

The Journal of **Common Sense Science**

FOUNDATIONS OF SCIENCE

November 2016
Volume 19
Number 4

What Is Charge?

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Abstract. The concept of charge has been idealized in science over time. The Jains of India and the natural philosophers of Greece conceived of charge and mass as properties of the monad structures of matter. During the industrial revolution charge was conceived of as a fluid. Then Coulomb in an attempt to write precise mathematical equations for the force between electric charges represented them as simple mathematical points. The observed quantization of the charges of elementary particles with quarks having $1/3$ and $2/3$ the charge e of the electron and proton suggests that the monad has a charge of $e/3$ and the electron consists of at least 3 monads. The experiments of Winston Bostick creating solitons from the electrodynamic fluid or field led to the identification of the soliton or monad as a continuous toroidal ring of rotating charge. Finally the derivation of an improved version of electrodynamics from the complete set of the empirical equations of electrodynamics using the energy potential instead of the vector potential explains the emission and absorption of radiation and radiation reaction if the building blocks of charge are continuous periodic structures in the shape of a toroidal ring of rotating charge. The modern science view that electric charge is the quantized static physical property of elementary particles that causes them to experience a force when placed in an electromagnetic field is misleading. It appears that elementary particles are constructed of monads or solitons of the electromagnetic field which attract and repel one another to great distances due to the tensile strength or rigidity of the electromagnetic fields from which they are formed.

Introduction. In a previous article entitled “What is Mass?”[1], the history of the concept of mass was

traced from the 6th century BC Jains of India [2, 3, 4, 5] to the Greek natural philosophers of the 5th and 4th centuries BC [6, 7]. According to these ancient philosophers all matter was composed of monads. There were two types of monads, i.e. monads and anti-monads. The properties of matter such as mass and charge were determined by the structures of monads that made up different kinds of matter. The Greek philosophers realized that the monad must be atomic or uncuttable if it was the smallest building block of all matter.

When Isaac Newton (1643-1727 AD) many centuries later developed his theory of gravity and inertia, he regarded mass as an inherent static property of the particles that make up a massive body. A few centuries later the existence of atomic and nuclear mass defects in the Periodic Table of Atoms showed that mass is not an inherent static property of atomic material bodies. Not long after that, Einstein defined mass as $E = mc^2$. Within a century after that, the Russian scientist A. L. Dmitriev observed that gravitational mass does not obey the usual interpretation of $E = mc^2$, but instead has regions where the mass decreases with increasing temperature or energy as well as regions where mass increases with increasing temperature or energy.[8, 9] The Russian data suggests that mass is dependent on some dynamical changes that are occurring within the body of matter, i.e. mass depends on the dynamical changes of atomic and lattice structures within the body with temperature.

Shortly thereafter **The Universal Force Volume 1** [10] was published in which the force of gravity was identified with the electrodynamic force between

vibrating neutral electric multipoles (primarily dipoles). This work identified mass with the vibrational energy E of vibrating neutral electric multipoles. These multipoles were formed by structures within elementary particles, the atom and the lattice. **Electric multipoles are usually defined in terms of charge, but what is charge?**

History of Charge. According to Aristotle, Thales of Miletus (624-547 B.C.) discovered around 600 B.C. that rubbing amber with a wool cloth created an electric charge in the amber causing bits of straw to be attracted to it. When one rubs amber with wool, the amber becomes electrically charged with negative charge and the wool becomes charged with the opposite or positive charge. The bits of straw are electrically neutral, but when negatively charged amber is brought near to them, even though straw is not a conductor, i.e. the charges within it are not free to move about as a current, the negative charges in the straw have enough mobility that they are repelled by the charged amber. This leaves a net positive charge on the parts of the straw nearest the amber. The charged amber attracts the straw bits which fly up and stick to the amber.

In 1600, the English scientist William Gilbert coined the New Latin word *electricus* from ἤλεκτρον (*ēlektron*), the Greek word for *amber*, which soon gave rise to the English words "electric" and "electricity". In 1660 Otto von Guericke invented the first primitive electrostatic generator consisting of a continuously rotating sulfur globe that could be rubbed by hand with a piece of cloth. In 1675 Robert Boyle reported that electrostatic attraction and repulsion can act across a vacuum with no material medium. In 1729 Stephen Gray classified materials as conductors and insulators.

In 1733 C. F. du Fay [11], proposed that electricity comes in two varieties that cancel each other, and expressed this in terms of a two-fluid theory. When glass was rubbed with silk, du Fay said that the glass was charged with *vitreous electricity*, and, when amber was rubbed with fur, the amber was charged with *resinous electricity*.

In 1752 Benjamin Franklin established a link between lightning and electricity by flying a kite into a thunderstorm and transferring some of the charge into

a Leyden jar. He showed that the properties of the lightning charge were the same as charge produced by an electrostatic generator. He proposed that there was only one electrical fluid known as the luminiferous ether. The ether permeated all matter and space. He posited that rubbing insulating surfaces together caused this fluid to change location, and that a flow of this fluid constitutes an electric current. He also posited that when matter contained too little of the fluid it was "negatively" charged, and when it had an excess it was "positively" charged. For a reason that was not recorded, he identified the term "positive" with vitreous electricity and "negative" with resinous electricity.

In 1839, Michael Faraday showed that the apparent division between static electricity, current electricity, and bioelectricity was incorrect, and all were a consequence of the behavior of a single kind of electricity appearing in opposite polarities. It is arbitrary which polarity is called positive and which is called negative. Positive charge can be defined as the charge left on a glass rod after being rubbed with silk. [12]

This qualitative concept of charge remained in vogue until 1785 A.D. when Coulomb started making quantitative observations of the electrostatic force between charged bodies. Following the advice of Isaac Newton in his book **Mathematical Principles of Natural Philosophy** he wrote precise mathematical equations to describe electrostatic forces between two charged bodies assuming that charges were just points with no size. This was the simplest approximation from a mathematical point of view.

$$\vec{F}_{12} \propto \frac{q_1 q_2}{r^2} \hat{r} \quad (1)$$

In 1767 Joseph Priestly proposed the electrical inverse-square force law between positive and negative charge. In 1785 Charles Coulomb introduced the inverse-square law of electrostatics.

In 1820 Hans Christian Orsted united the separate sciences of electricity and magnetism when he observed that a changing electric current produces a magnetic field as it flows through a wire. That same year André-Marie Ampère proposed a combined theory of electricity and magnetism. He presented Ampère's Law describing the magnetic force between

two electric currents. He showed that parallel currents flowing in the same direction attract one another and parallel currents flowing in the opposite directions repel one another.

In 1831 Michael Faraday discovered his law of electromagnetic induction. He found that when he wrapped two insulated coils of wire around a massive iron ring and then passed a current through one coil, a momentary electric current was induced in the other coil. He then found that if he moved a magnet through a loop of wire, or vice versa, an electric current also flowed in the wire. He proposed that electromagnetic forces and fields extended into empty space around the conductor. Faraday proposed the concept of lines of flux emanating from charged bodies and magnets to provide a way to visualize electric and magnetic fields. His demonstrations that a changing magnetic field produces an electric field, mathematically modeled by his Law of Induction became one of Maxwell's equations. This work has evolved over time into the unified field theory. Here an attempt is made to describe all the fundamental forces and elementary particles in terms of a single field.

In 1833 Heinrich Lenz introduced the first electrodynamic law emanating from the principle of conservation of energy. According to Lenz's Law if an increasing (or decreasing) magnetic flux induces an electromotive force (EMF), the resulting current will oppose a further increase (or decrease) in magnetic flux, i.e. an induced current in a closed conducting loop will appear in such a direction that it opposes the change that produced it. In 1845 Michael Faraday discovered that light propagation in a material can be influenced by external magnetic fields. In 1854 Gustav Robert Kirchhoff published Kirchhoff's Laws on the conservation of electric charge and energy which are used to determine currents in each branch of a circuit.

In 1865 James Clerk Maxwell published his landmark paper "A Dynamical Theory of the Electromagnetic Field" [13] in which using his Maxwell's equations he demonstrated that electric and magnetic forces were two complementary aspects of electromagnetism. He showed that the associated complementary electric and magnetic fields of electromagnetism travel through space, in the form of

waves, at a constant velocity $c = 3 \times 10^8$ m/s. He also proposed that light is a form of electromagnetic radiation and that waves of oscillating electric and magnetic fields travel through empty space at a speed that can be predicted from simple electrical experiments. Thus he concluded that light (including radiant heat, x-rays, etc.) is an electromagnetic disturbance in the form of waves propagated via the electromagnetic field according to electromagnetic laws.

In 1897 J. J. Thomson discovered the electron by performing a series of experiments studying the nature of the electric discharge in a high-vacuum cathode-ray tube. He interpreted the deflection of the cathode rays by electrically charged plates and magnets as evidence of "bodies much smaller than atoms", i.e. electrons. Eventually he estimated the value of the charge of the electron.

In 1905 Albert Einstein proposed the Theory of Special Relativity in which he rejected the existence of the ether as unnecessary for explaining the propagation of electromagnetic waves. Instead, Einstein asserted as a postulate that the speed of light is constant in all inertial frames of reference, and went on to assert a number of revolutionary (but highly counter-intuitive) consequences including time dilation, length contraction, the relativity of simultaneity, the dependence of mass on velocity, and the equivalence of mass and energy.

In 1920 Arthur H. Compton performed experiments where beams of short-wavelength X rays were aimed at elements of low atomic weight. He discovered that some of the X-rays scattered by the elements are of longer wavelength than they were before being scattered. Classically the size and shape of electrons in the target atoms could account for the change in the x-rays' wavelength, but politically everything had to be done with quantum mechanics. In 1924 Louis de Broglie postulated the wave nature of electrons and suggested that all matter has wave-like properties. In 1985 Winston H. Bostick, the last graduate student of Arthur Compton, published his paper "The Morphology of the Electron" [14] in which he revealed his experimental findings that electrons are built of solitons of the electromagnetic field. These solitons are the monads of the Jains of India and the natural philosophers of Greece. They are vortices in

the electromagnetic field that have the shape of a toroidal ring when viewed in certain ways. Solitons can be created in any fluid and the toroidal ring observed. [15, 16]

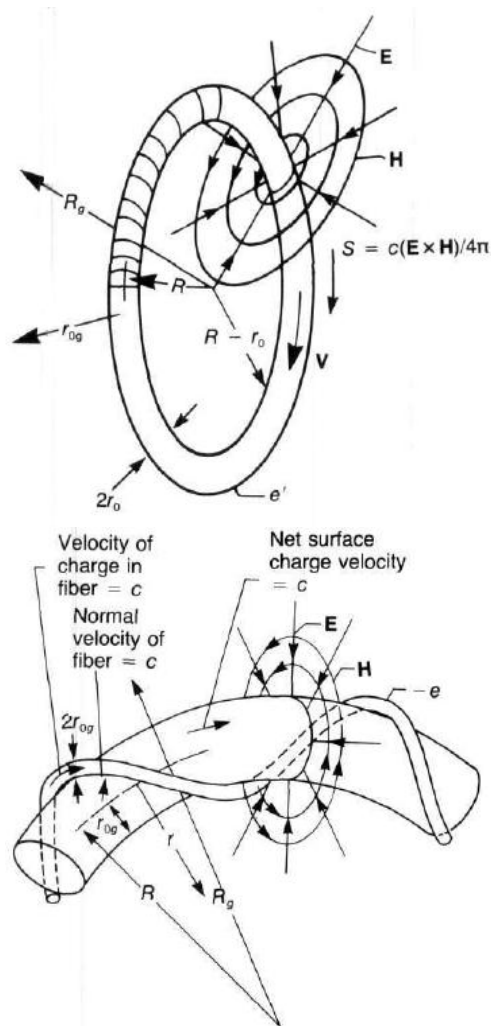


Figure 1 Bostick's Toroidal Ring Soliton

Twenty-first century experiments with the fluid dynamics of air have demonstrated the creation of toroidal solitons with smoke rings. Experiments with the fluid dynamics of water have demonstrated the creation of toroidal and half toroidal structures in water by adding dye to the vortices of the water.



Figure 2 Man Blowing Smoke Rings



Figure 3 Half Toroidal Ring Structure in Water Using Dye [16]

Twentieth century experiments have demonstrated that the electric charge of elementary particles is quantized. Most elementary particles have a charge of e equal to 1.602×10^{-19} coulombs. However, some particles called quarks have charges which are integer multiples of $1/3 e$. Thus quantization of charge suggests that the electron and positron consist of 3 negative and 3 positive monads respectively. The proton consists of even more monads, because it contains both monads and anti-monads in order to have a greater mass than the electron and positron.

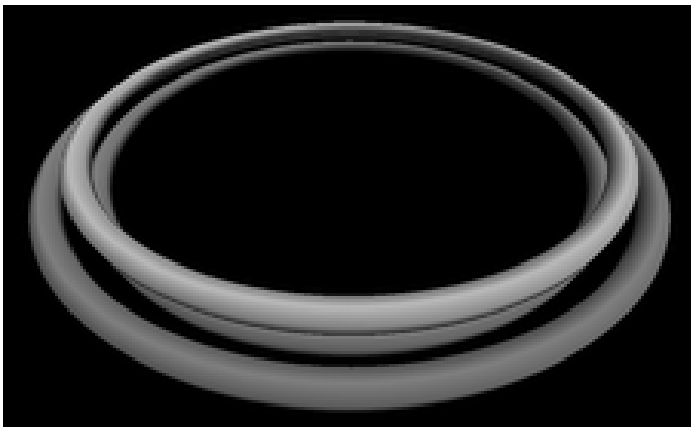


Figure 4 Electron Composed of Three Toroidal Rings or Monads Bound by Ampere's Law

In 2013 the book **The Universal Force Volume 1**[10] was published. It derived a more complete version of electrodynamics by using the complete set of the empirical equations of electrodynamics, i.e. Ampere's Law, Faraday's Law, Gauss's Electrostatic and Magnetostatic Laws, Lenz's Law, and Lorentz's Law. Unlike Maxwell's equations that were based only on the first four of the six empirical equations of electrodynamics and the non-physical vector potential, the improved version of electrodynamics is based on the complete set of empirical equations plus the energy potential to conserve both energy and charge. Maxwell's approach obtains expressions for the electric and magnetic fields as well as the electromagnetic force in terms of the relative separation r and the relative velocity v of the charges and currents. The improved more complete version of electrodynamics obtains expressions for the electric and magnetic fields as well as the electromagnetic force in terms of the relative separation r , relative velocity v , relative acceleration a and the relative radiation reaction da/dt . Maxwell's equations are incomplete because they do not directly describe radiation and radiation reaction by including the acceleration a terms and radiation reaction da/dt terms.

In the derivation of the radiation reaction terms in the improved version of electrodynamics, three terms are obtained. Two of the terms are subject to boundary conditions, but the third term is not. Experimentally the radiation reaction is in agreement with the third term. In order for the first two terms (which are subject to boundary conditions) to evaluate to zero, the building blocks of all charged matter must be in the form of a toroidal ring with periodic charge rotation around both the circumference of the ring and

the cross section of the ring. This is the same shape that Winston Bostick discovered for the soliton of the electromagnetic field and that fluid dynamics of solitons in air and water confirm.

Summary. The history of the notion of charge was reviewed from the 7th century BC to the present. It appears that the Jains of India and the natural philosophers of Greece were correct in their notion that all matter was composed of monads and anti-monads which correspond to modern day solitons and anti-solitons of the electromagnetic field in the shape of a toroidal ring. They were also correct in saying that the monad, the building block of all matter, was continuous and uncuttable. Finally they were also correct in saying that the properties of matter, such as mass and charge, were determined by the monad structure of that type of matter.

During the industrial revolution C. F. du Fay introduced the two fluid model of charge. This was corrected by Benjamin Franklin from his experiments to the single electrical fluid called the luminiferous ether. From the later work of Arthur Compton, Winston Bostick and others it appears that the luminiferous ether is the electromagnetic field and all charges are just solitons of the electromagnetic field. According to William J. Hooper's experiments the electromagnetic field has tensile strength and satisfies all the properties of a fluid according to fluid dynamics. It also supports the notion of a true contact force mediated by the electromagnetic field with tensile strength. [17] Experiments with the fluid dynamics of air and water above appear to confirm the notion that charge is really just the structure of the soliton of the electromagnetic field that interacts with other electromagnetic fields.

Einstein's famous equation $E = mc^2$ depends on some energy E . The Russian Dmitriev has shown that the gravitational mass decreases with increasing temperature at certain temperatures due to changes in the internal structure of the lattice in violation of a general interpretation of energy. This leads to the interpretation that E refers to the vibrational energy of specific monad structures of matter.

Conclusions. The concept of charge appears to be poorly defined in modern science. In quantum field theory it appears to be idealized to a point particle

mathematical approximation for a soliton of the electromagnetic field which permeates all matter and space. An improved finite-size rotating spherical idealization cannot explain both the magnetic moment and the spin magnetic moment of particles like the electron. The more explicit spinning toroidal ring structure appears to be an improved mathematical approximation to a soliton. This improved approximation over the point particle idealization and the spinning spherical idealization gives rise to the notion that the soliton has a small finite size with well-defined boundaries, but this approximation may not fully describe the vortex nature of the soliton of the electromagnetic field which possesses tensile strength to great distances. An examination of solitons in water shows this vortex nature of the soliton extends to large distances with no well-defined boundaries, however use of a dye in the vortices also shows a well-defined finite-size toroidal ring structure. [15, 16] Thus we may tentatively say that charge is a specific structural characteristic of a monad or soliton in agreement with the Jains of India.

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