# ELECTRIC EXPLANATION OF INERTIAL MASS

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*All bodies are assumed to consist of electric charges. The inertial reaction force acting backwards on an accelerated body is shown to be a magnetically induced electric force acting on the charges. Inertial mass is then associated with that reaction force and acceleration in accordance with Newton's second and third laws. This deduction is considered to have potential in a possible reinterpretation of the foundations of modern physics.*

### Introduction

There is a need to develop a better physical concept of mass and the associated mass-energy relationship. Authors such as A. O'Rahilly have shown that many of the relativistic concepts need to be reinvestigated.[1] Of particular interest here is the physical mechanism for the inertial reaction exerted by an accelerated mass.

This present paper concentrates on an electrical interpretation of *inertial* mass. The term inertial is used to limit this study to the reaction effects associated with acceleration. In a previous paper the author developed an electric theory of gravitation.[2] The validity of both of these papers hinges on the assumption that all bodies consist of electric charges. That position was held in a previous paper that developed a new model of the proton and the neutron.[3]

A later paper will be developed in hopes of providing an alternate interpretation of the zero rest mass particles. The author is aware of the hazards inherent in this departure from the conventional modern physics of our day. Nevertheless he finds it impossible to reconcile such things as the tremendous amount of magnetic energy in the spin of a "classical" electron with the concept of equivalence of mass and energy. The author has shown that the spin magnetic energy of a classical electron is several thousand times its $mc^2$ energy.[4] He takes some comfort in knowing that H. A. Lorentz also pointed this out.[5] If one accepts the modern physics concept of a *point* electron the mass-energy problem is vastly more unexplainable.

The author believes that it is time to return physics to a philosophy that puts physical reasoning ahead of blind faith in relativistic concepts that lead to nonsensical contradictions. The hope is that this more classical approach will eventually lead to the solution of some of the presently unsolved problems in physics. This present paper attempts to develop a simple pictorial means of explaining some very basic principles of mechanics in terms of straightforward electromagnetic phenomena. That is hopefully one more step toward a simplification and unification of the basic principles of physics.

### 1. Inertial Mass

When a force is exerted on an object it is the *inertial mass* that limits the acceleration in accordance with *Newton's second law*, which may be written as Force = (mass) (acceleration) or simply

$$F = ma \tag{1}$$

Assuming that all the elementary particles in an object (even the neutrons) consist of electric charges,[6] one may show that inertial mass is due to induced electric force acting backwards on the charges when the object is accelerated. We shall make use of Eq. (1) and an electromagnetic phenomenon to deduce an electric formula for the inertial mass of an electron and a proton and extend the concept to all inertial mass.

This electric force acting backwards is the mechanism for *Newton's third law*. Newton's third law states that: *For every action* (force) *there is an equal and opposite reaction* (reverse force). The reaction force is the *inertial reaction* of the mass when the object is accelerated.* That is why mass is sometimes said to be the quantitative measure of inertia. Our derivation proceeds as follows: We first set up an integral for the force required to deliver magnetic energy into the field of an elementary charge. From that relation we derive an expression for the inertial mass of the charge in terms of the charge and its dimensions. We then deduce 1) the electromagnetic mechanism which generates the reaction force, 2) the means of delivering induction energy into the field, and 3) the power radiated out of the system. These present derivations are limited to longitudinal accelerations.

### 2. Force Required to Accelerate Charge

It can be shown that the *kinetic energy* of a charge moving with velocity much less than the speed of light is the *magnetic energy* developed in the field of the charge.[7] The magnetic energy in the field of a moving spherical charge is derived by integrating the energy density ($\frac{1}{2}\mu H^2$) over the whole volume $V$ outside of the sphere.

$$T = \int \tfrac{1}{2}\mu H^2 \, dV \tag{2}$$

where the magnetic energy has been denoted as the kinetic energy $T$. Before carrying out the integration, the magnetic field $H$ is expressed in terms of velocity $v$, field vector $D$, and the sine of the angle between vectors $v$ and $D$, (Fig. 1)

$$H = vD \sin\theta \tag{3}$$

The following additional substitutions are employed: the electrostatic field equation and the volume element along which $H$ is constant

$$D = \frac{q}{4\pi r^2} \tag{4}$$

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*This paper, and these comments, are restricted to dynamics: situations involving acceleration. It is hoped, in a later paper, to deal with Newton's third law as it applies in static situations.

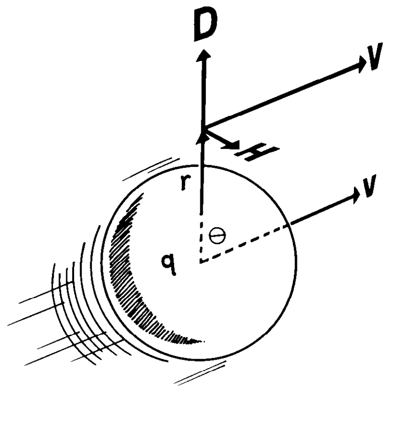


**Figure 1. Generation of magnetic field *H* by the motion of the *D* lines associated with charge *q* which moves with constant velocity *v*.**

$$dV = 2\pi r^2 \sin\theta \, d\theta \, dr \quad (5)$$

The integral is

$$T = \int_0^{\pi} \int_{r_0}^{\infty} \frac{\mu v^2 q^2 \sin^3\theta \, d\theta \, dr}{16 \pi r^2}$$

After integrating with respect to *r*

$$T = \int_0^{\pi} \frac{\mu v^2 q^2 \sin^3\theta \, d\theta}{16 \pi r_0} \quad (6)$$

In order to obtain an expression for the force, the kinetic energy is differentiated with respect to time, yielding power, and the power is then expressed in terms of force times velocity:

$$\frac{dT}{dt} = Fv \quad (7)$$

Carrying out that time derivation and dividing by v

$$F = \int_0^{\pi} \frac{\mu a q^2 \sin^3\theta \, d\theta}{8 \pi r_0} \quad (8)$$

Integration yields the required force equation

$$F = \frac{\mu q^2 a}{6 \pi r_0} \quad (9)$$

From Newton's second law, Eq. (1), and Eq. (9) one obtains the equation for inertial mass

$$m = \frac{\mu q^2}{6 \pi r_0} \quad (10)$$

This electric equation for mass applies to a spherical electron or a spherical proton, in which the charge is assumed to reside on the surface. H. A. Lorentz derived a similar equation for the mass of an electron in 1915.[8] This equation has also been applied to the proton in a previous paper.[9]

### 3. Induced Electric Reaction Force

According to Newton's third law, when there is a force acting on a charge, the reaction force acts *instantaneously*. It therefore must act *at the surface where the charge is*. No wave motion is involved in the reaction force at that instant, because the wave has not had time to move. We know that when the charge is accelerated that there will simultaneously be a rate of change in magnetic field *at the surface* of the charge. This rate of change of magnetic field at the surface of the charge *instantaneously* generates an induced electric field $E_0$ at the surface.

The total reaction force *F* during acceleration of the charge is the integral of the rearward components of the instantaneously induced electric vectors $E_0$ acting on the surface charge *q*. This induced electric field is tangential to the surface of the sphere. The induction process is illustrated by Figs. 2a and 2b. Fig. 2a shows the rotational direction in the curl of E around each vector $-dB/dt$ at the surface. The vector $-dB/dt$ is the negative rate of change of magnetic induction *B*. According to Maxwell's equation: $curl\ E = -dB/dt$. Fig. 2b shows the result, namely, that the induced $E_0$ at the *instant* of acceleration is confined to the surface (no wave propagation yet) and is tangential to the surface.

Due to symmetry the value of $E_0$ is constant around the spherical surface at angle $\theta$. The subscript 0 is added to emphasize that this is the value at the surface of the sphere. Setting up the integral so as to sum the rearward components of the electric force on each elementary surface

$$F = \int_0^{\pi} E_0 \sin\theta \, dq \quad (11)$$

and making the following substitutions:

$$dq = 2\pi\sigma r_0^2 \sin\theta \, d\theta \quad (12)$$

and the surface charge density

$$\sigma = \frac{q}{4\pi r_0^2}$$

the force equation reduces to

$$F = \int_0^{\pi} \frac{E_0 q \sin^2\theta \, d\theta}{2} \quad (13)$$

We solve for the induced electric field $E_0$ at the surface of the charge by equating the integrands in Eqs. (8) and (13).

$$E_0 = \frac{\mu q a \sin\theta}{4 \pi r_0} \quad (14)$$

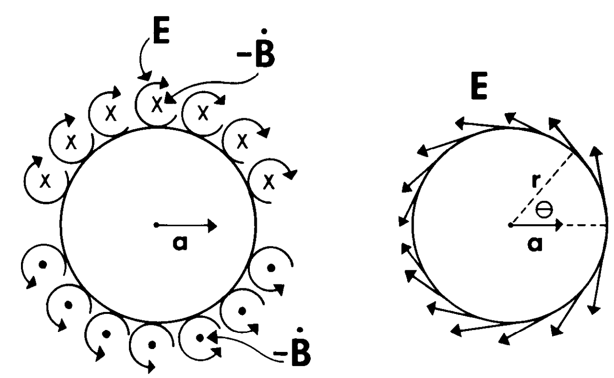


**Figure 2. Instantaneously induced electric field at the surface of the charge during acceleration.**
**Part (a) (left) shows the directional sense associated with *curl E* = $-\dot{B}$.**
**Part (b) (right) shows the electric field *E* at the surface.**

*This magnetically induced electric field and its force on the charge is the mechanism for the reaction force in Newton's third law.* This "hold-back" force on the electron will be "felt" by the external source which pushes the electron forward. Hence the physical mechanism for Newton's third law is the magnetically induced electric field acting backwards on the charge. Every body is, according to our theory, composed of electric charges. This explains why Newton's third law applies to "neutral" mass as well as to elementary charges.

### 4. Propagation of the Electric Vector into the Field

By aid of the constituent equation $B = \mu H$, Eq. (3) may be converted to the induction equation.

$$B = \mu v D \sin\theta$$

and by aid of Eq. (4)

$$\dot{B} = \frac{\mu a q \sin\theta}{4\pi r_0^2} \tag{15}$$

at the surface of the accelerated charge. In view of Eqs. (14) and (15)

$$E_0 = \dot{B} r_0 \tag{16}$$

This is the result that one would expect.

One may now derive a simple equation for $E$ in the field in retarded time, that is to say at the time the wave reaches the field point, not the time at which the wave was initiated at the source. This process is equivalent to removing time from the problem, making it much easier to solve.

The transverse electric wave $E$ is radiated out radially as a result of the acceleration of the charge. It obeys Maxwell's equation

$$\oint E \cdot ds = -\int \dot{B} \cdot dA$$

Taking the line integral around the elementary rectangular loop in Fig. 3 and expressing the enclosed area in incremental form one has $(E_2 - E_1)\Delta s = -\dot{B}\Delta s\ \delta r$ which reduces to

$$\frac{dE}{dr} = -\dot{B} \tag{17}$$

in the limiting case as the rectangular dimensions shrink toward zero. This important equation applies to the *transverse electric field E* in retarded time. The integral of Eq. (17) yields the successive values of E as the wave reaches successive radial distances. The integral equation is

$$\int_{E_0}^{E} dE = -\int_{r_0}^{r} \dot{B}\, dr$$

In view of Eq. (15) and the radial direction of the wave propagation

$$E_0 - E = \int_{r_0}^{r} \frac{\mu a q \sin\theta\, dr}{4\pi r^2} \tag{18}$$

which yields

$$E_\theta = \frac{\mu a q \sin\theta}{4\pi r} \tag{19}$$

after integration and substitution of Eq. (14) for $E_0$. $E_\theta$ is the electric field as the $E$ wave passes a particular point distance $r$ and angle $\theta$ with respect to the center of the spherical charge. The subscript $\theta$ has been added to emphasize the fact that it is a transverse electric field, at right angles to the direction of propagation of the wave.

### 5. Energy Propagated into the Induction Field

The magnetic field which is produced in this process is called the induction field. Poynting's vector may be employed to derive the rate of propagation of magnetic energy into the induction field. The Poynting vector $E \times H$ (read E cross H) gives the *intensity* and *direction* of the electromagnetic wave propagation into the field. When the electric field $E_\theta$ is induced at the surface of the spherical charge it is paired with the magnetic field $H_\phi$ at that point and generates the wave shown in Fig. 4. Note that the $E_\theta$ makes a 90° angle with $H_\phi$ and the cross product vector points outward in the radial direction and has the magnitude $E_\theta H_\phi$.

The derivation of the equation for intensity $I$ is self-evident from the following equations:

$$I = E_\theta H_\phi \tag{20}$$

From Eqs. (3) and (4) the expression for the magnetic field at the surface of the charge is

$$H_\phi = \frac{q v \sin\theta}{4\pi r_0^2} \tag{21}$$

This magnetic vector moves on out, providing the value

$$H_\phi = \frac{q v \sin\theta}{4\pi r^2} \tag{22}$$

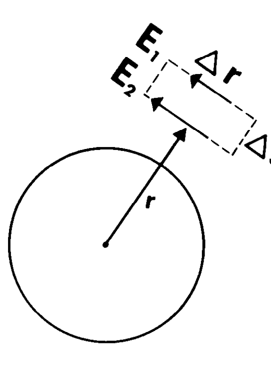


**Figure 3. Rectangular path of integration that encloses the magnetic flux *B* ΔS Δr.**

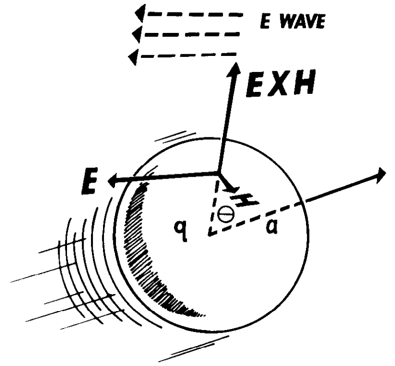


**Figure 4. Electric wave resulting from Poynting's vector *E* × *H* applied to the induced electric field *E* and the magnetic field *H*.**

at every field point $(r,\theta)$. The velocity $v$ is the velocity that the charge had at the prior time, the time the wave emanated from the surface of the charge. This wave moves outward with speed $c$, filling out the magnetic field very quickly. Substituting Eqs. (19) and (22) into Eq. (20) yields

$$I = \frac{\mu a v q^2 \sin^2\theta}{16\pi^2 r^3} \qquad (23)$$

which is the intensity (watts/meter$^2$) of this induction wave as it passes the point $(r,\theta)$ in the field. It is delivering the magnetic energy into the field as a result of the acceleration of the charge. This energy is retained in the field as magnetic energy, so long as the charge is not decelerated. We repeat this *induction field* of magnetic energy is stored in the field, not radiated away like a radio wave. We shall consider the radiated wave in a later section.

The total power involved in generating this induction field is the integral of the intensity over the whole surface of the sphere. Employing the surface element of area $dA = 2\pi r_0^2 \sin\theta \, d\theta$

$$\text{Power} = \int_0^\pi \frac{\mu v a q^2 \sin^3\theta \, d\theta}{8\pi r_0} \qquad (24)$$

which yields

$$\text{Power} = \frac{\mu v a q^2}{6\pi r_0} \qquad (25)$$

Remembering that $m = \mu q^2/6\pi r_0$, Equation (24) may be put in the form *Power = mav* or simply *Power = Fv* which gives a check on this work.

## 6. Electromagnetic Radiation

When a charge is accelerated the added energy is transferred into the induction field and into electromagnetic radiation. The radiation differs from the induction. The energy in the induction field continues to be "field bound" to the charge and move along with it. The radiated energy goes on out into space. An example of radiated energy is the energy in a radio wave. Whereas the induction energy is like the energy in a transformer's magnetic field. It is temporarily stored but will be shifted back into another form if the charge motion is decreased. The electromagnetic radiation is propagated out into space with the speed of light.

To deduce the radiation power we make use of "Ohm's law" for the electromagnetic field. This law was developed by D. Schelkunoff.[10] According to this law with every $E$ wave in electromagnetic radiation there is the associated $H$ wave and the law relating them is

$$\frac{E}{H} = \eta \qquad (26)$$

where $\eta$ is the intrinsic impedance into which the wave moves. It is given by the equation

$$\eta = \left(\frac{\mu}{\epsilon}\right)^{1/2} \qquad (27)$$

and in free space has the value 377 ohms.

In the radiation field (far field) the $E$ and $H$ are normal to each other and both are inversely proportional to $r$, not $r^2$.

From the electric vector Eq. (19) and Ohm's law Eq. (26) one obtains

$$H_\phi = \frac{\mu q a \sin\theta}{\eta 4\pi r} \qquad (28)$$

Remembering that the speed of an electromagnetic wave $c = (\mu\epsilon)^{-1/2}$ and noting that $\mu/\eta = 1/c$ the equation reduces to

$$H_\phi = \frac{q a \sin\theta}{4\pi r c} \qquad (29)$$

The intensity $I$ is given by Poynting's vector $(E \times H)$, namely

$$I = \frac{\mu q^2 a^2 \sin^2\theta}{16\pi^2 r^2 c} \qquad (30)$$

Taking the element of area $dA = 2\pi r^2 \sin\theta \, d\theta$ and integrating over the surface of a sphere of radius $r$, the power

$$P = \frac{\mu q^2 a^2}{6\pi c} \qquad (31)$$

This is the same as the expression deduced by Arnold Sommerfeld and others for the Lorentz electron.[11]

An extension of the solution to relativistic velocities will probably yield similar results but with the inclusion of some form of the factor $\gamma = (1 - v^2/c^2)^{-1/2}$ or multiples of it. For example, Sommerfeld[12] shows that the relativistic expression for power radiation is

$$\text{Power} = \frac{\mu q^2 a^2 \gamma^6}{6\pi c} \qquad (32)$$

which is the same as Eq. (31) except for the $\gamma^6$ factor.

## 7. The Unsolved Problem

Although we have successfully accounted for the reaction force on the elementary charge resulting from the delivery of induction energy into the field, we have not deduced the reaction force resulting from the electromagnetic radiation. Fortunately, for most practical problems this radiation reaction force is extremely small and can be neglected. However, this radiation reaction force can not be neglected in some of the high energy accelerators of our day. There is of course experimental evidence of approximately what this force is under those conditions. Nevertheless there does not as yet exist a completely satisfactory theoretical solution to the radiation reaction force. The following quotes from J. D. Jackson's widely acclaimed graduate textbook in electrodynamics illustrates this basic problem with present day physics.

"—a completely satisfactory treatment of the reactive effects of radiation does not exist. The difficulties presented by this problem touch one of the most fundamental aspects of physics, the nature of an elementary particle. Although partial solutions, workable within limited areas, can be given, the basic problem remains unsolved. One might hope that the transition from classical to quantum-mechanical treatments would remove the difficulties. While there is still hope that this may eventually occur, the present quantum-mechanical discussions are beset with even more elaborate troubles than the classical ones."[13]

This problem is not restricted to the high-velocity case. It has not been satisfactorily solved in the nonrelativistic case. To illustrate one of the difficulties, consider a particular solution listed by Arnold Sommerfeld,[14] namely

$$F = \frac{\mu q^2\, da/dt}{6\pi c} \qquad (33)$$

It depends on $da/dt$, the rate of change of acceleration, not acceleration. It could not work during constant acceleration because that would imply that $F = 0$; but force is required to produce the constant acceleration and the associated radiation. This would be a violation of the law of conservation of energy. Sommerfeld of course knew the limitations of this solution; but neither he nor anyone else has been able to give a general solution. When it is done it will undoubtedly require a modification of Newton's second law, because Newton did not consider any radiation effects.

It is hoped that this unsolved problem will emphasize the need to reinvestigate some of the foundations of physics.

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# NATURAL SELECTION AND THE CHRISTIAN VIEW OF REDEMPTION

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*The theory of natural selection is irreconcilable with the Christian view of redemption. According to the theory of evolution, mankind and other species have common ancestors. Natural selection occurred through a process of the survival of the fittest, according to which species that were not sufficiently adapted to the environments in which they lived were unable to survive. The theory of natural selection is dependent upon the assumption that there was death in the world before the appearance of man and that death played a part in the development of modern man, since man is a product of the process of the survival of the fittest. Such a theory cannot be reconciled with the Christian view of redemption, according to which: (1) man's susceptibility to physcal death was a result of the curse placed upon him as a result of the fall and (2) mankind has been released from the effects of the curse, including physical death, through the resurrection of Christ from the dead. If, as the theory of natural selection would require, death existed before the appearance of man upon the earth and man inherited mortality from his forbears, then it would be inconsistent to maintain (1) that man's susceptibility to physical death was a result of the curse, (2) that there is any redemption from physical death through Christ, (3) that there will be a physical resurrection of the dead at the end of the age and (4) that there was a physical resurrection of Jesus Christ from the dead.*

### Natural Selection and the Christian View of Redemption

For more than 120 years, the western world has become increasingly enamoured with the idea of the evolution of species, which is alleged to provide us with a compelling model for an understanding of the origin of all of life, and, most importantly, of the origin of mankind with his unfathomable intricacy of mind and complexity of personality. It is interesting that prior to the publication of Darwin's *Origin of Species* in 1859, the dominant scientific world view in the English-speaking world and in western Europe was derived, for the most part, from the Judaeo-Christian Scriptures, according to which all species were created separately and were made to reproduce, each according to its own kind. It is true that there were some who urged doctrines akin to evolution even before the *Origin* appeared but these were in disrepute.

According to the theory of natural selection, those species best adapted to their respective environments have survived, whereas others that have been less

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