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On the Magnetostatic Inverse Cube Law and magnetic monopoles

André Michaud
srp2@globetrotter.net
Service de Recherche Pédagogique
http://pages.globetrotter.net/srp/

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Abstract:

1) 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 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.

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1 Coincidence of magnetic poles of localized particles

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, which is 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 that would allow experimentally confirming this inverse cube law of distance for magnetic interaction between magnetic fields whose poles coincide.

Considering that the invariant inverse cube law of distance of the 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 define such an experiment to irrefutably confirm the physical reality of this fundamental law.

It is mandated besides by deBroglie's hypothesis on the possible internal dynamic structure of localized photons ([1], p.277), which is at the origin of the development of the expanded Maxwellian 3-spaces geometry model ([2]) and ([6]).

2 Coincidence of magnetic poles of circular loudspeaker magnets

Interestingly, there does exist at the macroscopic level a type of magnets that provides the same magnetic geometry as that mandated by structure for point-like behaving 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 which are always magnetized parallel to thickness[1] 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 magnetic field have to behave precisely as if they physically coincided and consequently obey far fields interaction law, which will be borne out by the data that we will collect.

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 ([13], p.47) in a different context, and the detailed procedure was subsequently published in 2000 ([6], Appendix A), and are now reproduced in this separate paper.

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

3 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^o spherical reversal of the 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.

This is not without reminding of 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

[1] The magnets used are made by Arnold Magnetics Ltd. Part Number 29375, ceramic ferrite magnetized parallel to thickness.

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 both fields are in the expansion and regression phases of their magnetic aspects at the same time.

To create a mental image of what relative parallel and antiparallel spins involve at the fundamental level, parallel spin behaves 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.

Antiparallel spin on the other hand amounts to two birthday baloons being cyclically inflated and deflated in alternance. They can never occupy more than the volume of only one fully inflated balloon.

4 Inverse cube interaction vs 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 very short distance from one another 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 can overcome it when the particles are very close to each other. We will shortly verify that the inverse cube law perfectly matches that criterion.

Consequently, a direct parallel can be drawn between the macroscopic bipolar magnetic fields of such circular magnets and the bipolar magnetic fields of electrons that are associated to the property named "spin" since electrons behave as point-like particles, which means as already mentioned that both poles of their own magnetic fields can only likewise coincide.

5 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 (wave packet, 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 speak of spin as being "only a quantum number" specific to Quantum Mechanics, which tends to unduly dissociate it from the magnetic aspect of electrons.

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

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.

6 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 and member of the former USSR Academy of Sciences ([12], p. 129 (p.195 in the original Russian edition)). We will discuss these two effects in a separate paper ([13]).

But let us come back to our main subject.

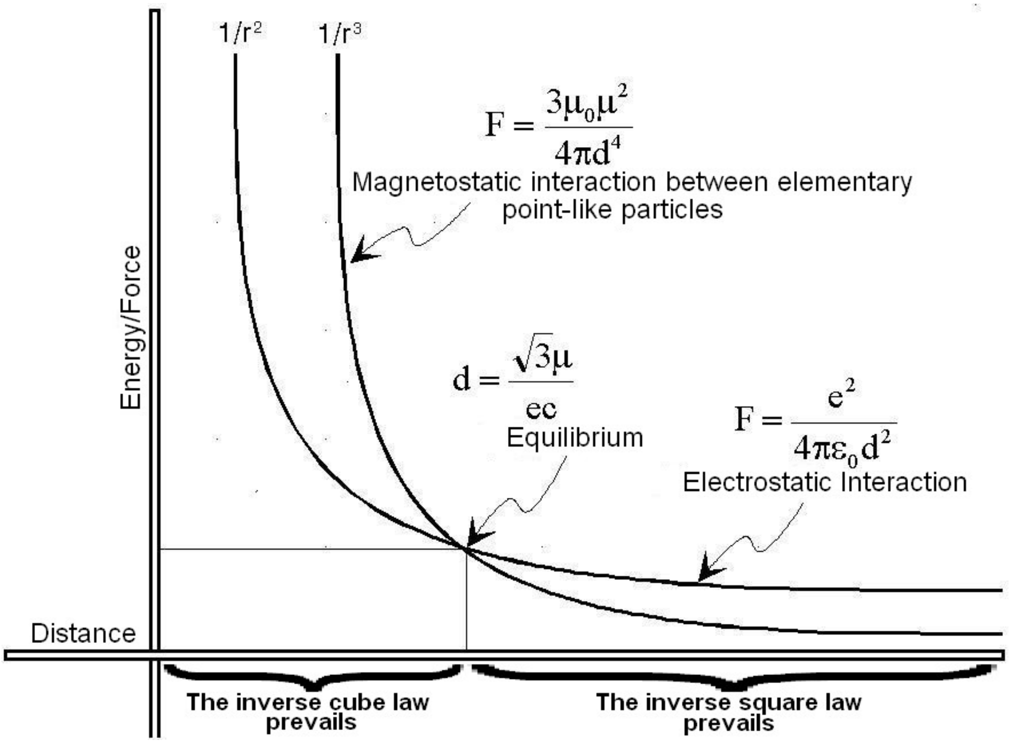
7 Localization of parallel-antiparallel electrons pairs

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 that layer is to switch to anti-parallel 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 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 however 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 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 of the distance interaction starts dominating to render capture possible.



8 Configuration of the magnetic poles in elementary particle

At this point, the reader may wonder at the usefulness of carrying out an experiment such as the one we are about to describe. Let us consider that given that all elementary particles whose existence can be physically confirmed by scattering (photon, electron, positron, quark up, quark down, muon, tau) behave as if they were point-like, it can only be concluded that without exception, both poles of their own respective magnetic fields have to mandatorily coincide by structure, as is the case for thin donut shaped circular loudspeaker magnets.

Consequently, the interest of this experiment 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 produced by these magnets, whose density of static energy spherically decreases from the center outwards.

Technically speaking, it is said that the field produced by a permanent magnet is **magnetostatic** since it is stable and does not vary in intensity over time. It is stable because it is produced by a particularly stable configuration of certain unpaired electrons in atoms of the material that are captured in forced parallel spin orientation, which forces the field of each of the electrons involved to combine in sufficient numbers to become detectable at our level as a macroscopic magnetic field.

This means that macroscopic fields do not appear as magnets are approaching each other, but are by nature permanently present since the electrons that produce them have a permanent existence and orientation.

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 of valence electrons (one valence electron being contributed by each atom involved), which results in a mutual cancellation of magnetic fields of the electrons of each of these pairs. The stable magnetic fields of magnets are due to forced parallel alignment of the spins of some unpaired electrons in the internal electronic layers of atoms.

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 comparison 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.

9 Experimental confirmation of the inverse cube law

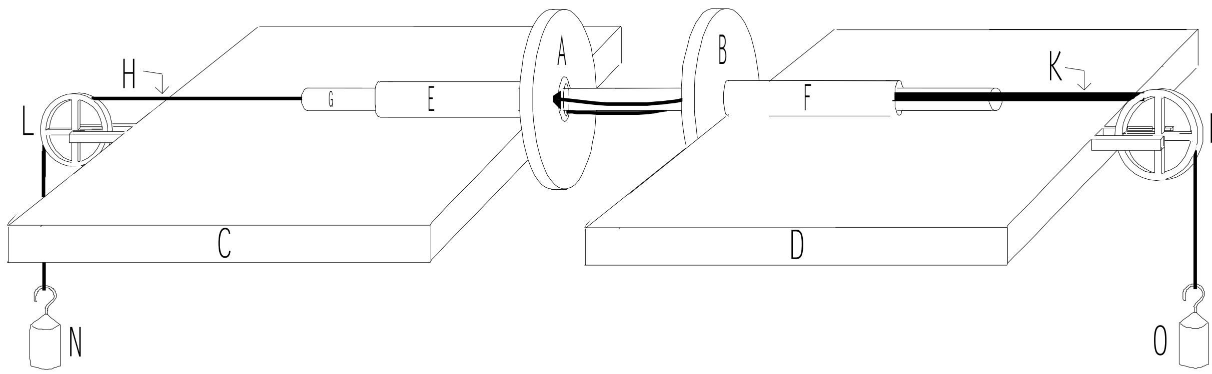
Let us now proceed to the description of the experiment. Given that controlling such an experiment is very difficult when magnets attract, all observations were carried out with magnets placed in a position to repel each other, meaning in a state of parallel spin of all electrons supporting the fields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

9.1 – Description of the apparatus

Let us examine the equipment that was used:



A and B: Circular ceramic loudspeaker magnets[2] dimensions: Outer diameter 7.1 cm; Inner diameter 3.1 cm; thickness 0.84 cm; magnetized parallel to thickness. Manufactured by Arnold Engineering Co., 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 that pull the magnets towards each other. One end of thread H is securely fastened between tube F and magnet B and let 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 masses, the sum of which makes up the total mass noted in column P of the following table.

[2] In schools where the SRP Air Cushion Table is used to teach classical mechanics, teachers will recognize the pair of circular magnets or magnetic pucks, as well as the pulleys that are accessories of the apparatus (Internet Catalogue: **pages.globetrotter.net/srp/**).

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

9.2 – 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 90º 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 the table is the mean distance calculated from these 4 measurements.

9.3 – Experimental data collected

Table of Measurements of Repulsion between 2 Loud-speaker Circular Magnets					
	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

9.4 – 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. In the fourth column is an inverse cube relation between pressure and distance can be represented by the following generic formula:

$$P = 1/r^3$$

This relational formulation however, although traditional, masks somehow the very important fact that 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 a 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

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

The 4th column in our table 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 available to conduct the experiment, and even with as few as these 8 meaningful readings[3], one can observe that the values obtained clearly hover about an approximately constant level.

Another telltale that a cubic relation is involved comes from observing lines 1 and 5. We observe that as the distance in line 5 is half that of line 1, the mass used needed to be 8 times that of line 1 (instead of 4 times mandated by the inverse square law), which is consistent with a force increasing with the cube of the distance and not with the inverse square law since the latter would involve a mass only 4 times that of line 1 when the distance is doubled. Consequently, the following first draft generic equation, involving a spherical relation between 2 "magnetic masses", so to speak, seems appropriate to represent the interaction that we just verified between our two magnets.

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

where M_m symbolically represents the magnetic intensity of each magnet, that is, the magnetic moment of each magnet, usually symbolized by μ, $G_?$ represents a magnetic constant that should obviously be μ_0, and $4\pi d^3/3$ which is the standard equation used to establish the volume of a sphere represents the spherical interaction over distance d, that is the interaction as a function of the inverse cube of the distance.

9.5 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 it 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.

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[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 too light, relative to the friction inherent to the system, which did not allow even the most delicate shaking and re-balancing of the floating rafts to stabilize at a sufficiently constant distance for the mass being used. A mass of 0.05 kg was the smallest mass that did allow such relatively constant distance to be obtained over 10 fold retries.

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

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

Let us now compare this final equation stemming from the analysis of the collected data to the standard equation for calculating the force between equal force bar magnets[4] 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** ([11],p 93), which is a given with our circular magnets since that in their case, the north and south poles of each magnet geometrically coincide and distance **l** equals zero by structure:

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

We immediately observe that the force obtainable for bar magnets is double that which we experimentally obtained with our donut shaped magnets.

9.6 Proof of cyclic reversal of magnetic polarity

Let us 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, and that our two circular magnets although also involving 2 pairs of poles, behave as if each pair within each circular magnet coincides with the geometric center of the magnet, meaning that the corresponding measurable distance **l** between opposite poles inside a bar magnet reduces to zero in the case of a loud-speaker donut shaped magnet.

This difference highlights a very important fact, because even if we found a way to reduce to zero this distance **l** between the poles of one bar magnet, we would logically expect that the force calculated in an experiment involving two such bars would still be double even when length **l** reaches zero inside each bar since the 4 poles would still theoretically be deemed to be statically present at the same time according to classical electromagnetism, whereas our experiment

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[4] 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 that can easily be derived from Maxwell's first equation.

This leads to believe that it 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.

Indeed, due to the impossibility of magnetic poles coincidence in the wave concept of Maxwell's theory, only the inverse square law of distance is required to fully account for a macroscopic wavelike description of observable macroscopic electromagnetic phenomena.

The magnetostatic inverse cube interaction becomes obvious and axiomatically required only when is taken into account the fact that at the fundamental level, for electromagnetic particle with point like behaviour, both poles of their magnetic field can only geometrically coincide at their center. It is mandatorily the case for photons and all massive elementary electromagnetic particles, such as electrons, up quarks, down quarks, muon and tau particles, whose point like behaviour has been indisputably confirmed.

Consequently, despite the fact that it is mentioned in the Halliday & Resnick textbook, it turns out to still be totally empirical and be supported by no classical theory whatsoever!

confirms that this is not the case with loud-speaker donut shaped magnets, whose poles of each magnet behave as if they precisely coincided (length **l** = 0).

This behaviour precisely confirms 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 but are 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 physically present at any given moment) at a frequency that obviously depends on the energy of the particle that produces it, presumably the carrying energy induced at the orbital on which the unpaired contributing electrons reside.

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, the answer is simple. It simply momentarily transfers to electrostatic space as electric state energy for photons ([6], Chapter 6 – Internal mechanics of the photon), and to normal space as neutrinic state energy for massive particles ([6], Chapter 22 - Neutrinos) as dual quantities moving in opposite directions until all of the magnetic energy has been transferred to then start back moving into magnetostatic space, thus initiating the next cycle.

If we transpose this alternating dipolar behaviour to the elementary electromagnetic particles level, that obey the same rule by similarity due to their point-like nature, 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.

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, circular loudspeaker magnets interact as if they were separate magnetic monopoles.

9.7 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 1g gravitational acceleration at mean sea level. This allows calculating the force corresponding to each mass used during our experiment (second column of the table in **Section 9.3**).

The magnetic moment of a magnet (μ) being defined in Joules per Tesla (J/T), just as for the Bohr magneton, and starting from previous 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 of our table, 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 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 it belongs.

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**)

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

From equation (1) from the previous page, we can 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)

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

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

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

Now with the value of **r** from line 5 of the table, that is 5 cm from each other

$$B = \frac{3\mu_0\mu}{8\pi d^3} = \frac{3\mu_0\mu}{8\pi(.05)^3} = 0.015341434 \text{ T}$$

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.

$$B = \frac{3\mu_0\mu}{8\pi d^3} = \frac{3\mu_0\mu}{8\pi(8{,}4E-3)^3} = 3.235475484 \text{ T}$$

9.8 The inverse square law and magnetic interaction

But let's get back to our table. As a reference with respect to the inverse square law which is often mistakenly considered to apply in magnets interaction, the fifth column in our table represents the figures obtained when applying **P x r^2 = Constant** to the raw data experimentally obtained.

It should be obvious that these figures do not tend to hover about an approximately constant level as do the figures in the fourth column, but increase as the distance shortens between the magnets. The demonstration is thus clear that the inverse square law does not apply to the magnets used and by extension cannot apply either to the magnetic interaction of elementary particles behaving point like.

If we now consider again the first relational equation that we 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), our table 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 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.

10 Permanent electron-nucleon magnetic repulsion

The reader may already have drawn a parallel between these equilibrium states at given distances of our magnets and another equilibrium state, at the level of elementary particles that has mystified scientists for a century.

Could it be that an equilibrium state of the same nature finally explained why escorting electrons cannot crash on their own on atomic nuclei, despite the electrostatic attraction that seems to mandate such crashing, but that observation clearly proves cannot happen?

10.1 Equilibrium between two opposing forces

Scatterable elementary particles having both an electric aspect (that obeys the inverse square law of distance) and a magnetic aspect (that obeys the inverse cube law of distance as we have just analyzed), one could easily surmise that the states of equilibrium of electronic layers in atoms could possibly involved magnetic interaction on top of the well understood electrostatic interaction!

What if in a hydrogen atom, as the electron comes closer to the proton, the mean magnetic interaction between proton and electron became repulsive for reasons to be identified and repelled it, while if it got farther away, the electrostatic attraction would dominate again, bringing it back so that the motion of the electron generally stabilized about a mean equilibrium distance, that would of course be the well known Bohr radius, within the statistical spread predicted by Quantum Mechanics?

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 (never attractive).

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

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[5] in magnetostatic space, meaning that no magnetic interaction would occur between two particles unless their constantly expanding-contracting magnetic energy spheres enter into 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.

10.2 The elementary particles of the hydrogen atom

Let us first put in perspective a few points that we previously analyzed regarding the Bohr hydrogen atom. For the electron, we are dealing with two distinct electromagnetic quantities, the electron proper with its 510,998.9 eV rest mass energy and its carrier-photon with its 27.2 eV energy. Given that a first approximation will be more than 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 1,149,747.5 eV and 4,598,990.2 eV their three carrier-photons each have an energy of 310,457,837 eV, as determined in ([6], Chapter 17), which represents approximately 300 times more energy than that of the particles that they carry, which means that here, 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 S.L.A.C. facility, which is coherent with the conclusion of the present model that the valence quarks are much less energetic than their carrier-photons.

In an isolated hydrogen atom, one can conceive that the motion of the electron would not be inhibited and that it could, in the fundamental state, effectively move at the velocity that the

[5] An energy sphere whose extent in magnetostatic space depends on the amplitude as a function of the frequency of the particle, with the speed of light standing as the absolute maximum velocity that the energy making up the particle can travel at even within the particle's internal dynamic structure.

energy of its carrier-photon allows, that is, 2,187,691.252 m/s (classical), which would cause it to cover for each orbit a distance of 3.32491846E-10 m ([6], Chapter 25), as accounted for by the Hydrogen nuclear wobble.

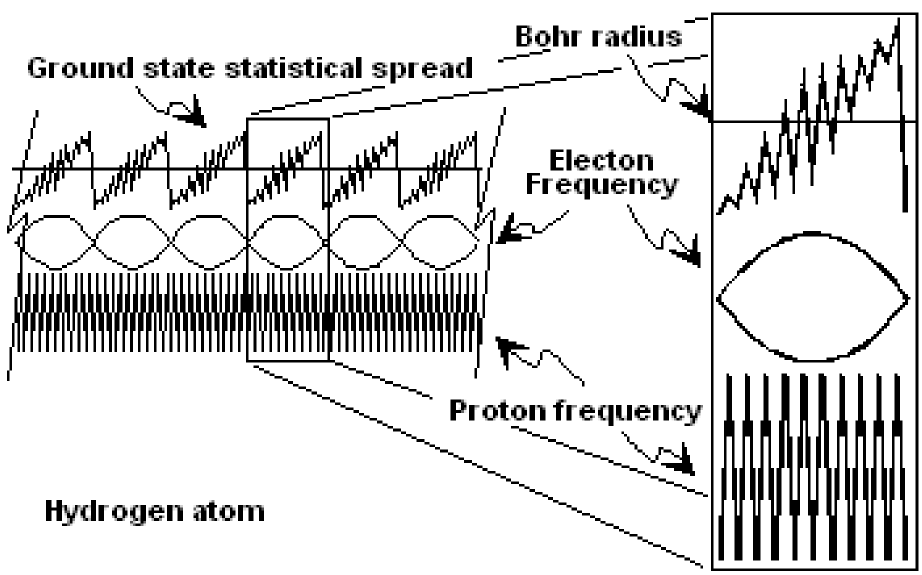
10.3 Correlation of the frequencies of the particles involved

The absolute wavelength of the electron rest energy being 2.426310215E-12 m ([6], Section 9.2), it is easy to calculate that the electron would cycle very precisely 137.0359998 times[6] between magnetostatic space and normal space at each orbit, this value shows by the way that at each turn, the 137th complete cycle of the electron energy will terminate 8.734668247E-14 m before the corresponding cycle of the previous orbit.

We would then be in a position to calculate very precisely at which point of its electromagnetic phase and at which point of the orbit an electron would be at any moment in the future by starting from any specific arbitrary point of the orbit!

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 eV each, that is 4.974082389 E-11 Joules, which corresponds to a frequency of 7.506837869E22 Hz, and to a wavelength of 3.993591753E-15 m, which means that during each electromagnetic cycle of the electron, the energy of the carrier-photons of the nucleus cycle 607.5508879 times.

Let us now examine the following figure that represents 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:



10.4 Permanent magnetic repulsion due to frequencies difference

The upper sequence represents the axial travel of the electron about its average distance from the nucleus (the Bohr orbit). The central sequence represents the variation in intensity of the magnetic presence of the energy of the electron during each of its cycles. The lower sequence represents the 607.5508879 intensity variations of the magnetic presence of the nucleus carrier-

[6] Isn't it interesting to observe that this value is exactly equal to the inverse of the fine structure constant (α).

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 600 times greater than that of the electron, and that at least 2 of the carrier-photons of the proton are always in parallel spin with respect to the third, and that their energies consequently add up to correspond to 1200 times the energy of the electron.

Let us also remember that in this model, the presence of the energy of elementary 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). Looking at the isolated segment, one can easily visualize that at the beginning of the cycle of the electron, while the intensity of the magnetic presence of the nucleus increases in the first part of the first of its 607 cycles, thus coming in opposition to the magnetic presence of the electron which also is in its increasing phase, the latter, being very light with respect to the nucleus, will of course be repelled a certain distance with respect to the nucleus.

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, it will find itself in anti-parallel situation with respect to the electron magnetic presence which is still in its increasing phase, and that there will then be attraction between the electron and the nucleus.

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, and thus **there will be a <u>physical impossibility</u> for the electron to be brought back all the way to the distance it was 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 being 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 falls 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 (obeying the law of inverse square of the distance), until the intensity of the magnetic presence of the energy of the electron becomes sufficient again at the beginning of the following cycle of the magnetic presence of the electron energy for the progressive repulsive interaction to start dominating again.

10.5 The restricted 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 acceleration and deceleration coupled with the limiting speed of light as an asymptotic limit velocity, while being maintained in a stable manner at an average distance from the nucleus corresponding to the Bohr radius by opposing electrostatic attraction and magnetic repulsion that we just analyzed and that are at play between nucleus and captive electron.

Such an axially zigzagging motion of the trajectory seems to be the only mechanical possibility regarding the ground state of hydrogen when considering a permanently localized electron. This motion is apparently made more erratic yet in this bound state by continued action of the Zitterbewegung motion described in ([6], Chapter 25), caused by the interaction between the electron magnetic field and the magnetic field of its own carrier-photon.

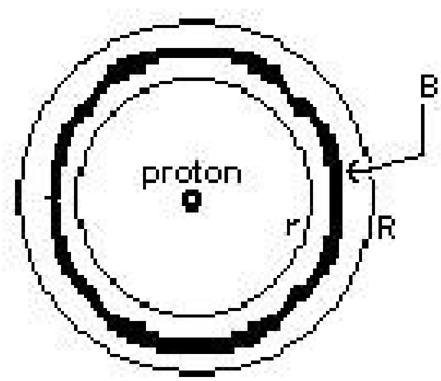
To summarize, the probabilistic spread of possible locations of the electron in motion, traditionally represented by this form of the wave equation:

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

allowing the statistical spread to reach infinity, must be modified to account for the limits imposed by the inertia of the electron during transverse acceleration and deceleration and the limiting speed of light to the following form:

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

where d represents the farthest transverse distance that these two limiting factors impose on the localized electron in motion.



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

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

10.6 End of the reign of the Heisenberg Uncertainty Principle?

But despite this apparent complexity, it does not then seem unrealistic to think that an appropriate mathematical development based on the mechanics of this model could one day allow calculating with great precision all future physically possible locations of a localized electron in the QM statistical distribution, with as a starting point any point arbitrarily chosen on the orbital within the boundaries set by considering the asymptotic speed of light as an absolute speed limit for the localized electron in relation with its inertia, thus putting an end to the unconditional reign of the Heisenberg Uncertainty Principle.

11 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 atomic stable and metastable states as involving the electrostatic attraction against magnetic repulsion equilibrium that we just analyzed?

Much more research, experimentation and calculation than what can be laid out at this stage 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[7], the magnetic interaction between electron and proton obeys by structure the far fields interaction law, which means that their magnetic relation will obey the point-like far fields equation (1) that we established previously

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

We also just clearly establish 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 that if this mean repulsive force is to exactly counteract the electrostatic attractive force, it will be exactly equal and opposite to the attractive force calculated with the Coulomb equation. So we can pose

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

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 $\boldsymbol{\mu}^2$ from equation (4) needs to be replaced by a representation reflecting this difference. So equation (4) will be rewritten as

$$F = \frac{3\mu_0(\mu_1\mu_2)}{4\pi d^4} = 8.238721759\,E-8\,N \tag{5}$$

And if we then isolate this product, since we know the values of all other terms in equation (4) since $d = a_0$ by definition, we can now obtain a numerical value for this product

$$\mu_1\mu_2 = \frac{F4\pi d^4}{3\mu_0} = 2.153491216\,E-48\,J^2/T^2 \tag{6}$$

What remains to be done now is to clarify from theory the respective values of $\boldsymbol{\mu}_1$ and $\boldsymbol{\mu}_2$ for them to match the experimentally obtained values.

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[7] For comparison, if we imagine the proton being the size of the Sun, 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 planetary system!

11.1 Composite orbiting electron magnetic moment (μ_1)

It was clarified in ([14]) how the experimentally measured value of the electron magnetic moment (μ_e) can be calculated from theory.

Summarily put, its theoretical classical value is calculated from the gyromagnetic moment equation mentioned at the beginning of this appendix

$$\mu_B = \frac{eh}{4\pi m_o} = 9.27400899\,E-24\ J/T \qquad (7)$$

The same separate chapter clarified 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 a 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 than the theoretical Bohr magneton value. 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 current 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 local magnetic field allows it by becoming higher than for straight line motion with the same energy, by a value that can be theoretically established by a factor of 1.00161386535E-3 ([14]), which is very close to the currently accepted factor, as we will presently see.

This other chapter allowed clearly identifying the phenomenon of **magnetic drift**[8] as the natural cause of this difference, a phenomenon that must be associated to all closed circular translation motion, and that is very well understood in high energy circular accelerators.

The manner in which the measured value is traditionally reconciled with the theoretical Bohr magneton has been to multiply the latter by an ad hoc factor named the g factor of the electron, whose definition lies beyond the scope of this paper, but whose value, theoretically set at 2 for other purposes, is further adjusted after the fact to fit the measured magnetic moment value, so to speak, to g/2 =1.001159653 from the ratio of the actual measured value to the theoretical Bohr value, to account correctly for the experimentally measured value of the electron magnetic moment in the hydrogen atom. So

$$\mu_e = \frac{g}{2}\frac{eh}{4\pi m_o} = 9.28476362\,E-24\ J/T \qquad (8)$$

A note of interest before pushing further is the conclusion drawn in ([6], Chapter 25) that the Bohr magneton (μ_B) does not involve in any way the rest mass energy of the electron but rather and very precisely half of the **added electron carrying energy** induced at the Bohr rest orbit! Consequently, **it cannot possibly be a property of the electron proper**, **but rather a property of its added carrying energy** as induced at the Bohr radius.

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[8] An increase of the local ambient magnetic field associated to a corresponding decrease of the local ambient electric field proportional to the gyroradius of the closed orbit involved.

Consequently, the measured so-called electron magnetic moment ($\boldsymbol{\mu}_e$), which involves by structure the same amount of added energy, but electromagnetically distributed in such a way that its local magnetic field is increased to account for the circular translation motion, obviously **must also be a property of the same added carrying energy**[9].

But while the measured electron carrying energy magnetic moment ($\boldsymbol{\mu}_e$) 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 captive of 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 ($\boldsymbol{\mu}_e$).

But before we can calculate the actual electron rest mass magnetic field, which is the other component of the composite orbiting electron magnetic moment $\boldsymbol{\mu}_1$, we need to first establish the value of the proton magnetic moment which will be equal by definition to $\boldsymbol{\mu}_2$ in equation (4), since in the far fields perspective, the hydrogen atom nucleus will be dealt with as if it was a point like particle.

11.2 Hydrogen nucleon magnetic moment ($\boldsymbol{\mu}_2$)

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

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

This value is named the nuclear magnetic moment ($\boldsymbol{\mu}_N$). 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 ([15]) for readers interested in further exploring this experiment.

So, we traditionally obtain the actual measured value of the proton magnetic moment ($\boldsymbol{\mu}_p$) by multiplying the nuclear magnetic moment ($\boldsymbol{\mu}_N$) by this ad hoc proton g factor, and since $\boldsymbol{\mu}_2$ is equal to $\boldsymbol{\mu}_p$ by definition in equation (4), we can pose

$$\boldsymbol{\mu}_2 = \boldsymbol{\mu}_p = \boldsymbol{\mu}_N \times 2.792775597 = 1.410606633E\text{-}26 \text{ J/T} \tag{10}$$

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 carrying-photons which together make up the scatterable structure of the proton. We will discuss this issue later.

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[9] Added, of course, on top of the electron rest mass energy.

11.3 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)

$$(\mu_e + \mu_E)\mu_2 = \frac{F4\pi d^4}{3\mu_0} = 2.153491216E-48 J^2/T^2 \quad (11)$$

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:

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

11.4 Orbiting electron magnetic field (B_e)

From ([6], Chapter 25), 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

$$B_e = \frac{E}{2\mu_E} = \frac{8.18710414E-14}{2\times 1.526829964E-16} = 268.1079208\,T \quad (13)$$

We can now obtain the corresponding energy density from

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

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

$$V = \frac{E}{U_B} = \frac{8.18710414E-14}{2.86008823E10} = 2.862535517E-24\ m^3 \quad (15)$$

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

$$r = \sqrt[3]{\frac{3V}{4\pi}} = 8.808205226E-9\,m \quad (16)$$

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:

$$A = \frac{hc}{2\pi E_B} = 7.251632784E-9m \qquad (17)$$

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.

12 Proton composite magnetic moment

As previously mentioned, the measured magnetic moment of the proton (equation (10)), that is $\boldsymbol{\mu_p}$ = 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.

12.1 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 components. From the analysis carried out in **Chapter 25**, 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 sphere possible, which cannot possibly be the case for the constantly oscillating energy making up each particle.

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

$$B = \frac{\pi\mu_0 ec}{\alpha^3\lambda_C{}^2} = 8.289000221E13\,T \quad \text{and} \quad U = \frac{B^2}{2\mu_0} = 2.733785545E33\ \ J/m^3$$

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 space 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 confirmed 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.

12.2 Magnetic moments of the proton components

Now, what we could do as a first approximation of specific magnetic momenta of the proton inner components would be to take as a reference the mean energy density that can be associated with the measured proton magnetic moment (**μ_p** = 1.410606633E-26 J/T). For this purpose, we must calculate the total magnetic energy that is to be associated 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 drift of these particles 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 **Chapter 17**.

Knowing that frequency f = E/h and that wavelength λ = c/f, since amplitude A= λ/2π. We can thus write:

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

Absolute Amplitudes of the Proton Constituting Particles			
Particle	Energy (E)	Amplitude $\left(A = \frac{hc}{2\pi E}\right)$	Space concerned
Up Quark	1.842098431E-13 J	1.716263397E-13 m	Magneto-static
Down Quark	7.368393804E-13 J	4.290658445E-14 m	
Photon-porteur de chaque quark	4.974082389E-11 J	6.35599868E-16 m	
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.

12.3 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 drift at their respective gyroradii implies that their magnetic fields involves a quantity of energy corresponding to that of a 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.

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

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

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 drift factor in relation with their gyroradius, the latter being 1.252776701E-15 m.

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 energy of the 3 quarks and treat this total quantity as a single particle being accelerated by the energy of the three photons:

$$E = 2E_u + E_d = 1.105259067\text{E-12 J} \quad (20)$$

Likewise, we can add the energy of the three carrier photons and treat it as a single quantity

$$K = 3E_{c\text{-}p} = 1.492224717\text{ E-10 J} \quad (21)$$

Making use now of equation (2) from ([14]), let's calculate the magnetic drift factor of the three carrier-photons energy:

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

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:

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

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

$$E = 1.74443114\text{E-10 J} \quad (24)$$

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, but 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 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 this figure 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:

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

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

$$U_p = \frac{{B_p}^2}{2\mu_0} = \frac{(6.183265764E15)^2}{2\mu_0} = 1.521233803E37\ \ J/m^3 \quad (26)$$

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 the 6 proton components (3 quarks plus 3 carrier-photons). Research is ongoing to identify criteria that would allow more precisely pinpointing their actual densities.

12.4 General considerations

The reader can further analyze the data provided, or even personally repeat this rather easy to reproduce experiment with magnets, which would allow obtaining more data points, graphing the curve and matching it to ideal inverse cube and inverse square curves, calculate best-fit exponent, etc.. It is important however to use flat circular donut-shaped loudspeaker type magnets, for reasons that must be obvious at this point. Presently, this is a novel and interesting experiment that appears in no textbook and that can be rather easily carried out in any high school physics lab.

Obviously, magnetic fields that come close to one another tend to then move on their own towards or away from each other depending on whether they both are in relative anti-parallel or in parallel orientation. If we prevent this motion from taking place, as when we maintain by force the two magnets of this experiment 5 cm from each other for example, this tendency to start moving manifests itself under the guise of a resistance to our action, a "pressure" that remains constant if we maintain the distance, and which is in fact a measure of the intensity of the force of attraction or repulsion at that distance.

The force of attraction and repulsion that we associate with magnetic fields seems stable and inexhaustible. If the material into which the field is anchored isn't modified in its configuration, that force will not decrease in intensity with time and will always induce the same quantity of kinetic energy in other magnetic fields that will approach at the same distance.

As a side issue, the measurable weight of objects on the Earth is nothing else but a resistance of the same order that objects and the Earth offer each other to the motion that gravitation induces in them at the distance to which this resistance occurs between them, as we will analyze in ([13]).

We could then be led to think that if, while a magnet is maintained at a fixed distance from another magnet, in such a way that the motion induced between them could not be expressed, the level of this quantity of kinetic energy was decreased somehow, by radiation under the form of free kinetic energy (photons) for example or rotation (Second Law of Thermodynamics), while the distance is maintained, that the quantity of kinetic energy which corresponds to this distance would be instantaneously renewed and maintained between the fields.

The quantity of kinetic energy induced by the magnetic field seems to be cumulative. It is this state of fact that produces the phenomenon of acceleration if the magnets involved are not forcibly being maintained at a fixed distance. The phenomenon is much more difficult to observe when there is repulsion, because, given that the two magnets will immediately move further apart from each other, and that the quantity of kinetic energy induced at any given distance during the motion decreasing as a function of the inverse cube of the distance, the velocity ultimately acquired will tend to quickly stabilize since the action of the field will rapidly become infinitesimal, much more rapidly than if the inverse square law of gravitation was involved.

On the other hand, when the magnets are positioned so that there is attraction, the velocity will increase at a stunning rate for the same reason, meaning that at each point of the motion, the quantity of kinetic energy induced will increase as the inverse function of the cube of the decreasing distance. So, we must be very wary of the severity of the pinching that we could experience if we do not hold the magnets prudently. They could even break into pieces if they are made of ceramic, but the pieces have no chance of escaping.

The violence of the collision is due by the fact that the quantity of kinetic energy induced at each distance is cumulative. The quantity of kinetic energy that has been accumulated at the moment of contact will have become much higher than the level allowed, so to speak, at contact distance, this is why the totality of the excess quantity of kinetic energy accumulated since the beginning of the acceleration in excess of the energy induced at contact distance be converted to kinetic energy at the instant of contact. The pressure that can be measured afterwards between the magnets at contact distance can in no way exceed or be less than that allowed by the kinetic energy that can be induced at the precise distance of contact. The freed excess kinetic energy that will not immediately escape from the material as photons will progressively diffuse as thermal energy in the bodies that have come in contact.

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