On The Magnetostatic Inverse Cube Law and Magnetic Monopoles

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Abstract:- It can be demonstrated experimentally that interaction between magnetostatic fields for which both poles geometrically coincide obeys the inverse cube law of attraction and repulsion with distance (far fields interaction law) which proves by similarity that localized (in the sense of behaving as if they were point-like) electromagnetic elementary particles must obey the same interaction law since both of their own magnetic poles have to coincide with each other by structure, given their point-like behaviour. 2) As a corollary, and contrary to electric dipoles whose two aspects (opposite sign charges) can be separated in space and observed separately, it can also be demonstrated that both aspects of magnetic dipoles whose poles coincide can be separated only in time, which characteristic highlights the fact that point-like behaving scatterable elementary electromagnetic particles can magnetically interact only as if they were physical magnetic monopoles at any given moment. 3) The related cyclic polarity reversal of the magnetic aspect of elementary electromagnetic particles such as electrons, quarks up and quarks down and of their carrying energy brings a new and very interesting explanation to the reason why electrons cannot crash on their own onto nuclei despite electrostatic attraction by demonstrating that magnetic interaction between nuclei and electronic escort can only be repulsive.

Keywords:- Magnetic monopoles, magnetic interaction, Bohr atom, isolated hydrogen atom, circular magnets, 3-spaces model.

I. COINCIDENCE OF THE MAGNETIC POLES OF LOCALIZED ELEMENTARY PARTICLES

By definition, localized elementary particles are those that extensive scattering experimentation have been shown to always behave as point-like particles during collisions. They include a very restricted set of particles, that is, the five stable electron, positron, up quark, down quark and finally the photon; and the 2 unstable particles muon and tau and their antiparticles, the latter two converting to electrons at the final stage of their decay (positrons for their antiparticles). All of these particles are electromagnetic in nature and by structure, both poles of their magnetic field have no choice but to physically coincide given their point-like behavior.

Many consider the inverse cube law of interaction between magnetic fields to be a postulate or even not to apply at all. We will examine here a very simple experiment that demonstrates that the magnetostatic inverse cube interaction law is by no means a postulate, but a real physically existing law at play between magnetostatic fields for which both poles geometrically coincide, instead of the inverse square law that is so often assumed in the community, and even wrongly associated with all types of magnetic interaction in many physics introductory textbooks.

Strangely, although we have had at our disposal for hundreds of years, easy to reproduce experiments allowing experimental confirmation of the inverse square law of distance for electrostatic interaction (Coulomb's law), no trace can be found of an experiment experimentally confirming this inverse cube law of distance for interaction between magnetic fields whose poles coincide.

Considering that the invariant inverse cube law of distance of magnetic interaction between point-like behaving elementary particles is just as fundamental as the invariant inverse square law of distance of electrostatic interaction between these same particles, it seemed appropriate to develop such an experiment to irrefutably confirm the physical reality of this fundamental law.

It is mandated besides by de Broglie's hypothesis on the possible internal dynamic structure of localized photons ([2], Section X), which is at the origin of the development of the expanded Maxwellian 3-spaces geometry model ([2]) and ([6]).

II. COINCIDENCE OF MAGNETIC POLES OF CIRCULAR LOUDSPEAKER MAGNETS

Interestingly, there does exist at the macroscopic level a type of magnet that provides the same magnetic geometry as that mandated by structure for point-like behaving scatterable elementary particles. They are in fact very common and their specific use is the reason why they need to be magnetized in this manner.

They are thin donut shaped loud-speaker magnets that are always magnetized parallel to thickness for the loudspeaker coil to travel easily while permanently seeking to keep perfect axial alignment. This means that both north and south poles of their associated bipolar macroscopic magnetic field have to behave precisely as if they physically coincides and consequently obey far fields interaction law, which will be borne out by the data collected.

Another interesting feature of such magnets is that their magnetic poles, on top of coinciding with each other, also coincide with the geometric center of the magnet.

The results of the original experiment carried out with this type of magnets were alluded to in 1999 ([15], p.47) in a different context, and the detailed procedure was subsequently published in 2000 ([6], Appendix A), and is now reproduced here in this separate paper.

Before describing the experiment however, some particulars of magnetic fields must be put in proper perspective.

III.   ANTIPARALLEL AND PARALLEL RELATIVE SPINS

A relative polarity reversal between two such magnets (placing them so that they attract each other, which corresponds to antiparallel spin) amounts to a 180° reversal of the related spherically shaped magnetic fields with respect to each other within magnetostatic space, which parallels to a high degree the manner in which two electrons meet when one is in the expansion phase of its magnetic aspect while the other is in the regression phase of its own magnetic aspect ([16], Section XVII).

This is not without reminding Heitler and London's observations in 1927 regarding the state of relative parallel and antiparallel spin orientation of electrons to explain covalent bounding ([5], p.264) as well as the natural distribution of electrons by pairs on atoms orbitals ([3], p.219), according to which "If the spins of 2 electrons are of the same orientation, the exchange energy corresponds to a repulsion between the atoms… but if contrariwise both spins are of opposite orientation, the exchange energy corresponds to an attraction which for a very small distance between the two atoms, cancels out and becomes a repulsion if the atoms get nearer yet to each other", as well as the natural distribution of electrons by pairs in atoms' orbitals according to the Pauli exclusion principle ([3], p.219), according to which for two electrons to be able to occupy the same orbital, both must have opposite spins.

Parallel spin on the other hand occurs when the magnetic fields of both electrons are synchroneously in the expansion or regression phases.

To create a mental image of what relative parallel and antiparallel spins involve at the fundamental level, two electrons approaching each other while in parallel spin orientation behave metaphorically speaking like two birthday balloons being cyclically inflated and deflated both at the same time (we will see why further on). They will then occupy twice the volume of only one balloon being fully inflated.

Alternately, two electrons interacting close to each other while in antiparallel spin orientation behave as two birthday balloons being cyclically inflated and deflated in alternance. They can never occupy more than the volume of only one fully inflated balloon within magnetostatic space.

IV.   INVERSE CUBE INTERACTION VERSUS INVERSE SQUARE INTERACTION

Interestingly, with regards to Heitler and London's conclusions on the covalent link, it seems that the only possibility for two electrons to so paradoxically attract when they are at a very short distance from each other despite their mutual electrostatic repulsion (that obeys the inverse square law), would be that another force simultaneously be at play locally that would obey a higher order exponential law than the inverse square law, so it could overcome the latter when the particles are very close to each other. We will shortly verify that the inverse cube law perfectly matches this criterion.

V.   LOCALISATION VERSUS DELOCALISATION

But since referring to a mutual "relative orientation" of electrons mandates localization, which would be in contradiction with the current Copenhagen philosophy view of electrons as being spread out in space as they move (ref: wave packets, Uncertainty Principle) or as they vibrate or move in atoms in the only way that the wave function can mathematically represent them; little if any information is readily available on the correspondence of spin versus magnetic orientation in currently popular physics textbooks, most if not all of which were written with the Copenhagen school philosophy in the background.

This is why so many physicists generally speak of spin as being "only a quantum number" specific to Quantum Mechanics, which tends to unduly dissociate it from its direct relation to the magnetic aspect of electrons.

$$\frac{\mu_B}{S_z} = \frac{e}{m} = \text{Classical Bohr gyromagnetic moment, meaning that} \quad \mu_B = \frac{eS_z}{m}$$

Although even in QM spin is associated to the magnetic moment of charged particles, even this magnetic moment is seen by so many as a simple, and practically mechanical, angular momentum ($S_z = \pm\frac{1}{2}\hbar$) with no specific reminder that it concerns the magnetic aspect of the particle.

This is why, to seemingly avoid dealing with this apparent disconnect between the Copenhagen interpretation and experimental reality, physical magnetic parallel and antiparallel association of electrons is generally treated separately, typically only in texts discussing the properties of magnetic materials, and with very little if any reference to Quantum Mechanics. A good example of such a text is the chapter on Properties of Magnetic Materials of the **CRC Handbook of Chemistry and Physics** ([4], p.12-117), that leaves no question unanswered regarding the magnetic nature of the physical spin of electrons.

We will see further on that it is perfectly possible to reconcile the presence of localized magnetostatic fields for electrons with Quantum Mechanics when proper restrictions are applied to the normalization range of the wave function.

VI.   THE EINSTEIN-DE HAAS AND BARNETT EFFECTS

Unfortunately, one can also note, except in German speaking countries where very interesting magnetic effects are the subject of frequent college level experimentation projects, the almost worldwide absence of information in undergraduate as well as in graduate level textbooks on the experimentally verified relation between forced parallel spin orientation of unpaired electrons at the particle level and the resulting macroscopic angular momentum observed in experiments conducted with ferromagnetic materials, let alone even mention of the names of these effects.

They are the **Einstein-de Haas effect** and the reciprocal **Barnett effect**. In view of the fact that no mechanical explanation coherent with the Copenhagen interpretation of QM has ever been found to explain macroscopic magnetism at the atomic level ([11], p. 655), one can only regret such a widespread neglect of such fundamental information.

The only brief mention of these two important effects that I know of in a popular formal textbook is to be found in a series written by Lev Landau et al., Nobel prize winner and member of the former USSR Academy of Sciences ([12], p. 129 (p.195 in the original Russian edition)). These two effects are analyzed in a separate paper ([13]).

VII.   LOCALIZATION OF PARALLEL-ANTIPARALLEL ELECTRONS PAIRS

The scatterable elementary particles making up nucleons (point-like behaving up and down quarks) as well as their powerful carrier-photons also having spin since they also are electromagnetic in nature, it seems reasonable to think that the electromagnetic equilibrium established between nuclei particles and electrons of the electronic layers would have a role to play in forcing the latter to magnetically orient only in two possible ways on their layers.

Once an isolated electron is captured and electromagnetically stabilized on a layer, whatever magnetic orientation the nucleus particles and electrons already in place on other electronic layers in the atom force it to maintain, the only way a second electron can now complete this layer is to switch to relative antiparallel orientation to associate with it, otherwise it will be repelled as concluded by Heitler and London. This amounts to physical quantization of the spin, since only two relative magnetic orientations are physically possible.

Of course the question comes to mind as to whether two free moving electrons could associate in this manner. Experimental reality reveals that the answer is no.

The reason is that since electrostatic repulsion obeying the inverse square law of distance and magnetic interaction obeying a higher order inverse law, electrons have to be so close to each other for the magnetic interaction to dominate that this can really happen only when one of the electrons is physically captive in an atom in some form of electromagnetic equilibrium and is consequently unable to escape the encounter when another electron closes in with enough energy to reach the point where the magnetostatic inverse cube law of the distance interaction starts dominating to render capture possible.
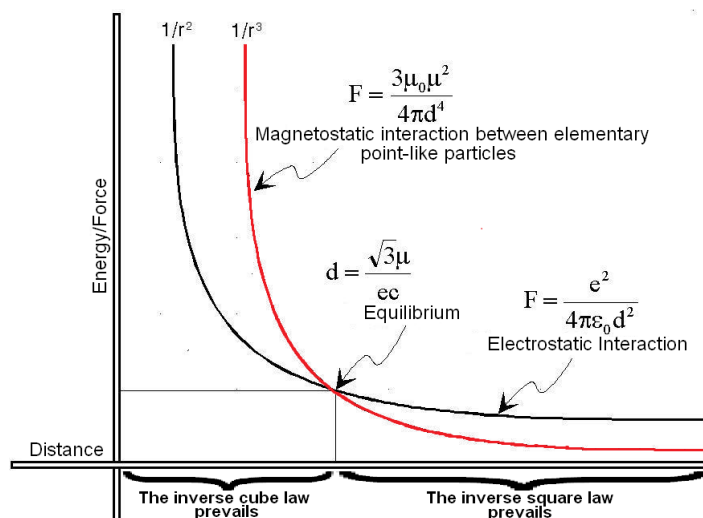
Fig.1: Intersecting inverse square and inverse cube force curves.

VIII.   CONFIGURATION OF THE MAGNETIC POLES IN ELEMENTARY PARTICLE

The interest in carrying out this experiment with circular magnets lies in the fact that it allows verifying at our scale, directly on the lab bench, the behavior of the only possible discrete magnetic field configuration that can exist at the physically scatterable point-like elementary particles level!

We will assume here that we will not be measuring the law of interaction between the physical magnets themselves, but rather the law of interaction between the magnetic fields anchored in these magnets, whose density of static energy spherically decreases from the center outwards by structure.

Technically speaking, it is said that the field produced by a permanent magnet is **magnetostatic** because it is stable and as such does not vary in intensity over time. It is stable because it is produced by a particularly stable configuration of certain unpaired electrons in some atoms of the material, electrons that are immobilized by the local electromagnetic equilibrium in forced mutual parallel spin orientation, which causes the individual magnetic fields of each of these electrons to combine by addition in sufficient numbers to become detectable at our level as a single larger macroscopic magnetic field.

This means that macroscopic magnetostatic fields do not come into existence as the magnets are approaching each other, but are by nature permanently present to full extent as long as the electrons responsible for its existence remain locked in position into the material.

The electrons of the external electronic layer of atoms, that is, the valence electrons, do not play any role here. The outer layer valence electrons are primarily involved in linking atoms into molecules by anti-parallel spin alignment by pairs (one valence electron being contributed by each atom involved), which results in a mutual cancellation by antiparallel alignment of the magnetic fields of the electrons of these pairs.

The apparently undifferentiated nature of quantized kinetic energy, the "fundamental material" that elementary particles are made of is such, that the individual fields of forced parallel spin aligned unpaired electrons seem to simply join each other and add to each other as if they became a single larger entity, somehow metaphorically like rain drops will join to form pools in which it becomes impossible to distinguish individual drops.

In the case of the magnetic fields of our magnets however, a quantity of the overall field equal to that provided by each electron obviously remains intimately rooted in each of the participating electrons, since if a magnet is ground into dust and if the grains of this dust are separated, it has been experimentally observed that each grain becomes a weaker magnet in proportion to its size, with respect to the size of the original magnet. In other words, each electron takes back its marbles, so to speak, and the global field gives way to as many smaller fields as there are individual grains of magnet dust.

When a magnet is heated, the magnetically aligned unpaired electrons of the internal electronic layers of atoms become charged with an energy that causes them to locally vibrate, a vibration that will affect the alignment of their spins, which will progressively modify their configuration by forcing their spins to stop remaining parallel to the point when the associated macroscopic magnetic field ceases to be perceptible.

When the magnet is cooled, the macroscopic field will reappear inasmuch as the heat did not permanently alter the molecular configuration that allowed it, that is if the spins of electrons in the internal electronic layers that made up the initial macroscopic field become parallel again in the same manner. In other words, when we manipulate a permanent magnet, we directly manipulate, at our scale, an enormous magnetic field which is the very material that electrons are made of.

IX.   EXPERIMENTAL CONFIRMATION OF THE MAGNETOSTATIC INVERSE CUBE LAW

Let us now proceed to the description of the experiment. Given that controlling such an experiment is very difficult when magnets attract, all observations were carried out with magnets placed in a position to repel each other, meaning in a state of parallel spin of all electrons supporting the fields of both magnets.

The following physical set up forces the magnets to remain as perfectly aligned and parallel to each other as possible, which allows mentally visualizing both magnetic fields as if they were two invisible perfectly elastic spherical "objects" that physically occupy volumes in space extending of course beyond the physical body of each flat magnet.

The maximum experimental limit of proximity will be reached when the physical volume of the magnets prevents reducing further the center-to-center distance between the fields.

A.   Description of the apparatus

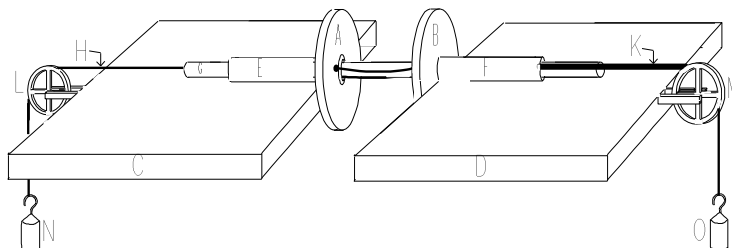Let us examine the equipment that was used:

Fig.2: Magnetostatic inverse cube experiment apparatus.

A and B: Circular ceramic ferrite loudspeaker magnets with the following dimensions: Outer diameter 7.1 cm; Inner diameter 3.1 cm; thickness 0.84 cm. Magnetized parallel to thickness. Manufactured by Arnold Magnetics Ltd, Part Number 29375.

C and D: Styrofoam floating rafts 22 cm x 15 cm that must be floated on water deep enough to allow masses N and O to hang freely without touching the bottom of the container used.

E and F: Guiding tubes fitted perpendicularly inside the inner hole of each magnet. Tube E is fitted to magnet A and tube F is fitted to magnet B.

G: A 30 cm guiding rod loosely fitted inside both tubes E and F that insures that both magnets remain as perfectly aligned and parallel as possible at all times.

H and K: 30 cm threads holding masses N and O and that pull the magnets towards each other. One end of thread H is securely fastened between tube F and magnet B and made to slide freely between guiding rod G and the inside of guiding tube E. The other end hangs freely down over the edge pulley L.

Similarly, one end of thread K is securely fastened between tube E and magnet A and let to slide freely between guiding rod G and the inside of guiding tube F. The other end hangs down freely over the edge pulley M.

N and O: pairs of equal size calibrated masses, the sum of which makes up the total mass noted in column P of the following table (**Table I**).

As many different size pairs of calibrated equal masses as required can be used to obtain as many measurements as the experimentalist wishes.

B.   Procedure

After each pair of masses is put in place, the whole floating assembly is delicately shaken as the floating rafts are re-balanced horizontally by means of secondary masses placed in the corners of the rafts to remove any stress between the guiding rod and the inside of the guiding tubes.

Once the assembly is stabilized with the guiding rod sliding as freely as possible inside the guiding tubes, a straight edge ruler is used to measure the distances between the magnets at 3 points located at 90° from each other on the outside circumference of the magnets: on both sides, and also on the top edge.

The distance between the lower edges of the magnets, which is located below water, is triangulated from the distances already obtained from the first 3 measurements. To take into account that each field is most intense at the geometric center of the magnets, the thickness of one magnet is added to all four measurements to insure true "center-to-center" measurement between the fields. The distances posted in column **r** of **Table I** is the mean distance calculated from these 4 measurements.

C. Collected experimental data

Table I: Data collected from the magnetostatic inverse cube experiment

	P	F=P x 9.80665 N	r	P x r^3	P x r^2
1	.05 kg	0.4903325 N	.1 m	5.000000 E-5	5.00000 E-4
2	.13 kg	1.2748645 N	.076 m	5.706688 E-5	7.50880 E-4
3	.21 kg	2.0593965 N	.063 m	5.250987 E-5	8.33490 E-4
4	.33 kg	3.2361945 N	.057 m	6.111369 E-5	1.07217 E-3
5	.41 kg	4.0207265 N	.05 m	5.125000 E-5	1.02500 E-3
6	.49 kg	4.8052585 N	.047 m	5.087227 E-5	1.08240 E-3
7	.57 kg	5.5897905 N	.046 m	5.548152 E-5	1.20612 E-3
8	.65 kg	6.3743225 N	.0445 m	5.727873 E-5	1.28716 E-3

The reason for only 8 readings to have been noted during this experiment is linked to the difficulty involved in taking readings with masse smaller than 0.05 kg and larger than 0.65 kg with the apparatus being used.

Masses smaller than 0.05 kg were not sufficiently massive relative to the friction inherent to the system to allow even the most delicate shaking and re-balancing of the floating rafts to stabilize at a sufficiently constant distance for the masses being used as sequences of 10 times retries were performed. A mass of 0.05 kg was the smallest mass for which such relatively constant distance was obtained over 10 fold retries.

All readings noted from 0.05 to 0.65 kg are means taken for 10-fold retries with each set of masses. As for masses larger than 0.65 kg, the readings became uncertain on account of warping of the delicate pulley-raft junctions that begins to be noticeable with such masses.

D. Analysis of the data

In this table, the first column gives the amount of mass (the pressure exerted) in kg (**P**) required to maintain the magnets at distance **r** in meters (center-to-center of the thickness of each magnet) that appears in the third column. The following equation, representing a pressure being applied as a function of an inverse cube relation with distance was used to interpret the data collected:
$P = 1/r^3$

This relational formulation however, although traditional, somehow masks the very important fact that in an inverse cube relation, the product of a pressure by the third power of a distance is a constant. In the present case, this constant will be a number allowing calculating the distance at which the magnetic fields of the magnets stabilize to counteract pressure as a function of the inverse cube law of distance, a constant that could tentatively be named ***magnetostatic equilibrium constant***.

The actual relation is then much more clearly represented if the formula is reorganized in the following manner

$$P \text{ x } r^3 = \text{Magnetostatic equilibrium constant}$$

Column 4 of **Table I** thus contains the results of applying this last formula to the raw data from the first and third columns. Observation will show that despite important fluctuations due to the rudimentary means used to conduct the experiment, and even with as few readings as these 8 meaningful readings, one can observe that the values obtained clearly hover about an approximately constant level.

For comparison with the inverse square law, column 5 of **Table I** contains the values obtained by applying formula $P \text{ x } r^2$. We can observe that the values in this column definitely are not hovering about an approximately constant level, which would be the case if the relation obeyed the inverse square law. This lack of stability definitely rules out an inverse square relation being involved for pressure as a function of distance in this experiment.

If we now consider again the first relational equation derived from the experimental data (**P x r^3 = Magnetostatic equilibrium constant),** we observe that the dimensions involved are **kg•m^3**, and ignoring the two most extreme values measured (line 1 and line 4), **Table I** allows establishing a first approximation value of this constant for our two magnets at **P x d^3 = 5.4076545E-5 kg•m^3**. This constant now allows easily calculating in a simplified manner either the pressure to be applied for any separating distance and vice-versa that we care to consider between these two magnets. Equation **F=Pg** of the second column will then allow calculating the related force, and finally, equation **E=Fd** will give the related energy in joules.

Another telltale that a cubic relation is involved comes from examining lines 1 and 5. We observe that while the distance noted line 5 is half that of line 1, the mass being used needed to be 8 times that of line 1 (instead of 4 times that would have been mandated by an inverse square law), <u>which is consistent with a force increasing with the inverse cube of the distance</u> and not with the inverse square law.

Consequently, the following first draft generic equation, involving a spherical relation between the 2 "magnetic spheres", that were axiomatically assumed to be real about the circular magnets, seems appropriate to represent the interaction that we just verified between these magnets.

$$E = G_? \frac{3M_m^2}{4\pi d^3} \tag{0}$$

where M_m symbolically represents the magnetic intensity of each magnet, that is, the magnetic moment of each magnet, usually symbolized by μ.

$G_?$ on its part, represents a magnetic constant that should obviously be the known constant of ***magnetic permittivity*** of vacuum (μ_0), and finally $4\pi d^3/3$, which is the standard equation used to establish the volume of a sphere and represents the spherical interaction over distance d, that is, the interaction as a function of the inverse cube of the distance.

E.   Comparing loudspeaker magnets to bar magnets

A dimensional analysis of this generic equation reveals that as it stands, it provides only an energy in Joules, which confirms that on top of the inverse cube relation, we need to divide the equation by the center-to-center distance between the two magnetic spheres to really obtain a "force" in Joules per meter (J/m), that is, in Newtons. From these considerations, we can now write the final equation giving the intensity of the force between our two circular magnets at any given distance **d** from each other.

$$F = \frac{3\mu_0\mu^2}{4\pi d^4} \tag{1}$$

Let us now compare this final equation (1) stemming from the analysis of the data collected during this experiment to the standard equation (1a) used for calculating the force between equal force bar magnets being approached parallel to each other and whose poles within each magnet are evidently at some distance **l** (**small letter l**) from each other and whose distance between the bars (d) must be larger than **l** for the formula to remain valid ([11],p 93), which is always the case with our circular magnets since the north and south poles within each magnet geometrically coincide and that distance **l** in their case is equals zero by structure in their case:

$$F = \frac{3\mu_0\mu^2}{2\pi d^4} \quad \text{which is of course the same as} \quad F = \frac{3\mu_0\mu^2}{4\pi d^4} + \frac{3\mu_0\mu^2}{4\pi d^4} \tag{1a}$$

We immediately observe that the force obtainable for bar magnets is double the force measured during the circular magnets experiment.

A note of highly particular interest in the case of this recognized "standard equation" (1a) for bar magnets interaction is that nowhere is there explained how it can be derived from any classical theory whatsoever, contrary to the Coulomb equation for electrostatic interaction that can easily be derived from Maxwell's first equation.

This leads to believe that equation (1a), available in standard textbooks on electrodynamics, for example ([11],p 93), was simply extrapolated from experiments such as this one, and was quoted on account of its undisputed conformity with experimental observation even though it turned out to be impossible to derive from Maxwell's electromagnetic theory.

So, despite the fact that it is mentioned in the Halliday & Resnick textbook, for example, as a standard equation, it turns out to still be totally empirical and be supported by no classical theory whatsoever!

F.   Proof of cyclic reversal of magnetic polarity for geometrically coinciding north and south poles

Let us now recall that two bar magnets involve 2 separate pairs of poles, each pair being physically separated within each bar magnet by distance **l**, in constant separate interaction with the 2 poles of the other bar, while the two circular magnets of our experiment also involve 2 pairs of poles, but having distance **l** equal to zero within each magnet.

This difference highlights a very important fact, because even if we found a way to progressively reduce to zero this distance **l** between the poles inside each bar magnet, it could logically be expected that the force calculated in an experiment involving two such bars would remain double even when length **l** reaches zero inside each bar since the 4 poles would still be deemed to be statically present and permanently active at the same time according to classical electromagnetism, whereas our experiment confirms that this is not the case with the circular magnets used during the experiment, whose poles do coincide (length **l** = 0 within each magnet).

This behaviour effectively confirms out of any doubt that in the case of circular loudspeaker magnets, where the "opposite poles" within each magnet geometrically coincide by structure, **both north and south poles within such magnets behave as if they were not simultaneously present at the same moment but were acting in alternance and not simultaneously**.

This can be explained only by a cyclic oscillation of the "magnetic" energy involved between a spherical expansion phase to some maximum followed by a spherical regression to zero (mandatory if only one

of the two poles of each magnet is to be physically present at any given moment) at a frequency that obviously depends on the energy of the particles that produces it, presumably the carrying energy induced at the orbital on which the unpaired contributing electrons reside.

If we transpose this alternating time-wise dipolar behaviour to the elementary electromagnetic particles level, that obey the same rule by similarity due to their point-like behavior, it also confirms that **the magnetic aspect of elementary electromagnetic particles is monopolar by structure at any given instant** and that it can only be the high frequency alternating rate of expansion-regression in magnets where the poles do not coincide that causes the magnetic aspect of the associated macroscopic magnetic fields to appear as being statically bipolar, and behave at the macroscopic level in accordance with near fields rules.

Now where can the energy supporting the magnetic field go as it falls to zero at the end of the spherical regression phase if this sustaining energy is assumed to be incompressible as shown in ([7])?

In the expanded space geometry model ([2]), the answer is simple. It simply momentarily transfers to electrostatic space for photons ([2], Section XXII), and to normal space for massive particles ([16], Section XVII) as dual quantities moving in opposite directions in these spaces until all of the magnetic energy has been transferred to then start back moving into magnetostatic space, thus initiating the next cycle.

In other words, contrary to electric elementary monopoles (opposite sign elementary charges) that can be observed separately in space, elementary magnetic monopoles can be separated only in time. Paradoxically, this means that at any given instant, <u>circular loudspeaker magnets interact as if they were separate magnetic monopoles</u> just like elementary electromagnetic particles.

G. The relative magnetic fields of the circular magnets

It is well established ([13]) that a pressure of 1 kg has been defined as corresponding to a force of 9.80665 Newtons being applied at mean sea level on the Earth, which is the force required to offset the 1 g gravitational acceleration at mean sea level. This is what allowed calculating the force corresponding to each mass used during our experiment (Column 2 of **Table 1**).

The magnetic moment of a magnet (μ) being defined in Joules per Tesla (J/T), just as for the Bohr magneton, and starting from equation (1), we can now calculate the magnetic moment of each of our circular magnets, that we assume to be identical. Isolating μ in (1) and using the values from columns **F** and **r** of line 1 in **Table I**, we obtain the following approximate value :

$$\mu = \sqrt{\frac{4\pi r^4 F}{3\mu_0}} = \sqrt{\frac{4\pi(.1)^4 0.4903325}{3\mu_0}} = 12.78452841 \text{ J/T}$$

Assuming that the magnetic material of the magnets is made of atoms all having the same local dipole moment, the dipole moment of each magnet would then be made up of the sum of these local dipole moments. Further assuming that only one electron per atom contributes to the field, then μ would be the sum of the magnetic dipole moments of the carrying energy of each of these electrons that in turn depends on the energy level of the orbital to which they belong.

A few calculations with arbitrary distances and magnetic intensities of equal "magnetic masses" will show that the increase in force effectively numerically obeys the inverse cube law and that for each halving of a distance, the force will be multiplied by 8 as our experiment reveals. Let's remember that we postulated that these magnets are the physical anchoring sites of two spherical magnetic fields that extend beyond the magnets.

And now that we know the magnetic moment of our magnets, we finally are in a position to calculate the intensity of the magnetic fields of our experimental magnets at any distance from their geometric center along the axis normal to their surface. We established in a prior paper ([7], equation (35)) a neat relation involving only magnetic moment (μ), corresponding energy (E) and corresponding magnetic field (**B**)

$$\mu = \frac{E}{2\mathbf{B}} \qquad \text{in which we can isolate} \qquad \mathbf{B} = \frac{E}{2\mu} \tag{2}$$

From equation (1) we can now easily establish the equation for the energy corresponding to this dipole moment

$$E = Fd = d\frac{3\mu_0\mu^2}{4\pi d^4} = \frac{3\mu_0\mu^2}{4\pi d^3}$$

If we now substitute this definition of E in equation (2):

$$\mathbf{B} = \frac{E}{2\mu} = \frac{3\mu_0\mu^2}{2\mu 4\pi d^3} = \frac{3\mu_0\mu}{8\pi d^3} \tag{3}$$

Making use again of the value of **r** from line 1 in **Table I**, we obtain the intensity of the magnetic field in Tesla when the magnets are 10 cm from each other

$$\mathbf{B} = \frac{3\mu_0\mu}{8\pi d^3} = \frac{3\mu_0\mu}{8\pi(.1)^3} = 1.917679279 \text{ E} - 3 \text{ T}$$

With the value of **r** from line 5 of **Table I**, that is 5 cm from each other:

$$\mathbf{B} = \frac{3\mu_0\mu}{8\pi d^3} = \frac{3\mu_0\mu}{8\pi(.05)^3} = 0.01534143\ 4\ T$$

Which is exactly 8 times the field intensity that we just calculated for a distance of 10 cm. We finally are in a position to establish the maximum magnetic field intensity of our magnets when both magnets are in physical contact. The thickness of one magnet being 0,84 cm, the distance center to center of both associate fields is then 0,84 cm, that is 8,4 E-3 m.

$$\mathbf{B} = \frac{3\mu_0\mu}{8\pi d^3} = \frac{3\mu_0\mu}{8\pi(8,4E-3)^3} = 3.23547548\ 4\ T$$

X. PERMANENT ELECTRON-NUCLEON MAGNETIC REPULSION
Equilibrium between two opposing forces

Localized scatterable elementary electromagnetic particles, such as the electron and up and down quarks, having both an electric aspect (obeying the inverse square interaction law) and a magnetic aspect (obeying the inverse cube interaction law), it can forcefully be asserted that the states of equilibrium of electronic layers in atoms mandatorily involve both types of interaction.

It can then be hypothesized that to explain rest orbital stability in a hydrogen atom for example, as the electron comes closer to the proton than its rest orbital, the magnetic interaction between proton and electron could, for reasons to be identified, become repulsive to the point of overcoming the electric attraction between electron and proton and repel the electron, whereas if it got farther away than the rest orbital, the electrostatic attraction could dominate again, bringing it back so that the motion of the electron generally stabilizes about a mean equilibrium distance, that would of course be the well known mean rest orbital at the Bohr radius, to which the statistical spread predicted by Quantum Mechanics averages out.

It goes without saying that such an electromagnetic equilibrium distance specific to each electrons-nuclei configuration could exist only if the magnetic interaction between nuclei and electronic escorts could only be exclusively repulsive (<u>never attractive</u>) whenever electrons come closer to the nucleus than the local electromagnetic equilibrium would allow.

In this regard, the spherical expansion-regression dynamic structure of elementary particles magnetic behavior predicted by the 3-spaces model, strongly supported by the previous circular magnets experiment, does offer a wonderful surprise! **We will now see that in this model, the magnetic interaction between nucleons and electrons <u>can effectively only be exclusively repulsive!</u>**

Two different approaches can be considered in context, depending on the manner in which we chose to consider the extent of magnetic interaction in space as a function of the inverse cube of the distance. In both cases however, the same reason explains why electrons can only be magnetically repelled by atomic nuclei.

The first is the traditional purely mathematical approach based on the premise that this interaction would act to infinity like electrostatic interaction.

The second, more natural at the physical level in the present model, is based on the premise that this interaction would not extend beyond the maximal physical extent of the energy sphere of a particle in magnetostatic space, an energy sphere whose extent in magnetostatic space depends on transverse amplitude as a function of the frequency of the particle, as analyzed in ([2], **Section K**), implying that no magnetic interaction would occur between two particles unless their constantly expanding-contracting magnetic energy spheres enter in physical contact with each other.

But given that both approaches explain the permanent repulsion between nuclei and electronic escorts by the same reason, we will develop the demonstration from the first possibility, which is simpler to elaborate.

H. The elementary particles making up the hydrogen atom

Let us first put in perspective a few points previously analyzed regarding the Bohr hydrogen atom. For the electron, we are dealing with two distinct electromagnetic quantities, the electron proper with its 0.5109989 MeV rest mass energy and its 27.2 eV carrier-photon.

Given that a first approximation will quite sufficient to explain the mechanics of the phenomenon, we will take into account only the magnetic field of the electron since that of its carrier-photon is relatively negligible.

As for the proton, the situation is much more interesting, and somewhat unexpected. While the energies of the two up and one down quarks are respectively 1.1497475 MeV and 4.5989902 MeV ([6], Section 17.10) their three carrier-photons each have an energy of 310.457837 MeV as determined in ([6], Section 17.12), which represents approximately 300 times more energy than that of the particles that they carry. This means that it would be the invariant rest mass energy of the quarks themselves that is negligible!

The minor contribution of the valence quarks (up and down) to the proton spin has in fact been demonstrate in 1995 at the SLAC facility, which is coherent with the conclusion of the present model that the valence quarks are much less energetic than their carrier-photons.

In light again of the fact that a first approximation is sufficient for the demonstration, we will use the well known Bohr model parameters to study the behavior of the electron in an isolated hydrogen atom in which

the motion of the electron is not inhibited by the local electromagnetic equilibrium; where the electron can effectively move at the velocity that the energy of its carrier-photon allows, that is, 2,187,691.252 m/s (classical), which would cause it to cover a distance of r_0 x 2π = 3.32491846E-10 m at each orbit (r_0 being the Bohr radius).

I. Correlating the frequencies of the particles involved

With the absolute wavelength of the electron rest energy 2.426310215E-12 m (the electron Compton wavelength), it is easy to calculate that the oscillating half of the electron rest energy will cycle very precisely 137.0359998 times between magnetostatic space and normal space at each orbit. Isn't it interesting to observe here that this value is exactly equal to the inverse of the fine structure constant (α)?

Actually, this value shows that at each turn, the 138th cycle of the electron rest energy will begin 8.734668247E-14 m before an orbit is completed compared to the point where it began in the previous orbit. This means also that we would be in a position to calculate very precisely at which point of an electron's electromagnetic phase and at which point of the orbit an electron would be at any moment in the future, if we were to define as a starting point any specific arbitrary point of the orbit. This will be discussed later on.

Let us now consider the absolute wavelength of the carrier-photons of the up and down quarks, whose energy, in this model, is 310.457837 MeV each, that is 4.974082389 E-11 Joules (**[17], Section 17.12**), corresponding to a frequency of 7.506837869E22 Hz, and to a wavelength of 3.993591753E-15 m. This means that during each electromagnetic cycle of the electron, the energy of the carrier-photons of the nucleus will cycle 607.5508879 times.

Let us now examine **Fig.3** representing an arbitrary segment corresponding to 6 of the ~137 cycles that the rest mass energy of the electron will complete during one orbit, with an isolated segment representing one of these electronic energy cycles:
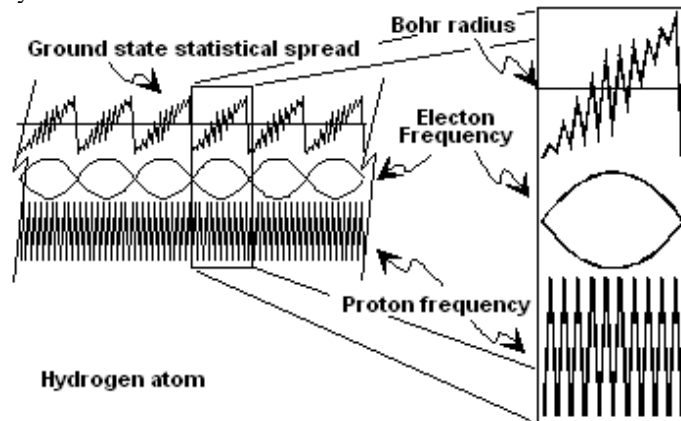

Fig.3: Representation of the conflicting magnetic fields frequencies in the hydrogen atom.

J. Permanent magnetic repulsion due to frequencies difference

The upper sequence in **Fig.3** represents the axial travel of the electron about its average distance from the nucleus (the Bohr orbit) corresponding to the corrected limited statistical spread of the wave function (see **Section L** below). The central sequence represents the variation in intensity of the magnetic presence of the electron rest energy during each of its cycles. The lower sequence represents the 607.5508879 intensity variations of the magnetic presence of the nucleus carrier-photons that occur during each magnetic cycle of the electron. Obviously, the intensities (and number of cycles per second for the proton) are not represented to scale here, since the energy of each quark carrier-photon is about 600 times that of the electron, and that 2 of the carrier-photons of the proton are always in parallel spin by structure with respect to the third, and that their energies consequently add up to about 1200 times the energy of the electron.

Let us also remember that in the 3-spaces model, the presence of the energy of elementary electromagnetic particles in magnetostatic space varies during each cycle from zero to a maximum (a period during which it is repulsive) to then diminishes to zero (a period during which it is attractive). For simplicity's sake, we will ignore here the magnetic drift inherent to the fact that the elementary particles involved are moving on closed orbits (see Section T below for the proton components magnetic drift and paper ([14]) for the orbiting electron magnetic drift).

Looking at the isolated segment, one can easily visualize that at the beginning of the electron magnetic cycle, the electron being very light with respect to the nucleus, will be repelled a certain distance with respect to the nucleus, due to the intensity of the magnetic presence of the nucleus increasing in the first part of the first of its 607 cycles, thus coming in opposition to the presence of the electron magnetic energy which also is in its increasing phase.

One can also easily understand that when the magnetic intensity of this first cycle of the nucleus will start diminishing towards zero thus becoming attractive, that is, in anti-parallel relation with respect to the

electron magnetic presence, which is still in its increasing phase, and that there will be magnetic attraction between the electron and the nucleus in addition to the electrostatic attraction.

And it is here that the mystery unravels, because, given that attractive and repulsive magnetic force obeys an exponential inverse interaction law with distance, the attractive force between proton and electron, which are now located further away from each other than when the repulsive force was applied during the first part of the cycle of the nucleus, will mandatorily be weaker starting at this farther distance.

Consequently, **there will be a <u>physical impossibility</u> for the electron to be brought all the way back to the distance it was at, at the beginning of the rising magnetostatic phase of the energy of the proton**, since the duration of the attractive phase is the same as that of the repulsive phase while the force being applied at the start of the attractive phase is less than that applied at the start of the repulsive phase!

The same situation will be reproduced for each of the following 606 cycles of the nucleus carrier-photons magnetic presence. The result can only be a progressive motion of the electron away from the nucleus, made up of very precise to and fro motions until the intensity of the magnetic presence of the electron energy becomes too small to finally momentarily fall to zero, moment during which all magnetic interaction having disappeared, the electron will fall freely towards the proton as it now obeys the only force still active, the electrostatic force, until the intensity of the magnetic presence of the energy of the electron becomes sufficient again at the beginning of the following magnetic cycle of the electron energy for the progressive repulsive interaction to start dominating again.

K. Limiting the statistical spread of the wave function

So this process of cyclically varying magnetic equilibrium forces the electron to move continuously in order to progressively occupy all of the physically possible locations of the statistical distribution defined by the Quantum Mechanics wave equation, but with the restriction that the spread is mandatorily restricted only to the set of locations allowed by the inertia of the electron as it sustains transverse accelerations and decelerations, while being maintained in a stable manner at an average distance from the nucleus corresponding to the Bohr radius by the opposing electrostatic attraction and magnetic repulsion that we just analyzed.

When considering a permanently localized electron, such an axially zigzagging motion of the trajectory seems to be the only mechanical possibility regarding the ground state of hydrogen atom and other light atoms ionized to the point of having only one remaining accompanying electron. This motion is apparently made more erratic yet in this bound state by continued action of the Zitterbewegung motion described in (**[6], Section 25.11**), caused by the interaction between the electron magnetic field and the magnetic field of its own carrier-photon.

To summarize, the probabilistic spread of possible locations of the electron in motion in the isolated hydrogen atom is traditionally represented by this form of the wave equation:

$$\int_{-\infty}^{+\infty} |\psi|^2 \, dxdydz = 1$$

which allows the statistical spread to reach infinity. To account for the limits imposed by the inertia of the electron during transverse accelerations and decelerations it must be modified to the following form:

$$\int_{-d}^{+d} |\psi|^2 \, dxdydz = 1$$

where d represents the farthest transverse distance about the mean Bohr radius that this limiting factor impose on the localized electron in motion.
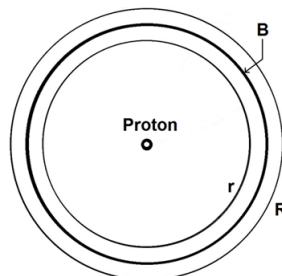

Fig.4: Maximum extension of the possible statistical electronic spread of the hydrogen atom.

In the case of the electron in the hydrogen atom ground state for example, when no outside forces are applied, this statistical spread will be limited to a circular axial two-dimensional band circling the nucleus, the inner limit of which would be the closest distance (r) that this limiting factor will allow toward the atom's center of mass, while its outer limit will be the farthest distance (R) that this limiting factor will allow, and the set of most probable locations averaging out to the Bohr radius.

A recent experiment making use of a photo-ionization microscope definitely validates this restriction of the traditional theoretical statistical spread of the wave function by directly recording the orbital structure of an excited hydrogen atom immobilized in a static electric field ([17]). The ring structure predicted by the 3-spaces theory (**Fig.4**) is clearly recognizable in the projections recorded during the experiment, that show clearly defined and separated rings corresponding to the rest orbital and the further away metastable orbitals to which the electron repeatedly jumped during the experiment.

Of course, due to interactions with surrounding matter, this band is likely in reality to spread at the limit to a 3D volume circumscribed by the surfaces of two concentric spheres whose inner and outer radii will respectively be r and R. So it is to this volume exclusively that the normalization condition must apply, any other localization in space becoming physically impossible.

L.   End of the reign of the Heisenberg Uncertainty Principle?

It must be noted here that the projection recorded during the Aneta Stodolna et al. experiment ([17]) involved tens of thousands of orbits of the electron about the immobilized nucleus, and that it is then logical that an apparent "probabilistic cloud " would appear on the recording within the r and R limits of the "probability ring", due to the 8.734668247E-14 m displacement of the beginning of the 138th electron magnetic cycle of each successive orbit, as analyzed in Section J.

But despite this apparent complexity, it does not seem unrealistic to think that based on the electromagnetic equilibrium revealed by the 3-spaces model it would become eventually possible to calculate with great precision all future physically possible locations of a localized electron in the QM statistical distribution in an isolated hydrogen atom, with as a starting point any point arbitrarily chosen on the orbital within the boundaries set by its inertia and transverse accelerations and decelerations for a single orbit, thus putting an end to the unconditional reign of the Heisenberg Uncertainty Principle.

XI.   GENERAL ELECTRONS-NUCLEI ELECTROMAGNETIC EQUILIBRIUM

The remaining question now is: How do the various pulsating magnetic spheres involved in a stable hydrogen atom interact, as each of them cyclically reverses its spin at its own frequency? And how could the sum of these interactions possibly explain all naturally occurring electronic and nuclear stable and metastable states as involving an electrostatic attraction against a magnetostatic repulsion equilibrium as we just analyzed?

Much more research, experimentation and calculation is required to completely clarify the issue. But we can definitely put in perspective the complete list of elements that must be taken into account.

The first such element regarding the hydrogen atom is that the ratio of the mean rest orbital distance of the electron to the central proton versus the proton diameter being about ten thousand to one. For comparison, if the proton was enlarged to reach the size of the Sun, all dimensions of the hydrogen atom being enlarged in relation, then the electron would orbit it 30 times further away that the Earth, that is, as far as Neptune! Seen from Neptune, the Sun would appear point-like with no obvious diameter; just the brightest star in the Universe. For all practical purposes, such an atom would be as large as the entire Solar System!

The magnetic interaction between electron and proton then obeys by structure the far fields interaction law, which means that their magnetic relation will obey far fields equation (1) that was established previously:

$$F = \frac{3\mu_0 \mu^2}{4\pi d^4}$$

We also clearly established the fact that the resultant of the magnetic interaction between the electron and the various components making up the proton can only be repulsive to various degrees, irrespective of relative spin orientation, and if this mean repulsive force exactly counteracts the electrostatic attractive force at the mean Bohr radius¸ then we can equate equation (1) to the Coulomb equation as applied to the Bohr radius:

$$F = \frac{3\mu_0 \mu^2}{4\pi d^4} = k \frac{e^2}{r_o^2} = 8.238721759 \, E - 8 \, N \tag{4}$$

Since we know from experimental verification that the magnetic moment of the orbiting electron and that of the hydrogen nucleus are not equal, then the term μ^2 from equation (4) needs to be replaced by a representation reflecting this difference. So equation (4) will be rewritten as:

$$F = \frac{3\mu_0 \, (\mu_1 \mu_2)}{4\pi d^4} = 8.23872175 \, 9 \, E - 8 \, N \tag{5}$$

And if we then isolate this product, since we know the values of the other terms in equation (4) because **d** now equals **r_0** by definition, we can now obtain a numerical value for this product

$$\mu_1 \mu_2 = \frac{F 4\pi d^4}{3\mu_0} = 2.153491216 \, E - 48 \, J^2/T^2 \tag{6}$$

What remains to be done now is to clarify from theory the respective values of **μ_1** and **μ_2** for them to match the experimentally obtained values.

M. Composite orbiting electron magnetic moment (μ_1)

In a previous paper ([14]) it was analyzed how the experimentally measured value of the electron magnetic moment (μ_e) can be calculated from theory.

Summarily, its theoretical classical value is calculated from the gyromagnetic moment equation previously mentioned in Section V:

$$\mu_B = \frac{eh}{4\pi m_o} = 9.27400899 \ \text{E - 24 J/T} \tag{7}$$

Paper ([14]) also clarifies why this value, known as the "Bohr magneton", can only apply in physical reality to an electron moving in straight line with the same energy as that of an electron on the hydrogen atom rest orbital.

Actual measurements have conclusively shown that the real value of the so called electron magnetic moment on a hydrogen atom rest orbital is noticeably higher in value than the theoretical Bohr magneton. This measured value has been established to be 9.28476362E-24 J/T within a relative standard uncertainty of ± 4.0E-10.

The reason for this difference, unexplained by current classical theories, becomes obvious in the 3-spaces model due to the simple fact that the electron on the hydrogen rest orbital can only move, if at all, in a closed orbit about the nucleus, an orbit that can be approximated to an ellipse and ultimately to a circle for calculation purposes, a closed orbital motion that can be sustained only if the electron carrying-photon's magnetic field become higher in energy density than for straight line motion with the same energy, by a factor that can be theoretically established at 1.00161386535E-3 ([14]).

Paper ([14]) allowed clearly identifying the phenomenon of **magnetic drift** as the natural cause of this difference, a phenomenon that must be associated to all closed circular translation motion of elementary electromagnetic particles, and that is very well understood in high energy circular accelerators. The **magnetic drift** is an increase of a particle's carrier-photon's magnetic field density associated to a corresponding decrease of the particle's carrier-photon's electric field density proportional to the gyroradius of the closed orbit involved.

The manner in which the measured value is traditionally reconciled with the Bohr magneton has been to multiply the latter by an ad hoc factor named the g factor of the electron, theoretically set at 2 for other purposes, is further ad hoc adjusted fit the measured magnetic moment, to g/2 =1.001159653 from the ratio of the actual measured value on the Bohr value. So

$$\mu_e = \frac{g}{2} \frac{eh}{4\pi m_o} = 9.28476362 \ \text{E - 24 J/T} \tag{8}$$

But while the measured electron carrying energy magnetic moment (μ_e) has been shown to be sufficient to account for the circular translation motion of the electron at the rest orbital gyroradius, there is need to also take into account the intrinsic magnetic field of the electron rest mass proper to fully account for the intensity of the repulsive relation between the orbiting electron and the central nucleus, particularly since the electromagnetic energy making up the electron rest mass is much larger than the added amount of carrying energy induced at the Bohr orbit, the latter being fully accounted for by the measured so-called electron magnetic moment (μ_e).

But before we can calculate the actual electron rest mass magnetic field, which is the other component of the composite orbiting electron magnetic moment μ_1, we need to first establish the value of the proton magnetic moment which will be equal by definition to μ_2 in equation (4), because in the far fields perspective, the hydrogen atom nucleus will be dealt with as if it was behaving as a point-like particle.

N. Hydrogen nucleon magnetic moment (μ_2)

Historically, the value of the hydrogen proton magnetic moment is theoretically approximated in a manner similar to that of the Bohr magneton (equation (7)), by replacing the mass of the electron by the mass of the proton, so

$$\mu_N = \frac{eh}{4\pi m_p} = 5.05078317 \ \text{E} - 27 \ \text{J/T} \tag{9}$$

This value is named the nuclear magnetic moment (μ_N). But, just like the measured electron magnetic moment, the proton magnetic moment proves to be higher than this calculated value, and quite considerably this time, by a so-called ad hoc proton g factor of 2.792775597.

The first measurements of the proton magnetic moment were conducted by Estermann, Frish and Stern in 1932. A confirming experiment, also involving Estermann and Stern, was conducted in 1937 and is put in reference ([1]) for readers interested in further exploring this experiment.

So, we traditionally obtain the actual measured value of the proton magnetic moment (μ_p) by multiplying the nuclear magnetic moment (μ_N) by this ad hoc proton g factor, and since μ_2 is equal to μ_p by definition in equation (4), we can pose

$$\mu_2 = \mu_p = \mu_N \ \text{x} \ 2.792775597 = 1.410606633\text{E-26 J/T} \tag{10}$$

which is the actual measured hydrogen atom nucleus magnetic moment. This magnetic moment of the proton however can only be the resultant of the combined magnetic interaction between the 2 up quarks, the single down quark, and their 3 powerful carrying-photons which together make up the scatterable structure of the proton. We will discuss this issue later.

O. Orbiting electron rest mass magnetic moment (μ_E)

Let us now rewrite equation (6) to account for the fact that μ_1 is a composite value made up of the so-called electron magnetic moment (μ_e), that we now know is the electron carrying energy magnetic moment, plus the actual electron rest mass magnetic moment that we will symbolize by (μ_E)

$$(\mu_e + \mu_E)\mu_2 = \frac{F4\pi d^4}{3\mu_0} = 2.15349116E-48 J^2/T^2 \tag{11}$$

Isolating μ_E, we obtain **the real electron rest magnetic moment**, since the other two magnetic moments involved are **the real measured values** of the only other two magnetic components involved, that is, that of the carrying energy of the orbiting electron, and that of the central proton, which makes up the nucleus of the hydrogen atom:

$$\mu_E = \frac{F4\pi d^4}{3\mu_0\mu_2} - \mu_e = 1.526829964E-16 J^2/T^2 \tag{12}$$

P. Orbiting electron magnetic field (B_e)

From paper ([7]), we know that the magnetic field of an elementary particle can be calculated by dividing half of its rest energy by its magnetic moment, so

$$B_e = \frac{E}{2\mu_E} = \frac{8.18710414 E-14}{2 \times 1.52682996 4E-16} = 268.107920 \ 8 \ T \tag{13}$$

We can now obtain the corresponding energy density from

$$U_B = \frac{B_e^2}{2\mu_0} = \frac{(268.1079208)^2}{2\mu_0} = 2.860088223 \ E10 \ J/m^3 \tag{14}$$

Since this density is a measure of energy over the corresponding volume, we can now determine the actual real volume within which the electron rest mass magnetic energy will oscillate at its rated frequency

$$V = \frac{E}{U_B} = \frac{8.18710414 \ E-14}{2.86008823 \ E10} = 2.86253551 \ 7E-24 \ m^3 \tag{15}$$

Since this volume is spherical by structure, let us calculate the radius of this volume

$$r = \sqrt[3]{\frac{3V}{4\pi}} = 8.80820522 \ 6E-9 \ m \tag{16}$$

which is totally consistent with the idea that the orbiting electron rest mass magnetic field clearly interacts with that of the hydrogen nucleus, which is located at the slightly shorter mean distance of 5.291772083E-11 m (The Bohr radius).

A further point of major interest is that the radius of the electron rest mass magnetic field that we just calculated (equation (16)) turns out to be practically equal to the absolute amplitude of the accompanying carrying energy of 4.359743805E-18 Joules induced at the Bohr ground state:

$$A = \frac{hc}{2\pi E_B} = 7.25163278 \ 4E-9 m \tag{17}$$

Now this concludes the overview of the factors required to eventually mathematically completely address the issue of the magnetic repulsion between the nucleus and the electron of the hydrogen atom that exactly counteracts their electrostatic attraction at a mean distance corresponding to the Bohr ground orbit.

XII. PROTON COMPOSITE MAGNETIC MOMENT

As previously mentioned, the measured magnetic moment of the proton (equation (10)), that is:
μ_p = 1.410606633E-26 J/T,

can only be the resultant of the combined magnetic interactions between the 2 up quarks, the single down quark and the 3 carrying-photons making up the scatterable structure of the proton.

We just saw how to correctly calculate all aspects of the hydrogen atom magnetic repulsion between electron and proton that explains why it is impossible for the electron to crash on its own on the nucleus despite electrostatic attraction. There now remains to analyse the corresponding electrostatic versus magnetic equilibrium relation between the internal components of the proton proper.

Q. Effective energy density of proton's components

The hurdle in clarifying this issue relates to the difficulty in determining the specific energy density to be applied to the magnetic fields of each of the six electromagnetic components of the proton. From the analysis carried out in paper ([7]), it would be quite easy to calculate the absolute limit energy densities of the various elementary particles making up the proton. This absolute density however would apply only if each particle's energy was statically regrouped in the smallest spheres possible, which cannot possibly be the case for the constantly oscillating energy making up each particle and their carrier-photons.

For the electron rest mass magnetic field for example, we just saw (equation (13)) that the relative magnetic field of the electron rest mass turns out to be 268.1079208 T at the rest orbital mean distance from the nucleus, corresponding to an energy density (equation (14)) of 2.860088223E10 J/m^3, even though their respective absolute limit values would be

$$B = \frac{\pi\mu_0 ec}{\alpha^3 \lambda_C^2} = 8.28900022 \ 1E13 \ T \quad \text{and} \quad U = \frac{B^2}{2\mu_0} = 2.733785545E33 \ J/m^3$$

Again, let us emphasize that these absolute limits correspond to the maximum density of a theoretical static sphere within which all of the electron's energy would be isotropically and statically concentrated.

Obviously, the pulsating magnetic energy of the real electron does not distribute in space in this manner, but would rather visit a much larger spherical volume within which the mean energy density would be maximum at the center of the volume occupied by the electron and would decrease as a function of distance from the center up to a maximum radial distance that remains to be ascertained and that would be the radius of the volume really visited by the energy in oscillating motion of the electron.

The density obtained with equation (14) would thus simply be the density of the magnetic energy of the electron at the point of equilibrium between nucleus and electron, point that would of course be located between the nucleus and the mean electron rest orbital.

R. Magnetic moments of the proton components

Now, what can be done as a first approximation of specific magnetic momenta of the proton inner components is to take as a reference the mean energy density in relation with the measured proton magnetic moment (μ_p = 1.410606633E-26 J/T). For this purpose, we must calculate the total magnetic energy that needs to be related to this magnetic moment.

Since all components of the proton are translating on closed orbits, their individual magnetic moments will by definition be more intense than if the same particles were travelling in a straight line due to the mandatory magnetic drift of the oscillating half of their carrying energy towards magnetostatic space as a function of their respective gyroradii, as clarified in ([14]).

Let us first lay out a table of the energy of the various elementary scatterable particles making up the proton and their associated carrier-photons that need be considered as analyzed in ([6], Chapter 17).

Knowing that frequency f = E/h and wavelength λ = c/f; since amplitude A= $\lambda/2\pi$, we can thus write:

$$A = \frac{hc}{2\pi E}$$

Table II: Absolute amplitudes of the proton constituting scatterable particles

Absolute Amplitudes of the Proton Constituting Particles			
Particle	Energy (E)	Amplitude $\left(A = \dfrac{hc}{2\pi E} \right)$	Space concerned
Up Quark	1.842098431E-13 J	1.716263397E-13 m	Magneto-static
Down Quark	7.368393804E-13 J	4.290658445E-14 m	Magneto-static
Carrier-photon of each quark	4.974082389E-11 J	6.35599868E-16 m	Magneto-static
Proton Radius in Normal space		1.252776701E-15 m	Normal
Coplanar Rotation Diameter		3.344237326E-13 m	Electrostatic

Eventually, the various integrated absolute amplitudes of the particles making up the proton and their gyroradii should allow calculating the physical extent of the magnetic energy spheres of the nucleon components within magnetostatic space.

S. Calculation of the magnetic drift of the proton components

Account must be taken however of the fact that the extent of the spatial volume occupied by each of these magnetic spheres is directly influenced by a **magnetic drift factor**. We know already from experimental evidence ([6], Chapter 17) that this magnetic drift factor is 4/3 for the up quark and 5/3 for the down quark.

The three quarks' magnetic drifts at their respective gyroradii imply that their magnetic fields involve a quantity of energy corresponding to that of particles with higher energy than these quarks but that would be moving in a straight line. So let's first calculate the increased total energy that these quarks would have if they became these hypothetical higher energy particles moving in straight line.

$$\text{Increased energy (up quark)} = E_u \times \frac{4}{3} = 2.456131241 E-13 J \tag{18}$$

$$\text{Increased energy (down quark)} = E_d \times \frac{5}{3} = 1.228065634 E-12 J \tag{19}$$

As for the three quarks carrier-photons, which are moving in circle in normal space, the method defined in ([14]) makes it relatively easy to calculate this magnetic drift factor in relation with their gyroradius, the latter being 1.252776701E-15 m, that is the known radius of the proton in normal space.

Considering that the three quarks form a rigid structure rotating about the normal space axis at a velocity determined by the energy of three carrier photons, we can add together the rest energies of the 3 quarks noted in **Table II** and treat this total quantity as a single particle being accelerated by the energy of the three photons:

$$E = 2E_u + E_d = 1.105259067E-12 J \tag{20}$$

Likewise, we can add the energy of the quarks three carrier-photons (from **Table II**) and treat it as a single quantity

$$K = 3E_{c-p} = 1.492224717 E-10 J \tag{21}$$

Making use now of equation (12) from separate paper ([14]), let's calculate the magnetic drift factor of the three carrier-photons energy, using the values obtained with equation (20) and (21) for E and K:

$$\text{magnetic\_drift} = \frac{\delta\mu}{\mu_B} = \frac{\sqrt{4EK + K^2}}{2\pi(2E + K)} = 0.159137985 \tag{22}$$

Which means that the total energy of 3 photons having the same magnetic field as these carrier-photons (moving in circle) but that would be moving in straight line would correspond to the total energy of the 3 carrier-photons multiplied by 1.159137985, so:

$$\text{Increased energy (carrier photons)} = K \times 1.159137985 = 1.729694352 E-10 J \tag{23}$$

which makes the total increased energy corresponding to the increased drifted magnetic energy of the 6 components of the proton to the sum of the figures obtained from equations (18), (19) and (23), so

$$E = 1.74443114E-10 J \tag{24}$$

which is a figure 16% higher than the actual energy of the proton rest mass. But let us recall that this apparent increase is only hypothetical. Let's remember that it only represents the total energy that a hypothetical particle moving in straight line, while having the same magnetic moment as that of the magnetically drifted magnetic moments of the 6 particles making up the proton as they move on closed orbits.

In physical reality, this only implies that while the magnetic energy of the scatterable components of the proton is increased by 16%, its related electric energy is diminished by the same amount, which leaves the proton with the same well known energy associated with its rest mass. But for calculation purposes, it simply is more convenient to work with the increased total energy since exactly half this energy corresponds very precisely with the real energy making up the real magnetically drifted moment of the proton.

Now from the figure obtained with equation (23) and the known measured magnetic moment of the proton (μ_p = 1.410606633E-26 J/T) we can calculate the actual magnetic field of the proton:

$$B_p = \frac{E}{2\mu_p} = \frac{1.74443114 E-10}{2 \times 1.410606633E-26} = 6.183265764E15 \ T \tag{25}$$

which in turn allows calculating the corresponding mean magnetic energy density of the proton

$$U_p = \frac{B_p^2}{2\mu_0} = \frac{(6.183265764E15)^2}{2\mu_0} = 1.521233808E37 \ J/m^3 \tag{26}$$

Of course, this figure is a first level approximation of the proton energy density, which by definition can only be an average of the actual individual densities of its 6 scatterable components (3 quarks plus 3 carrier-photons).

XIII. CONCLUSIONS

1) The easily reproducible experiment described in Section IX grounded on the considerations previously exposed proves out of any doubt the inverse cube relation with distance between the magnetic fields of magnets whose both north and south poles physically coincide, proving by similarity that the same inverse cube interaction law applies to point-like behaving scatterable elementary electromagnetic particles such as electron, positron, and quarks up and down.

2) This experiments also proves, by comparing equation (1) obtained from the data gathered during the experiment, with the standard equation (1a) used to calculate the interaction between bar magnets whose poles are at some distance from each other within each magnet, that the magnets used in the experiment behave as

monopoles since the comparison reveals that the strength of their interaction is only half that of bar magnets, revealing that with these circular magnets only 2 poles are simultaneously interacting in relation with **l**=0 compared to 4 simultaneously interacting poles when **l** > 0 within bar magnets.

The fact that only two poles are simultaneously interacting during the experiment, coupled with the fact that the same magnets can also be physically placed in parallel (repulsion) and antiparallel (attraction) orientation also proves that all 4 poles do exist in these magnets, which can be explained only by their being present in alternance by pairs (one pole at a time in each magnet), which is coherent with the 3-spaces model de Broglie internal dynamic structure of elementary electromagnetic particles described in papers ([2]) and ([16]).

By similarity, it can be concluded that the magnetic fields of point-like behaving scatterable elementary particles are magnetic monopoles at any given instant, in expansion from zero to maximum during half of each cycle and then from maximum to zero during the other half.

3) Finally, the reason why electrons do not crash on nucleons in atoms in spite of their permanent electric attraction is explained by the permanent and unavoidable magnetic repulsion between nucleon and electronic escort as described, revealing the existence of an electromagnetic equilibrium distance between electric attraction and magnetic repulsion corresponding to the mean Bohr orbit in the isolated hydrogen atom.

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