What is Mass?

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Abstract. Isaac Newton's views regarding gravitational mass as an inherent static property of the particles that make up a massive body are explored. The existence of atomic and nuclear mass defects in the Periodic Table of Atoms show that mass is not an inherent static property of the particles making up atomic material bodies. This plus the observed irregularities in the temperature dependence of the gravitational mass indicates that Einstein's $E = mc^2$ definition of mass is only partially correct, since it cannot explain the experimentally observed regions of mass decrease with increasing temperature or energy. The electrodynamic approach to the force of gravity as being due to a weak electrodynamic force between vibrating neutral electric multipoles is shown to predict the correct order of magnitude for the force of gravity and that it is only attractive. The electrodynamic approach to the force of inertia as being due to the force between a net charge and a vibrating neutral electric multipole is shown to predict the origin and nature of inertial mass in accordance with Mach's Principle. Assuming that inertial mass and gravitational mass are proportional allows the prediction of the Universal Gravitation Constant G as well as the explanation of gravitational mass. Thus the arguments of Henri Poincare from metatheory that both the force of gravity and mass are of electrodynamic origin are confirmed.

Introduction. There are many criticisms in modern times of Newton's Universal Law of Gravitation. One important criticism is that Newton considered mass to be an inherent static property of the substance that constitutes a body of matter. This is equivalent to the statement that matter acts as the static source of gravitation. Thus the substance of matter is assumed to have an intrinsic power to attract other matter situated at some distant point. Furthermore this power appears to be transmitted instantaneously through space with an action-at-a-distance character that cannot be properly explained. In Newton's own words

> That one body may act upon another at a distance through a vacuum, without the mediation of anything else, by and through which their action and force may be conveyed from one to the other, is to me so great an absurdity, that I believe no man who has in philosophical matters a competent faculty of thinking, can ever fall into it. [1]

The dependence of the gravitational field intensity of a body of matter M on the inverse square of the distance from its center to the center of another body m is based on the idealization that the flux of the intensity of the gravitational field through a closed surface containing the body is constant. While mathematical calculations based on this assumption do confirm the inverse square dependence of the gravitational force with the distance of separation of the bodies, the

physical interpretation of the gravitational field through a surface remains unclear. So little is known about the nature of this field that it is not even known whether it is static or dynamic in character or that something is continually being emitted from the body or flowing into the body generating the gravity field.

Definitions of Static Mass. Consider some of the factors in Newton's law of gravitation.

$$\boldsymbol{F_G(r) = G\frac{Mm}{r^2}} \quad \mathbf{(1)}$$

Newton referenced the concept of the density of matter when he spoke of the quantity of matter Q_M contained in a body M. He said, "The quantity of matter is the measure arising from its density and volume conjunctly."[2] Also he said that, "There is a power of gravity tending to all bodies proportional to the several quantities of matter which they contain."[3] In many of the explications regarding his force law, Newton states that the gravitational force between two bodies consists of the force of gravitation between the particles of which the bodies are composed. The more particles the bodies contain the stronger the force of gravitation. For the limiting case in which each of the bodies consists of only one particle, the gravitational field will be stronger for the particle of bigger volume, since the quantity of matter Q_M is greater in that case if one assumes a constant mass per unit volume. It then follows that the quantity of matter Q_M in a body is given by the product of the number N of particles times their respective volume w. Using Newton's definition for the quantity of matter, the density is obtained as

$$\boldsymbol{d = \frac{Q_M}{V} = \frac{Nw}{V}} \quad \mathbf{(2)}$$

where N is the total number of particles of volume w that are aggregated into the macroscopic body of volume V.

From equation (2) one sees that the density of matter d is dimensionless. It represents the fraction of the volume of a massive body occupied by the atoms of that substance. This is in striking contrast with the modern definition for the density of matter, which is in units of Kg/m^3. The unit of the kilogram has been introduced into the definition of the density of matter, because the particles making up a macroscopic body are not counted. Instead, the weight of the object is compared with that of another body taken as unit and called the kilogram. It is important to note here that this procedure of comparing the bodies with the aim of finding the absolute quantity of mass that they contain is useless, because the conventional unit for the quantity of mass, the kilogram, is not defined with respect to the quantity of mass that it supposedly represents. Therefore the procedure of comparing a body with the standard kilogram body in order to find an absolute physical quantity, such as the quantity of matter in it, will not offer any absolute or relevant information. This can only give, in the best case, a relative physical quantity that may be useful for commerce. Note that the comparison with the kilogram is based on circular logic, since this relative physical quantity is obtained by weighing, and this process involves the action of the gravitational force. Thus it yields no specific information about the root cause of the

gravitational force. The nature of the gravitational force and its way of action are not revealed. Also the origin and nature of mass are not revealed.

It is often stated that the quantity of matter in a body is proportional to its weight and that, since the proportionality constant is the same for all objects or particles in matter, the quantity of matter contained in a body can be found by comparing its weight with that of a body considered as a standard unit. The quantity of matter found by this procedure is called mass. However, what is overlooked in this type of reasoning is that the same body placed in empty interstellar space will show no evidence of the property of mass, although the quantity of matter obviously remains unchanged. Only upon accelerating the body will the effect of inertia come into play, but this only shows that what is called mass is a thoroughly dynamical effect. Mass should be treated as a dynamical effect. This character of mass implies that the mass derived from weighing is also not an intrinsic property of the body, but the result of a dynamical effect which has not been discovered until now and needs to be elucidated. This dynamical effect should be determined by the intrinsic properties of such structures as quarks, electrons, protons and neutrons that make up the atoms of the massive body.

From Newton's statement that the attractive force of gravity between two bodies is proportional to the quantity of matter particles that they contain, we can express this statement in mathematical terms by rewriting equation (1) as

$$\boldsymbol{F_{G\prime} = G' \frac{\Omega \varepsilon N w}{r^2}} \quad (\mathbf{3})$$

where Ω and N represent the total numbers of particles that make up bodies M and m respectively, and ε and w represent the volumes of the constitutive particles that make up the bodies M and m.

The absolute density of matter D of the body M is expressed by an equation identical to that used in the case of body m. For this case equation (2) becomes

$$\boldsymbol{D = \frac{\Omega \varepsilon}{W}} \quad (\mathbf{4})$$

where W is the total volume of body M. Using the equations for the absolute densities of matter and equation (3) the gravitational force becomes

$$\boldsymbol{F_{G\prime} = G' \frac{DWdV}{r^2} = G' \frac{\Omega \varepsilon N w}{r^2}} \quad (\mathbf{5})$$

This way of writing Newton's Law of Gravitation assumes that there is only one type of atom or particle in body M and one type of atom or particle in body m. Thus equation (5) must be rewritten to allow different contributions of multiple types of atoms to the gravitational force. Using the subscript i for the n different types of atoms in mass m and the subscript j for the m different types of atoms in mass M one obtains

$$F_{G'} = G' \frac{\sum_{i=1}^{n} \Omega_i \varepsilon_i \sum_{j=1}^{m} N_j w_j}{r^2} \quad (6)$$

However, modern science claims that these atoms consist of elementary particles. In each neutral atom there are z electrons, z protons, and n neutrons. Each of these particles can have different gravitational properties and must be accounted for separately. Thus equation (6) must be rewritten to allow different contributions of these particles to the gravitational force. Using the subscripts i, j, and k for the proton, electron and neutron elementary particles in atoms of mass M and in mass m one obtains

$$F_{G'} = G' \frac{\left(\sum_{i=1}^{z} \Omega_i \varepsilon_i + \sum_{j=1}^{z} \Omega'_j \varepsilon'_j + \sum_{k=1}^{n} \Omega''_k \varepsilon''_k\right)\left(\sum_{i=1}^{z} N_i w_i + \sum_{j=1}^{z} N'_j w'_j + \sum_{k=1}^{n} N''_k w''_k\right)}{r^2} (7)$$

Equation (7) assumes the force of gravity due to these different elementary particles is static and can just be summed. However, if the force of gravity is due to some dynamical effect involving these components of elementary particles and atoms, there could be more than one type of dynamical effect and that effect could involve structures of these components.

Experimental Evidence That Mass Is Not a Static Property of Matter. In atomic physics and nuclear physics there is a quantity known as the mass defect of the atom or the mass defect of the nucleus. This quantity is the difference between the mass of the atom or nucleus and the sum of the masses of the electrons, protons and neutrons of which it is composed. The measured mass of an atom is generally less than the sum of the masses of the electrons, protons, and neutrons in the atom, but not always. Mass defects vary from +0.0078 for heavy hydrogen or deuterium to -0.1 for elements in the middle of the periodic table to +0.051 for uranium. See Figure 1 below. Thus mass cannot be a static property of elementary particles. The mass defect of atoms cannot be predicted by assigning a constant mass to each of the elementary particles that make it up.

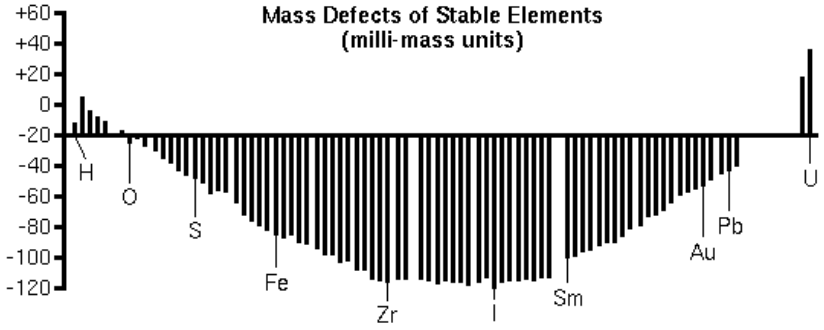

Figure 1 Graph of the Mass Defects of the Stable Elements [4]

Einstein's law $E = mc^2$ has been generalized to say that the measured mass of the atom at 0^o K plus the total binding energy of the atom is equal to the measured mass of the atom at 0^o K.

$$E + E_B = mc^2 = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} c^2 = m_0 c^2 + \frac{1}{2} m_0 v^2 + \cdots$$

$$\textbf{\textit{Total Energy} + \textit{Binding Energy} = \textit{Rest Mass} + \textit{Kinetic Energy}} \quad (8)$$

Recently the temperature dependence of the force of gravity between two massive bodies has been measured by A. L. Dmitriev. [5, 6] It is evident that what is actually happening in reality is not yet fully accounted for in modern science. The data below shows both a decrease and an increase in the mass of a body with increasing temperature or energy. This suggests that the gravitational force depends on some dynamical changes occurring within the body of the mass that depends on the particle structures within the body. With increasing energy it appears that some of the structures change and can no longer support that particular dynamical process contributing to the force of gravity.

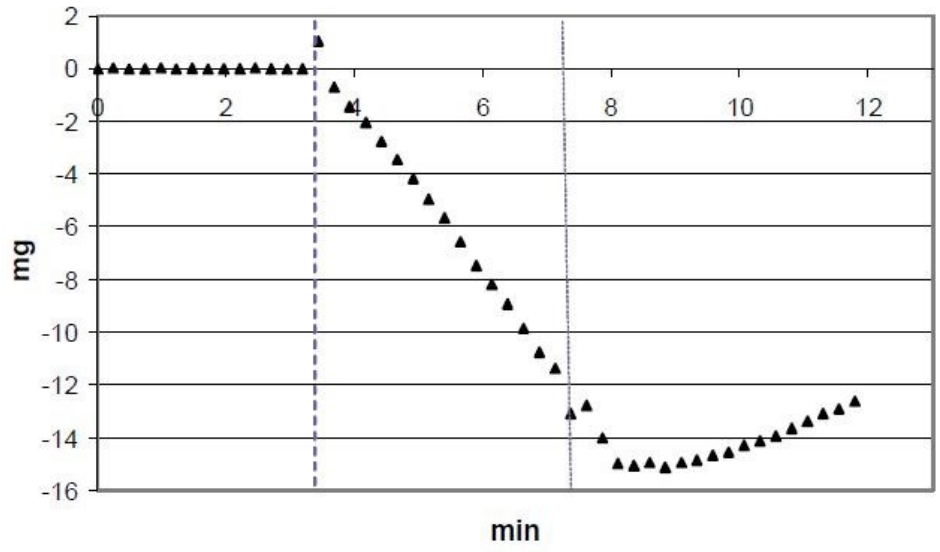

Figure 2 Change of Gravitational Mass of a Brass Rod in the Process of its Heating [5]

Note in Figure 2 that as the temperature starts to rise the mass first increases a little bit from its original constant value, then decreases for a range of temperature, then starts to increase again according to $E = mc^2$. The decrease appears to be due to structural changes within the mass. These structural changes could be due to changes in the binding energy or changes in the dynamical process causing the force of gravity.

Monad Is the Smallest Building Block of Atoms, Elementary Particles and Quarks. Winston Bostick, the last Ph.D. graduate student of Nobel Prize winner Arthur Compton, discovered what he called the plasmoid. [8, 9] The plasmoid is a soliton or standing wave of the electromagnetic field. Bostick found that plasmoids were the strongest structures known to man and tried to make a bottle from them to contain controlled thermo-nuclear fusion. Up to that time all known materials made of atoms quickly disintegrated when exposed to controlled thermo-nuclear fusion processes. Bostick was not successful in making a bottle out of plasmoids to contain controlled thermo-nuclear fusion, but he did discover what he believed to be the true "atom" or "monad" of all matter, i.e. the finite size continuous toroidal ring of charge rotating at the speed of light. [8] From these monads quarks, electrons, protons, neutrons, chemical atoms and molecules were made. [10]

In Chapter 6 of the book **The Universal Force Volume 1 – Derived from a More Perfect Union of the Axiomatic and Empirical Scientific Methods [7]** the radiation reaction terms in the universal electrodynamic force are derived. Three terms are obtained. Two of the three terms are subject to boundary conditions and the third term is not. Experimentally only evidence for the third term of the radiation reaction force is obtained. The boundary conditions could cause the first two terms to evaluate to zero if the most fundamental structure in electromagnetic particles consists of a periodic continuous charge flowing at the velocity of light in the shape of a toroidal ring. This is the atom or monad of Winston Bostick, the Indian Jains of the 6th century BC and of the Greek natural philosophers of the 5th and 4th centuries BC.

Logic Requires Gravity to Be Due to a Very Weak Electromagnetic Force Term. In Chapter 7 of the same book [7] logical arguments are given from metatheory (the theory of theories) made by Henri Poincare that the force of gravity must be of electrodynamic origin. Poincare derives the theorem that no two fundamental theories can have the same mathematical form such as $1/r^2$. He also derives the theorem that no two fundamental theories can employ the same fundamental constant such as c the velocity of light. Since Newton's force of gravitation and the electrodynamic force are both proportional to $1/r^2$ and general relativity employs c in its equation that describe gravity, and the strength of the force of gravity is approximately 10^{-40} as strong as the electrodynamic force, Poincare argues from the logic of metatheory that the force of gravity is due to a very weak secondary electrodynamic force.

In Chapter 8 of the same book [7] the hierarchy of electrodynamic interactions is investigated. The strength of the electrodynamic force between vibrating neutral electric dipoles is calculated and found to be proportional to $(v/c)^4$. For vibrating electric dipoles consisting of atomic electrons and nuclear protons in the shape of toroidal charge rings, this force was found to be approximately 10^{-40} as strong as the Coulomb force between charges and the same strength as the force of gravity. Furthermore the force was found to only be attractive like the force of gravity.

In Chapter 10 of the book [7] the force of inertia F = ma is derived and found to be due to the force between a net charge and a vibrating neutral electric dipole. In this instance the inertial mass could be defined as the coefficient of the acceleration a in the derived force. It turns out to be a function of the vibrational energy of the vibrating neutral electric dipoles and higher order neutral vibrating multipoles such as quadrupoles and octupoles. For vibrating neutral electric dipoles the inertial mass m_i is derived to be

$$\boldsymbol{m_i = \left(\frac{2e^2}{3\pi R c^2}\right)\left(\frac{A^2\omega^2}{c^2}\right)} \quad \mathbf{(9)}$$

where A is the amplitude of the dipole vibration, ω is the frequency of vibration and R is the distance to the center of mass of the universe. Note that this definition of inertial mass satisfies Mach's Principle in that the value of the local mass depends on the structure and matter distribution of the universe. If the universe is homogeneous and isotropic, as assumed by Einstein's Special and General Relativity theories, this derived electrodynamic definition of the

force of inertia and inertial mass is invalid and Mach's Principle is invalid. Fortunately the Cosmic Microwave Background Radiation distribution coupled with the atomic red and blue Doppler shifts identify the center of the universe and the motion around it. Also the atomic redshifts about that defined center obey the modern version of Bode's gravity quantization law formulated by Stanley Dermott confirming spherical shells of galaxies about that center at quantized radii.

If one assumes that inertial and gravitational masses are proportional, then one can obtain a value for the universal gravitational constant G in terms of electrodynamic constants and the distance R to the center of the universe. This approach is the only one that can predict the value of G and that gravity is quantized.

The Dynamical Value of Gravitational Mass. In a second book **The Universal Force Volume 2 – An Electrodynamic Model of Elementary Particles** [10], the electron, neutron and proton are found to consist of multiple monads or toroidal charge rings in particular combinatorial geometry structures. Combinatorial geometry determines the number and type of stable or semi-stable structures. One has to determine the properties of each monad structure in the complete set of these structures and then identify them with the experimentally observed elementary particles. In doing this one must be able to predict all the observed decay modes of each of these elementary particles, their reactions, their charge, their spin, their magnetic moment, and their mass.

In the same fashion that the dynamic structures have been obtained for the various elementary particles, the dynamic structures of atoms and molecules have been obtained again using combinatorial geometry. These are presented in a third book **The Universal Force Volume 3 – An Electrodynamic Model of Atoms and Nuclei**. [11] The model of the atom presented there is able to predict the atomic emission spectra in the extreme ultraviolet for hydrogen and helium which previous theories of the atom could not do using idealized point particle electrons. In this model of the atom the electrons, consisting of finite-size toroidal charge rings, do not orbit the nucleus but form a number of shell structures supporting periodic vibrations. This enables atoms to form molecules and crystal lattices with various structures. As the temperature of the atomic material rises, some of these structures come apart reducing some of the vibrational energy modes of the material and its effective gravitational mass. On the other hand those vibrating structures which do not come apart cause their contribution to the mass to increase with increasing energy generally supporting $E = mc^2$.

Summary. Isaac Newton's views regarding gravitational mass were explained. The notion that the gravitational mass was an inherent static property of the particles that make up the massive body was explored. The existence of atomic and nuclear mass defects showed that mass was not an inherent static property of the particles making up atomic material bodies. Furthermore decreases in the gravitational mass with increasing temperature indicated that Einstein's $E = mc^2$ definition of mass was only partially correct. It could not explain the unexpected regions of decreasing mass with increasing temperature or energy.

The electrodynamic approach to the force of gravity as being due to a weak electrodynamic force between vibrating neutral electric multipoles predicted the correct order of magnitude for the force of gravity and that it is only attractive. The electrodynamic approach to the force of inertia as being due to the force between a net charge and vibrating neutral electric multipoles predicted the origin and nature of inertial mass. Assuming that inertial mass and gravitational mass are proportional allows the prediction of the Universal Gravitation Constant G as well as the gravitational mass. Gravitational and inertial mass are shown to be due to multipole vibrations of the toroidal charge rings or monads of matter. Thus the arguments of Henri Poincare from metatheory that gravitation is of electrodynamic origin seem to be confirmed.

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