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Physical Explanations of Electrostatic Force, Gravity and Inertia

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Abstract

The paper is an attempt to give physical explanations for the causes of electrostatic, gravitational and inertial forces. This is done by considering an electric charge, of magnitude Q, as an impregnable spherical shell, with its radial field pulling the surface, equally outwards. A stable structure, such as an electron, is maintained with constant radius a, energy E_n and mass m. It is proposed that the electrostatic field lines of force from adjacent charges, Q and K, are curved to give a resultant pulling force of repulsion or attraction. The electric field due to charge Q, at the location of another charge K, and the field due to K at Q, are curved, becoming slightly reduced for force of repulsion and similarly increased for force of attraction, to make for a net gravitational force of attraction. A charge Q moving at a constant velocity v bears its radial electrostatic field E_o, without distortin. But, due to the finite speed of light c, change in velocity of Q is not instantaneously communicated to all the fields. Consequently, the lateral field lines become curved, to create a reactive electric field E_a opposed to acceleration. The field E_a is supposed to act at time t, on the charge Q, to create the inertial force $QE_a = -m(dv/dt)$. For a neutral body of mass M, containing N/2 positive and N/2 negative charges, the forces add to $NQE_a = -M(dv/dt)$, thereby explaining the cause of inertia, as a force internal to a body, opposing acceleration or deceleration. An important result of the paper is the replacement of warping of four-dimensional space-time continuum surrounding a body, according the theory of general relativity, with physical curvature of electric field lines from electic charges composing a body. It is hoped to contribute in resolving some of the problems of modern physics, such as the nature of space and gravity.

Keywords: ***Acceleration; Electric charge; Field; Force; Inertia; Mass; Relativity; Velocity***

1. Introduction

Over the ages, gravity has remained an enigma, more so after the great physicist, Sir Isaac Newton, had enunciated the universal inverse square law of gravity in 1687 [1,2]. The cause of force of gravity has defied explanations in classical mechanics [3] and relativistic mechanics [4,5]. Such a pervasive and persistent force may have a simple explanation which has escaped the attention of modern physicists, who are cruising in space-time continuum at breakneck speed.

Gravitation succumbed to complicated mathematical expressions. Hence, there emerged the formulation of the theory of general relativity [6-8] or Einstein's theory of gravity [9,10]. The theory of general relativity, which ascribes gravitation to distortion, curvature or warping of four-dimensional space-time continuum, in the presence of matter, is a brilliant, revolutionary and very appealing proposition [11,12]. It is the reigning doctrine of physics today. General relativity, extending into several extra dimensions, has stretched the dimension of imagination, by the modern physicists, too far, but so far, without any experimental verification. The search for an explanation of gravitation has continued with the roping in of quantum mechanics to bring up gravitational quantum physics [13].

This paper assumes an electric charge, like an electron, to be an impregnable spherical shell of radius a. It considers the electric fields, from a stationary charged particle, to be in radial straight lines, acting from the centre, pulling the surface of the charge equally outwards. The pulling forces act equally, directed from the centre, to be in equilibrium and maintain a stable structure. This idea of field lines is in line with the remarkable perception of physical lines of force treated by Maxwell [14,15]. Visualisation of lines of force should assist in explaining the cause of electrostatic force of repulsion or attraction between charges, in accordance with Coulomb's law [16]. It may give a physical explanation of the cause of gravitational force of attraction between bodies composed of charges and the cause of inertia of a body under acceleration. It may even lead to a realistic unification of electrostatics and gravitation. Indeed, every phenomenon in nature has a physical explanation and a mathematical expression, subject to experimental verification.

11. Curvature of electric field lines

A charged particle remains stationary or moves at constant velocity, carrying along its straight field lines of force. In the event of any imbalance in the radial pull of the field lines, due to the presence of another charge, the charge moves in the direction of the resultant force with acceleration or deceleration. The field lines between electric charges Q and K become curved to produce a resultant field $\mathbf{E}_Q$ on charge K and $\mathbf{E}_K$ on charge Q and a force $K\mathbf{E}_Q$ equal to $Q\mathbf{E}_K$ of repulsion or attraction, in accordance with Coulomb's inverse square law [16].

Due to the finite speed of light, if an electric charge suffers acceleration or deceleration, the sudden change of velocity is not instantaneously communicated to all the fields. Consequently, the field lines become curved. The lines lateral to the direction of acceleration are most affected, providing a positive component to pull the charge in the opposite direction of acceleration. The converse happens in the case of deceleration. The crux of the matter here is bending of field lines from an electric charge, instead of curvature or warping of space-time continuum surrounding a body, according to general relativity.

1.2 Mass of an electric charge

The electrostatic energy or intrinsic energy E_n of an electric charge of magnitude Q in the form of a spherical shell of radius a, is given by the well-known classical formula:

$$E_n = \frac{Q^2}{8\pi\varepsilon_o a} \qquad (1)$$

where ε_o is the permittivity of free space. The author [17] has proposed a mass-energy equivalence law as:

$$E_n = \frac{1}{2}mc^2 = \frac{m}{2\mu_o\varepsilon_o} = \frac{Q^2}{8\pi\varepsilon_o a} \qquad (2)$$

where μ_o is the permeability of space and c is the speed of light in a vacuum, as determined by James Clerk Maxwell [18]. Equation (2) gives the mass m of an electric charge Q, a hollow sphere of radius a, as the groundbreaking formula:

$$m = \frac{\mu_o Q^2}{4\pi a} \qquad (3)$$

Equation (3) makes mass m and charge Q independent of speed of a charged particle.

Equation (3) shows that mass m of a particle of charge Q is proportional to Q^2. As such, there should be a gravitational force of attraction between electric charges Q and K, in accordance with Newton's inverse square law [1], as well as elecrrostatic force of repulsion or attraction, in accordance with Coulomb's inverse square law [16]. For a neutral body, the strong electrostatic forces of repulsion and attraction cancel out exactly everywhere in space, while the weak gravitational forces attraction remain and add up. This is in line with the author's electric field model of the aether [19] and in contrast to the epola (electron-positron lattice) model by Professor Menahem Simhony [20] and the Dirac model (infinite sea of particles with negative energy) [21,22] and other particulate models.

1.3 Arrangement of sections of the paper

The second part of the paper gives a physical explanation of the cause of electrostatic force, illustrated with diagrams of field lines from an electric charge. The issue is extended to neutral bodies containing equal numbers of positive and negative electric charges. For a neutral body, the strong electrostatic forces of repulsion and attraction, proportional to the product of the charges, in accordance with Coulomb's law, cancel out exactly everywhere in space. The matter also touches on a charged particle moving with velocity **v** and creating a magnetic field **H** perpendicular to the direction of motion.

The third part of the paper gives a physical explanation of the cause of gravitational force of attraction between two electric charges or between two neutral bodies composed of equal numbers of positive and negative charges. While, for a neutral body, the strong electrostatic forces of repulsion and attraction cancel out exactly everywhere in space, the weak gravitational forces of attraction, proportional to the product of square of two charges, remain and add up in accordance with Newton's universal law.

The fourth part, also illustrated with diagrams of field lines from an electric charge, deals with physical explanation of the cause of inertial force due acceleration of a body. An inertial field acts only on the charge producing it, at its location. It is not manifested outside a neutral body containing equal numbers or equal amounts of positive and negative charges. The paper makes extensive discussions on the results and ends with three conclusions.

2. Physical Explanation of Cause of Electrostatic Force

Fig. 1 shows an isolated positive charge *+Q*, in the form of a spherical shell of radius *a*, with straight lines of the electric field directed away from the charge. In Figure 2 the straight field lines of a negative charge *-K* are directed towards the charge. The lines, indicated by arrows, show the direction of force on a positive charge placed in the field.

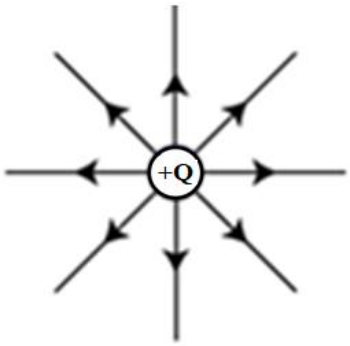

Fig. 1. Electrostatic field of an isolated positive charge +Q in the form of a spherical shell of radius a. The radial field lines pull the surface charge outwards.

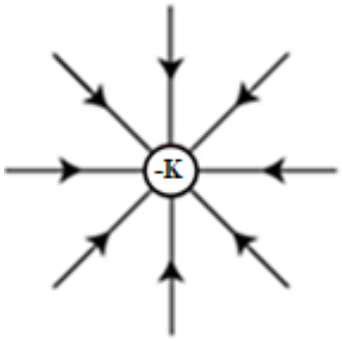

Fig. 2. Electrostatic field of an isolated negative charge -*Q* in the form of a spherical shell of radius *a*. The radial field lines pull the surface charge outwards.

It is as if the lines of force are equally pulling the surface of each charge (positive or negative) outwards, acting from the centre. In effect, the fields of an electric charge exert a pulling force on the same charge producing the field. With no resultant force on the charge, it stays in equilibrium, under tension, but remains stationary or moves with constant velocity, taking its straight electrostatic field lines along with it, without distortion, as in Figures 1 and 2. Any imbalance in the fields of an electric charge *Q*, due to the presence of another charge, should cause *Q* to move in the direction of the resultant electric field or force, with acceleration or deceleration and emissionof radiation.

Fig. 3 depicts two stationary like-charges *+Q* and *+K*, under repulsion and in Figure 4 the two unlike charges, *+Q* and *-K*, are under attraction. The field lines in Figures 3 and 4 are no longer straight but curved to make for the force of repulsion in Figure 3 and force of attraction in Figure 4. In Figure 3 the field lines of force subtract between the charges and add behind the charges and it is as if the charges are being pulled away from one another with a pulling force of repulsion **F**.

In Fig. 4 below, the field lines of force add between the charges and subtract behind them and it is as if the charges are being pulled towards one another with a pulling force of attraction **F**.

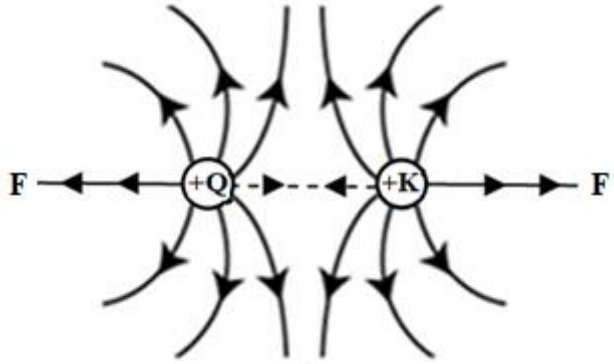

Fig. 3. Field lines of two stationary like charges +*Q* and +*K* under force of repulsion **F**.

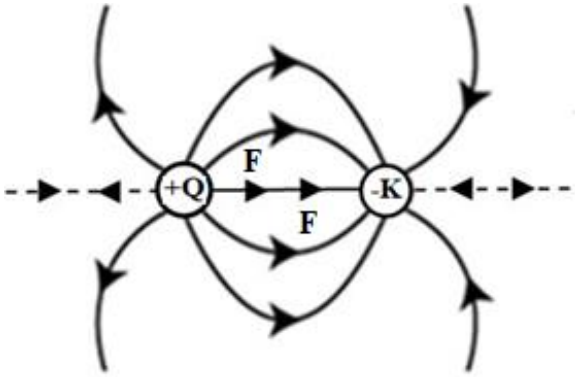

Fig. 4. Field lines of two stationary unlike charges +*Q* and -*K* under force of attraction **F**.

2.1 Positive charge as a source and negative charge as a sink.

Another way of looking at the picture, concerning the electric field lines in Figs. 1, 2, 3 and 4 above, is to consider a positive charge as a source of 'electrical compression' (above space-level), with field of intensity **E** whose effect is propagated with the velocity of light **c**, of magnitude *c*, away from the source. A negative charge may be considered as a sink of 'electrical rarefaction' (below space-level), with field of intensity -**E** whose effect is propagated with the velocity of light **c**, of magnitude *c* away from the sink. Therefore, an electrostatic field, as a vector quantity of intensity $\mathbf{E}_o$ and magnitude E_o, may be expressed as:

$$\mathbf{E}_o = \frac{E_o}{c}\mathbf{c} \qquad (4)$$

2.2 Visualisation of magnetic field

A magnetic field **H** may be visualized as ripples of 'electrical compression' or 'electrical rarefaction' in empty space, perpendicular to the electrostatic field of intensity $\mathbf{E}_o$, which is moving with velocity **v**, such that:

$$\mathbf{H} = \varepsilon_o \mathbf{v} \times \mathbf{E}_o \qquad (5)$$

where ε_o is the permittivity of space. Similar ripples are encountered in the atmosphere with respect to a moving body, whereby air rushes in, to fill the vacuum created and cause a drag. Motion of an electric charge in empty space is without a drag, but the ripples should be present to give the impression of a magnetic field. The magnetic field in equation (5) does not carry any energy, as there is no work done in creating it. Change in **H** with acceleration of the charge, is responsible for electromagnetic induction in accordance with Faraday's law.

3. Physical Explanation of Cause of Gravitational Force

3.1 Electrostatic and gravitational forces between two charges

Fig. 5 shows two electric charges Q and K as spherical shells of radii a and b and masses m_1 and m_2 respectively, separated by a distance r in space. The small force **f** between the charges, is a combination of electrostatic forces of repulsion or attraction given by Coulomb's law and gravitational force of attraction given by Newton's law, thus:

$$\mathbf{f} = \pm\frac{QK}{4\pi\varepsilon_o r^2}\hat{\mathbf{u}} - G\frac{m_1 m_2}{r^2}\hat{\mathbf{u}} \qquad (6)$$

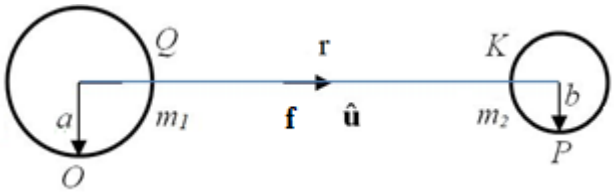

Fig. 5. Force **f** between electric charges Q and K at O and P separated by distance r.

where $\hat{\mathbf{u}}$ is a unit vector in the direction of force of repulsion and G is the gravitational constant. In equation (6) the force of repulsion is positive between like charges or attractive (negative) between unlike charges. The force of gravity is always (negative) attractive.

Substituting for the masses m_1 *and* m_2 from equation (3), where m_1 is proportional to Q^2 and m_2 is proportional to K^2, into equation (6), gives the force of repulsion as:

$$\mathbf{f} = \frac{QK}{4\pi\varepsilon_o r^2}\hat{\mathbf{u}} - G\frac{m_1 m_2}{r^2}\hat{\mathbf{u}} = \frac{QK}{4\pi\varepsilon_o r^2}\hat{\mathbf{u}} - \chi\frac{Q^2K^2}{r^2}\hat{\mathbf{u}} \qquad (7)$$

where χ = is a constant. For unlike charges (Q and $-K$), the force of attraction becomes:

$$\mathbf{f} = -\frac{QK}{4\pi\varepsilon_o r^2}\hat{\mathbf{u}} - \chi\frac{Q^2K^2}{r^2}\hat{\mathbf{u}} = -\left(\frac{QK}{4\pi\varepsilon_o r^2} + \chi\frac{Q^2K^2}{r^2}\right)\hat{\mathbf{u}} \qquad (8)$$

An interpretation of equations (7) and (8) is that the force of repulsion, between like charges, is reduced by xQ^2K^2/r^2 and the force of attraction, between unlike charges, is increased by the same amount. Net increase in force of attraction, the gravitational force of attraction, is:

$$\mathbf{f}_G = -\chi\frac{Q^2K^2}{r^2}\hat{\mathbf{u}} \qquad (9)$$

Let us assume that an electric field $\mathbf{E}_Q$, from a charge Q, on encountering another like charge K, is somehow reduced, by opening out, so that it becomes ($\mathbf{E}_Q$ - $\alpha K\mathbf{E}_Q$), where α is a constant of proportionality. Similarly, the field $\mathbf{E}_K$, on encountering the charge Q, becomes ($\mathbf{E}_K$ - $\beta Q\mathbf{E}_K$). The force of repulsion between the chages Q and K becomes:

$$\mathbf{f} = K(\mathbf{E}_Q - aK\mathbf{E}_Q) = Q(\mathbf{E}_K - bQ\mathbf{E}_k) \qquad (10)$$

As the electrostatic force $K\mathbf{E}_Q = Q\mathbf{E}_k$, the gravitational force in equation (10) becomes:

$$\mathbf{f}_G = -aK^2\mathbf{E}_Q = -bQ^2\mathbf{E}_k$$

$$\mathbf{f}_G = \frac{-\alpha K^2 Q}{4\pi\varepsilon_o r^2}\hat{\mathbf{u}} = \frac{-\beta Q^2 K}{4\pi\varepsilon_o r^2}\hat{\mathbf{u}} \qquad (11)$$

Equation (11) obtains if $\alpha = \eta Q$ and $\beta = \eta K$, so that:

$$\mathbf{f}_G = \frac{-\alpha K^2 Q}{4\pi\varepsilon_o r^2}\hat{\mathbf{u}} = \frac{-\beta Q^2 K}{4\pi\varepsilon_o r^2}\hat{\mathbf{u}} = \frac{-\eta Q^2 K^2}{4\pi\varepsilon_o r^2}\hat{\mathbf{u}} = \frac{-\chi Q^2 K^2}{r^2}\hat{\mathbf{u}} \qquad (12)$$

Equation (12) is identical to equation (9), if:

$$\chi = \frac{\eta}{4\pi\varepsilon_o} \qquad (13)$$

3.2 Force of gravity between two neutral bodies

A neutral body consists of equal numbers or equal amounts of positive and negative electric charges. It is obvious that a neutral body does not have a resultant electric field to exert any force of repulsion or attraction on other bodies or other charges in space, but the gravitational forces of attraction, proportional to the sum of square of the charges, remain and add up. The gravitational force of attraction $\mathbf{F}_G$ between one body of mass M_1 consisting of $N_1/2$ positive charges and $N_1/2$ negative charges, each of magnitude Q and another body of mass M_2 containing $N_2/2$ positive charges and $N_2/2$ negative charges, each of magnitude K, is obtained from equations (9), as the sum:

$$\mathbf{F}_G = -G\frac{M_1 M_2}{Z^2}\hat{\mathbf{u}} = \sum \mathbf{f}_G = -\frac{\chi}{Z^2}\sum_{n=1}^{N_1} Q_n^2 \sum_{n=1}^{N_2} K_n^2\hat{\mathbf{u}} = -\frac{\chi}{Z^2} N_1 N_2 Q^2 K^2\hat{\mathbf{u}} \qquad (14)$$

where Z is the distance between the centers of gravity of the masses. Both numbers N_1 and N_2, may, of course, be infinitely large. It should be noted that the gravitational force of attraction $\mathbf{F}_G$, between two neutral bodies, is independent of relative velocity between the bodies. The gravitational force of attraction depends only on the separation of the bodies in space, in accordance with Newton's universal inverse square law.

4. Physical Cause of Inertia

It was pointed out that the electric fields of an electric charge exert a pulling force on the same charge. Figure 6 depicts a stationary charge or one moving at constant velocity $\mathbf{v}$, relative to an observer. The field lines, at constant velocity, are as in Figure 1, relative to the moving charge. But, relative to an observer, the fields are increased in the forward direction and reduced in the backward direction, to account for the kinetic energy of the particle.

In Fig. 7 the charge moves with acceleration $d\mathbf{v}/dt$. As a result of finite speed of light, if a charge Q suffers acceleration, the sudden change of velocity is not instantaneously communicated to all the fields. Consequently, the field lines become curved, as in Fig. 7. "Similarly, the field lines become curved in Fig. 8, to make for resultant field $\mathbf{E}_a$, and inertial force $-K\mathbf{E}_a$, in the direction of deceleration. The curved field lines in Figs. 7 and 9 give a physical explanation for the cause of inertia."

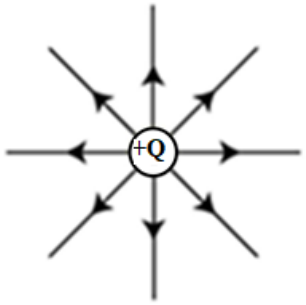

Fig. 6. Electric field lines of a particle of charge Q moving with constant velocity **v.**

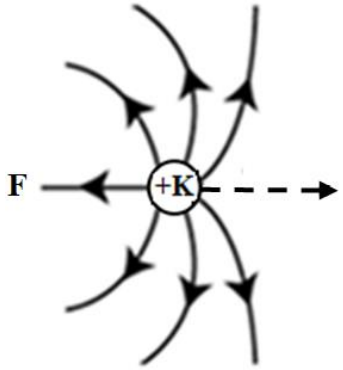

Fig. 7. Electric field lines of a particle of charge K and mass m moving with inertial force $\mathbf{F} = -m(d\mathbf{v}/dt)$.

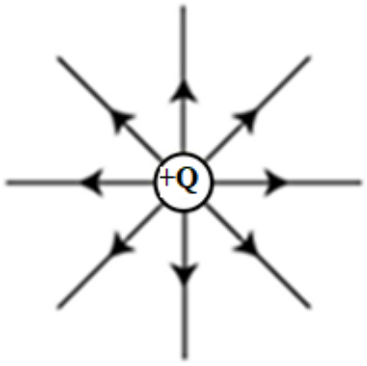

Fig. 8. Electric field lines of a particle of charge Q moving with constant velocity **v**

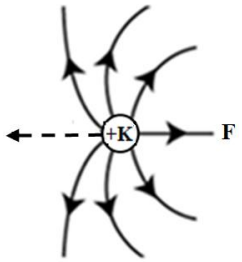

Fig. 9: Electric field lines of a particle of charge K and mass *m* moving with inertial force $\mathbf{F} = -m(d\mathbf{v}/dt)$.

Newton's first law of motion, often called the law of inertia, identifies inertia as the force required to accelerate or decelerate the motion of a body. The second law defines force **F** in terms of acceleration *d***v**/*dt* imparted to a body or particle of constant mass *m*, moving at time *t* with velocity **v** and acceleration *d***v**/*dt* as vector:

$$\mathbf{F} = m\frac{d\mathbf{v}}{dt} \qquad (15)$$

Newton's third law of motion gives the inertial force as a reaction equal to and in the opposite direction of the the impressed force **F**. Mathematically, the second law of motion contains the first and third laws. The significance of Newton's laws of motion may be stated to the effect that *'at any point and time, the vector sum of forces acting on a body is zero'.* This zero-sum of forces applies to stationary as well as moving bodies with or without acceleration.

Newton's second law of motion, as expressed in equation (15), is one of the most important principles in physics, with *m* as a constant, equal to the rest mass, contrary to the special relativity. In this case, inertia or inertial force, the tendency of a body to resist being accelerated, becomes the reactive force, equal and opposed to the accelerating force. A particle of charge *Q*, moving at a constant speed, carries along its own electrostatic field $\mathbf{E}_o$. If a charged particle is accelerated, it takes some time, because of the finite speed of light, to impart the effect, sudden change of velocity, to the surrounding fields. So, a positive component of the electrostatic field appears in the opposite direction of acceleration. As such, a reactive or induction electric field of intensity $\mathbf{E}_a$, proportional to and in the opposite direction of acceleration, is generated. In so far as an electric charge is always affected by an electric field, particularly its own electric field, it is proposed that $\mathbf{E}_a$ acts on the same charge *Q*, producing it, to generate the reactive force or inertial force $\mathbf{f} = Q\mathbf{E}_a$, such that:

$$\mathbf{f} = Q\mathbf{E}_a = -m\frac{d\mathbf{v}}{dt} \qquad (16)$$

The field $\mathbf{E}_a$ may be obtained in terms of charge potential and acceleration to get equation (2).

For a body of mass *M* composed of *N/2* positive charges and *N/2* negative charges, under acceleration *d***v**/*dt*, the inertial forces on the respective charges add up to give total **I**, as:

$$\mathbf{I} = N\mathbf{f} = NQ\mathbf{E}_a = -Nm\frac{d\mathbf{v}}{dt} = -M\frac{d\mathbf{v}}{dt} \qquad (17)$$

Each of the reactive electric fields ($\mathbf{E}_a$) acts only on and at the location of the charge producing it. The ($\mathbf{E}_a$)s are not externally manifested, as being equally positive and negative in a neutral body, they cancel out exactly outside. Equation

(17) explains inertia **I** of a body, the tendency of the body to resist acceleration, as a self-induced force residing in the body.

5. Results and Discussion

From the results of this paper, the following discussions may ensue:

- An electron or positron, each with charge of magnitude *e*, is supposed to be an impregnable hollow sphere. It is the basic constituent of matter with radius *a* as the smallest length in nature, the surface charge as the largest and intrinsic charge *e* as the smallest unit.
- It is argued that electric fields of a charged particle exert a pulling force on the charge and that electrostatic force of repulsion or attraction, is due to curvature of the field lines. The curvature of the field lines, due to the presence of another charge, brings about the resultant field and force of repulsion or attraction, as a pulling force, between electric charges in space.
- Gravitation is the result of a slight reduction (opening-out) of the electric field of a charge where it encounters a like charge, thereby slightly decreasing the force of repulsion. It is also the result of a slight increase (closing-in) of the electric field of a charge where it encounters an unlike charge, thereby slightly increasing the force of attraction. The net gravitational force of attraction, like the electrostatic force, is a pulling force.
- A charged particle, moving with constant velocity, bearing its field, without distortion, relative to itself, suggests space, at any point or direction, to be infinite and unbounded.
- The curvature of the field lines due to acceleration of an electric charge is what brings about the reactive field and force of inertia equal and opposite to the accelerating force.
- Curvature of a field is manifested here, in the context of bending of electric fields lines from charges, not the warping of the surrounding four-dimentioal space-time continuum.
- The gravitational force of attraction between bodies is independent of their relative velocity, depending only on the separation of the bodies in space.
- Motion of a body in a gravitational field is without radiation, so that change in kinetic energy is equal to the change in potential energy.
- A change in gravitational force of attraction between two bodies, from what it should be in terms of Newton's inverse square law, would be transmitted at the speed of light *c*.

6. Conclusion

This paper has succeeded in giving physical explanations for the causes of electrostatic, gravitational, and inertial forces. It justifies the following conclusions, based on a charged particle, like an electron or positron, being an impregnable hollow sphere with the field lines of force pulling the surface charge outwards, acting from the centre.

- Subtraction of electrostatic field lines of force between two like charges and addition of the field lines behind them, make for pulling force of repulsion, and vice versa for pulling force of attraction between two unlike charges.

- Gravitation is a pulling force between two bodies containing electric charges, resulting from bending of field lines such that electrostatic forces of repulsion are slightly reduced, and forces of attraction similarly increased, to provide a net force of attraction.
- Inertia is electrical in nature and a property residing in a body, resulting from curvature of electric field lines of force from the charges composing a body, if it suffers a sudden change in velocity, that is acceleration or deceleration.

REFERENCES

1. Newton I. Mathematical Principles of Natural Philosophy (Translated by F. Cajori). University of California Press, Berkeley; 1964.
2. Chandrasekhar S. Newton's Pricipia for the Common Reader. Oxford University Press Inc., New York; 1995.
3. Symon K.R. Mechanics. Addison-Wiley Publishing Co. Inc., London; 1961.
4. Einstein A. On the Electrodynamics of Moving Bodies. Ann Phys. 1905;17:891.
5. Einstein A, Lorentz HA. The Principles of Relativity, Matheun, London; 1923.
6. Geroch R. General Relativity from A to B, Chicago: Univ. of Chicago Press; 1981.
7. Wald R. General Relativity. University of Chicago Press; 1984.
8. Chutz A. A First Course in General Relativity. Cambridge University Press; 2009.
9. Stephani H. General Relativity: An Introduction: An Introduction to the Theory of the Gravitational Field. Cambridge University Press; 1990.
10. Hartle J. Gravity: An Introduction to Einstein's General Relativity. Addison-Wesley, San Francisco; 2003.
11. David JG. Revolutions in Twentieth-Century Physics. Cambridge University Press; 2013.
12. Scott AW. Breaking in the 4-Vectors: the Four-Dimensional Movement in Gravitation,1905–1910. Springer, Dordrecht; 2007.
13. Aspelmeyer M. Brukner C, Giulini D, et al. Focus on Gravitational Quantum Physics. New J Phys. 2017;19: 050401.
14. Maxwell JC. On Faraday's Lines of Force. Trans Cantab Phil Soc. 1855;1(1):155-229.
15. Maxwell JC. On Physical Lines of Force. Phil Mag. 1861;A90(131),11-23.
16. Spavieri G, Gillies GT, Rodriguez M, et al. Physical Implecations of Coulombb's Law. Metrologia. 2004;41(5): S159.
17. Abdullahi MD. On the Energy and Mass of Electric Charges in a Body. [Online]. Available: https://www.academia.edu/7692116/On_the_Energy_and_Mass_of_Electric_Charges_in_a_Body
18. Maxwell JC. A Treatise on Electricity and Magnetism. 3rd ed., Cambridge University Press; 1873.
19. Abdullahi MD. An Electric Field Model of the Aether; 2019.
20. Simhony M. Invitation to the Natural Physics of Matter, Space and Radiation. The Hebrew University, Jerusalem; 1994; 292p.
21. Dirac P. A Theory of Electrons and Positrons. Nobel Lecture, Dec. 12, 1933.
22. Petroni NC, Vigier JP. Dirac's Aether in Relativistic Quantum Mechanics. Found Phys. 1983;3(2):253-286.

Author Biography

Musa D. Abdullahi was born in Katsina, Nigeria, in 1941. He had primary education in Katsina and secondary education at Barewa College, Zaria from 1954 to 1959. He won Northern Nigerian Government Scholarship for GCE Advanced Level course at the Technical College Dundee, Scotland and undergraduate study at the University of Manchester, England. He obtained Bachelor of Science Degree, in 1965. He joined the Civil Service in 1972, holding many top positions, before retiring in 2000, as Director of Engineering Services, Federal Ministry of Works and Housing, Abuja, Nigeria. Currently, he is a Visiting Chief Lecturer with the Department of Electrical and Electronics Engineering, Kaduna, Polytechnic. His research interests include electromagnetic fields and radiation, electrodynamics, special and general relativity, gravity and Ether Theory.

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