \frac{1}{2} \frac{2}{\underbrace{\mu_0 c}_{\approx 137}} \frac{h}{e^2} e,\end{aligned}$$

where $\frac{2}{\mu_0 c} \frac{h}{e^2} \approx 137$ is the inverse of the Fine Structure Constant

[Cohen, p.54]

$$\boxed{\mathfrak{M} \approx 3 \cdot 10^8 \frac{137}{2} e}$$

This huge magnetic charge may enable us to detect a Dirac Magnetic Monopole in an experiment.

The enormous size of the elementary magnetic charge calls for confirmation of the units in the formula

3.

Checking of Units for the Elementary Magnetic Charge

The electric MKS force between two electric charges q_1 , and q_2 at distance r is

$$F_e = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2},$$

where ϵ_0 is the vacuum Permittivity.

Hence,

$$\epsilon_0 = \frac{1}{4\pi} \frac{1}{F_e} \frac{q_1 q_2}{r^2}$$

Therefore, the unit of ϵ_0 is

$$\frac{1}{\text{Newton}} \frac{(\text{Coulomb})^2}{(\text{meter})^2}.$$

The Vacuum Permeability is

$$\mu_0 = \frac{1}{\epsilon_0 c^2}.$$

Therefore, the unit of μ_0 is

$$\text{Newton} \frac{(\text{meter})^2}{(\text{Coulomb})^2} \left(\frac{\text{sec}}{\text{meter}} \right)^2 = \frac{\text{Newton}}{(\text{Ampere})^2}$$

The magnetic MKS force between two magnetic charges m_1 , and m_2 at distance r is

$$F_m = \frac{\mu_0}{4\pi} \frac{m_1 m_2}{r^2},$$

Hence,

$$m_1 m_2 = \frac{4\pi}{\mu_0} F_m r^2$$

Consequently, the unit of the magnetic charge is

$$\sqrt{\frac{(\text{Ampere})^2}{\text{Newton}} \text{Newton}(\text{meter})^2} = (\text{Ampere})(\text{meter})$$

This is precisely the unit of

$$\mathfrak{M} \approx c \frac{137}{2} e.$$

Indeed, the unit of ce is

$$\frac{\text{meter}}{\text{sec}} \text{Coulomb} = (\text{meter})(\text{Ampere})$$

We proceed to show that Dirac's formula for the magnetic charge yields no magnetic charge whatsoever.

4.

Dirac's incorrect Vector Potential yields no Magnetic Charge

Dirac obtained for the elementary magnetic charge, [Dirac, p.68, formula 9],

$$\frac{1}{2} \frac{\hbar c}{e} = \frac{1}{2} \frac{\hbar c}{e^2} e = \frac{137}{2} e$$

where $\frac{\hbar c}{e^2} \approx 137$ is the CGS inverse of the Fine Structure Constant [Cohen, p.54].

Then, the magnetic charge is in units of electric charge, which is non-physical. The confusing CGS unit system leads to a result that cannot be verified even in terms of its units.

Therefore, we need to derive Dirac's result in the MKS system.

Dirac's erroneous CGS vector potential

$$\vec{A} = \frac{\hbar}{ec} \vec{\kappa},$$

Converts to the MKS potential

$$\vec{A} = \frac{\hbar}{ec^2} \vec{\kappa}$$

Then, erroneously,

$$\nabla \times \vec{\kappa} = \frac{ec^2}{\hbar} \underbrace{\nabla \times \vec{A}}_{\vec{B}}$$

and

$$\frac{ec^2}{\hbar} \mu_0 \mathfrak{M}_{\text{error}} = 2\pi.$$

Therefore, the MKS elementary magnetic charge of a Dirac magnetic monopole is

$$\begin{aligned} \mathfrak{M}_{\text{error}} &= \frac{2\pi}{\mu_0} \frac{\hbar}{ec^2}, \\ &= \frac{1}{c} \frac{1}{2} \frac{2}{\underbrace{\mu_0 c e^2}_{\approx 137}} h e, \end{aligned}$$

where $\frac{2}{\mu_0 c e^2} \frac{h}{e} \approx 137$ is the inverse of the Fine Structure Constant [Cohen, p.54]

$$\mathfrak{M}_{\text{error}} \approx \frac{1}{c} \frac{1}{2} \frac{137}{e} e.$$

But the units of e / c are not units of a magnetic charge:

$$\text{Coulomb} \frac{\text{sec}}{\text{meter}} \neq (\text{meter})(\text{Ampere}),$$

because

$$(\text{Ampere})(\text{sec}) \frac{\text{sec}}{\text{meter}} \neq (\text{meter})(\text{Ampere}),$$

because

$$(\text{sec})^2 \neq (\text{meter})^2,$$

because

$$\text{sec} \neq \text{meter}.$$

5.

The Force between the Monopoles in a Magnetic Dipole

Dirac concludes [Dirac, p.71]

“ ...the question of why isolated magnetic poles are not observed. The experimental result⁴

$$\frac{\hbar c}{e^2} = 137$$

shows that there must be some dissimilarity between electricity and magnetism (possible connected between the cause of dissimilarity between electrons and protons) as the result of which we have,

not elementary magnetic charge = e

but

$$\text{elementary magnetic charge} = \frac{137}{2} \times e$$

This means that the attractive force between one-quantum poles of opposite sign is

$$(137 / 2)^2 \approx 4692$$

times that between electron and proton

⁴ in CGS.

This very large force may perhaps account for why poles of opposite signs have never yet been separated”

In fact, the magnetic charge of the pole is irrelevant to the breakup of a magnet into its North and South poles.

What prevents the separation is the very small distance between the poles in the dipole. Since the force is proportional to the inverse squared distance between the poles, that distance must be way smaller than the distance between poles from different dipoles. Then, when a magnet breaks, it will always break between its dipoles.

In any event, a huge force does not guarantee large energy. If the monopoles are generated in the breakup of a magnetic dipole, their energy may be negligible, and undetectable.

6.

The Energy of a Magnetic Monopole

A collection of dipoles, which we call a magnet, always breaks up along its dipoles.

How can the North and South poles of a dipole be separated?

The discussion of the force between poles may lead to the wrong notion that a Magnetic dipole is a static pair of North and South poles.

In fact, it is commonly accepted that a Magnetic dipole is an indivisible electric current loop, such as

1) the Hydrogen Electron orbit, or,

2) the Hydrogen Proton orbit,

or, as argued in [Dan], when the Neutron is viewed as a mini-Hydrogen Atom. the electric current is

3) the Neutronic Electron Orbit, or

4) the Neutronic Proton orbit

The only way to break such electric current loop is to split its energy between two photons. In analogy with matter-antimatter interaction, we will assume an even split of the energy, and an even split of the magnetic charges. One of the photons will carry a

North pole magnetic charge, and the other the same size of South pole magnetic charge.

The photonic electromagnetic energy contained in an electric current loop may be small, and if it splits into two photons, one carrying North magnetic pole, and the other carrying the South magnetic pole, then both will have negligible masses, and be undetectable.

Perhaps, magnetic monopoles were not detected so far because they may be almost massless.

In any event, two attracting magnetic poles may appear as a consequence of the demolition of an electric current loop.

7.

The Magnetic Monopoles that Compose the Electron Magnetic Dipole in the Neutron are almost massless

In [Dan], we established that the Neutron is a Mini-Hydrogen Atom composed of an electron and a proton:

We showed that the Neutronic Electron has

$$1^{\text{st}} \text{ Orbit Radius } r_N \sim 9.398741807 \times 10^{-14} \text{ m},$$

$$\text{Speed } v_e \sim 51,558,134 \text{ m/sec},$$

$$\sim 23.5 \times (\text{Speed in Hydrogen}).$$

$$\text{Frequency } \nu_e \sim 8.73067052 \times 10^{19} \text{ cycles/second},$$

$$\sim 13,271 \times (\text{Hydrogen Electron Frequency}),$$

in the range of Hard X Rays:

$$\text{Quantum of Angular Momentum } \sim (0.043132065)\hbar,$$

$$\text{Zero Point Energy } \sim -7671 \text{ eV},$$

$$\sim 564 \times (\text{Hydrogen's Zero Point Energy})$$

with photon frequency $\sim 3.708097094 \times 10^{18}$ cycles/sec

In particular, we computed the Magnetic Energy of the dipole generated by the electron's orbit. We showed [Dan1,p.23] that the Electron's Magnetic Energy in its orbit is

$$\begin{aligned} U_{\text{magnetic}} &= \frac{1}{4} \mu_0 r_N e^2 \nu_e^2 \\ &= \frac{1}{(4\pi)^2} \mu_0 v_e^2 e^2 \frac{1}{r_N} \end{aligned}$$

Indeed, the current due to the electron's charge e that turns ν_e cycles/second is

$$I = e\nu_e$$

The Magnetic Energy of this current is [Benson, p.486]

$$\frac{1}{2} LI^2.$$

By [Fischer, p.97]

$$L = \mu_0 \frac{\pi r_N^2}{2\pi r_N} = \frac{1}{2} \mu_0 r_N.$$

Thus, the magnetic energy due to the electron charge is

$$\begin{aligned} \frac{1}{2} \frac{1}{2} \mu_0 r_N (e\nu_e)^2 &= \frac{1}{4} \underbrace{\mu_0}_{\frac{4\pi}{10^7}} r_N e^2 \underbrace{\nu_e^2}_{\frac{1}{4\pi^2} \omega_e^2} \\ &= \frac{1}{(4\pi)^2} \mu_0 v_e^2 e^2 \frac{1}{r_N}, \\ &= \frac{\pi}{10^7} r_N e^2 \nu_e^2 \end{aligned}$$

Substituting

$$\mu_0 = \frac{4\pi \text{ Newton}}{10^7 (\text{Ampere})^2}$$

$$r_N \sim 9.398741807 \times 10^{-14} \text{ meter}$$

$$e \sim (1.60217733)10^{-19} \text{ C}$$

$$\nu_e \sim 8.73067052 \times 10^{19} \text{ cycles/second}$$

The units check out. Indeed,

$$\frac{\text{Newton}}{(\text{Ampere})^2} (\text{meter})(\text{Ampere} \times \text{sec})^2 \left(\frac{\text{cycles}}{\text{sec}} \right)^2 = (\text{Newton}) \times (\text{meter})$$

The dipole magnetic energy contained in the electron current loop is

$$\begin{aligned} \pi 10^{-7} (9.398741807) 10^{-14} (1.60217733)^2 10^{-38} (8.73067052)^2 10^{38} &= \\ &= (5.777446796) 10^{-18} \text{ Joule} \\ &= (5.777446796) 10^{-18} \frac{1}{(1.60217733) 10^{-19}} \text{ electron Volt} \\ &= (36.05997794) \text{ eV} \\ &\sim 36 \text{ eV} \end{aligned}$$

Perhaps, in a radio-active decay of the Neutron into its electron and proton, when the electron's magnetic dipole disintegrates, the dipole breaks down into two monopoles. The electromagnetic energy locked in the dipole splits evenly into two monopoles of opposite magnetic signs. A particle that carries a North magnetic charges, and a particle that carries a South magnetic charge.

The energy carried by each particle is about

$$18\text{eV}.$$

In comparison, the electron-neutrino energy is about 7eV

By mass-energy equivalence, the mass of each particle is about

$$\frac{\frac{1}{2}(5.777446796)10^{-18}}{c^2} = (3.209692764)10^{-33}\text{kg}$$

in terms of electron's mass, $m_e = (0.91093897)10^{-30}\text{kg}$

$$\begin{aligned} &= \frac{(3.209692764)10^{-33}}{(0.91093897)10^{-30}} m_e \\ &= \frac{3.523499235}{1000} m_e \end{aligned}$$

If the particle carrying the magnetic monopole is a photon, taking

Planck constant $h = (6.6260755)10^{-34}\text{Jsec}$, its frequency is about

$$\begin{aligned} \nu_{\mathfrak{M}} &= \frac{\frac{1}{2}(5.777446796)10^{-18}}{(6.6260755)10^{-34}} \\ &= (4.35962946)10^{15}\text{cycles/sec} \end{aligned}$$

Its wave length is about

$$\begin{aligned} \lambda_{\mathfrak{M}} &= \frac{c}{\nu_{\mathfrak{M}}} \sim \frac{3 \cdot 10^8 \text{meter/sec}}{(4.35962946)10^{15} \text{cycles/sec}} \\ &= (6.881318756)10^{-8} \text{meter} \end{aligned}$$

in the Ultra-Violet range.

Clearly, this level of energy is difficult to detect. Neutrinos are almost massless, and monopoles generated from the current loops of the Hydrogen electron measure are almost massless

8.

The Magnetic Monopoles that compose the Proton's Magnetic dipole in the Neutron are almost massless

In [Dan], we established that the Neutron is a Mini-Hydrogen Atom composed of an electron and a proton:

We showed that the Neutronic Proton has

$$1^{\text{st}} \text{ Orbit Radius } \rho_p \sim 2.209505336 \times 10^{-15} \text{m},$$

$$\text{Speed } V_p \sim 7,905,145 \text{ m/sec},$$

$$\sim 24 \times (\text{Hydrogen Proton Speed}).$$

$$\text{Frequency } \nu_p \sim 5.69422884 \times 10^{20} \text{ cycles/sec},$$

$$\sim 13,223 \times (\text{Hydrogen Proton Frequency}),$$

in the range of Gamma Rays:

$$\text{Quantum of Angular Momentum} \sim (0.277007069)\hbar,$$

$$\text{Nuclear Binding Energy} \sim -326,308 \text{ eV},$$

$$\sim 553 \times (\text{Hydrogen's Nuclear Energy Binding})$$

$$\frac{\text{Electron Orbit Radius}}{\text{Proton Orbit Radius}} = \frac{r_N}{\rho_p} \sim 42.5,$$

In particular, we computed the Magnetic Energy of the dipole generated by the proton's orbit. We showed [Dan1,p.27] that the Proton's Magnetic Energy in its orbit is

$$\begin{aligned} U_{\text{magnetic}} &= \frac{1}{4} \mu_0 \rho_p e^2 \nu_p^2 \\ &= \frac{1}{(4\pi)^2} \mu_0 V_p^2 e^2 \frac{1}{\rho_p} \end{aligned}$$

Indeed, the current due to the proton's charge e that turns ν_p cycles/second is

$$I = e\nu_p$$

The Magnetic Energy of this current is [Benson, p.486]

$$\frac{1}{2} LI^2.$$

By [Fischer, p.97]

$$L = \mu_0 \frac{\pi \rho_p^2}{2\pi \rho_p} = \frac{1}{2} \mu_0 \rho_p.$$

Thus, the magnetic energy due to the Proton's charge is

$$\begin{aligned} \frac{1}{2} \frac{1}{2} \mu_0 \rho_p (e\nu_p)^2 &= \frac{1}{4} \mu_0 \rho_p e^2 \underbrace{\nu_p^2}_{\frac{1}{4\pi^2} \Omega_p^2} \\ &= \frac{1}{(4\pi)^2} \mu_0 V_p^2 e^2 \frac{1}{\rho_p}. \end{aligned}$$

$$= \frac{\pi}{10^7} \rho_p e^2 \nu_p^2$$

Substituting

$$\mu_0 = \frac{4\pi}{10^7} \frac{\text{Newton}}{(\text{Ampere})^2}$$

$$\rho_p \sim 2.209505336 \times 10^{-15} \text{meter}$$

$$e \sim (1.60217733)10^{-19} \text{C}$$

$$\nu_p \sim 5.69422884 \times 10^{20} \text{ cycles/sec}$$

The units check out. Indeed,

$$\frac{\text{Newton}}{(\text{Ampere})^2} (\text{meter}) (\text{Ampere} \times \text{sec})^2 \left(\frac{\text{cycles}}{\text{sec}} \right)^2 = (\text{Newton}) \times (\text{meter})$$

The dipole magnetic energy contained in the proton current loop is

$$\begin{aligned} & \pi 10^{-7} (2.209505336) 10^{-15} (1.60217733)^2 10^{-38} (5.69422884)^2 10^{40} = \\ & = (5.777446406) 10^{-18} \text{Joule} \\ & = (5.777446406) 10^{-18} \frac{1}{(1.60217733) 10^{-19}} \text{electron Volt} \\ & = (36.05905918) \text{eV} \\ & \sim 36 \text{eV} \end{aligned}$$

Indeed, the proton current loop, and the electron current loop contain the same magnetic energy

$$\frac{\pi}{10^7} r_N e^2 \nu_e^2 = \frac{\pi}{10^7} \rho_p e^2 \nu_p^2$$

because

$$r_N \nu_e^2 = \rho_p \nu_p^2$$

because

$$r_N \underbrace{(2\pi\nu_e)^2}_{\omega_e} = \rho_p \underbrace{(2\pi\nu_p)^2}_{\omega_p}$$

That is,

$$\omega_e^2 r_N = \omega_p^2 \rho_p$$

because the acceleration of the electron towards the proton equals the acceleration of the proton towards the electron (the signs are opposite).

Perhaps, in a radio-active decay of the Neutron into its electron and proton, when the proton's magnetic dipole disintegrates, the dipole breaks down into two monopoles. The electromagnetic energy locked in the dipole splits evenly into two monopoles of opposite magnetic signs. A particle that carries a North magnetic charges, and a particle that carries a South magnetic charge.

The energy carried by each particle is about

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By mass-energy equivalence, the mass of each particle is about

$$\frac{\frac{1}{2}(5.777446406)10^{-18}}{c^2} = (3.20969244)10^{-33}\text{kg}$$

in terms of electron's mass, $m_e = (0.91093897)10^{-30}\text{kg}$

$$\begin{aligned}
&= \frac{(3.20969244)10^{-33}}{(0.91093897)10^{-30}} m_e \\
&= \frac{3.523498888}{1000} m_e
\end{aligned}$$

If the particle carrying the magnetic monopole is a photon, taking Planck constant $h = (6.6260755)10^{-34}$ Jsec, its frequency is about

$$\begin{aligned}
\nu_{\mathfrak{M}} &= \frac{\frac{1}{2}(5.777446406)10^{-18}}{(6.6260755)10^{-34}} \\
&= (4.35962917)10^{15} \text{ cycles/sec}
\end{aligned}$$

Its wave length is about

$$\begin{aligned}
\lambda_{\mathfrak{M}} &= \frac{c}{\nu_{\mathfrak{M}}} \sim \frac{3 \cdot 10^8 \text{ meter/sec}}{(4.35962917)10^{15} \text{ cycles/sec}} \\
&= (6.881319221)10^{-8} \text{ meter}
\end{aligned}$$

in the Ultra-Violet range.

Clearly, this level of energy is difficult to detect. Neutrinos are almost massless, and monopoles generated from the current loops of the Neutron proton are almost massless.

9.

The Magnetic Monopoles that Compose the Electron Magnetic Dipole in the Hydrogen are undetectable

The Hydrogen Electron has

$$1^{\text{st}} \text{ Orbit Radius } r_H \sim 5.29277249 \times 10^{-11} \text{ m},$$

In [Dan4, p. 44], we showed that the Hydrogen Electron has

$$\text{Speed } v_H \sim 2,189,781 \text{ m/sec},$$

In [Dan4, p. 47], we showed that the Hydrogen Electron has

$$\text{Frequency } \nu_H \sim 6.58472424 \times 10^{15} \text{ cycles/second},$$

The Magnetic Energy of the dipole generated by the electron's orbit is

$$\begin{aligned} U_{\text{magnetic}} &= \frac{1}{4} \mu_0 r_H e^2 \nu_H^2 \\ &= \frac{1}{(4\pi)^2} \mu_0 v_H^2 e^2 \frac{1}{r_H} \\ &= \frac{\pi}{10^7} r_H e^2 \nu_H^2 \end{aligned}$$

Substituting

$$\mu_0 = \frac{4\pi \text{ Newton}}{10^7 (\text{Ampere})^2}$$

$$r_H \sim 5.29277249 \times 10^{-11} \text{ meter}$$

$$e \sim (1.60217733)10^{-19} \text{ C}$$

$$\nu_H \sim 6.58472424 \times 10^{15} \text{ cycles/second}$$

The units check out. Indeed,

$$\frac{\text{Newton}}{(\text{Ampere})^2} (\text{meter})(\text{Ampere} \times \text{sec})^2 \left(\frac{\text{cycles}}{\text{sec}} \right)^2 = (\text{Newton}) \times (\text{meter})$$

The dipole magnetic energy contained in the electron current loop is

$$\begin{aligned} \pi 10^{-7} (5.29277249) 10^{-11} (1.60217733)^2 10^{-38} (6.58472424)^2 10^{30} &= \\ &= (1.850671972) 10^{-23} \text{ Joule} \\ &= (1.850671972) 10^{-23} \frac{1}{(1.60217733) 10^{-19}} \text{ electron Volt} \\ &= (1.155068961) 10^{-4} \text{ eV} \\ &\sim \frac{1}{10,000} \text{ eV} \end{aligned}$$

Perhaps, in a disintegration of the Hydrogen Atom into its electron and proton, when the electron's magnetic dipole breaks down, the dipole splits into two monopoles. The electromagnetic energy locked in the dipole splits evenly into two monopoles of

opposite magnetic signs. A particle that carries a North magnetic charges, and a particle that carries a South magnetic charge.

The energy carried by each particle is about

$$\frac{1}{20,000} \text{eV}.$$

In comparison, the electron-neutrino energy is about 7eV

By mass-energy equivalence, the mass of each particle is about

$$\frac{\frac{1}{2}(1.850671972)10^{-23}}{c^2} = (1.028151096)10^{-40} \text{kg}$$

in terms of electron's mass, $m_e = (0.91093897)10^{-30} \text{kg}$

$$\begin{aligned} &= \frac{(1.028151096)10^{-40}}{(0.91093897)10^{-30}} m_e \\ &= \frac{1.128671766}{10,000,000,000} m_e \end{aligned}$$

If the particle carrying the magnetic monopole is a photon, taking

Planck constant $h = (6.6260755)10^{-34} \text{Jsec}$, its frequency is about

$$\begin{aligned} \nu_{\mathfrak{M}} &= \frac{\frac{1}{2}(1.850671972)10^{-23}}{(6.6260755)10^{-34}} \\ &= (1.396506855)10^{10} \text{cycles/sec} \end{aligned}$$

Its wave length is about

$$\lambda_{\mathfrak{M}} = \frac{c}{\nu_{\mathfrak{M}}} \sim \frac{3 \cdot 10^8 \text{meter/sec}}{(1.396506855)10^{10} \text{cycles/sec}}$$

$$= (2.148217167)10^{-2}\text{meter}$$

in the Microwave range.

Clearly, this level of energy is undetectable. Neutrinos are almost massless, and monopoles generated from the current loops of the Hydrogen electron measure as massless

10.

The Magnetic Monopoles that compose the Proton's Magnetic dipole in the Hydrogen are undetectable

In [Dan2], we showed that the Hydrogen Proton has

$$1^{\text{st}} \text{ Orbit Radius } \rho_{\text{p in H}} \sim 1.221173735 \times 10^{-12} \text{m},$$

In [Dan1, p. 36], we showed that the Hydrogen Proton

$$\text{Speed is } V_{\text{p in H}} \sim 330,420 \text{ m/sec},$$

In [Dan1, p. 40], we showed that the Hydrogen Proton

$$\text{Frequency is } \nu_{\text{p in H}} \sim 4.30634292 \times 10^{16} \text{ cycles/sec},$$

The Magnetic Energy of the dipole generated by the proton's orbit is

$$\begin{aligned} U_{\text{magnetic}} &= \frac{1}{4} \mu_0 \rho_{\text{p in H}} e^2 \nu_{\text{p in H}}^2 \\ &= \frac{1}{(4\pi)^2} \mu_0 V_{\text{p in H}}^2 e^2 \frac{1}{\rho_{\text{p in H}}} \\ &= \frac{\pi}{10^7} \rho_{\text{p}} e^2 \nu_{\text{p}}^2 \end{aligned}$$

Substituting

$$\mu_0 = \frac{4\pi \text{ Newton}}{10^7 (\text{Ampere})^2}$$

$$\rho_{\text{p in H}} \sim 1.221173735 \times 10^{-12} \text{m}$$

$$e \sim (1.60217733)10^{-19} \text{C}$$

$$\nu_{\text{p in H}} \sim 4.30634292 \times 10^{16} \text{ cycles/sec}$$

The units check out. Indeed,

$$\frac{\text{Newton}}{(\text{Ampere})^2} (\text{meter})(\text{Ampere} \times \text{sec})^2 \left(\frac{\text{cycles}}{\text{sec}} \right)^2 = (\text{Newton}) \times (\text{meter})$$

The dipole magnetic energy contained in the proton current loop is

$$\begin{aligned} \pi 10^{-7} (1.221173735) \times 10^{-12} (1.60217733)^2 10^{-38} (4.30634292)^2 10^{32} &= \\ &= (1.826273061) 10^{-23} \text{Joule} \\ &= (1.826273061) 10^{-23} \frac{1}{(1.60217733) 10^{-19}} \text{electron Volt} \\ &= (1.139869493) 10^{-4} \text{eV} \\ &\sim \frac{1}{10,000} \text{eV} \end{aligned}$$

Indeed, the proton current loop, and the electron current loop contain the same magnetic energy

$$\frac{\pi}{10^7} r_{\text{H}} e^2 \nu_{\text{H}}^2 = \frac{\pi}{10^7} \rho_{\text{p in H}} e^2 \nu_{\text{p in H}}^2$$

because

$$r_{\text{H}} \nu_{\text{e}}^2 = \rho_{\text{p in H}} \nu_{\text{p in H}}^2$$

because

$$r_{\text{H}} \underbrace{(2\pi\nu_{\text{H}})^2}_{\omega_e} = \rho_{\text{p}} \underbrace{(2\pi\nu_{\text{p}})^2}_{\omega_p}$$

That is,

$$\omega_{\text{H}}^2 r_{\text{H}} = \omega_{\text{p}}^2 \rho_{\text{p}}$$

because the acceleration of the electron towards the proton equals the acceleration of the proton towards the electron (the signs are opposite).

Perhaps, in a disintegration of an Hydrogen Atom into its electron and proton, when the proton's magnetic dipole breaks down, the dipole splits into two monopoles. The electromagnetic energy locked in the dipole splits evenly into two monopoles of opposite magnetic signs. A particle that carries a North magnetic charges, and a particle that carries a South magnetic charge.

The energy carried by each particle is about

$$\frac{1}{20,000} \text{eV}.$$

In comparison, the electron-neutrino energy is about 7eV

By mass-energy equivalence, the mass of each particle is about

$$\frac{\frac{1}{2}(1.826273061)10^{-23}}{c^2} = (1.014596145)10^{-40} \text{kg}$$

in terms of electron's mass, $m_e = (0.91093897)10^{-30} \text{kg}$

$$\begin{aligned}
&= \frac{(1.014596145)10^{-40}}{(0.91093897)10^{-30}} m_e \\
&= \frac{1.113791569}{10,000,000,000} m_e
\end{aligned}$$

If the particle carrying the magnetic monopole is a photon, taking Planck constant $h = (6.6260755)10^{-34}$ Jsec, its frequency is about

$$\begin{aligned}
\nu_{\mathfrak{m}} &= \frac{\frac{1}{2}(1.826273061)10^{-23}}{(6.6260755)10^{-34}} \\
&= (1.378095572)10^{10} \text{ cycles/sec}
\end{aligned}$$

Its wave length is about

$$\begin{aligned}
\lambda_{\mathfrak{m}} &= \frac{c}{\nu_{\mathfrak{m}}} \sim \frac{3 \cdot 10^8 \text{ meter/sec}}{(1.378095572)10^{10} \text{ cycles/sec}} \\
&= (2.176917234)10^{-2} \text{ meter}
\end{aligned}$$

in the Microwave range.

Clearly, this level of energy is undetectable. Neutrinos are almost massless, and monopoles generated from the current loops of the Hydrogen proton measure as massless

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