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Mass in the Universal Inertial Field – A Revised Version

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Summary

The analysis of a previous paper (1) pointed towards the existence of a universal, isotropic inertial field which permeated all space and resisted the acceleration of mass. This gave the appearance that mass increased with velocity, whereas in fact it remains unchanged. This is in contrast to the Special Theory of Relativity which predicts that mass increases with velocity, with the consequence that the length of intervals of time and space must also change.

The present paper develops a methodology for evaluating the resistance of such an inertial field to the acceleration of a particle of mass. The inertial resistance is called *R*, and it is measured in newtons. The value of *R* increases hyperbolically with the velocity of the particle. The methodology involves transformation of the hyperbola to rectangular form. The reciprocal of *R* then becomes a straight line when plotted against velocity, and so it can be characterised by two points.

The concept of a universal inertial field for mass fits well with the new theory that light consists of rotating electromagnetic dipoles (2). This theory requires that there should exist a medium of space which is universal and isotropic, and accepts electromagnetic induction. The model of inertial resistance to the movement of mass suggests that this too may be a property of the same medium of space, one which applies to mass.

The model allows calculation of the quantity of energy generated in the inertial resistance field, and the increasing force required to cause unit acceleration as the particle increases in velocity. The magnitude of this force increases to infinity at a velocity which is equal to the speed of light in vacuo.

In this model the connection between the velocity of mass and light is that the energy generated in the inertial field is in fact electromagnetic. Light of increasing energy, and hence electromagnetic frequency, is generated and radiated away as the particle accelerates. As the particle approaches the speed of light, light energy is shed as fast as energy is pumped in, and so the particle can go no faster. Hence the limiting value for particle velocity of $3\text{x}10^8$ ms^{-1}, which is the speed of light.

It is shown that the model is compatible with the Law of Conservation of Momentum.

Tests are proposed to validate the model experimentally.

The model raises the possibility that velocities approaching the speed of light may also affect other phenomena such as electric charge. A further possibility is that different phenomena may interact under these conditions.

The model may offer an explanation of the nature of inertia. It could form the basis of a Universal model embracing all phenomena.

1. The Inertial Field Model

In the inertial field model it is suggested that mass as a quantity of matter stays constant in terms of the number and mass of atoms, but that the increasing force required for acceleration results from interaction with an inertial field as the velocity of light is approached.

The nature of the interaction is such that the resistance of the field to the acceleration of unit mass increases hyperbolically with velocity. The limit of attainable velocity is reached at the asymptote of resistance and velocity. The form chosen to model this is a rectangular hyperbola in which the resistance tends to infinity at a definite value of velocity, the speed of light. Other curves, such as the parabola or the exponential increase indefinitely, so that there is no cut off value to give a limiting velocity.

The difficulty of relating to velocity is that it must always be relative. Everything is moving: the Earth, the solar system, the galaxy etc. There is no degree of freedom, no firm place from which to measure. By contrast, acceleration is measurable from zero wherever there is a stopwatch and a metre rule, because it is a local change of velocity. Hence the prima facie attraction of acceleration as a phenomenon which can be applied generally.

However the analysis which resulted in the new theory of light suggested that velocity must in fact always be relative to a general phenomenon in the form of a medium of space, even if the relative value was uncertain. On this basis a methodology for handling the uncertainty was developed as follows.

Zero velocity v_0 is defined as the position of rest measured at the point on Earth at which the standard of mass is also defined. The velocity of light c is also measured from a position of rest here on Earth i.e. it is measured relative to the standard v_0. The parameter c is called v_{lim} here during the analysis. Thus the hyperbolic function which relates inertial resistance to velocity can be drawn as in Figure 1.

The value of the inertial field resistance R at v_0 is just above the asymptote, which itself has an uncertain value because it is an indeterminate distance away back along the x-axis.

If a constant force is applied to a particle at v_0, it produces an acceleration. However, as velocity increases, it produces less acceleration, because of inertial resistance; velocity continues to increase, but at a diminishing rate i.e. the acceleration which the force produces decreases. To maintain a uniform acceleration, the applied force must increase by the factor R at every stage. When force is removed, acceleration ceases and velocity continues at the increased level. The implication is that when force is reapplied at the higher level of velocity, an increased force with the appropriate value of R will be required to produce unit acceleration.

By contrast, in the Newtonian world one unit of force always produces one unit of acceleration, whatever the starting velocity. It is this prediction which is seen to break down as the body approaches the speed of light.

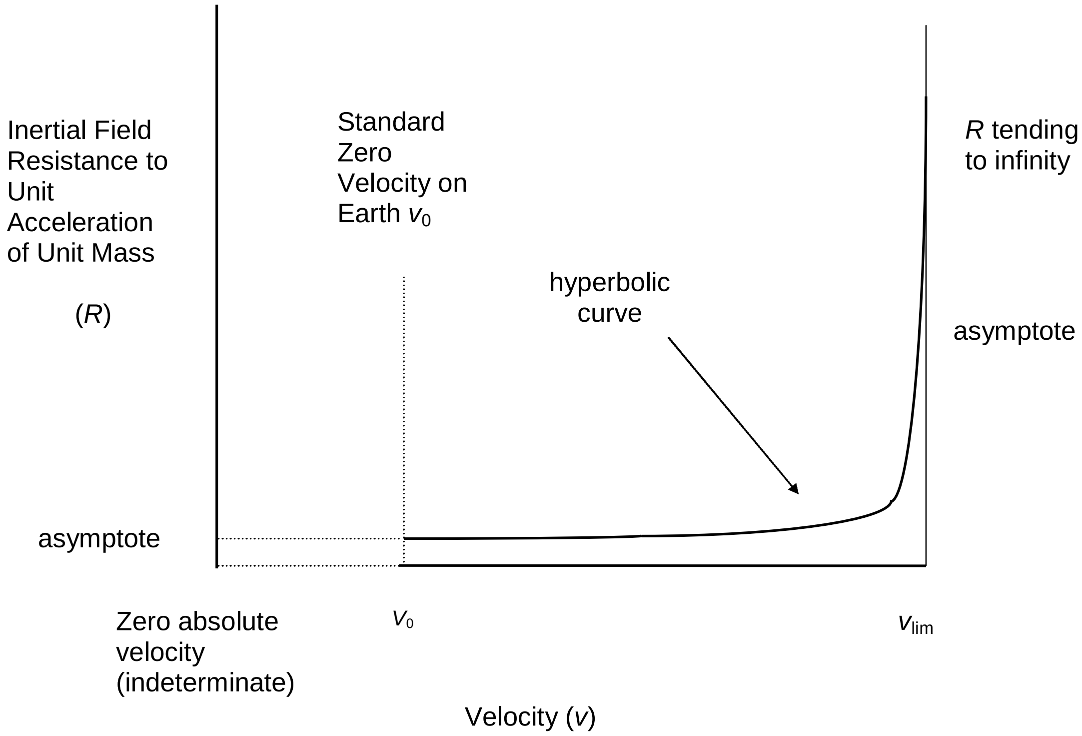

Figure 1. Increase of Inertial Field Resistance *R* with Velocity

The corollary is that bodies all over the Universe may have velocities which are different from that of Earth i.e. they may have velocities relative to v_0 and values of *R* to match according to the Earth's framework of units. However, for each individual body its own framework of units could be derived from its own rest mass on the spot.

The value of *R* may be calculated as follows. It is a characteristic of the hyperbola that it can be converted to rectangular form, the reciprocal of which is a straight line with a negative slope. Thus a graph of $1/R$ as a function of velocity is a straight line which cuts the *x*-axis at v_{lim}, the limiting value for velocity. If $1/R$ is zero at the limiting value of velocity, the corresponding inertial field resistance *R* is infinite, which is what is required.

Two points are sufficient to characterise the straight line. This provides a means to evaluate R without the need to specify the values at the indeterminate point.

2. Mathematics of Transformation to Rectangular Hyperbola Form

The basis for this transformation is as follows. The equation for a hyperbola is:

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$$

where a and b are the usual algebraic constants. This transforms to a rectangular hyperbola with the formula:

$$xy = c^2$$

where c in this case is the next algebraic constant after a and b, and the new axes, which are at right angles to each other, are the former asymptotes.

Let $z = 1/x$, then:

$$y = c^2 z$$

which is a straight line with slope dy/dz.

3. Evaluation of the Inertial Field Resistance *R*

This transformation is used to obtain the graph in Figure 2.

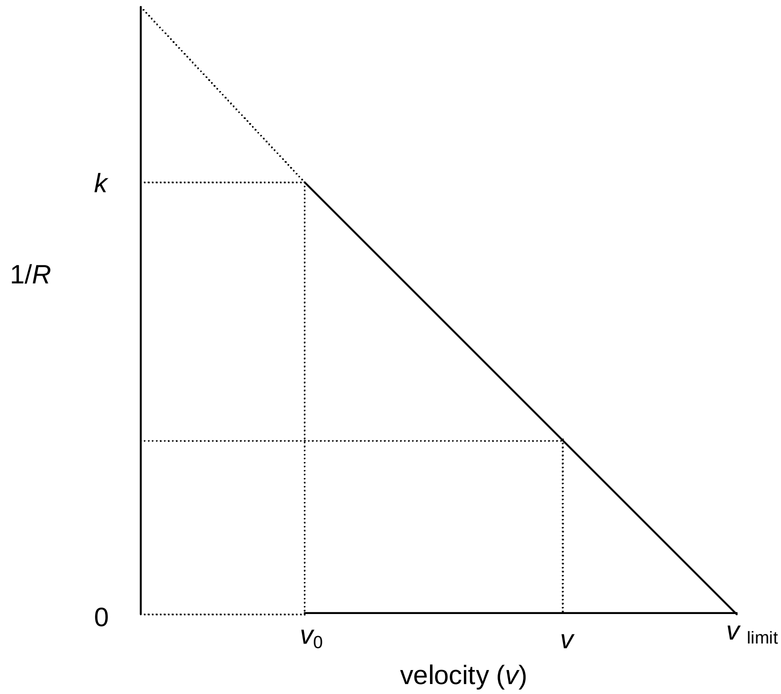

Figure 2. Reciprocal of Inertial Field Resistance versus Velocity

Velocity v is the standard velocity measured from the Standard Zero Velocity v_0, which is termed 'zero' velocity on Earth. Let the value of $1/R$ at v_0 be k. Then, by similar triangles

$$\frac{k}{v_{\lim} - v_0} = \frac{k - 1/R}{v - v_0}$$

from which

$$\frac{k(v - v_0)}{v_{\lim} - v_0} = k - \frac{1}{R}$$

and

$$\frac{1}{R} = k - \frac{k(v - v_0)}{v_{\lim} - v_0}$$

so that

$$\frac{1}{R} = k\left(1 - \frac{v - v_0}{v_{\lim} - v_0}\right)$$

Suppose the force exerted by unit mass at rest is defined as one Newton i.e. $k = 1$ at $v_0 = 0$, which is what is used in practice. This then calibrates R as follows:

$$\frac{1}{R} = 1\left(1 - \frac{v - 0}{v_{\lim} - 0}\right)$$

which becomes

$$\frac{1}{R} = 1 - \frac{v}{v_{\lim}}$$

and

$$\frac{1}{R} = \frac{v_{\lim} - v}{v_{\lim}}$$

Hence

$$R = \frac{v_{\lim}}{v_{\lim} - v}$$

The variable R is in effect the ratio of two velocities measured in conventional units of time and displacement, and so it is a number. Since it has been calibrated in newtons, it is a number of newtons. It is suggested that it could appropriately be called the Inertial Field Resistance *R*.

The value of v_{lim} measured from v_0 is the velocity of light *c*. Therefore,

$$R = \frac{c}{c - v} \qquad (1)$$

The resistance of the inertial field to unit acceleration of a body of unit mass increases as the ratio of the speed of light to the difference between the speed of light and the body's velocity, both measured from v_0, the Standard Zero Velocity.

4. The Quantity of Energy Generated in the Inertial Resistance Field

The fundamental equation for energy is:

energy = applied force x distance through which it is applied

where

applied force = mass x acceleration

If force F is applied over a distance x, then the work done W is

$$W = \int_0^x F dx$$

In the absence of an inertial field, which is the conventional analysis, this becomes

$$W = m\int_0^x a \ dx$$

or

$$W = m\int_0^x v\frac{dv}{dx} \ dx = m\int_0^x v \ dv$$

By integration this gives

$$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

This is the kinetic energy which a body gains in going from velocity *u* to velocity *v*, and since we have defined *u* as $v_0 = 0$,

$$W = \frac{1}{2}mv^2$$

By the work-energy theorem, the work done by the force acting on the body is equal to the change in kinetic energy of the body. Hence this derivation of the usual expression for kinetic energy.

However, in an inertial field the force *F* needed to cause acceleration is no longer a constant but *R*, which is a function of velocity. The equation for work done becomes:

$$W = m\int_0^x Ra \, dx$$

By the procedure used above,

$$W = m\int_0^x Rv\frac{dv}{dx}dx$$

The work *W* done in taking a body from rest to velocity *v* in the presence of an inertial resistance field is

$$W = m\int_0^v Rvdv \qquad (2)$$

This expression cannot be integrated by calculus because the term *R*, being a hyperbola, has the form 1/*x*. The value of *W* must be obtained by counting squares.

The introduction of the inertial resistance field requires a modification of the statement of the work-energy theorem quoted above. The work done by forces acting on the body is equal to the change of kinetic energy of the body plus the energy dissipated in overcoming the inertial field. So if W_k is the kinetic component and W_f is the inertial field component, then

$$W = W_k + W_f \qquad (3)$$

The parameter W_k is given by the analysis in the absence of an inertial field i.e. the conventional expression for kinetic energy. This is equivalent to setting *R* = 1.

$$W_k = \frac{1}{2}mv^2 \qquad (4)$$

Kinetic energy is the potential energy of the moving body which may be transferred to another body by contact.

The quantity of energy dissipated into the inertial field is therefore the difference between these two expressions i.e.

$$W_f = m\int_0^v Rvdv - \frac{1}{2}mv^2 \qquad (5)$$

5. The Partition of Forces

Figure 1 shows the increasing value of *R*, which is the force required to cause unit acceleration, at each value of velocity. However, from the definitions of Newtonian analysis, only 1*N* is required to cause unit acceleration, whatever the velocity. Thus using equation (1) it is possible to calculate how much of the applied force is required at each velocity to overcome inertial field resistance. It is in fact *R*-1.

If the velocity is zero, the body is at rest and

$$R = \frac{c}{c-0}$$

from which *R* = 1. This is exactly the force required to cause unit acceleration of the body, and so nothing left over to dissipate in overcoming the inertial field. That is the definition.

However, if the initial velocity is one unit, then

$$R = \frac{c}{c-1}$$

This can be expanded to

$$R = \frac{c-1}{c-1} + \frac{c-c+1}{c-1}$$

from which

$$R = 1 + \frac{1}{c-1}$$

Hence 1 unit of force goes to supplying kinetic energy and the rest is dissipated in overcoming the inertial resistance field.

Similarly if the initial velocity is 2 units, then

$$R = \frac{c}{c-2}$$

from which

$$R = \frac{c-2}{c-2} + \frac{c-c+2}{c-2}$$

and

$$R = 1 + \frac{2}{c-2}$$

Hence 1 unit of force goes into producing the increase of kinetic energy as velocity increases from 1 to 2, and the rest is dissipated in overcoming the inertial resistance field.

If the initial velocity is $c/3$, then

$$R = \frac{c}{\left(c - \frac{c}{3}\right)} = \frac{3}{2} = 1 + \frac{1}{2}$$

Thus at a third of the speed of light, for every unit of force which goes into increasing the kinetic energy of the body, half a unit is dissipated in overcoming the inertial resistance field.

If the initial velocity is $c/2$, then

$$R = \frac{c}{\left(c - \frac{c}{2}\right)} = 2 = 1 + 1$$

i.e. at half the speed of light, for every unit of force which goes into increasing the kinetic energy of the body, an equal force is dissipated in overcoming the inertial resistance field.

When v reaches the speed of light, R is infinite. All applied force is dissipated in the inertial resistance field. The body can go no faster.

Results of these calculations are shown in the Table below.

This is just another way of describing the hyperbolic increase of force required to produce unit acceleration against the resistance of the inertial resistance field for any initial velocity, as shown graphically in Figure 1.

Initial Particle Velocity	Component of Applied Force which Increases Particle Kinetic Energy	Component of Applied Force which is Dissipated in Overcoming Inertial Resistance Field
0	1	0
1	1	1/(*c*-1)
2	1	2/(*c*-2)
c/3	1	0.5
c/2	1	1
2*c*/3	1	2
3*c*/4	1	3
4*c*/5	1	4
9*c*/10	1	9
95*c*/100	1	19
99*c*/100	1	99
999*c*/1000	1	999
c	0	infinite

Table. The Partition of Applied Force Between the Kinetics of the Particle and the Inertial Resistance Field

6. The Form of the Energy Generated in the Inertial Resistance Field

The first version of this paper concluded that energy dissipated by a particle accelerating in an inertial field is transported away at the speed of light. The new theory of light (2) suggests a simple explanation why this is so: it is light. Interaction of an accelerating particle with the medium of space produces electromagnetic radiation.

The mechanism proposed in the theory of light for producing electromagnetic radiation is that increasingly rapid oscillating movement of electrons along the bonds which bind particles induces a parallel and opposite movement of charge in the medium of space by the process of electromagnetic induction. At a particular energy level, the energy of activation, the oscillation is vigorous enough to produce a rotating electromagnetic dipole in the medium of space which separates from the bond and is thrust away at the speed of light by the magnetic component which must always accompany a moving electrical charge. This disturbance in the medium of space is a quantum i.e. it has a definite energy level, because it is related to the structure of the bond which generated it. The rate of rotation of the dipole represents the frequency of the electromagnetic emission.

This paper proposes that an accelerating particle produces similar disturbances in the medium of space. The inertial field effect is the response of the medium of space to acceleration of particles with the property of mass. Electromagnetic dipoles are generated in space and emitted as the velocity of the particle increases. The energy of the electromagnetic emission depends on the velocity of the particle through the medium of space at that point. The higher the velocity, the greater the resistance to acceleration, and the greater the energy of the emission. The energy which the emission contains thus increases hyperbolically with the velocity of the particle at the instant of emission.

Increase of velocity requires a force which is applied in the medium of space by other particles, even if through an intermediary ‘field’. The proposed mechanism is consistent with that put forward in the new theory of light.

The suggested mechanism of acceleration through an inertial field is as follows. Force is applied to a body at rest which causes unit acceleration. At this stage the force is consumed entirely in increasing W_k, the kinetic energy of the particle. This in fact results from the definition of unit force. However for each unit of acceleration which a force causes after that, work W_f is done against the resistance of the inertial field. At some point W_f increases to the point of ‘activation’ at which the quantum of light which this work represents is shed into the medium of space. Up to that point the particle has been associated with both components of work, W_k and W_f. After the quantum of electromagnetic radiation has been shed, the particle is in a constant velocity state. It is associated only with W_k its kinetic energy.

As acceleration recommences, this time from a higher velocity, the process begins again. Both kinetic and associated field energy build up, until the activation energy of electromagnetic induction is reached, and emission takes place. This emission has greater energy in accordance with the hyperbolic function *R*. The particle is again left in a constant velocity state, but its kinetic energy W_k, is also greater because of its increased velocity. And so on.

Two practical tests suggest themselves for such a mechanism. First, it should be possible to observe an entire spectrum of electromagnetic emissions from a body undergoing acceleration. The frequencies of emissions should be related hyperbolically to velocity. Such spectra, if observed, would provide information both about the nature of the particle undergoing acceleration and about the medium of space.

Secondly, it should be possible in principle to observe electromagnetic emissions at the lowest detectable frequency, because the value of *R* rises further above the asymptote as soon as velocity increases above the unit level. The thesis is that any increase of *R* must represent dissipation of applied work into the inertial field, either potential, because the activation energy has not been reached, or actual, as soon as it has. Accelerating bodies ought to hum electromagnetically!

7. Conservation of Momentum

The inertial field hypothesis could on the face of it conflict with the conservation of momentum. If a body travelling at high velocity collides with another body, the result may be that the second body emerges from the collision with a much higher velocity than it had before collision. This might suggest that the second body has undergone some form of acceleration, which according to this paper ought to result in the generation of electromagnetic emission, and so vitiate the Law of Conservation of Momentum.

Change of velocity at the instant of collision is not usually mentioned in connection with the Law of Conservation of Momentum even in conventional analysis. Nor are all collisions perfectly elastic i.e. energy may in practice leak out of the system. But this is not through the electromagnetic mechanism proposed above.

The explanation provided by this paper is that in perfectly elastic collisions momentum is transferred instantaneously during impact. The bodies bring only their kinetic energies to the collision, because they are not accelerating. They then adjust to their new velocities while they are in contact. Any electromagnetic adjustments take place within the system i.e. without acceleration through the medium of space. The bodies then leave the point of impact with new constant velocities. No acceleration, no emissions of electromagnetic energy. Thus the Law of Conservation of Momentum is observed.

There is, however, a wider question. What exactly collides with what during ‘collision’. Billiard balls are structures built of atoms which are composed of electrons circling a nucleus, both of very much smaller dimensions than the atom itself. The atom is composed almost entirely of the medium of space.

Thus when billiard balls collide, the forces which they exert on each other arise entirely from the interaction of their electrons and nuclei. The chances of these particles hitting each other directly are extremely small because of their size, quite apart from the influence of their electrical charges. In fact they may never collide in the sense of coming into contact. When they approach each other, they may be pulled together by forces of attraction, but at some point they are repelled by other forces, As a result they are either held at a distance from each other by the resultant bonds with the medium of space in between, or they deflect each other and go their separate ways.

The suggestion by analogy with the mechanism of diffraction in the new theory of light is that such particles undergo orbital interaction rather than collision. Electrons are orbiting their nuclei at velocities which are a significant fraction of the speed of light. Their interaction takes the form of deflection of these orbits, which in turn is transmitted to the other particles in their atomic systems i.e. the other electrons and the nucleus. They change direction and then continue in orbit, rather than being reflected at a boundary, as implied by the Law of Conservation of Momentum. The difference is that there is no change of orbital speeds, just direction, because they have identical masses. Thus there is no acceleration in the line through the medium of space, and therefore no emission of electromagnetic radiation.

The implication of this is that it is an orbital mechanism which gives rise to electron diffraction, rather than wave behaviour, or indeed mechanical collision mechanisms. Collision of fundamental particles is observed to produce hyperbolic rebound curves, which is not compatible with billiard ball collisions.

It seems likely that the Law of Conservation of Momentum as commonly observed is a characteristic of macrostructures which undergo many such orbital interactions during the process of collision. The effect is the resultant of all the possible random orientations in each body. Single fundamental particles cannot have this characteristic.

The corollary is that there may be a level of particle structure at which the macro (billiard ball) phenomenon gives way to the micro (orbital) phenomenon.

There is the possibility of testing the orbital interaction theory by firing identical particles such as electrons at each other at equal, constant velocities in opposing beams. If the collision theory holds, there should be lateral deflections throughout the whole hemisphere, because no particular angle will be selected. If, however, there is an orbital mechanism at work, deflections may take place at a small number of given angles, which is in effect diffraction.

It seems likely that orbital interactions will in fact occur because it has been claimed that quite large bodies can be made to diffract, not only atoms, but also ‘bucky balls’. This has been adduced as evidence of the inherently wave nature of matter. The analysis here suggests that they diffract because they are full of electrons etc and small enough to respond to the orbital interaction mechanism.

Rutherford’s original experiment on the deflection of α-particles by a nucleus showed quite clearly that the paths of the particles after deflection were various forms of hyperbola.

8. A Universal Model

It is unlikely to be a coincidence that the same number $c = 3 \times 10^{8}$ appears as both the speed of light in vacuo and the limiting velocity of mass expressed in metres and seconds. It suggests a common Universal and isotropic field with which light and mass are interacting, but that the interactions take different forms for the two phenomena. The conclusion would be that it is the nature of these interactions which characterises light and mass.

The analysis of this paper suggests how mass and light are connected. The postulated inertial field is just another manifestation of the same medium of space which accepts electromagnetic disturbances in the form of light. Accelerating masses produce the radiation of hyperbolically increasing quantities of electromagnetic energy until they are emitting as much energy as they receive to accelerate them. The point at which this occurs is the speed of light.

The argument depends on the existence of a medium of space. Tests are proposed both for the new theory of light and the emission of light caused by accelerating mass. If these prove to validate the models, that would be good evidence for the existence of the medium of space. The models are based on the known and verifiable phenomena of electromagnetic induction.

Mass may not be the only phenomenon which responds to acceleration through the medium of space in this way. For instance, it may be that electrical charge shows a similar effect. Certainly moving charges are different from static charges in that they generate magnetic fields. It is motion that links electrical charges and fields with magnetic poles and fields, as in electrodynamics. However, all these effects were originally characterised at relatively slow speeds compared with the speed of light. They too may encounter resistance or some comparable phenomenon.

There is the further complication that we are really looking at one system, of which the individual phenomena are different manifestations. These are in effect components of the system, and they may interact i.e. masses which also have charge may behave quite differently from masses which carry no charge. The corollary would be that sole electric charges might behave quite differently from charges associated with mass, if one could conceive a situation in which they could be observed separately in this way. Magnetic poles are another component, but it might be necessary to separate ‘quantum’ poles from other particles to evaluate any effect. This might be impossible because permanent magnetism might be a bulk property which depends on immobilisation of charge in a surrounding structure.

Interaction with the medium of space might help to explain the phenomenon of inertia generally. A standard velocity is in effect fixed on Earth in the form of v_0. All departure from this velocity requires acceleration against an inertial field. This departure is measured against a standard unit of acceleration measured at v_0, which is in effect the phenomenon of inertia. In Newton’s equations the resistance of the medium of space to acceleration is constant. In the inertial field model the resistance of the medium of space to acceleration increases hyperbolically with velocity.

However, it would be equally valid to arrange the hyperbola such that it cut the inertial resistance axis closer to the origin on extrapolation back through an infinite distance along the velocity axis. In this hypothetical case the value of R would be <1. A standard of inertia i.e. a unit of acceleration could be established anywhere along the x-axis. On Earth we happen to have specified it as $1N$ at our particular velocity v_0, which we have called zero velocity.

In one important respect the inertial field analysis is definitely Newtonian: effects have causes. There are no inexplicable probabilities. It is a deterministic world which depends on inputs and outputs.

The advantage of the decomposition of the new analysis is that it allows simplicity of interpretation for fundamental phenomena such as gravity. All input forces can be added as vectors in the usual way, whatever their origin; inertial, gravitational attraction, electrical attraction or repulsion etc. The effect which they produce on the acceleration of mass, for example, will then depend on their resultant. If the effect seems less than the Newtonian equation predicts, it is because inertial field effects are acting in opposition to the applied force, which is the conventional Newtonian balance of forces.

The inertial field hypothesis appears to be consistent with experimental observations of the behaviour of mass without invoking the whole apparatus of Relativity. In the wider context of the medium of space, it may provide the basis of a Universal model.

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