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MICROWAVE PROPULSION FOR SPACECRAFT: A MECHANISM OF ACTION

By

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Abstract: A test conducted by Eagleworks Laboratories at the NASA Johnson Space Center in Houston has drawn attention to the emdrive propulsion system developed in 2006 at Space Propulsion Research Ltd in the south of England. Our confidence is stretched to the limit by claims that a spacecraft could continuously accelerate itself without ejecting propellant but an explanation is required if the experiment is repeatable. This experiment presents General Relativity with a paradox of action without equal and opposite reaction. An explanation may be found in Mach's Principle, if there is interaction between electrical conduction in its reflectors and acceleration of distant charges.

Key words: propulsion, gravity, Special Relativity, electromagnetic action, emdrive

Introduction

Eagleworks Laboratories at the NASA Johnson Space Center have tested the emdrive developed by Roger Shawyer at Space Propulsion Research Ltd, (Shawyer, 2013). These experiments were originally conducted at Space Propulsion Research Ltd in the South of England, then repeated in 2010 by North Western Polytechnical University aeronautics school in China (Yang *et al*., 2011) and more recently by Cannae LLC in the USA.

Guido Fetta at Cannae has developed a device similar to Shawyer's, with the capacity to produce continuous thrust at higher specific thrust levels than any ion engine. Yang Juan and his colleagues at North Western Polytechnical University have confirmed the Chinese results (Yang *et al*., 2013) and now both the emdrive and the Cannae drive have been tested and confirmed by this careful NASA study (Brady *et al*., 2014).

The Problem

It is so easy for researchers to be mislead by natural optimism that other physicists and engineers must assume results like these are false, until they are firmly established as practical fact. Thrust output equivalent to one Newton per kilowatt of electrical input, is very difficult to measure and too feeble to be useful except in orbit, where it is very expensive to test. What makes the Eagleworks report so interesting is the care they have taken to measure actual thrust output from two different devices. They do appear to work, so what then, is their mechanism of action.

Electrical current has inertia relative to its conductor. When microwave energy is resonant between parallel ends of a waveguide the mechanism of reflection is, absorption which induces current in the conductor and then emission when that current is deflected by a boundary or discontinuity within the conductor causing the current to change direction. When a waveguide has different sized reflectors at either end and contains resonant electromagnetic energy reflecting between those reflectors, then the inertia of the current within the conductors has a longer duration in the more extensive conductor surface.

The propulsive force demonstrated by Shawyer, and others (Yang *et al*., 2013), (Brady *et al*., 2014), is a consequence of that inertia having a component on a vector normal to the surface of the reflector (Rothman, 2008). When electromagnetic energy is resonant within the asymmetric waveguide, the difference between the duration of its inertia in the more extensive reflector and the duration of its inertia in the less extensive reflector compounds with the amount of contained radiation, producing a continuous unidirectional force.

This would contravene the established law of equal and opposite reaction unless that force is an interaction with distant matter. It is then necessary to re-examine the mechanism of inertia. Within mass, negative charges are more widely dispersed than positive charges, simply because the orbital radii of electrons is a displacement from the protons at their nuclei.

In MKS units and in the simplest available terms, all forces between separate objects including free atoms and individual charges, are equal to the sum of attractive and repulsive forces between individual charges (Wheeler *et al*., 1949), (Hoyle *et al*., 1995),

$$F = \sum_{n_q=1}^{n_q} kq_+q_-/(r_{n+-})^2 + \sum_{n_q=1}^{n_q} kq^2/(r_{n++})^2 + \sum_{n_q=1}^{n_q} kq^2/(r_{n--})^2 \quad \ldots \quad (1)$$

where q is the individual charge in Coulomb, n_q is the number of charge interactions of each type (attraction between opposite charges, repulsion between negative charges and repulsion between positive charges), k is the electromagnetic constant and n includes all permutations of charge interaction between the objects, r_{+-} being the distances between the opposite charges, r_{++} being the proton proton distances and r_{--} being the electron electron distances.

The unavoidable consequence of acceleration of any mass is then, that it will induce some acceleration of motion or current in distant matter. This is because the change in the rate of evolution of the geometry between their respective charges, alters the balance of their interactions. Resistance to inertial change may be an inductive relationship with the universe. This accounts for the persistence of motion, if inertia is a consequence of the sum of all electromagnetic interactions, due to the following relationships.

Geometry to Consider

In a universe with roughly constant density at large scales, there is an exponential increase of mass with distance from a point. For this description of inertia to be considered it is necessary to examine the geometry within which it must be resolved. The volume of a sphere is,

$$V = \frac{4}{3}\pi r^3$$

the volume of a spherical shell, V_s of constant thickness, $r_2 - r_1$, is,

$$V_s = \frac{4}{3}\pi r_2^3 - \frac{4}{3}\pi r_1^3$$

$$V_s \propto (r_2^3 - r_1^3)$$

and at large distances where density is constant, the mass of a shell,

$$m_s \propto (r_2^3 - r_1^3)$$

In SI units, electrical force between charges,

$$F = +/- \, k \, q^2/r^2$$

where, k, is the electromagnetic constant and, q, is measured in Coulomb. Then for a neutral mass, any force induced by acceleration of its charges due to their uneven distribution,

$$F \propto (m_2 \, m_1)/r^2$$

Where, m_1 is constant and

$$m_2 = m_s$$

we can state, using these arguments,

$$F \propto (r_2^3 - r_1^3)/r^2$$
$$F \propto (r_2 - r_1)$$
$$F \propto t$$

where, t, is the thickness of the shell. There being an overwhelming number of shells of equal thickness in the distant universe than there are nearby, it is reasonable to presume that any inductive relationship due to the acceleration of neutral mass will be dominated by interaction with the remote universe, irrespective of the density of local masses.

That gravity could be an electromagnetic interaction is also indicated by the similarity between the kinetic energy gained during a fall and the quantity of energy resulting from; a multiplication of the time dilation experienced during that fall and the total electromagnetic energy within the falling mass. If you multiply the total electromagnetic energy,

$$E = mc^2$$

within a mass which is falling, by the time dilation,

$$(\Delta T_{max} - \Delta T_{min}) / \Delta T_{min}$$

that it falls through, you get a result in Joules of energy which is the same as the kinetic energy gained from the fall,

$KE = mv^2/2$

Over a given distance, through a known dilation of time, in a vacuum, there is a balance between the electromagnetic energy exposed to time dilation and the energy of motion generated,

$$((\Delta T_{max} - \Delta T_{min}) / \Delta T_{min})E = KE$$

This is a strong indication that gravitational acceleration is an electromagnetic effect. Despite the exponential decrease of electromagnetic force with distance between any pair of charges, the above relations leave no doubt that any inductive relationship (due to the acceleration of neutral mass) must be completely dominated by interaction with the remote universe, irrespective of the density of local masses.

An Explanation

Gravity can also be explained by the interaction of charges. Attractive electrical forces between the opposite charges of separate objects sum to a force not completely balanced by the sum of force due to electron electron repulsive forces plus the sum of proton proton repulsions between those objects. The geometry responsible for the balance of these forces is not obvious because less than half of the habitual sphere of an electron, about a hydrogen atom, is at a lesser distance from a remote charge than the separation between its proton and that remote charge.

The true balance of these forces results from a combination of the differing ranges of separation between charges as well as their distribution within those ranges, and the inverse square nature of those forces of interaction. The approximate net gravitational force between two objects,

$$F_g = \sum_{n_q=1}^{n_q} kq_+q_- / (r_{n+-})^2 + \sum_{n_q=1}^{n_q} kq^2/(r_{n++})^2 + \sum_{n_q=1}^{n_q} kq^2/(r_{n--})^2 \approx G\, m_2 m_1/r^2 \qquad \ldots \quad (2)$$

where G is the gravitational constant, m_1 and m_2 are the objects and F_g is the force of attraction between them.

From Einstein's Princeton Lecture concerning the principle of equivalence, "In the immediate neighbourhood of an observer, falling freely in a gravitational field, there is no gravitational field." The only acceleration relative to the distant universe may be acceleration which is different to the local acceleration due to gravity because both gravity and inertia have the same mechanism of action. This accounts properly for the principle of equivalence without need for General Relativity.

The varying distribution of opposite and like charges is, however, only part of the solution, a mechanism of interaction between charges is also necessary. The simplest possible explanation is that the dilation of time is the mechanism of interaction for all inertial, gravitational and electromagnetic interactions. Gravity and electrostatic force have identical behaviours, as demonstrated unequivocally by Milliken's oil drop experiment. That they should share time dilation as their mechanism of action constitutes such a simple method of unification that it should at least be considered.

Before Special Relativity properly resolved relativity mathematically, the most difficult task for physics was to explain the action of force at a distance. General Relativity was slowly accepted as a mechanism of action for gravity but electrostatic force was not resolved in the same way. Conservation of energy might be better satisfied if it was. In General Relativity acceleration due to gravity is a transmutation of atomic energy into inertial energy in strict accordance with the change in the rate of progress of time which an object is subject to, conservation of energy is satisfied. Why should the action of charges upon each-other not meet that same requirement?

Llewellyn Thomas resolved the conservation of energy in the mechanism of capture of electrons into atomic orbitals. He also explained the splitting of Fraunhofer lines in the radiation produced when electrons rise into higher orbitals while influenced by magnetic fields. Thomas's solutions work because they satisfy conservation of energy but their logic was not followed through to the insight which it reveals. If the capture of an electron into an atomic orbital requires it to move into a field of time dilation then the incorporation of time dilation into all electromagnetic interaction has already been proven. To state the case any less bluntly disregards the need for conservation of energy.

The paradox inherent in quantum mechanics can then be relieved, as it should be because there is no energy in electromagnetic fields from the covariant perspective. The energy of a photon is only separate from its emission and absorption when those interactions are considered from a point perspective (Einstein, 1922). That point perspective is distorted by reduction of time to a constant passage, in a universe where the reality of differing passage of time in different locations invalidates energy conservation for an object observed from any other point perspective not moving at the speed of light. A clear notion of complex time resolves all of these issues.

Inertial and electromagnetic forces have been interpreted as being of a different nature to gravity, because electrical forces were not understood when gravity was first analysed mathematically. Reverence for Galileo, Kepler and Newton have caused us to miss the obvious, that gravity behaves in the same way as electrical interaction.

Conclusion

General Relativity incorporates time dilation as a mechanism of action for gravity but the complexity introduced may be unnecessary. Electrical interaction can account for gravitational interaction more simply provided that the dilation of time inherent in change of separation between charges is appreciated. The benefit of this approach is that both gravity and inertia can be recognised as electromagnetic effects and the paradox presented by Rodger Shawyer's experiments can be resolved.

If Shawyer's results are validated by continued repeats it will profit us to develop the emdrive into a functional propulsion technology. To do this requires funding. The notions expressed here lack mathematical development, they are an attempt to start the conversation addressing the need for a theoretical explanation to support funding submissions for this dynamic field of experimentation.

NASA is not as casual with its scientific credibility. The fact that they have released this report (Brady *et al*., 2014), is an indication that they have confidence in their results. The emdrive is not a free energy device, it requires electrical energy, coolant and sophisticated electronic management. It will also require a lot of development before it replaces current propulsion technology but with that development, the improvements in aircraft and spacecraft performance will likely be astounding.

What does this mean for space exploration. According to Shawyer, emdrive has the potential to reduce the cost of accelerating a payload out of the atmosphere and into geostationary orbit, from thirty thousand dollars per kilogram to just a few hundred. Round trips to Mars could be reduced from years of dangerous travel to missions lasting just a few weeks. It would be a terrible mistake to discard the potential that the emdrive appears to show, just because it challenges our notions of physical force.

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