Evolution of a Free-running Magnetic Motor Concept
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1. Introduction

This paper takes the reader through a method of developing magnetic motors using a new starting point. If such motors are to free-run they must obtain their energy from the atomic magnetic dipoles that supply the permanent magnetism. For many years such dipoles have been considered as arrays of persistent current circulations, and if these are to supply energy then each closed loop circulation must have a voltage induced into it of a polarity that "loads" the atomic circulatory current sources. Should this be done and energy extracted, the term "quantum dynamo" seems an apt description of those atomic dipoles. The source power for those dynamos is whatever keeps electrons permanently moving around atomic nuclei or keeps electrons permanently spinning, and clearly that would be the source of the extracted energy.

Currently the only method of inducing voltage into a closed loop that is accepted by the scientific establishment is by a time-changing magnetic flux passing through the loop. We will later challenge that perception by demonstrating that voltage can be induced by loop movement (more specifically orbital rotation) within a field pattern and where flux within the loop remains constant, but before doing so is there any evidence that a recognized *changing* flux applied to the quantum dynamos actually does "load" them to extract energy, and if so where does the energy appear? Let us imagine a cylindrical rod permanent magnet with a coil around it, and we pass current through the coil to supply a magnetic field B_A to be added to the static field B_M already existing in the magnet, i.e. within its inter-atomic space. When this is done we find that the magnetic energy density W stored in the inter-atomic space within the magnet as given by $W = \frac{B^2}{2\mu_0}$ has three components from the square of the sum $(B_M + B_A)$ yielding $W = \frac{B_M{}^2 + 2B_M B_A + B_A{}^2}{2\mu_0}$. The first of these components is the magnetic energy density already existing in the static field. The third is the magnetic energy density supplied from the coil. The second term is magnetic energy density supplied from the atomic current circulations responsible for the magnet's property. So here the changing magnetic field ***has*** drawn energy from the quantum dynamos and it appears in the inter-atomic space, often referred to as the "air space occupied by the magnet" as used in determining load-lines on magnet BH curves. The interchange of energies is more readily understood if the magnet is replaced by its surface current equivalent (see next section), and we imagine a DC energized air-cored solenoid in place of the magnet, around which we wind a second coil that supplies the changing flux. When the current in that second coil is turned on the magnetic energy density within the solenoid gains that $\frac{B_M B_A}{\mu_0}$ term from the imaginary solenoid's current source; it sees a voltage pulse induced by the change of flux when the outer coil is energized. So here we have evidence that the quantum dynamos do indeed deliver energy, however in this case that energy is not accessible to us, over a full cycle that energy gets fed back to the quantum domain.

2. Equivalent Surface Current of a Magnet

Figure 1 (taken from *Electromagnetic Theory for Engineers and Scientists* by Allen Nussbaum) shows the surface current J_{MS} equivalent for a cylindrical magnet. This effective current flows in an infinitely thin sheet but may be conveniently modelled by a close wound solenoidal coil of N turns covering the surface of the magnet. The equivalent ampere-turns NI is given by $NI = Ml$ where M is the magnetization and l the length of the magnet. For modern rare-earth magnets M may be obtained from the known remanence B_R by $M = \frac{B_R}{\mu_0}$ where μ_0 is free space permeability.

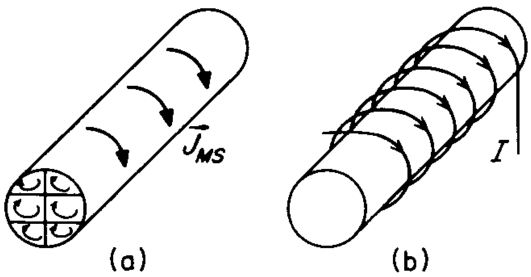

Figure 1. The Amperian surface current for the cylindrical magnet

For simplicity we will consider a thin disc magnet that is equivalent to a single turn closed (shorted) loop carrying current I. And to make things even more simple we will consider only rectangular disc magnets as rectangular loops. Thus this thin rectangular disc magnet is modelled as four line currents.

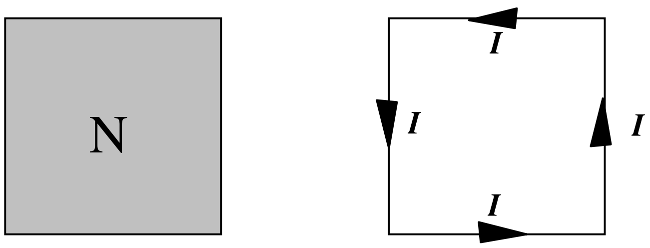

Figure 2. Current loop for rectangular disc magnet

We can prove that replacing a magnet by this edge current approach does give correct answers, using the FEMM 2D simulator. Figure 3 shows on the left a FEMM simulation set up for a thin disc magnet between two other magnets, with the central magnet orientated for maximum torque. On the right is seen the edge current equivalent where the central magnet has been replaced by two conductive strips with current flowing in the z dimension (into or out of the screen).

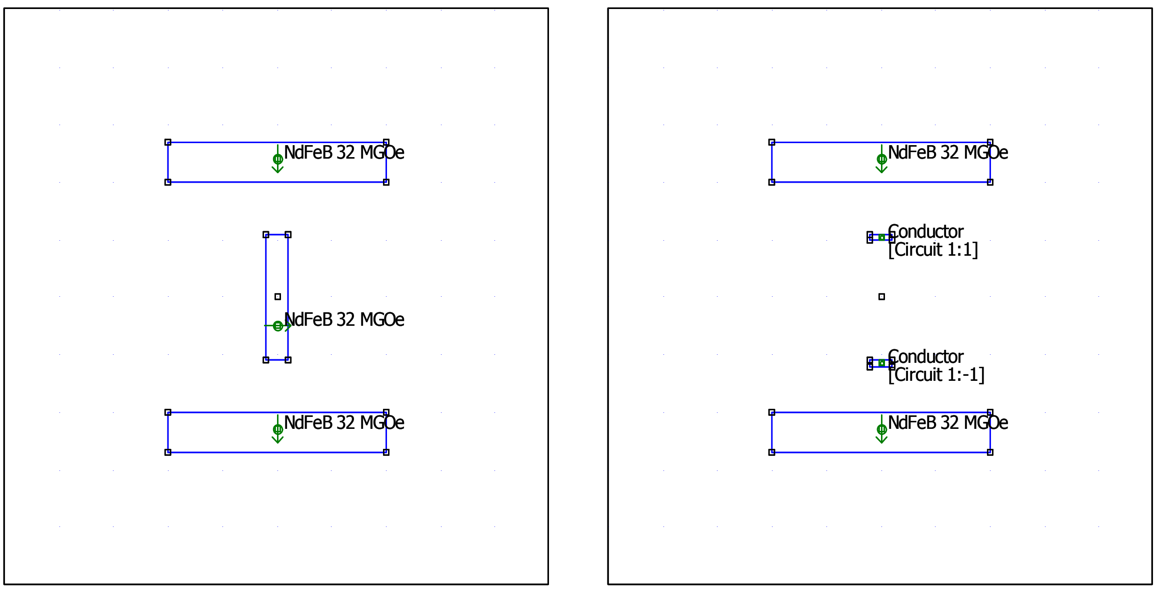

Figure 3 FEMM set up for showing the edge current concept.

Figure 4 shows the results of the simulations where it is seen that the field patterns for the two approaches are identical. Also shown are the stress tensor masks used by FEMM for calculating the torques, that are seen to have the same value to within 3 decimal places.

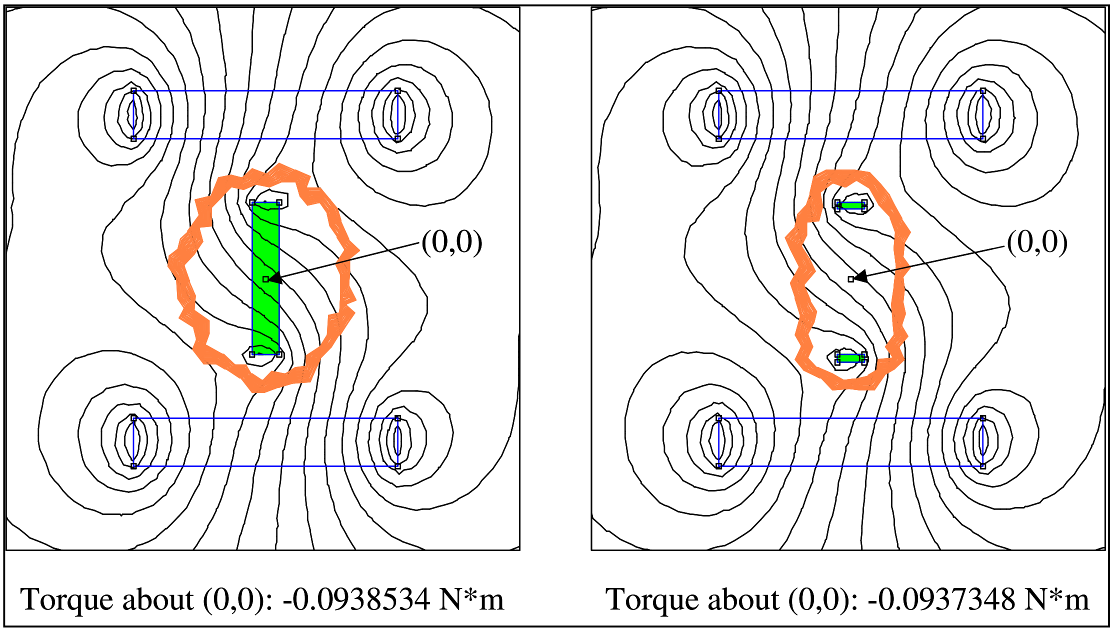

Figure 4. Simulations of magnet and edge current equivalent

With the knowledge that using edge currents gives correct results we can now use those currents to analyse and visualise forces on them. Figure 6 shows the magnetic field from the two outer magnets that is applied to the edge currents (this is simply an FEMM run with the conduction currents set to zero). Whereas the total field patterns in Figure 4 might be interpreted as the field lines bent around the conductors attempting to push the conductors aside, this has no scientific validity. In contrast the field lines in figure 5 passing through the conductors are at right angles to the current, hence we can apply Fleming's LH rule to obtain the force direction on each conductor and Ampere's Law to calculate the magnitude of that force. This is a much clearer interpretation of where the forces apply to the magnets, they appear at the outer rim much like Coreolis forces do on precessing gyroscopes.

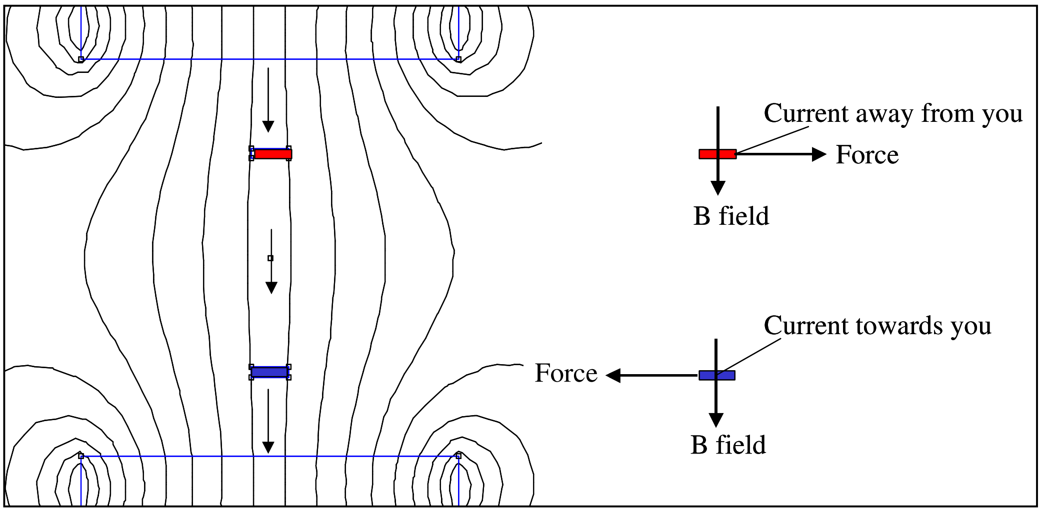

Figure 5. Application of Fleming's LH rule

Thus we have three methods for determining the torque on a magnet, all of which give the same answer:-

- Using FEMM to calculate the torque on the magnet using the stress mask integral procedure.
- Using FEMM to calculate the torque on the equivalent edge currents of the magnet using the stress mask integral procedure.
- Using FEMM to obtain the external field applied to the edge surface positions of the magnet then using Ampere's Law on differential current elements ($d\mathbf{F} = Id\mathbf{l} \times \mathbf{B}$) to calculate the forces on the known current values placed there.

Of these the third method is recommended as it allows one to better understand where the forces apply themselves to the magnet. It gives an appreciation of the forces that differs from the usual concept of N and S poles being acted upon by external fields, primarily because by definition poles are point objects and the pole faces of magnets are not points. We see that for disc magnets the forces act at the outer edge, and not over the pole face surface.

However there is a further benefit of using this approach. If the magnet is assumed to rotate over a small angular distance the forces (or torque) do work, supplying a unit of mechanical energy to the output. The movement of the edge currents through the externally applied field induces voltage onto those currents thus extracting a unit of energy from the current source (i.e. loading the quantum dynamos) and this unit of energy exactly accounts for the mechanical output. This is the Conservation of Energy (CoE) law being shown to work as it does in all conventional electric motors, but unlike those, here we are not using an externally applied current passing through conductors, we are using the atomic dipole currents considered as quantum dynamos. This applies to any permanent magnet system that supplies energy by movement. This application of CoE to the atomic dipoles is a new approach, and all we need to do to obtain a free running magnet motor is to create a system where the induced voltage on the quantum current source is DC, not AC, or has a DC component. (This is considered impossible in current teachings but we challenge that.) We must also ensure that this continual extraction of energy from the magnet is not countered by a continual absorption of energy (i.e. given back to the quantum domain) in another part of the system.

3. Moving Magnet Considerations.

The technology applying to loud speakers that employ a moving voice coil attached to a conical diaphragm is well known. The coil moves within a circular slot that carries a radial magnetic field. Figure 6 shows such a radial field within a wide slot where we have placed a thin disc magnet orientated to obtain maximum torque from the field passing through it.

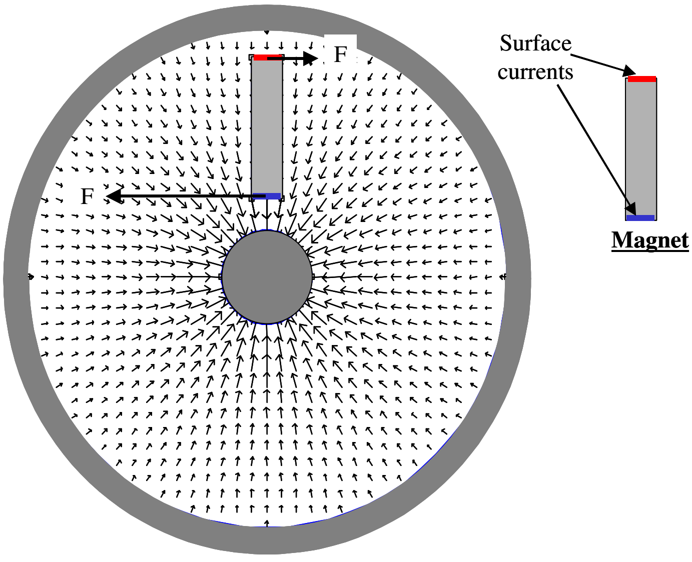

Figure 6. Magnet in a radial field

The red and blue lines represent the surface currents flowing into and out of the page. The central grey area is the magnetically soft core where the flux flows into the z direction. The magnet is assumed to be rectangular so that its outer edge surface currents are truly represented by the two current strips shown. The force couple obtained from the magnet's surface currents using Fleming's LH rule are shown. Clearly there is a torque applying to the centre of the magnet, and it might be expected to find that transferred to the centre of the system, hence allowing the magnet to translate in an orbital motion around the slot. However the two forces on the magnet's edges are not equal because the field strengths are not equal, the field strength (hence the force on the conductor) is inversely proportional to the radius. Since the torque for a given force is proportional to the radius the net result is zero torque about the central rotation axis.

To counter this disadvantage we could divert flux from passing through one of the edge currents. Figure 7 shows some permeable material attached to either side of the outer edge current attracting the flux lines so that fewer now pass through the surface there.

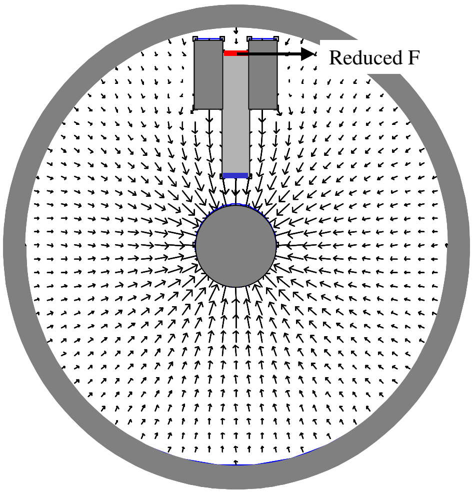

Figure 7. Magnet with attached soft material

The two forces on the magnet are now changed from that of Figure 6, the outer force is reduced in magnitude such that the magnet itself now obtains a torque about the rotation centre. Similarly Figure 8 shows some permeable material attached to either side of the inner edge current so as to attract flux lines away from the surface there, the inner force is reduced in magnitude and that also allows the magnet to obtain an orbital torque.

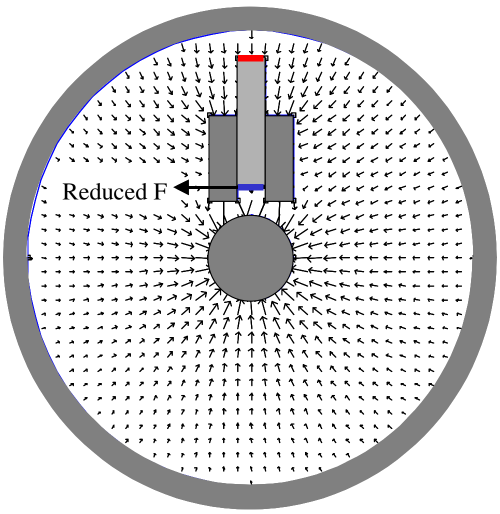

Figure 8. Magnet with attached soft material

However this system is not the answer to our problem and is unlikely to free run. The equivalent current concept applies to magnetized magnetically soft material, so we must take into account the equivalent currents of the permeable material pieces as magnetized by the flux from the magnet. Unlike permanent magnets that are intended to have uniform magnetization throughout their volume, magnetized soft material generally does not have uniform magnetization hence not only are there equivalent surface currents but also volume currents. These currents in the presence of the radial applied field also create forces, and in the configurations shown in Figures 7 and 8 we find that the torque on that material almost exactly cancels the torque on the magnet. However that cancellation is not exact, and there is no EM law that says it should be. It can be realized that the soft material drawing flux away from one edge current moves with the rotating magnet, thus the edge current there is not moving relative to a fixed field and there is no induced voltage. However the edge current at the other end of the magnet ***is*** moving relative to a fixed field, and does obtain induced voltage. Thus here the closed current loop does see an induced DC voltage, and were we to put a coil in place of the magnet we could measure that DC voltage. Here the quantum dynamos continually give up energy, and unfortunately most of that energy then gets passed back to the quantum domain via the quantum dynamos within the soft material.

4. Conclusion

We have shown that by using the surface current equivalent for permanent magnets (and both surface current and volume current equivalents for magnetized soft material) a much clearer picture emerges of where the forces on magnets apply themselves. Further to that it gives us an insight into the source of the energy when a magnet performs work, that source being the perpetual motion of the orbital electrons that supply the magnetism. It has also been shown that it is possible to conceive a system where a rotor magnet moving within a static radial field in a circular gap supplied by a fixed magnet (as in moving coil loud speaker systems) can be made to exhibit driving torque. Of interest is the ability of inducing a static (DC) voltage into a moving coil, something that to date has been considered impossible. That we can do these things is an omen for the future, and it is to be hoped that readers of this paper will be encouraged to evolve free running magnet motors that

(a) are less complex than those that have so far been demonstrated
(b) can easily be replicated
(c) where it is clearly known why and how they work
(d) where the source of the free energy is known and
(e) that are accepted by the scientific establishment.

It is not clear when the equivalent current concept for magnets was first evolved, they are certainly discussed in *The Feynman Lectures on Physics* and that is over 50 years ago. It is a sobering thought that the EM laws applying to moving conductors that ensure our classical electric motors obey CoE also apply to those imaginary currents on moving magnets, hence the route to obtaining free energy from moving magnets has been hidden in plain sight since then. Those very laws that enforce CoE not only tell us that magnet motors are possible but also tell us where the energy comes from.