NASA's Space-Probes Pioneer Anomaly and the Mass-Charge Repulsive Force

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It is reported that something has gradually dragged two of America's oldest space probes-Pioneer 10 and Pioneer 11- a quarter-million miles off course. This is called the pioneer anomaly. Astrophysicists have struggled for 15 years in vain to identify the infinitesimal force at play. It is shown that the anomaly should be due to a newly discovered force from the sun. Such a force is due to a charge - mass interaction, derived from general relativity. For a charge q and another particle of mass m, with a distance r between them, the static repulsive force is q^2m/r^3. Furthermore, such a force is not subject to electromagnetic screening, and this has been verified experimentally. Because of the r^{-3} - dependence, the repulsive force becomes increasingly negligible as the distance r increases. This effect can be observed as the pioneer orbital anomaly. It is conjectured also that the anomaly of a planetary probe would be due to charge-mass interaction that includes the current-mass attractive force. Thus, all of the anomalies are related to the mass-charge interaction and thus are natural consequences of extending general relativity. Concurrently, it is pointed out that Einstein's equivalence principle is also crucial in understanding unification. **Key Words:** pioneer anomaly, repulsive force, charge-mass interaction, charged capacitors, $E = mc^2$. 04.20.-q, 04.20.Cv

1. Introduction

It was reported [1] that beyond the edge of the solar system, something has gradually dragged two of America's oldest space probes-Pioneer 10 and Pioneer 11- a quarter-million miles off course. Astrophysicists have struggled for 15 years in vain to identify the infinitesimal force at play. The pioneer anomaly, as it is called, throws a monkey wrench into celestial mechanics.

The anomaly officially materialized in 1988, 16 years after NASA Pioneer 10 traveled toward the outer planets. The 568-pound spacecraft has been designed to stay in radio contact with Earth just 21 months, time enough for it to become the first spacecraft to pass through the asteroid belt, the first to fly past Jupiter and the first to visit the outer solar system. The plutonium-powered probe, however, transmitted data 31 years until 2003.

As it sped through space, a specialist in radio-wave physics named John Anderson at NASA's Jet Propulsion Laboratory noticed an odd thing. The spacecraft was drifting off course. The discrepancy was less than a few hundred-millionths of an inch per second for every second of space-flight, accumulating year after year across billions of miles. Then Pioneer 11, an identical probe escaping the solar system in the opposite direction, also started to veer off course at the same rate.

Dr. Anderson monitored the trajectories six years before calling attention to the matter. "I'm a little like an accountant," Dr. Anderson said. "We have Newton's theory and Einstein's theory, and when you apply them to something like this- and it doesn't add up – it bothers me."

Not everything in solar system adds up, of course. The moon's actual orbit is off its calculated course by about six millimeters a year. No one knows why. The standard yardstick for length on an interplanetary scale, the Astronomical Unit, grows by about seven centimeters a year. Scientists have yet to agree on an explanation. At least four recent planetary probes experienced such unaccountable changes in velocity as they passed Earth, Dr. Anderson and his colleagues reported.

None prompted the scrutiny given the Pioneer anomaly. In hundreds of technical papers, Dr. Slava Turyshev and scores of other space scientists considered and eliminated most mundane explanations, including fuel leaks, software bugs, mechanical flaws, navigation errors, fading plutonium power, planetary influences, the solar wind, even the effect of the ocean tides and local plate tectonics on the placement of ground antennas. Others proposed more far-fetched scenarios; the tug of the dark matter, the accelerating expansion of the universe or a break down of gravity's most fundamental laws.

Indeed, Dr. Turyshev at the Jet Propulsion Laboratory and his colleagues around the world regard the pioneer probes as the largest test of Newton's law of gravity ever conducted. By that axiom, refined by Einstein, any two objects in the universe exert gravitational attraction on each other proportional to their mass and are affected predictably by the distance between them.

"We would expect the two spacecraft to follow Newton's law of gravity," Dr. Turyshev said, "but they in fact fail to confirm Newton's law, If Newton is wrong, Einstein is wrong too."

After six years of work, the researchers expect to finish restoring the last data filed next month. Based on a partial analysis of the data that took six years to restore, Dr. Turyshev reported in April (2008) at a meeting of the American Physical Society that at least 30% of the force can be attributed to heat radiating from the probe. "The rest is unknown," he said.

In the year ahead, Dr. Turyshev and his colleagues plan to use the vintage data to create a computer flight simulation of the two Pioneer missions with a precision never before possible. That may finally lay it to rest. There is some hope that his would show a new physics," Dr. Turyshev said, "With the Pioneers, we are exploring uncharted territory."

So far, all existing theories failed to explain the additional weak force, which appears at long distance. In this paper, it will be shown that the pioneer anomaly is due to the interaction between charge and mass that has a very different dependence on distance [2, 3] because the Sun has many charged particles (see Section 5). Thus, Anderson and Turyshev are essentially right.

2. Pioneer Anomaly, Flyby Anomaly, and a New Force beyond General Relativity

It is noted that Space-Probes Pioneer 10 & 11 were heading for opposite directions. This would eliminate the possibility that the cause, as reported, were beyond the solar system. If the sources of this anomaly were beyond the solar system, the effect would appear to be attractive for one pioneer, but repulsive for the other. It has been observed that when far away from the sun, the slowing down of leaving speed from the solar system appears to be larger than that from Newtonian theory [4]. 1)

Anderson and his colleagues discovered [5, 6] that four spacecraft each raced either a tiny bit faster or slower than expected when they flew past the Earth en route to other parts of the solar system. Anderson said, "There is something very strange going on with spacecraft motions. We have no convincing explanation for either the Pioneer anomaly or the flyby anomaly."

The only exception is the case of Messenger, which approached the Earth at about latitude 31 degrees north and receded from the Earth at about latitude 32 degrees south. "This near-perfect symmetry about the equator seemed to result in a very small velocity change, in contrast to the five other flybys," Anderson explained — so small no anomaly could be confirmed. Another case of uncertainty is the second flight of Galileo spacecraft in December 1992, because any possible velocity increase was masked by atmospheric drag of the lower altitude of 303 km. The four other flybys involved flights whose incoming and outgoing trajectories were asymmetrical with each other in terms of their orientation with Earth's equator. For the other cases of Galileo, NEAR, Cassini-Huygens, and Rosetta, all experienced an anomalous velocity increase after its Earth encounter.

Thus, Wikipedia, the free encyclopedia, defines the flyby anomaly as "an unexpected energy increase during Earth flybys of spacecraft". Moreover, there are significant unaccounted velocity increments at infinity after at the perigees. These facts imply that an unknown force that causes the flyby anomaly is a long range neutral repulsive force. Thus, it seems that these anomalies are beyond the reach of both Newton and Einstein. Thus, some prominent relativists claimed these anomalies must be due to experimental errors. (Even Turyshev and Antreasian, had said that most likely the anomaly is simply an error in the computer code that is used to shift between Earth-bound and space-based coordinate systems.) However, such a claim has been proven to be very unlikely since NASA seems to have exhausted all possibilities from existing theories [4].

However, these two kinds of anomalies may not be related to each other. An obvious problem is that the flyby anomaly is due to acceleration rather than a deceleration. Turyshev believes only that both involve spacecraft and both are called anomalies. "Nobody has established that the two are connected," he says. However, Anderson's not so sure. "Another thing in common between the Pioneer and these flybys is what you would call an unbound orbit around a central body," Anderson said. "For instance, the Pioneers are flying out of the solar system — they're not bound to their central body, the sun. For the other flybys, the Earth is the central body. These kinds of orbits just don't occur very often in nature — it could be when you get into an unbound orbit around a central body, something goes on that's not in our standard models."

In summary, the new forces must satisfy the following requirements: 1) it is a neutral force; 2) it is a long range force; 3) it is a force much weaker than the Newtonian gravitational force; 4) it is a repulsive force for the flyby anomaly; 5) it appears in unbound orbits though not noticeable for a closed orbit, 6) it leads to the additional constant deceleration on space-probe pioneers at very long distances. The requirement 5), observed by Anderson, implies that this new force has a distance dependency very different from r^{-2} . Thus, in addition to being a repulsive force, this requirement implies that the anomalies are definitely beyond the current theory of general relativity. However, this does not necessarily mean that these anomalies are not related to general relativity. In this paper, it will be shown that they are, in fact, closely related to general relativity.

Currently, there are four known forces, namely, as follows: the electromagnetic, the gravitational, the weak and the strong forces. The last two are short-range forces that operate on the nuclei scale, and the first two are long-range forces that can be observed on the macroscopic scale. The electromagnetic force is a force between charges, and the gravitational force is a force between masses. However, a natural question is, is there a force between a mass and a charge?

Recent theoretical research shows that there is indeed a repulsive force between the mass and the charge. It is found [2, 3] that this fifth force between two point-like particles is mq2/r3, where m is the mass of one particle, q is the charge of the other particle, and r is the distance between them. This is a very weak, long-range, repulsive, neutral force that satisfies requirement 5). The remaining problem is whether requirement 6) can also be satisfied. The existence of such a repulsive force has been preliminary verified by weighing charged capacitors because a charged capacitor has been observed to have less weight, although the distance dependency cannot be verified with such an experiment [2, 3]. In contrast, according to existing theory, the capacitor after charging should become heavier. Thus, E = mc2 is only conditionally valid and there is experimental evidence of a new force [2, 3]. In fact, general relativity has not been well understood starting from 1916 [7, 8] (see Sections 4 & 5).

A new explanation would be that there is a neutral weak force due to the mass-charge interaction, which is repulsive and reduces faster than a Newtonian force as the distance from the sun increases. Then, at a very long distance, the net effect may appear as a constant additional weak force that observations suggest. Recently, based on general relativity, a very weak repulsive neutral force of charge-mass interaction has been derived [2, 3]. Since the sun has many charged particles, this neutral force would be a suitable candidate. This infinitesimal weak force would produce the anomaly since it reduces faster than the Newtonian force (see Section 6). If only charge and mass are capable of producing long rang fields, this is the only possibility.

On the other hand, if general relativity is essentially correct, it should lead to understanding the observed anomaly. 1) In this paper, it will be shown that the charge-mass interaction derived from general relativity will provide a natural explanation to the pioneer anomaly as well as other planetary anomalies [1, 4]. Thus, what is being called an anomaly should actually be normal, and such a term just reminds us of our oversight.

3. The Charge - Mass Interaction and Conditional Validity of E = mc²

The charge - mass interaction, of course, involves new physics, but then both general relativity, and the theory of Newton would be at worst inadequate [8, 9]. Moreover, this very weak neutral charge-mass interaction is not subjected to electromagnetic screening, and thus seems to be uniquely suitable for the explanation of the pioneer anomaly. However, the discovery of such an interaction takes a long way involving the resolutions of some fundamental issues in general relativity.

First, in 1993 it is discovered [10, 11] that, for the dynamic case, linearization of the Einstein equation is not valid although it is valid for the static cases. Subsequently, it is found that the Einstein equation of 1915 does not have a dynamic solution just as Gullstrand [12] suspected in his report to the Nobel Committee. In 1995 it is concluded that modification of the 1915 equation is necessary by adding a source term of the gravitational energy-stress tensor, with a different coupling sign [11, 13]. 2) This new coupling sign is necessary to explain the binary pulsars experiment of Hulse and Taylor [13, 14].

Since coupling signs can be different, the formula E = mc2 cannot be generally valid. Moreover, it should be noted that the electromagnetic energy-stress tensor has its trace being zero, but the massive energy-stress tensor has a non-zero trace. Thus the electromagnetic energy is not equivalent to mass. Subsequently, it is found that Einstein's proof is incomplete because he only assumed but did not prove [15] that an electromagnetic wave is equivalent to massless particles, the photons. On the other hand, experimentally it is observed that the meson π_0 can decay to two photons. Thus, the energies of photons and the electromagnetic wave are not equivalent. It turns out that the photons actually also include gravitational energy [16]. Now, it is clear that another basic misunderstanding was that general relativity deals with only phenomena of macroscopic scale.

The non-equivalence between energy and mass is also confirmed by the Reissner-Nordstrom metric [17-19] as follows:

$$ds^2 = \left(1 - \frac{2M}{r} + \frac{q^2}{r^2}\right) dt^2 - \left(1 - \frac{2M}{r} + \frac{q^2}{r^2}\right)^{-1} dr^2 - r^2 d\Omega^2 \qquad (1)$$

where q and M are the charge and mass of a particle and r is the radial distance (in terms of the Euclidean-like structure [20, 21]) from the particle center. In this metric (1), the gravitational components generated by electricity have not only a very different radial coordinate dependence but also a different sign that makes it a new repulsive gravity in general relativity. After the publication of this metric, Einstein [22, 23] no longer insisted that the validity of $E = mc^2$ is unconditional. Nevertheless, some still hold on to unconditional validity [8] since the singularity theorems of Hawking and Penrose are depending on it [13].

Moreover, some argued that the effective mass could be considered as $M - q^2/2r$ ($c = 1$) since the total electric energy outside a sphere of radius r is $q^2/2r$ [24, 25]. However, if any energy has a mass equivalence, an increase of energy should lead to an increment of gravitational strength. However, although energy increases by the presence of a charge, the strength of a gravitational force, as shown by metric (1), decreases everywhere.

Nevertheless, theorists such as Herrera, Santos & Skea [26] argued that M in (1) includes the external electric energy. They overlooked that this would create a double counting of the electric energy in two different ways [9, 17, 25]. 3) Moreover, the gravitational forces would be different from the force created by the "effective mass" $M - q^2/2r$. In addition, if M included the external electric energy, then the inertial mass m_0 of the electron would be much smaller than M [27]. Moreover, according to the Einstein [28], since the electromagnetic energy-stress tensor is traceless, curvature R is independent of the electromagnetic energy-stress tensor, and thus the electric energy cannot be equivalent to a mass.

If the external electric energy of a particle were included with the mass M in (1), the gravitational mass would be larger than the inertial mass. Thus, the unconditional validity of $E = mc^2$ is a misinterpretation.

4. The Charge-Mass Repulsive Force and Extension of Einstein's Theory

To show the repulsive effect, one needs to consider only gtt in metric (1). According to Einstein [7, 15]

$$\frac{d^2x^\mu}{ds^2} + \Gamma^\mu{}_{\alpha\beta}\frac{dx^\mu}{ds}\frac{dx^\nu}{ds} = 0 \qquad (2)$$

where $\Gamma^\mu{}_{\alpha\beta} = (\partial_\alpha g_{\nu\beta} + \partial_\beta g_{\nu\alpha} - \partial_\nu g_{\alpha\beta})g^{\mu\nu}/2$

and $ds^2 = g_{\mu\nu}dx^\mu dx^\nu$. Consider only the static case $dx/ds = dy/ds = dz/ds = 0$. Thus

$$\frac{d^2x^\mu}{ds^2} = -\Gamma^\mu{}_{tt}\frac{dct}{ds}\frac{dct}{ds} \qquad (3)$$

where $-\Gamma^\mu{}_{tt} = -\frac{1}{2}(2\frac{\partial g_{t\nu}}{\partial ct} - \frac{\partial g_{tt}}{\partial x^\nu})g^{\mu\nu} = \frac{1}{2}\frac{\partial g_{tt}}{\partial x^\nu}g^{\mu\nu}$

since $g_{\mu\nu}$ would also be static. Note that the gauge affects only the second order approximation of g_{tt} [29]. For example,

$$g_{tt} \approx \left(1 - \frac{2M}{r} + \frac{2M^2}{r^2} + \ldots\right) \qquad (4a)$$

and

$$g_{tt} = \left(1 - \frac{2M}{r}\right) \qquad (4b)$$

are with respect to the harmonic gauge and the Schwarzschild solution, but the second order term is negligible.

For a particle P with mass m at r, since $g_{rr} \cong -1$, the force on P in the first order approximation is

$$-m\frac{M}{r^2}+m\frac{q^2}{r^3} \tag{5a}$$

Thus, the second term is a repulsive force. If the particles are at rest, then the action and reaction forces are equal and in opposite directions. The force acting on the charged particle Q has the same magnitude

$$(m\frac{M}{r^2}-m\frac{q^2}{r^3})\,\hat{r} \tag{5b}$$

where $\hat{r}$ is a unit vector.

However, for the motion of the charged particle with mass M, if one calculates the metric according to the particle P of mass m, only the first term is obtained. Thus, the geodesic equation is inadequate for the equation of motion. Moreover, since the second term is proportional to q^2, it is not a Lorentz force. 4) nor the radiation reaction force since the charged particle remains static.

Thus, it is necessary to have a repulsive force with the coupling q^2 to the charged particle Q in a gravitational field generated by masses. It thus follows that, force (8b) to particle Q is beyond current theoretical framework of gravitation + electromagnetism. 5) In other words, as predicted by Lo, Goldstein, and Napier [30], Einstein's general relativity leads to a realization of the inadequacy of general relativity just as electricity and magnetism lead to the exposition of their shortcomings.

For two point-like particles of respectively charge q and mass m, the charge-mass repulsive force is mq^2/r^3, where r is the distance between these two particles. Clearly, this force is independent of the charge sign. Such characteristics would make the repulsive effects easier to be verified [9] since a local concentration of electrons would increase such repulsion. The term of the repulsive force in (1) comes from the electric energy [2, 9].

An immediate question would be whether such a charge-mass repulsive force mq^2/r^3 is subjected to electromagnetic screening. It is conjectured that this force, being independent of a charge sign, would not be subjected to such a screening [2] although it should be according to general relativity. From the viewpoint of physics, this force can be considered as a result of a field created by the mass m and the field interacts with the q^2. Thus such a field is independent of the electromagnetic field and is beyond general relativity [2]. In fact, this has been confirmed since a charged capacitor does reduce its weight [31, 32].

Surprisingly, similar experiments have been done much earlier. For instance, to test the assumed "electro-gravitic propulsion by high potential electric field", the experiments of weighting charged capacity have also been done by T. Masha et al. [33, 34]. Just like Buehler [32], Masha also get weight reductions of capacitors after charged.

However, the r-3-dependence (unlike r-2-dependence) is difficult to test because it would be sensitive to the local surroundings. Thus, being a long distance effect, the pioneer anomaly provides an excellent opportunity to test such dependence. Obviously, to accommodate the mass-charge interaction, unification between gravity and electromagnetism is necessary.

To this end, Kaluza [35] proposed a five-dimensional general relativity to reproduce gravitation and electromagnetism from metric element g_{k5} ($k = x, y, z, t$). This started the Kaluza-Klein theories [36, 37] that assumed g_{55} as a constant. Instead of Kaluza's cylindrical condition that reduces the five variables to four, Klein speculated the metric elements are periodic functions of the fifth variable. However, nothing that can be verified comes out from such unification. Another deficiency of their theory is the inability to deal with radiation reaction forces just like Maxwell's theory [27]. Understandably, the theories of Kaluza and Klein are essentially abandoned and w(5b)criticized as unification in name only [30].

However, the theory of Lo et al. [30] has no cylindrical condition, no negligence of the metric elements, and the radiation reaction force can be included as essentially a function of the fifth variable. Thus, such a theory would provide a theoretical framework for unification. Moreover, based on their theory, the static charge-mass interaction would be generated from the metric element g_{55} [2, 3] that others have disregarded [36]. Moreover, in the static case, one does not have to worry about the fifth variable yet [30]. Since the static charge-mass interaction can be generated from g_{55}, one can claim theoretically that this new force is not subject to electromagnetic screening [2, 3], and this is verified experimentally [31-34].

5. The Charge-Mass Repulsive Force on a Space Probe Pioneer

The Reissner-Nordstrom metric was first published in 1916, the same year that Einstein published his first paper on general relativity. Normally, the necessary unification of gravitation and electromagnetism should have been recognized in a year or so since Einstein advocated such unification [7]. However, this was not recognized until 2006 [9], a good 90 years afterward. Of course, a main problem was that $E = mc^2$ was mistakenly regarded as unconditionally valid [8]. A related problem was the difficulty in clarifying confusions and rectifying errors because the coordinates were ambiguous [2, 3]. Moreover, Einstein's accurate predictions created a faith in his theories, and this makes a critical analysis overdue [38, 39].

Note that, the calculation of (5a) is essentially based on general relativity after related invalidities are removed. The five-dimensional theory is invoked only to justify that the new force is not subjected to electromagnetic screening. However, this is theoretically crucial to establish a charge-mass repulsive force, which is independent of electromagnetism. Then, the charge-mass repulsive force between a point charge q and a point mass m is

$$F=\frac{q^2 m}{r^3} \tag{6}$$

in the r-direction. This formula essentially comes from general relativity. The five-dimensional theory supports that it is not subjected to electromagnetic screening, and this is supported by the experiment of weighting charged capacitors. This new force would behave very differently from an attractive force, which is inversely proportional to the square of the distance r. However, due to the q^2 term, this formula should be modified for the case of a composite object consisting of many charged particles.

The space probes give a good opportunity to check the mass-charge interaction. If the repulsive force comes from the sun, then m in (9) would be mp the mass of the pioneer, and distance r would be R the distance between the sun and the space probe. However, the charge term is not clear since for the sun we do not know what the non-linear term q^2 should be.

Nevertheless, since such forces act essentially in the same direction, we could use a parameter P_s to represent the collective effect of the charges. 6) Then, the effective repulsive force F_p would be (see also Section 6)

$$F_p = \frac{P_s m_p}{R^3} \tag{7}$$

Since the neutral sun emits light and is in an excited state, the sun has many locally charged particles, and P_s is not negligible. If the data fits well with an appropriate parameter P_s, then this is another confirmation of the charge-mass interaction.

Since this force is much smaller than the gravitational force from the sun, in practice the existence of such a repulsive force would result in a very slightly smaller mass M_s for the sun, i.e.

$$F = \frac{M_s m_p}{R^2} - \frac{P_s m_p}{R^3} \tag{8a}$$

and

$$\frac{M_s m_p}{{R_0}^2} - \frac{P_s m_p}{{R_0}^3} = \frac{M_{ss} m_p}{R_0^2} \tag{8b}$$

for R_0. Then, we have

$$F = \frac{M_s m_p}{R^2} + \frac{P_s m_p}{R^2}\left(\frac{1}{R_0} - \frac{1}{R}\right) \tag{9}$$

Thus, there is an additional attractive force for $R > R_0$, the distance of the earth from the sun. Of course, if the space probe is charged, then there is another repulsive force with M_s being the mass of the sun and P_q due to such charges.

Moreover, such a force would not be noticeable from a closed orbit since the variation of the distance from the sun is small. However, for open orbits of the pioneers, there are great variations. When the distance is very large, the repulsive force becomes negligible, and thus an additional attractive force would appear as the anomaly. Such a force would appear as a constant over a not too long distance. Thus, the repulsive fifth force satisfies the overall requirements according to the data [4].

When the four planetary probes experienced unaccountable changes in velocity as they passed Earth, they experienced an additional repulsive force from the Earth because the core of the globe has charged currents. Moreover, depending on the way of approaching the globe, a planetary probe would also experience an additional attractive force due to current-mass interaction (see next section). The related force would be more complicated just as the Lorentz force is more complicated than the Coulomb force. Thus, a planetary probe would experience an additional acceleration or de-acceleration.

6. Conclusion

In conclusion, all anomalies would have a unified cause just as Anderson [1, 4-6] expected. The charge-mass interaction provides a theoretical explanation of the space-probe anomaly that so far no other theory can provide [1, 4]. This interaction should be further confirmed with the data from NASA's future theoretical simulations. These simulations would not be simple since there are other minor uncertain effects [4, 40]. However, since this new force is based on general relativity, its chance of success is great. Moreover, unlike other theories, this force was not proposed just to solve the pioneer anomaly. It is amazing that such a force explain the requirements from characteristics of the data so well, and thus deserves further investigation.

In current theory, the charge-mass repulsive force would be subjected to electromagnetic screening. From the viewpoint of physics, it is unnatural that a neutral force could be screened in such a way. From the viewpoint of the five-dimensional theory, however, the charge-mass repulsive force would be understood as the charge interacting with a new field created by a mass [2, 3]. Therefore, the repulsive force would have the characteristic of not being subject to such screening.

Current theory would predict that the weight of a charged capacitor increases slightly due to the change in energy. 7) However, in a five-dimensional theory, the charge-mass repulsive force is not subjected to screening [2, 3], and thus would make the charged capacitor lighter. In a charged capacitor, both the positive and the negative charges are concentrated, and thus an effect of the repulsive force would be observed as a lighter weight for the charged capacitor.8), 9) Moreover, since the existence of such a repulsive force has been verified [31-34], 10) its validity is independent of the five-dimensional theory.

Attempts to explain weight reduction of a capacitor after charged have been made; but all failed since the 50s. 10) For instance, Buehler [32] concluded that the force could not be directly associated with the interaction of the electric and magnetic fields of the earth. Masha et al. [33, 34] also conceded that we must search for an explanation on their experiments. This is consistent with the fact that the charge-mass repulsive force is not derivable from a four-dimension theory [2, 3].

Thus, the existence of the charge-mass repulsive force has been established. Moreover, similar to the electric energy, the magnetic energy would generate a current-mass force. According to the effect of a magnetic field in general relativity [41, p. 263], it is expected that the current-mass force would be an attractive force that is perpendicular to the current. 11) Naturally such a current related force would cancel part of the repulsive force. The completion of general relativity [2, 39] naturally leads to the necessary existence of the fifth force. Thus, the pioneer anomaly would be explained.

Einstein was a genius and the full meaning of general relativity is still emerging after 100 years although he also made mistakes. Einstein's general relativity has been successful only for the case of static fields since the Einstein equation must be modified with an added gravitational energy-stress tensor in the source [11, 13]. Although his covariance principle is invalid [42, 43], it can be removed without changing his predictions. Moreover, although his theory of measurement was invalid as pointed out by Whitehead [44], it can be rectified [20, 21]. Moreover, his formula $E = mc^2$ is conditionally valid. The magic is his equivalence principle and the related Einstein-Minkowski condition (see Appendix) that would remedy these problems. However, only a few theorists, such as Landau & Lifshitz [45] and Zhou [46, 47], took Einstein's equivalence principle seriously.

In this paper, it has been shown that the discovered interaction should be the cause of this pioneer anomaly. On the other hand, if general relativity is essentially correct as a test particle theory, it must lead to verification of the anomalies. Note that these anomalies have defeated all attempts of misinterpretation from "relativists" [1, 4-6, 40]. Now, experiments have finally provided examples that one cannot be settled with misinterpretations, misleading invalid mathematics, and/or deceptive logical errors that could fool many [11-13, 38, 39]. 12) It is very lucky that NASA has done such experiments inadvertently many years ago. However, in view of that the binary pulsars experiments were misinterpreted [49], the fifth force is likely to be resisted. 13)However, the fifth force is likely to be resisted 13) since it would show that the conditional validity of the formula $E = mc^2$, which many have mistaken as unconditional [8, 9, 16, 23, 24]. Moreover, logical immaturity, deficiencies in mathematics and misconceptions in physics would be unequivocally exposed since Einstein's covariance principle has been proven invalid [42, 43]. This is consistent with the fact that his theory of measurement is actually based on invalid applications of special relativity [38, 39]. This confirms that competency of experts in general relativity is an issue as Feynman pointed out [48]. Einstein's covariance principle was readily accepted, in part, due to the influence of gauge theories in particle physics. However, although the initial Yang-Mills theory is gauge invariant, the physical Yang-Mills theories are not gauge invariant to create the masses.

The weight reduction of charged capacitors supports the existence of a neutral mass-charge interaction. The spinning superconducting top experiments [50] support the mass-current interaction. 11) The pioneer anomaly would further confirm the existence of a mass-charge repulsive force with r^{-3}-dependence. Moreover, since the r^{-3}-dependency is derived from general relativity, this provides also a means of testing Einstein's general relativity.

The fifth force has been established, although the five-dimensional theory is still at a preliminary stage [2, 3]. However, it is further reaffirmed that assuming g_{55} as constant [36] is valid [2, 3]. A confirmation of the fifth force by the data from the pioneer anomaly would help to resurrect the five-dimensional theory. Note that Einstein's equivalence principle is crucial in understanding unification. It is also hoped that this paper will be useful for NASA to understand the pioneer anomaly better.

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Appendix: Einstein's Principle of Equivalence, the Einstein-Minkowski Condition

Einstein's equivalence principle is stated clearly in "The Meaning of Relativity" [7] as follows:

'Let now K be an inertial system. Masses which are sufficiently far from each other and from other bodies are then, with respect to K, free from acceleration. We shall also refer these masses to a system of co-ordinates K', uniformly accelerated with respect to K. Relatively to K' all the masses have equal and parallel accelerations; with respect to K' they behave just as if a gravitational field were present and K' were unaccelerated. Overlooking for the present the question as to the "cause' of such a gravitational field, which will occupy us latter, there is nothing to prevent our conceiving this gravitational field as real, that is, the conception that K'; is "at rest" and a gravitational field is present we may consider as equivalent to the conception that only K is an "allowable" system of co-ordinates and no gravitational field is present. The assumption of the complete physical equivalence of the systems of coordinates, K and K', we call the "principle of equivalence;" this principle is evidently intimately connected with the law of the equality between the inert and the gravitational mass, and signifies an extension of the principle of relativity to coordinate systems which are non-uniform motion relatively to each other.'

This principle is different from Einstein's 1911 assumption of equivalence with Newtonian gravity [15]. The Einstein-Minkowski condition [15, p. 161] has its foundation from mathematical theorems [51] as follows:

Theorem 1. Given any point P in any Lorentz manifold (whose metric signature is the same as a Minkowski space) there always exist coordinate systems (x_μ) in which $\partial g_{\mu\nu} / \partial x_\lambda = 0$ at P.

Theorem 2. Given any time-like geodesic curve Γ there always exists a coordinate system (so-called Fermi coordinates) (xμ) in which $\partial g_{\mu\nu} / \partial x_\lambda = 0$ along Γ.

Thus, the local space of a particle is locally constant, although not necessarily Minkowski. What Einstein added to these theorems is that physically such a locally constant metric must be Minkowski. Such a condition is needed for special relativity [7].

In fact, Einstein [15, p. 144] has given an example that illustrates Pauli's errors. However, like Pauli [52], few understand Einstein's equivalence principle correctly [53] because of inadequate background in pure mathematics. Thus, theorists commonly but mistakenly regarded [54] Pauli's version the same as Einstein's principle [15].14) The editor of Phys. Rev. D, Eric J. Weinberg even claimed that the differences have no experimental consequence [11]. Pauli's [52] version is as follows:

"For every infinitely small world region (i.e. a world region which is so small that the space- and time-variation of gravity can be neglected in it) there always exists a coordinate system K0 (X1, X2, X3, X4) in which gravitation has no influence either in the motion of particles or any physical process."

Based on Einstein's equivalence principle, it is proven that a physical space must have a frame of reference with a Euclidean-like structure [20, 21]. However, Einstein's equivalence principle was still not understood until the space contractions and the time dilation for the case of a rotating disk were explicitly derived [55]. In fact, in the 1993 press release on the Nobel Prize in Physics [49], Einstein's equivalence principle is implicitly rejected [56], in addition to other theoretical errors. 12).

Endnotes

The pioneer anomaly has no universally accepted explanation. However, it is also possible that current physical theory does not correctly explain the behaviour of the craft relative to the sun (Wikipedia).

Meanwhile, however, the position toward the Einstein equation of The Royal Swedish Academy of Sciences [49] incorrectly changed from skeptical to affirmative in the 1993 press release for awarding the Nobel Prize Physics [11, 13, 57].

Some theorists often take a conditionally valid mathematical expression as physically absolute and thus out of contact with the physical reality. This is a form of confusion on mathematics and physics.

Currently, for a charged particle under the influence of gravity, the Lorentz force and the radiative reaction force are added to the geodesic equation to form an equation of motion. For the static case, the radiative reaction force is absent [27].

We calculate the field generated by charge particle Q, then the force acting at particle P; and the field generated by P, then the force acting at Q. This approach (also used in electrodynamics) is valid because the field generated by a particle, does not make itself move. For the metric generated by P, the metric would be $ds^2 = (1-2m/\rho)dt^2 - \left[(1-2m/\rho)-1\right]d\rho^2 - \rho^2 d\Omega^2$, where (ρ, θ′, φ′) is a new coordinate system with P at the center. Thus, the force on Q in the ρ-direction would be only $-Mm/\rho^2$. However, there should be another term in the ρ-direction as mq^2/ρ^3.

The formula (7) is based on the assumption that the total force is the sum of each individual forces calculated separately. Of course, one cannot consider such an approach as completely accurate. However, we believe that this is a valid approximation since similar approach to the Newtonian gravity has been successful.

By combining the electromagnetic energy with other energy such as in the case of photons [16], the combined energy can be equivalent to mass. In other word, for total energy ET, Einstein's formula $E_T = m_T c^2$ is still valid [24].

W. Q. Liu (http://www.cqfyl.com) got certified results of lighter capacitors after charged [31] in a Chinese Laboratory of the Academy of Science. Also, his weighting of magnets is consistent with the claim of J. A. Wheeler [41, p. 263].

According to $m = E/c^2$, the mass increment of a charged capacitor is negligible. For a capacitor of 200μF charged to 1000 volt, the related mass increment would be about 10^{-12} gram.

Some related experiments can be stated in the Biefeld–Brown effect, http://en.wikipedia.org/wiki/Biefeld–Brown_effect.

Recently, Martin Tajmar and Clovis de Matos [50], from the European Space Agency, found that a spinning ring of superconducting material increases its weight much more than expected. Thus, they believed that general relativity had been proven wrong. However, according to quantum theory, spinning superconductors should produce a weak magnetic field. Thus, they are measuring also the interaction between an electric current and the earth, i.e. an effect of the fifth force!

Einstein's general relativity has not reached its goal that the influence of gravity is not instantaneous since his field equation has no solution that includes gravitational waves [11-13, 57]. Many theorists did not see that, for the dynamics case, linearization of Einstein equation is invalid in mathematics. The Hulse & Taylor experiments actually support a modified Einstein equation, and this error was recognized by Nobel Laureate Chandrasekha and Lo [11, 13] in 1995.

Based on theories of the four-dimensional space, some claimed that the fifth force does not act on a charged capacitor. However, such an objection is irrelevant since the fifth force theoretically exists in a five-dimensional theory. Experimentally the fifth force has been confirmed by measuring the weight of a charged capacitor.

Surprisingly, the journals specialized in gravitation also failed in understanding Einstein's equivalence principle [53, 55].

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