Is there an unknown field type?

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Abstract

If we consider the kinetic energy of a charged particle and equate it to its induced magnetic energy we find that the two are equal when ¾ of the rest mass/energy of the particle is bound up in its electric field. This leads to the concept of inertia being electromagnetic. (*in Electromagnetic Field Theory model there are many papers on the momentum of electric and magnetic fields and momentum is just inertia by another name, although in the Quantum Mechanics model the concept is deprecated).* Which poses the question, what is the other ¼ made of? Next we can put this in juxtaposition with the fact that electromagnetic radiation does not appear to follow the rules of general wave mechanics as the energy pulses rather than flows continually as happens in every other wave type. If, however, we assume the existence of another undetectable field alternating with the electromagnetic field then electromagnetic radiation collapses to the standard form. So is there a field type that we cannot detect except by its interaction with the electromagnetic fields, present in both matter and in electromagnetic waves?

Electromagnetic induction

A moving electric field of strength E will generate a magnetic field of strength **B**...

$$\mathbf{B} = \mu\varepsilon(\mathbf{v}x\mathbf{E})$$

The **v**-cross-**E** term means that if the electric field is normal to the direction of motion it generates $\mu\varepsilon(|\mathbf{v}||\mathbf{E}|)$, while if it is parallel to the direction of motion then the magnetic field is zero.

The energy density dW/ds in the electric field is...

$$\frac{\mathrm{dW}}{\mathrm{ds}} = \frac{\varepsilon|\mathbf{E}|^2}{2}$$

...whilst that in the magnetic field is...

$$\frac{\mathrm{dW}}{\mathrm{ds}} = \frac{\mathbf{B}^2}{2\mu}$$

$$= \frac{|\mu\varepsilon(\mathbf{v}x\mathbf{E})|^{\mathbf{2}}}{\mathbf{2}\mu}$$

$$= \frac{\mu\varepsilon^2|(\mathbf{v}x\mathbf{E})|^{\mathbf{2}}}{\mathbf{2}}$$

Hence, when an electric field is moving the ratio of the induced magnetic energy density to the electrical energy density is...

$$Energy\ density\ ratio = \frac{\frac{\mu\varepsilon^2|(\mathbf{v}x\mathbf{E})|^{\mathbf{2}}}{2}}{\frac{\varepsilon\,|\mathbf{E}|^2}{2}}$$

$$= \frac{\mu\varepsilon|(\mathbf{v}x\mathbf{E})|^{\mathbf{2}}}{|\mathbf{E}|^2}$$

$$= \frac{|(\mathbf{v}x\mathbf{E})|^{\mathbf{2}}}{\mathrm{c}^2|\mathbf{E}|^2}$$

When the electric field is normal to the direction of motion this reduces to...

$$= \frac{|\mathbf{v}|^{\mathbf{2}}}{\mathrm{c}^2}$$

...and when it is parallel to the direction of motion it is of course zero.

It follows that any particle with an electric field must require energy to make it move, in direct proportion to the magnetic field energy induced by that motion. This is "inertia". There may be other sources of inertia in a particle but applying the principle of Occam's razor causes us to ask why we would need two separate mechanisms for inertia in an electromagnetic particle.

Inertia & the 4/3rds problem

Now when a polar electric field (such as that of the electron) moves, one third of its electric field resolves into each orthogonal axis. We can without prejudice arbitrarily align one axis parallel to the direction of motion and the other two are then normal to it. Those axes normal to the direction of motion induce magnetic fields and the axis parallel to the direction of does not, so that the ratio of total induced magnetic energy to total electric field energy is simply:-

$$Total\ Field\ Energy\ ratio = \frac{2|\mathbf{v}|^2}{3\mathrm{c}^2}$$

Now compare that with a moving mass 'm' – the kinetic energy to rest energy ratio is (using $E=mc^2$):-

$$Total\ kinetic - rest\ Energy\ ratio = \frac{\mathrm{m}|\mathbf{v}|^2/2}{\mathrm{mc}^2}$$

$$= \frac{|\mathbf{v}|^2}{2\mathrm{c}^2}$$

Clearly mass has an inertia that can be accounted for by the electric field taking up just...

$$\frac{\frac{|\mathbf{v}|^2}{2\mathrm{c}^2}}{\frac{2|\mathbf{v}|^2}{3\mathrm{c}^2}} = \frac{3}{4}$$

...of the total rest energy of the particle. The other ¼ of the rest energy cannot be electromagnetic.

In summary, if a particle has a polar electric field that induces energy with motion, that particle must be supplied with that same energy to get it into motion, so the energy in the induced magnetic field donates inertial properties. It is unnecessary and overly complicated to propose two independent inertial mechanisms so let us assume that for particles with a polar electric field such as the electron, proton and neutron the magnetic field induction supplies all the inertia of the particle. If the whole of the rest energy of the particle lay in its electric field the inertia would be too high by a factor of 4/3, so that only ¾ of the particle's rest energy resides in it electric field. The other ¼ is something else. This is known as the 4/3rds problem.

A historical concept

Many years ago when this first surfaced scientists considered the last quarter of the rest mass to be a "glue" holding the electrical field in place, thinking that otherwise it would simply expand and dissipate into the cosmos. They believed that they could separate the electric field and the glue in particle-smashing experiments to better understand the properties of matter. When years of work failed in this task they rejected the theory and looked elsewhere. And now we have the confusing state of some models of the universe treating electrical fields as having inertia/momentum, and others looking elsewhere for the causes of momentum.

Let us now examine problems with the "glue" concept. First consider the boundaries of the electric field and ideal with the idea that something holds the boundaries in place against the tension of the field. With the electron the electrical field extends to infinity so is held in place by the boundaries of the universe – there is nowhere for it to expand to even in an infinite universe, so there is no need for boundary "glue" for the electron. Now one might imagine some "glue" is needed to keep the outer boundary of the neutron's electric field from expanding and dissipating into space, but if the neutron particle did and the electron did not the 4/3rd ratio we see would have to be different for each particle. However, it is the same so boundary "glue" is *not* what holds the structure of the particle together.

The nature of the last ¼ of the rest energy of an electromagnetic particle

It seems that the missing rest mass must be simply proportional to the energy in the electric field, which means it co-exists in space with the electric field at an exact energy ratio of 1:3. As such it cannot be holding anything in place. However, when an electron and a proton come together the only forces generated are by the electric field. This other ¼ is effectively invisible – a "Q"-field.

What seems likely is that no glue is needed – different particles are "containerised" from three parts electric field energy to one part something else by some unknown mechanism in order to create the particles we know. The rules of spacetime that determine the containerised structures of stable and semi-stable particles so far escape us; there may even be a continuum of structures from the massive to the minute, with only a very few showing enough stability to exist longer than transitionally. There may even be a host of undiscovered particles of such low energy that it renders them difficult to sense.

Now when an electron moves along a wire it generates a magnetic field outside the wire, even though the electric fields of the sub-atomic particles (protons and electrons) inside the wire cancel completely outside the wire so that there is no external electric field. The fact that we still see the induced magnetic field means that either it is the *full* untrammelled electric field of the moving electrons that induces the magnetic field, or the magnetic field is actually induced by the motion of the ¼ component of the electron which receives no electrostatic cancellation. The latter seems a logical approach but then requires that ¼ component to have a property that has a vector-like directional component but does not have the field-like property of cancelling on the superposition of oppositely directed components. This suggests that the ¼ component may generate the electric field statically and the magnetic field dynamically.

If the whole wire is moving we will get no induced magnetic field, and from the above behaviour we can reasonably assume that the electrons and protons both induce magnetic fields, but these induced fields cancel perfectly.

Some conclusions

- The particle's rest mass is ¾ electric field and ¼ something else.
- The ¼ "something else" may be the generator of the static electric field and the motionally-induced magnetic field.
- The electric field leads to inertia.

- The mechanism that containerises energy into particles is not known.

How Inductors work in Electrical Circuits

An interesting related effect occurs in the electronic circuit element known as an "inductor". Keep a wire stationary with respect to the observer and have a single conduction electron flow along the wire. Since the full field of the electron is involved in the induction then regardless of its electric field cancellation outside the wire, the motion-induced magnetic field appears outside the wire even though there is no electric field measurable there. Let us now standardise this experiment, so that for a certain specific velocity and distance from the centre of the wire the moving electron generates an induced magnetic field of amplitude B and energy density E:-

$$E = B^2/2\mu$$

Now take two widely separated wires, and pass a single electron through each. The total energy in the system is simply doubled.

Next, take the same two electrons but make them pass together side by side through the same length of wire. Here the induced magnetic field outside the wire is doubled by the addition of the two fields so the energy density quadruples because the energy density is proportional to the square of the magnetic field. If we take 'n' electrons, the induced magnetic field is nB and the magnetic energy goes up to n^2E.

We can take this further. If we have a constant current flowing along a wire we can make each electron perform its role many times by looping the wire into a coil. Electrons in each loop of the coil will add to the induced magnetic field B outside the coil so that the field, for an 't'-loop coil, will be increased by a factor of 't' and the energy density increased by t^2 (the geometry of the coil affects this calculation, but I am dealing in broad principles rather than in design details).

The energy density for a coil is therefore proportional both to the square of the number of electrons (the current) flowing through the coil, and the square of the number of loops in the coil. When we divide the total energy by the total number of moving electrons:-

$$\frac{n^2t^2E}{n} = nt^2E$$

We find that the total energy *per moving electron* is proportional to the number of electrons flowing times the square of the number of loops in the coil. Each electron now has much more magnetic field energy and therefore much more inertia. This is used in petrol car ignition systems, where the current is allowed to build up in such a coil then suddenly cut off; the massive inertia associated with each electron means that it will not be stopped so readily and the electrons are forced to one end of the coil where they are all so compressed together that very high voltages result, high enough to force their way across whatever path they can find, in this case crossing the gap of the spark plug to ignite the petrol.

A historical perspective of Maxwell's Equations

Why did it take so long for the equations for Electromagnetic Radiation to be developed? To see why, let us look at General Wave Theory first. In Wave Theory any continuous wave passing a point in space has a constant energy density. For example, when an acoustic wave passes an observer, he sees a wave of pressure (spring energy) alternating with a wave of kinetic energy. First the air is compressed (spring energy), then the compression is exchanged for kinetic energy as the air molecules move in coming out of compression, then that kinetic energy piles up into a rarefaction (also spring energy) which in turn causes another burst of kinetic energy as the air molecules reverse their motion, then continuing on for a new cycle. There is a 90-degree phase shift between the peaks of each component. Thus there are four quarter cycles – compression, motion, rarefaction, and reverse motion, alternating every 90 degrees between the two different forms of energy. The crucial thing to note is that at every point on the wave the sum of the compression/rarefaction energy and the motional/kinetic energy is always the same constant value for any given amplitude. This is true for both longitudinal waves and transverse (shear) waves. That is, *until* we come to electromagnetic radiation which is very different.

Now for a continuous *acoustic* wave of radian frequency 'ω' and amplitude 'A', the energy density at a point in space and time, for any value of time 't', may be given as ('k' is a constant):-

$$\mathrm{W} = k.A^2((Compression\ Energy) + (Kinetic\ Energy))$$

$$= \mathrm{k.A}^2(\sin^2(\omega t) + \sin^2(\omega t + \frac{\pi}{2}))$$

$$= \mathrm{k.A}^2(\sin^2(\omega t) + \cos^2(\omega t))$$

$$= \mathrm{k.A}^2(\sin^2(\omega t) + \sin^2(\omega t + \frac{\pi}{2}))$$

$$= \mathrm{k.A}^2$$

In other words there is a constant energy level passing a point in space.

What makes Electromagnetic Waves Different?

All waves of which we are aware have a constant energy density. All waves, that is, *except* for the electromagnetic wave – here there is a varying energy density with only the electromagnetic components, an electric field in perfect phase with a magnetic field. The electric and magnetic fields are a composite single entity – absorb electric field energy from the wave and the magnetic field is absorbed pro-rata. There is no visible counterpart at a 90 degree phase shift. Thus the energy density of an electromagnetic wave passing a point in space beats sinusoidally at twice the frequency of the electromagnetic wave. This is shown in Figure 1 below, with the electric field (the magnetic field is in the same phase) in blue and the energy density in purple:-

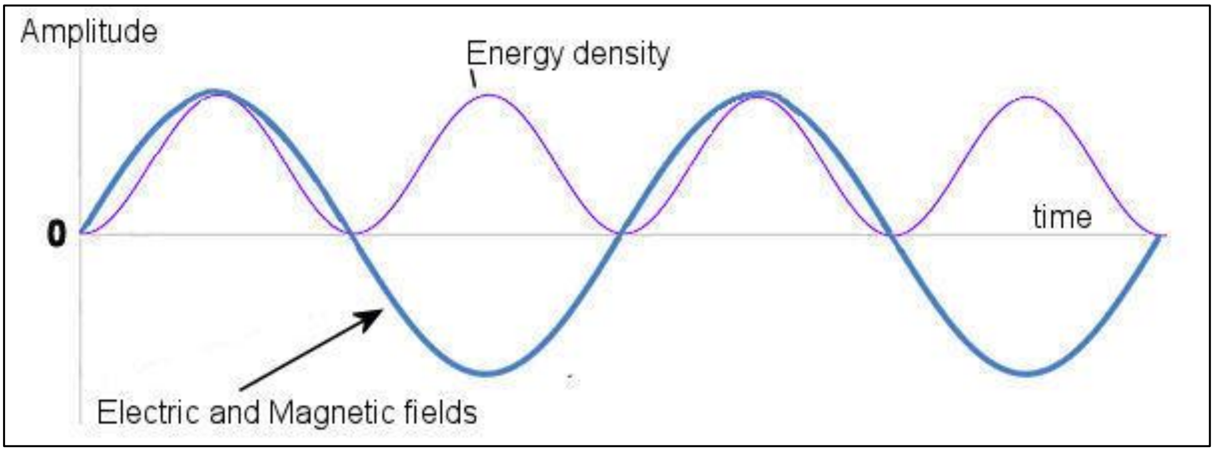

Figure 1

Near an antenna we can see the electric field alternating with the magnetic field in the "near-field" or induction zone where the field is being generated, but as the wave travels from the antenna into free space it changes so that in free space (the "far-field" region away from the antenna) it consists of an electric field that is in perfect sync with the magnetic field, with both fields rising and falling together. This difference between 'near field' and 'far field' is often used to tell how far away a nearby transmitter might be. There is no other observable field or force at a 90-degree offset as there is in other waves, meaning that the sum of all the energies in the wave in free space beats sinusoidally – it disappears altogether between peaks.

Thus the fundamental problem with the electromagnetic wave is that there is no alternative energy system to 'carry' the energy of one wave over to the next wave – it simply disappears at every zero-crossing leaving a blank. Nobody could see how, and in the end Maxwell came up with his famous equations that did not require this component. They work exceptionally well but there are always niggling doubts – why is the electromagnetic wave unique amongst all waveforms in not having a constant energy density? - How does it work out with the Principle of Conservation of Energy when the wave energy is lost at the end of a cycle and magically restored in the next cycle? Maxwell's use of the Grad function says "it just does" and answers nothing.

What if Electromagnetic waves were actually the same as all other waves?

What if there is indeed another energy form which has proved impossible to detect? Invisible to us but interacting with electromagnetic fields and alternating energy at a 90-degree phase shift with the electromagnetic wave so that the energy density of a wave passing a point is constant? It would likely be the propagating counterpart of our ¼ missing rest mass in the discussion of electromagnetic inertia above. Maxwell used the Gradient in his equations to bypass this missing part of the wave and even if there is no such "Q"-field the use of a virtual artefact of this type to replace the Gradient might simplify the equations for electromagnetic waves.