Origin of Inertial Mass

Various conflicting descriptions and theories on inertia have been offered to explain this basic property of matter:

> "Inertia is that property of a body which causes it to 'persevere in its state of rest or motion in a straight line unless it is compelled to change that state by forces impressed upon it.'" —Robert J. Hannon

> "Why does matter have inertia? When asked this question, many learned people say: 'In accord with Newton's first law of motion, ***a material body will continue in a state of rest or uniform motion unless compelled by some external force to change that state.'*** However, this is about the same as saying: ***'Matter has inertia because matter has inertia.'*** In other words, Newton's first law is merely a precise description of a natural phenomena without the slightest understanding of why it exists. Much to his credit, *Newton confessed that he could not explain why a material body obeys the law he himself annunciated." —Wm. VanDeusen*

> "Inertia manifests itself as follows. When the driver of a car slams on the brakes, his [arms and] body [press] forward on the steering wheel. Some force must be pushing the body. This is the force of inertia. Where does it come from? This has become one of the deepest riddles of science." *—Peter and Neal Graneau*

> "[In regard to] Mach's Principle…the inertia of a body is supposed to relate to the mass of the entire universe. Since the mass of the entire universe is a constant, a body's inertia should be a constant, but it clearly is not…. A body's inertia…relates to the dominant gravitational influence in and around that body. This brings in Einstein's relativity which has its own problems…. [T]he only answer having merit is the concept that inertia is with respect to the surrounding ether. The motion of that ether with respect to a body within it is clearly controlled by the gravity dominating that region of space…." *—Arnold G. Gulko*

A Causal Explanation of "Inertial Force"

Bergman succeeded in showing that inertia is not an intrinsic property of matter in the sense of inertial mechanics and that the so-called inertial forces are real forces. His argument is not based on a conception analysis of axioms of classical mechanics but on a quasi-electrodynamic mechanism for moving charged particles which he showed to be the cause for the inertial effect. The quantity of inertial force depends upon velocity and acceleration. Bergman's causal explanation of inertial forces as real, self-induced reaction forces is based on electrodynamic effects on the spinning charged ring model. According to this explanation, inertial mass is a derived concept and not a fundamental one. Because primary electrodynamic force laws determine inertial mass, force is necessarily a fundamental concept in physics.

—Johann Marinšek, "Descartes, the Inventor of the Principle of Inertia," Convegno *Cartesio e la scienza* 1596-1996 Perugia, Sept. 4-7, 1997.

Gravitational mass and inertial mass are distinct properties of matter that originate by fundamentally different mechanisms and relate to different forces. The force of gravity is an attraction of two bodies for each other. This article is concerned with inertial mass only and does not deal with gravitational mass.

In addition to gravity, Newton claimed, there existed another fundamental force of nature. In the *Principia*, Newton said that inertia is the "innate force of matter," with "a power of resisting, by which every body, as much as in it lies, continues in the present state, whether it be of rest, or moving uniformly forward in a right line." Newton wrote a mathematical equation ($F = ma$) to relate the inertial force, mass, and acceleration of an object. His equation for force is very different from other force laws which specify the distance between *two* objects.

Origin of The Force of Inertia. According to the *Standard Model of Elementary Particles,* inertial mass in an inherent property of *fermions,* the material particles. Along with spin, magnetic moment, and stability, a body's inertial mass is a fundamental property that needs no explanation but simply exists, as known from observation. In the *Standard Model,* no cause or origin of inertia is offered or needed.

Learned physicists may agree on what inertia is, but do not agree on the cause or origin of inertia because few physicists employ a valid model of matter. As Hannon states, "What, then, is inertia? We can have no valid explanation until we understand how 'forces' can be applied to 'bodies,' to 'accelerate' them."

Common Sense Science offers an explanation of the inertial force based on the spinning charged ring model of matter.

Because modern science considers inertial mass to be an *inherent* property of matter, mass is *not* seen as a property derived from a fundamental natural entity and primary laws, but as a fundamental relationship between force and acceleration, *i.e.* a *definition* or an *assumption.* But good science minimizes the number of assumptions and intrinsic properties, so *Common Sense Science* ***derived*** inertial mass from more fundamental electrical laws and a model of elementary particles that corresponds to the actual physical structure of electrons and protons. The complaint that Newton's laws of mechanics are "spooky actions at a distance" has been answered—an achievement that Newton would have welcomed.

Electrodynamic Origin of Inertia. An important property of matter is its tendency to maintain momentum, and a body in motion maintains its velocity unless an external force is applied. External forces can accelerate or decelerate matter in accordance with Newton's second law of motion. The inertial force is an opposing force arising within the object and exerted by it.

Inertial mass arises from electrostatic charge and current that exist in the elementary particles. All matter is composed of elementary particles (electrons and protons) and

receives its property of momentum from the charges and currents of its elementary particles.

Unlike the preceding methods that assume mass or deal with the forces between *two* bodies, our method includes **the effects of self-charge within a single body acting upon itself by the electromagnetic fields surrounding an object.** An additional feature of the method concerns the propagation of radiation and field fluctuations *which proceed outward from the source object* at the speed of light. In this approach, movement and redistribution of charge within a charged body cause (1) the outward propagation of energy, and (2) the speed of the propagation (as measured from the source). The latter proposition, that energy propagates at velocity *c with respect to its source,* reflects the implicit assumption of the Galilean Transformation, implements causality, and evidently applies most strongly in the near vicinity of the source object where surrounding fields have their greatest intensity.

Inertial Mass of Current. Russell Humphreys has shown that a current resists any force attempting to laterally accelerate the moving charge, thus revealing that electric current has inertial mass. His analysis shows that by Maxwell's First Equation, a moving current induces an electric field. Then, from Maxwell's Second Equation, an accelerated electric field produces an induced magnetic field within the region of the flowing current. The induced magnetic field interacts with the moving charge to produce the reaction force of Newton's second law; this force of reaction is, of course, the phenomenon of inertia.

Inertial Mass of Electric Charge. An elementary particle with distributed *electric charge* also possesses inertial mass. Unlike the case for current, the contribution from charge is unrelated to the velocity of the charge. It has been shown that charge and current contribute equal amounts of inertial mass when the current consists of charge moving with velocity equal to the speed of light.

Inertial Mass of a Charged Sphere. In 1977, Barnes, Pemper, and Armstrong showed that the inertial force of reaction is an effect on electrical charges produced in accordance with the primary laws of electricity and magnetism. The result they obtained "is the same solution one would obtain using the special theory of relativity for the electric field seen in the fixed frame of reference for the case of a charge q traveling by with uniform velocity. The remarkable thing about this new theory is that the assumptions of length contraction, time dilation, and constancy for the speed of light c were not necessary."

Effects of Acceleration. As shown in the preceding paragraph, acceleration modifies the electric and magnetic fields surrounding the charged object as illustrated in Figure 1 for the case of a charged sphere. The modified fields then cause a negative feedback force that resists acceleration by an interaction of the modified fields and the charge. In this way, inertial mass has been shown to be an electrical effect derived from first principles.

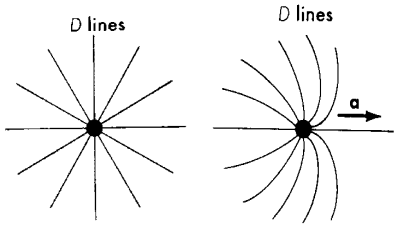

Figure 1. **D** lines for a spherical charge at rest (left) and under high acceleration (right). The **D** lines curve because propagation of electric field **E** changes are less than instantaneous. Acceleration breaks the symmetry of equal pressure over the surface of the sphere and flattens the sphere.

The field energy associated with a moving charged particle and the inertial force of reaction depend upon the velocity achieved by an accelerated particle. Barnes *et al.* described the force of reaction that opposes any attempt to accelerate the charge:

> "There is a physical reason to expect an interaction from the stationary frame of reference to the moving frame. When a charge is accelerated by a force there must be, according to Newton's third law, a reaction force exerted by the field back on the charge—a feedback phenomenon. Thus an altered electric field must develop during the acceleration which acts back on the charge like an inertial force opposing the acceleration."

Electrodynamics applied to Spinning Charged Ring. Electrodynamics analysis of a charged *sphere* is important for insight into physical processes. But electrons and protons have the shape of a thin *ring.* A sphere of charge compressed small enough to account for the rest mass energy is far too small to account for the particles' magnetic moments. For correspondence to the real physical world, an object of finite size and actual shape must be used for calculations to predict inertial mass. Derivation of forces on a charged ring at rest and being accelerated are given in technical papers listed below; for this article, the results are shown to illustrate the concept of the inertial force and show its origin.

For an electron at rest, the *charge* defining the ring electron is symmetrical with its axis. The charge and currents in the ring cause electric and magnetic *fields* to surround the ring as shown in Figure 2.

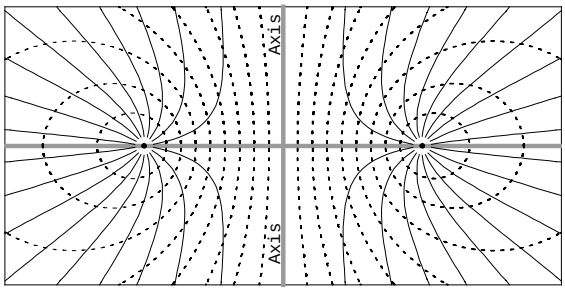

Figure 2. **E** lines (solid) and **B** lines (dashed) at evenly spaced angular intervals about the ring surface. Electric and magnetic fields show symmetry about the plane of a ring electron at rest (with no recent history of being accelerated).

As a charged ring electron is accelerated, a radiation field "grows" around the ring and travels with the ring—even while the radiation field begins to dissipate. During this period of acceleration, the self-contained charge of the ring electron modifies its

surrounding electromagnetic fields (see Figure 3), and magnetic induction stores energy in the space surrounding the electron—creating a radiation field. Current *I* circulating in the ring does not change. But the ring becomes smaller while energy, inductance, and accumulated magnetic flux all increase in proportion to γ (a measure of velocity relative to the speed of light).

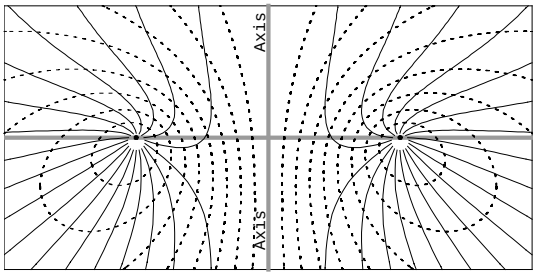

Figure 3. **E** lines (solid) and **B** lines (dashed) lag behind charged ring under acceleration upward to a velocity one-half the speed of light when γ equals 1.155. The electron radius has decreased by 13 percent. Symmetry of the **E** and **B** lines has been broken. **E** and **B** fields exert a greater pressure at the front (top) of the charged ring than at the rear, causing the inertial force that resists acceleration.

During the period of acceleration, energy is acquired in the fields surrounding the ring, and a corresponding increase in magnetostatic pressure at the surface of the ring makes it smaller. Energy is stored *in the ring* during a period of acceleration by decreasing its size, with a resulting increase of electrostatic energy and magnetostatic energy (or potential energy, see Figures 4 & 5).

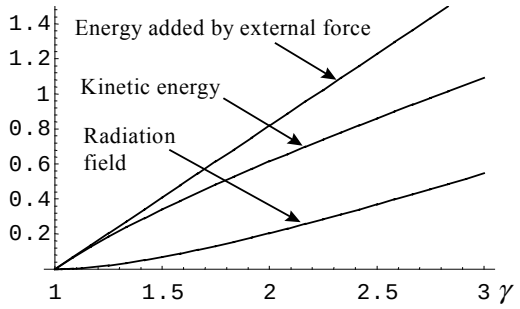

Figure 4. Dynamic Energy Stored by the Electron Ring.

Energy provided by an external force increases the electron's velocity, kinetic energy, and radiation-field energy. Energy added by the external force of acceleration provides the electron with kinetic energy and radiation field energy. Multiply energy (vertical axis) by 10^{-13} to get energy in Joules.

After a period of acceleration, the ring has acquired additional energy and a smaller size. Surrounding induction fields of electrostatic and magnetostatic energy and internal forces that give the electron its natural size begin to restore the electron to the size and rest-mass it originally possessed as a free electron. During this transition phase, energy previously accumulated is released by radiation into space at a rate that depends upon Faraday's law and Poynting's theorem. In a similar process, a neutron outside an atomic nucleus releases its beta-decay energy in about 10-13 minutes.

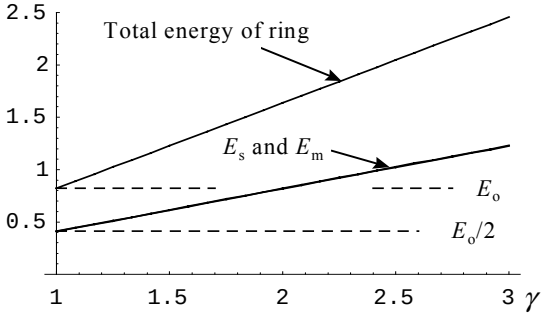

Figure 5. Compression Energy Stored by the Electron Ring.

Total energy stored in the ring by compression consists of electrostatic energy and magnetostatic energy. E_o is the rest-mass energy of the electron; $E_o/2$ is the electrostatic or magnetostatic energy of the electron at rest; E_s and E_m are nearly equal and represent the electrostatic and magnetostatic energies, respectively, of the compressed electron while being accelerated by an external force.

The Electron at Rest In a New Inertial Frame of Reference. The radiation field associated with an accelerated electron slowly leaves the electron once it is isolated from all accelerating fields. As energy accumulated (during a previous period of acceleration) is radiated into space, the electron returns to its stable position of a minimum energy potential by adjusting its size and various related electrical characteristics. Thus, the electron reverts to the same potential energy and rest-mass energy it possessed in the initial period when it was also a free electron at rest.

The acceleration previously experienced by the electron has now increased its velocity as measured with respect to its original frame of reference, and the electron has acquired kinetic energy in that (original) frame of reference. But in the new frame of reference established by reference to itself, the electron has only potential energy and is at rest.

Velocity and Inertial Frames of Reference. Understanding the radiation field (and various other energies accumulated when an electron is accelerated) provides insight into the meaning of *velocity* of an elementary particle and its *inertial frame of reference*. After a long period exceeding 10 minutes without acceleration, no radiation field exists and a particle's kinetic energy and velocity can be expressed with reference to any inertial frame. For reasons that are now clear, an inertial frame is one where acceleration and a radiation field are both absent.

But while a charged particle is being accelerated, or recently has been accelerated and still retains a radiation field, only one reference frame is suitable for specifying its velocity: a frame whose velocity coincides with the velocity of the charged particle at rest prior to acceleration. Only then is the velocity acquired during acceleration a meaningful term.

Inertial mass has been *explained* (not assumed) on the basis of fundamental concepts already presented; these concepts for explanation include self-charge effects, propagation of field changes outward from the charge with relative velocity c, and isotropy of directions in space. Some advantages and features of the electrodynamic approach are:

- It leads to a causal explanation of inertia; established laws of electrodynamics can be applied to explain the self-induced reaction force of inertia.

- The accepted equation for "relativistic" electrodynamics is obtained without the objectionable non-causal postulates of absolute space or Einstein's Special Theory of Relativity.

- An explanation is provided for the inertial force of reaction upon a *single* body.

Important Conclusions.

1. Electromagnetic Field Theory successfully explains how energy fields in space act on objects separated in space, and now EFT has shown *how to account for inertial mass* and *provide an explanation for causality in Newton's Laws of Mechanics***.**

2. Matter and its property of inertia are found wherever charge is found.

3. Inertial mass of charged particles is a derivative property of particles and their fields acting upon themselves to resist velocity changes.

4. Without an ether to restrain an object's velocity, the real measure of motion is with respect to itself (as in inertia), and matter can move at any velocity relative to other objects in the universe. This suggests that space travel can exceed a velocity of *c* relative to the earth, provided adequate fuel for acceleration is available at a suitable platform (one moving as fast as the spacecraft).

5. By referencing the propagation rate of fields to their source rather than an observer, and by applying the Galilean Transformation to all charge and current elements distributed over an entire particle, we have corrected electrodynamics, predicted and explained the origin of inertial mass, and found a causal explanation for the so-called "relativistic" effects of objects moving at high speed. ◆

Additional Reading on Inertial Mass

1. D. Bergman, "Theory of Forces," Common Sense Science **LN1** (1998).

2. P. Graneau and N. Graneau, *Newton Versus Einstein,* Carlton Press, Inc. New York, NY (1993).

3. D. Bergman and C. Lucas, "Physical Models of Matter," Common Sense Science **CO3** (1997).

4. D. Bergman, "Forces on Moving Objects," Common Sense Science **CO1** (1997).

5. D. Bergman, "Inertial Mass of Charged Elementary Particles," Common Sense Science **C02** (1997).

6. T. Barnes, et al., "A Classical Foundation for Electrodynamics," Common Sense Science **CR1** (1977).

7. C. Lucas, "Electrodynamics of Real Particles Versus Maxwell's Equations, Relativity Theory and Quantum Mechanics," Common Sense Science **TC3** (1992).