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On the Einstein-de Haas and Barnett Effects

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Abstract :

The orthogonal relation between the magnetic aspect (spin) of elementary particles' energy with respect to direction of motion of these particles can be demonstrated at the macroscopic level by mechanical means.

It can be proven that force aligning the spins of electrons in ferromagnetic materials causes the carrying energy of the electrons involved to align orthogonally to the field which can cause a motion detectable at the macroscopic level when that motion is not mechanically restrained (The Einstein-de Haas Effect).

It can also be proven that mechanically forcing electrons in ferromagnetic materials to move in a common direction forces the spin of their carrying energy to align parallel, causing their combined magnetic field to become detectable at the macroscopic level (the Barnett Effect).

In 1911, Albert Einstein and Johannes Wander de Haas, a renowned Dutch experimentalist, conceived of and performed a quite revealing experiment regarding the magnetic behavior of electrons, that came to be known as the Einstein-de Haas effect([1]).

Understanding, even before the property named "spin" was discovered, that macroscopic magnetic fields were due to some sort of alignment of electrons, they deduced that if, in a cylinder of ferromagnetic material, iron for example, that was made to hang from a thin thread, electrons were suddenly forced to align orthogonally with respect to the rotation axis provided by the supporting thread, by submitting the cylinder to a magnetic field, then electrons would suddenly align and their microscopic local angular momenta[1] and should combine to become observable at the macro level as an angular momentum of the suspended ferromagnetic cylinder.

And yes! As soon as the suspended cylinder was magnetized, it started to rotate! But to their surprise, the observed macroscopic angular momentum of the cylinder resolved upon calculation to only half the combined angular momenta that electrons would have if they orbited the nuclei, which dismissed the notion that motion of electrons on their orbits could be the cause of magnetism. The direct cause of macroscopic magnetism was identified only about a decade later when "spin" was discovered and its function understood.

[1] At the time, it was still assumed that electrons actually were always orbiting nuclei in atoms and it was that angular momentum that they were trying to cause to combine and observe at the macro level.

But their remarkable result was obtained all the same. They successfully demonstrated that it is possible to cause an observable rotating motion in ferromagnetic materials by simply forcing parallel alignment of the spins of individual unpaired electrons. The same effect is also observed when trying to magnetize paramagnetic materials.

But a still more intriguing effect had been observed a little earlier by Samuel Jackson Barnett. He discovered in 1909 that if a rod of demagnetized ferromagnetic material is suspended to a thin wire and made to rotate by any mechanical means, the rod becomes magnetized! Moreover, the strength of the resulting macroscopic magnetic field was directly proportional to the angular velocity of the rod! This is the Barnett Effect ([2]).

This means that when ferromagnetic materials, which contain unpaired electrons that the local electromagnetic equilibrium leave free to locally pivot as if mounted on gimbals, are mechanically set in motion, these electrons tend to pivot in such a way that their spins align as parallel as they possibly can even against their natural tendency to stabilize in the lowest mutually anti-parallel equilibrium configuration possible inside the material, like so many small magnets that would be left to freely swivel close to one another while being prevented from moving towards each other.

Now what in such mechanically induced motion could possibly force such an alignment of the spins of unpaired electrons in materials? It must be said that besides the mathematical "explanation" of Quantum Mechanics, no mechanical explanation was ever proposed to explain this phenomenon.

The 3-spaces model however definitely hints at a possible explanation. It is explained in Chapter **The Carrier-Photon** of the work that this paper is quoted from ([5]), how and why electrons carrier-photons have no choice but to align as anti-parallel as they can with respect to the electron that they "carry". Presently, since the frequency of a carrier-photon will seldom be an exact multiple of that of its companion electron, this alignment will be at best the closest to anti-parallel that the vectorial resultant of the dynamic interactions of their respective cyclic motion. But as long as the carrier-photon's energy remains stable, that "best-fit" anti-parallel alignment between carrier-photon and its captive electron will have no choice but to be quite rigidly maintained in such a relatively isolated two-particles system.

Without getting into the detail of relativistic variation of electron inertia due to elliptical orbits ([6], p.329), we have understood that the theoretical velocity of a free moving electron in the ground state of an isolated hydrogen atom is a function of the de Broglie wavelength of the energy of that carrier-photon, which happens to be, in this case, the length of the ground orbit, multiplied by its frequency, which is the number of times that the electron would circle the nucleus each second if local electromagnetic equilibrium allowed. We know that this translation motion of the electron in atomic hydrogen is real on account of the assumed wobble of the nuclei of such atoms that allowed Bohr to calculate very precisely the Rydberg constants of hydrogen and ionized helium from his model.

Presently, Bohr's results following this assumed wobble are the proof, without any doubt, that electron and nucleus are physically located at all times in the hydrogen and ionized helium atoms, and that despite the extent of the theoretical stretch of the mathematically established QM statistical spread, only the set of locations coherent with a moving electron being permanently localized can be occupied ([7]). However extended the zigzagging to and fro trajectory of the electron in an isolated hydrogen atom, they also are the proof that the orbital pattern is cyclic, and that eventual better understanding of the interaction between electrostatic attraction and magnetostatic repulsion between nucleus and electron will one day allow precise calculation of the electron's motion, at least in isolated hydrogen and ionized helium atoms, since this motion in more complex atoms may become too complicated for precise determination.

We also know that when two hydrogen atoms join to form a hydrogen molecule, it becomes impossible for the electrons to translate any more since they mutually capture in anti-parallel spin orientation midway between the nuclei (covalent bound), like two microscopic interpenetrating magnets, so that their de Broglie wavelength, which fundamentally can be only the actual distance covered by a massive particle per cycle of its carrying energy, becomes zero, even if the carrying-photon energy is still totally induced by the steady electrostatic force exerted by the nuclei and that consequently, the carrier-photons are left with no other option but to pulsate locally, constantly fighting to start moving again to restore their normal triply orthogonal electro/magnetic/spatial natural equilibrium, and constantly losing the battle against the overwhelming local strength of the inverse cube attraction that immobilizes the two anti-parallel magnetostatic aspects of the paired electrons.

Similarly, in ferromagnetic materials, some electrons are maintained somewhat stationary on their orbitals by the local electromagnetic equilibrium even though they are unpaired, and left free to locally pivot. Without entering the detail of domain alignment and resonance harmonizing of the phase of the frequencies of the carrier-photons of freely rotating electrons located on identical layers in all atoms of the material considered within each domain, it can be surmised that this forced suppression of the normal velocity component of the carrier-photon must then amount to a constant "pressure" for that velocity to be restored, and that any favorable circumstance is likely to cause that velocity component to start being expressed again. Consequently, it is not illogical to think that a forced mechanically induced motion of paramagnetic material could provide such a favorable circumstance.

Before going further, to better grasp this situation, let's consider by similarity a much more concrete equilibrium case, but this time induced by gravitation. The type of immobilization that we just considered for carrier-photons, with full energy[2] inducing force still being applied but also being countered (but not cancelled) by local electromagnetic equilibrium happens to be quite similar, paradoxically, to that of a mass lying at the surface of the Earth.

In a gravitational context, it was found convenient to express that relation as the ratio of *force per unit of mass* F/m (Newton per kg, or N/kg). This ratio is determined by the acceleration (g) at a specific distance from the center of the central mass (the Earth) at which the test mass (1 kg) will lies. So

$$F/m = g \qquad \text{or} \qquad F = mg$$

where F is the force expressed in Newtons ($kg.m/s^2$)

The value of g generally used is 9.8 m/s^2, which is the mean acceleration at the surface of the Earth. It is a means between the precise acceleration of 9.83208 m/s^2 at the poles and the precise acceleration of 9.78036 m/s^2 at the equator. The reason for this difference is that the poles are located closer to the center of the Earth than any point at the equator, due to a flattening of the planet resulting from the centrifugal "force" caused by the rotation of the Earth.

So since g is an acceleration, we can of course write

$$F = mg = ma$$

Now, we know that orbital acceleration is given by the product of the square of the angular velocity by the radius of the orbit, or alternately, by the square of the transverse velocity divided by the radius of the orbit, which is expressed as $a = \omega^2 r = v^2/r$, so similarly

$$a = g = \omega^2 r = \frac{v^2}{r} \quad \text{and} \quad F = mg = m\frac{v^2}{r}$$

Knowing that the equatorial radius of the Earth is 6378140 m, we can find the transverse velocity that a body would have if it was orbiting at ground level at the equator (hypothetically, of course). So, from $g = v^2/r$ we obtain the following velocity :

$$v = \sqrt{(g\,r)} = \sqrt{(9.78036 * 6378140)} = 7898.133028 \text{ m/s}$$

If we come back to equation $F = ma = mg = mv^2/r$, and if we assume a mass of 1 kg, we can now much more clearly observe that the force permanently being applied to this mass is

$$F = 1 \text{ kg} \times (7898.133028 \text{ m/s})^2 \div 6378140 \text{ m}$$

$$F = 9.78036 \text{ kg.m/s}^2 \text{ (Newton)}$$

[2] Energy that would cause motion if that motion was not hindered by local electromagnetic equilibrium.

This means that a 1 kg mass is maintained against the ground by a force of 9.78036 N at the equator. It also means that a force of 9.78036 N need be exerted to lift that 1 kg mass from the ground to offset the 9.78036 N force of attraction that maintains it against the ground.

Also, since the presence of surrounding matter prevents bodies from easily moving on their own transversally at ground level, the velocity of objects relative to surrounding matter at the surface of the Earth is typically zero, even though the orthogonal force acting on them would be sufficient to keep them orbiting at 7898.133028 m/s if they were left free to do so and if an impulse was provided to start them moving transversally.

Let's compare this velocity with the actual transverse velocity of the Earth at the equator due to its daily rotation, which is 474.8 m/s, which is just about 17 times slower than required for bodies at its surface to become weightless and truly be in orbit at ground level, if transverse motion was induced and if physical hindrance was not in the way.

So, coming back to the Barnett effect, it seems that the mechanically induced rotation of the rod is sufficient to cause the velocity repressed immobilized carrier-photons of the unpaired, free to swivel electrons of the ferromagnetic material, to start moving in the mechanically induced direction, which, due to the immovably rigid triply orthogonal electro-magnetic-spatial relation, will force parallel alignment of their electro-magnetic aspects, and in so doing, will force their rigidly captive companion electrons to align in "best-fit" anti-parallel opposition to the spins of their aligned carrier-photons in each domain, thus generating the macroscopically detectable magnetic field that the Barnett experiment reveals.

It may even be possible to consider that even the immobilized carrier-photons of the paired electrons may follow suit, even though their alignment cannot possibly disturb the anti-parallel pairing of their companion electrons and so couldn't possibly influence the strength of the macroscopic magnetic field, and that possibly all macroscopic motion may result in such alignment of the carrier-photons velocity component in the direction of motion. The same could possibly be surmised of materials where the crystalline structure would not permit the carrier-photons to resonate in phase in identifiable domains which would prevent the rise of a macroscopically detectable magnetic field.

A clear distinction must however be made between an *uncompensated mechanically induced rotation or translation* and a *permanently electrostatically or gravitationally compensated induced rotation or translation*, as analyzed in Chapter **Four Types of Permanent Attractors** ([5]).

The Barnett effect belongs by definition to the *uncompensated mechanically induced rotation* category, since energy is provided only for the initial impulse.

Conclusion

From these considerations, the question does come to mind as to whether stable permanently compensated Einstein-de Haas systems could naturally exist, since the effect is magnetically induced!

What about the very stable rotation of the Earth about its axis? To start with, we know that the core of the Earth is mostly iron, and that generally speaking, all planets of the Solar system that have satellites have rotation periods that are shorter than their translation period about the Sun ("days" shorter than their "years") while planets having no satellites do not rotate ("days" equal to their "years"), meaning that they always present the same side to their primary, local oscillation notwithstanding.

So, could the Moon's magnetic field, however weak, be strong enough to align a sufficient number of electrons in the Earth core to induce and maintain the age old stable rotation of the Earth? Could the tandem Earth-Moon be a stable giant Einstein-de Haas system?

Could the Einstein-de Haas effect be a factor in the rotation of all planets having satellites?

What a mind-boggling perspective!

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