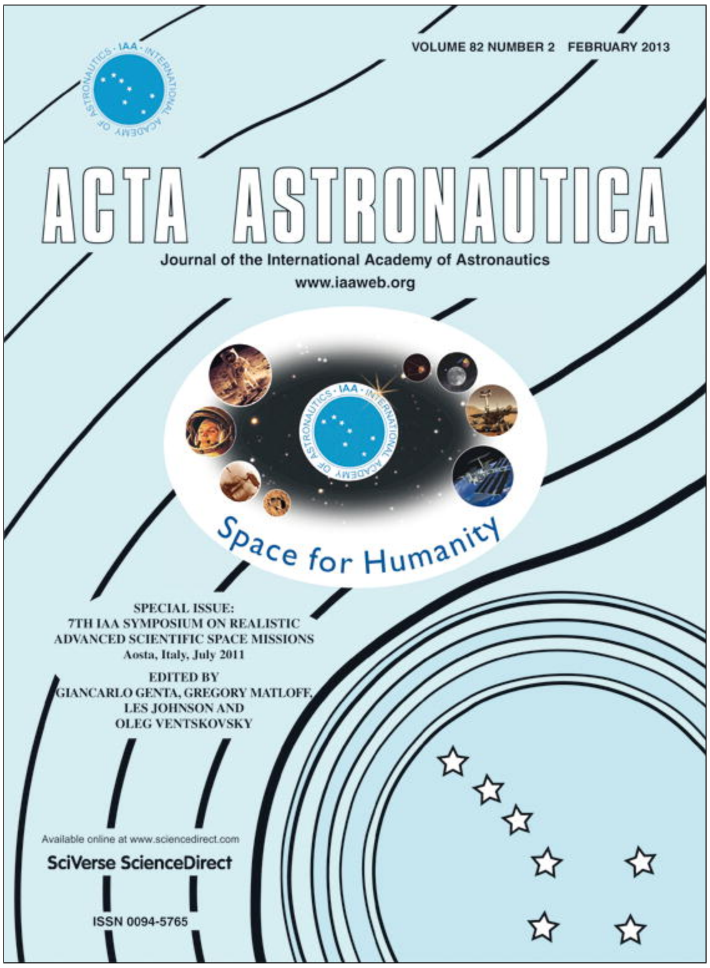
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Field propulsion systems for space travel

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ABSTRACT

Field propulsion systems were proposed by many researchers to overcome the speed limit of the conventional space propulsion system. Field propulsion system can be propelled without mass expulsion; its propulsion principle can induce a propulsive force (i.e., thrust) that arises from the interaction of the substantial physical structure. This notion is based on the assumption that space as a vacuum possesses a substantial physical structure. This evaluation examines the substantial physical structure regarding the space–time from both General Relativity in the view of a macroscopic structure and Quantum Field Theory in the view of a microscopic structure. Thus, several kinds of field propulsion system can be proposed by making these choices considering the structure of physical space.

1. Introduction

A breakthrough in creating new propulsion methods is required for the purpose of interplanetary travel and interstellar travel. Instead of conventional chemical propulsion systems, field propulsion systems, which are based on the General Relativity Theory, the Quantum Field Theory, and other exotic theories, are proposed by many researchers to overcome the speed limit of conventional space propulsion systems. A field propulsion system is not based upon usual momentum thrust but is propelled without mass expulsion. The propulsive force is a pressure thrust that arises from the interaction of space–time around the spaceship external environment and the spaceship itself; the spaceship is propelled against space–time structure.

The field propulsion principle is based on the assumption that space as a vacuum possesses a substantial physical structure. Minami [1] proposed a hypothesis about mechanical and a substantial physical property of space–time in 1988. Field propulsion is propelled receiving a propulsive force (i.e., thrust) that arises from the interaction of the substantial physical structure. The meaning of substantial physical structure regarding the space–time is conjectured from both General Relativity in the view of macroscopic structure, and Quantum Field Theory in the view of microscopic structure. Therefore, several kinds of field propulsion can be proposed by making choice of either physical concept. However, even if any propulsion system is selected; the propulsion principle of field propulsion system requires using the substantial physical structure of space.

The fundamental concept regarding the structure of physical space, the overview of several field propulsions proposed by many researchers and condensed summary of field propulsion system are described below.

2. Basic physical concepts applied for field propulsion

2.1. Physical structure of space as a vacuum

As previously mentioned, the propulsion principle of field propulsion is based on the assumption that space is a vacuum that possesses a substantial physical structure.

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Field propulsion is propelled receiving the propulsive force (i.e., thrust) that arises from the interaction of the substantial physical structure. One has to ask what is the meaning of substantial physical structure regarding the space–time? The answer is based from both General Relativity in the view of macroscopic structure and Quantum Field Theory in the view of microscopic structure. First, General Relativity is the geometric theory of gravitation and the gravitational field is explained by curved space. The curvature of space plays an important role. Although the curvature is mathematic, the curvature has relations with continuum mechanics such as expansion, contraction, elongation, torsion and bending. This physical relation indicates that the space–time continuum as a vacuum can be considered as a kind of elastic body in continuum mechanics. Therefore, the propulsion system used by General Relativity can be proposed from the standpoint of continuum mechanics. Second, space–time as a vacuum is generally viewed as a transparent and ubiquitous infinitive empty continuum, upon which physical events take place. However, quantum field theory and quantum electrodynamics (QED) view it as possessing vigor and vitality over different scales of time and space. Such vigor and vitality are the zero-point fluctuations of the vacuum electromagnetic field (vacuum perturbation), and the continuous creation and annihilation of virtual particle pairs that are iterated there in a Dirac sea. Further, according to the latest quantum optics, although until recently, it was considered that the control of vacuum perturbation was utterly impossible. At the present day, it is proven that the vacuum perturbation can be controlled by squeezed light technology. It is possible to increase the energy density locally above the vacuum state and vice versa, decrease the energy density locally below the vacuum state. That is the squeezed light generates the squeezed vacuum states and yields the coordination geometry of energy density for control. Moreover, the strings of superstring theory are considered as the threads of the space–time fabric. String seems to be the fundamental element of the substructure or fine structure of the space–time continuum. Supposing that the string is the constituent of space–time suggests the existence of possible quantum states for space–time. This indicates that entropy of space–time can be defined as an assembly or an ensemble of strings. Strings as the constituents of space–time correspond to an analogy similar to polymer chains in an elastic body. Since the statistical entropy is the logarithm of the number of states (i.e., degeneracy of the system), it is necessary to consider what kinds of physical states would exist. Therefore, a field propulsion system used with Quantum Field Theory is proposed from the standpoint of quantum physics.

Thus, although several kinds of field propulsion can be proposed by making different choices of physical concepts, the propulsion principle of a field propulsion system is identical in using the substantial physical structure of space, even if whether the constituents of physical structure involve curvature, zero-point fluctuations, or statistical entropy of string and so on.

2.2. Overview of space propulsion methods

A number of worldwide researchers are applying various advanced concepts and methods by incorporating General Relativity and Quantum Field Theory to use new ways of accomplishing space travel that differ from conventional methods.

Fig. 1 shows a representative example survey of several of these field propulsions currently proposed by many researchers in accordance with classification both of General Relativity in the view of macroscopic structure and Quantum Field Theory in the view of microscopic structure, which may involve some dogmatic assertions [1–16]. Since a field propulsion system does not expel any

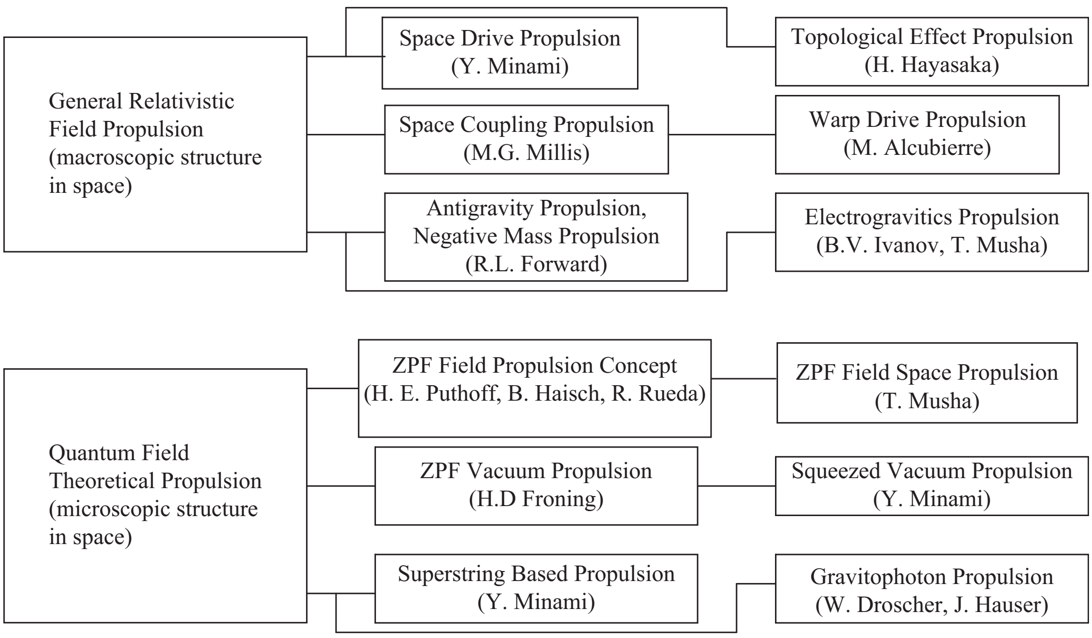

Fig. 1. Field propulsion classified map.

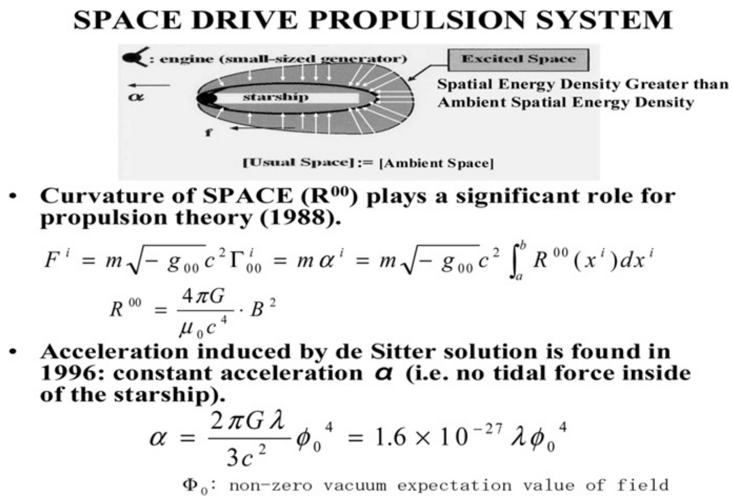

Fig. 2. Condensed summary of space drive propulsion principle.

momentum, it appears to violate the natural conservation law of momentum. However, the essential underlying principle of a field propulsion system is that space is not a state of absolute void, emptiness, or nothingness. Space is a physical reality, or has some physical structure as a continuum that can be reacted against under the right condition. Similarly, this structure of space may be a result of any or all of the fundamental forces of nature. As an example, a condensed summary of propulsion principle of Space Drive Propulsion System is shown as Fig. 2 [2,3].

3. Representative examples of field propulsion

3.1. General relativistic field propulsion system

Under the supposition that space is an infinite continuum, continuum mechanics can be applied to treat the so-called vacuum of space. This means that space is considered as a transparent elastic field. That is, space as a vacuum performs the motion of deformation that includes expansion, contraction, elongation, torsion and bending. The latest expanding universe theory (Friedmann, de Sitter, inflationary cosmological model) supports this assertion. Thus we can regard space as an infinite elastic body like rubber. If the space–time continuum curves, then an inward normal stress "—P" is generated. This normal stress, i.e., surface force serves as a pressure field (Fig. 3).

$$-P = N\times(2R^{00})^{1/2} = N\times(1/R_1+1/R_2) \quad (1)$$

where N is the line stress, R_1,R_2 are the radius of principal curvature of curved surface, and R^{00} is the spatial curvature.

It is now understood that the membrane force on the curved surface and each principal curvature generates the normal stress "—P" with its direction normal to the curved surface as a surface force. The normal stress –P acts towards the inside of the surface as shown in Fig. 3. A thin-layer of curved surface will take into consideration within a spherical space having a radius of R and the principal radii of curvature that are equal to the radius ($R_1=R_2=R$). Since the membrane force N (serving as the line stress) can be assumed to have a constant value, Eq.(1) indicates that the curvature R^{00} generates the inward normal stress P of the curved surface. The inwardly directed normal stress serves as a pressure field. When the curved surfaces are included in a great number, some type of unidirectional pressure field is formed. A region of curved space is made of a large number of curved surfaces and they form the field as a unidirectional surface force (i.e., normal stress). Since the field of the surface force is the field of a kind of force, the force accelerates matter in the field, i.e., we can regard the field of the surface force as the acceleration field. A large number of curved thin layers form the unidirectional acceleration field. Accordingly, the spatial curvature R^{00} produces the acceleration field α. Therefore, the curvature of space plays a significant role to generate thrust.

The mechanical structure due to the space–time continuum strain is described here from another point of view. As shown in Fig. 4, if the line element between the arbitrary two near points (A and B) in space region **S** (before structural deformation) is defined as $ds=g_i dx^i$, the infinitesimal distance between the two near points is given by $ds^2=g_{ij}dx^i dx^j$. Let us assume that a space region **S** is structurally deformed by external physical action and transformed to space region ***T***.

Since the degree of deformation can be expressed as the change of distance between the two points, we get:

$$ds'^2-ds^2 = (g'_{ij}-g_{ij})dx^i dx^j = 2e_{ij}dx^i dx^j \quad (2)$$

where g'_{ij} , g_{ij} is the metric tensor, e_{ij} is the strain tensor, ds'^2-ds^2 is the square of the infinitesimal distance between two infinitely approximate points x^i and x^i+dx^i.

Eq.(2) indicates that a certain geometrical structural deformation of space is shown by the concept of strain. In a word, the change of the metric tensor ($g'_{ij}-g_{ij}$) is due to the existence of mass energy or electromagnetic energy tensor that produces the strain field e_{ij}; the physical strain is generated by the difference of the geometrical metric of the space–time continuum. As well known in the continuum mechanics, the elastic force F^i is given by the gradient of stress tensor σ^{ij}, and using elastic law with the

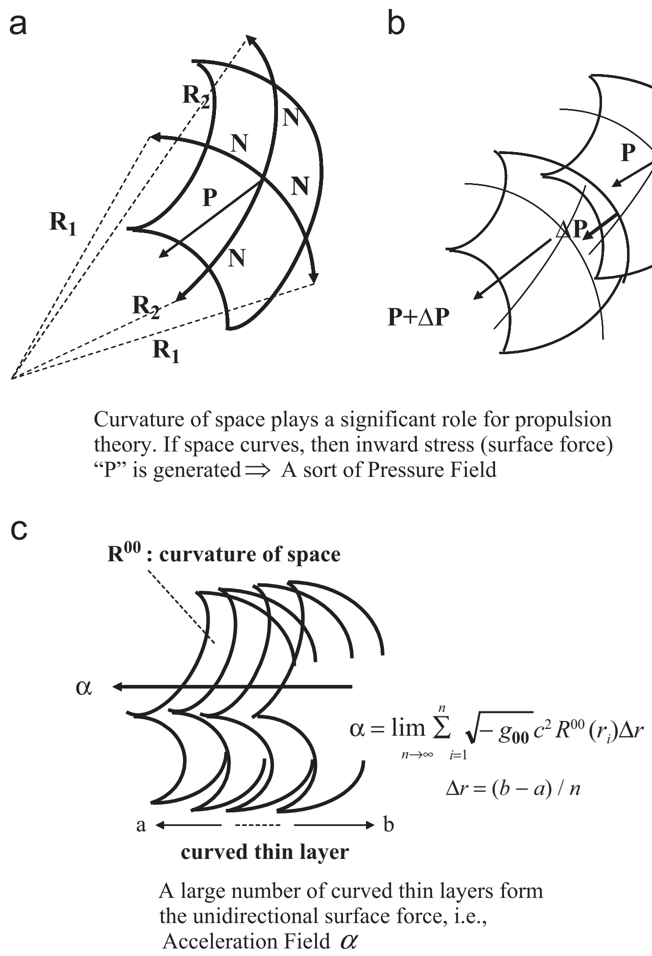

Fig. 3. Curvature of space.

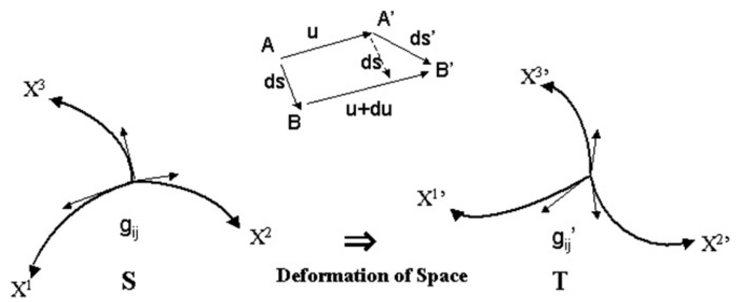

Fig. 4. Fundamental structure of space.

elastic modulus $E^{ij\mu\nu}$, if we apply the continuum mechanics to the above result, the strain tensor e_{ij} produces the stress field σ^{ij}. From the equilibrium conditions of continuum, we get:

$$-F^i = \sigma^{ij}{}_{;j} \text{ and } \sigma^{ij} = E^{ij\mu\nu} e_{\mu\nu} \quad (3)$$

The stress tensor $\sigma^{ij}$is a surface force and F^i is a body force. Here, notation ":"of $\sigma^{ij}_{;j}$ denotes covariant differentiation. As described above, an important analytical method relating the concept of continuum mechanics, acts as a deformation with the concept of Riemannian geometry that is similar to the parallel displacement of vector.

3.2. *Quantum field theoretical propulsion system*

According to Quantum Field Theory and Quantum Electrodynamics (QED), it can be seen that the quantum vacuum is filled with the zero-point electromagnetic field as shown in Fig. 5(a). However this electromagnetic field is in the state of non-radiating mode and we cannot recognize the influence of zero point fluctuation of a quantum electromagnetic field. In physics, the zero-point energy is the lowest possible energy that a quantum mechanical physical system may have and is the energy of $\hbar\omega/2$ of the ground state. Puthoff proposed the hypothesis that ordinary matter is ultimately made of sub-

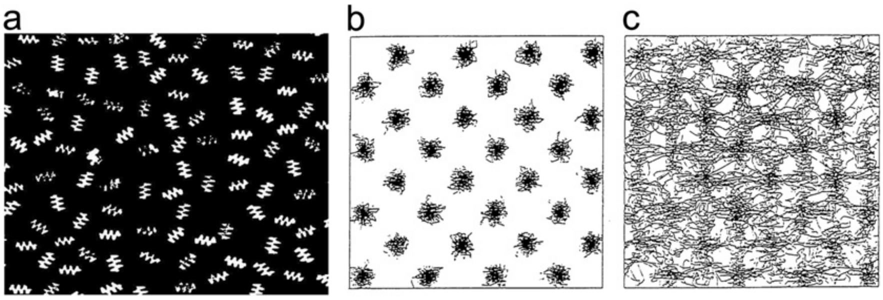

Fig. 5. Zero-point fluctuation of electromagnetic energy in a vacuum and fine structure of space.

elementary constitutive elementary primary charged entities (parton) bound in the manner of traditional elementary oscillators. Moreover, he has shown that Lorenz force arises in any accelerated reference frame from interaction of the parton with the vacuum electromagnetic zero point field (ZPF) to explain for inertia. From the electrodynamics Hamiltonian of the particle under high electromagnetic field and the analogy formula including a ZPF oscillating field derived by Haisch, Rueda and Puthoff [4], Musha derived the gravitational field induced by an external electric field shown as:

$$F \approx Z\sqrt{4\pi\varepsilon}\left(1+\frac{\pi}{8}\frac{e^4 G}{\varepsilon_0^2 m^2 c^8}\frac{N^2 R}{\Gamma_e \omega_e}E^2\right)EM \tag{4}$$

where Z is an atomic number of the dielectric material, M is its mass, Γ_e is the Abraham-Lorenz damping constant, N is a number of electrons per unit volume in a space including the dielectric material, R is a radius of the electron cloud and E is a magnitude of the impulsive electric field [5].

This formula suggested that a high impulsive electric field impressed upon a dielectric material might affect the inertia of the mass and it would produce a rapid acceleration without strain or stress inside of it.

In quantum field theory, the fabric of space is visualized as consisting of fields, with the field at every point in space and time acting as a quantized simple harmonic oscillator, with neighboring oscillators interacting with each other and these make a contribution from every point in space. This suggests that the structure of space–time is also composed of some kinds of physical microstates and offers the properties of entropy.

As previously stated, the strings of superstring theory are considered as the threads of the space–time fabric. In a sense, it is as if individual strings are the "shards" of the space–time continuum, and only when they appropriately undergo sympathetic vibrations, the conventional notions of space–time emerge. This indicates that strings might behave like the polymer chains of some elastic bodies like rubber. In general, elasticity has two kinds of nature: that is energy elasticity (crystalline elasticity) like spring and entropy elasticity (rubber elasticity) like rubber. Energy elasticity is due to the deformation of interatomic distance or displacement between molecules. It corresponds to the decrease of internal energy. Entropy elasticity (rubber elasticity) is due to thermal motion of the polymer chains. It corresponds to an increase in entropy. Elasticity of rubber is very different from that of crystalloid solids. Likewise, the elastic constant of rubber increases with temperature.

The space as vacuum is considered to preserve the properties of entropy elasticity from the viewpoint of the latest cosmology and theory of elementary particles. Further, the space acting as a vacuum is considered that the entropy of space–time can be defined as an assembly of strings, and strings as the constituents of space–time correspond to the polymer chains in the elastic body. As shown in the usual rubber elasticity, the elastic force is induced by entropy gradient in the direction of increasing entropy (from small entropy to large entropy). So the elastic force "F" from the field of entropy gradient can be generated.

The excited space shows the property of rubber elasticity, and as is well known in the statistical theory of rubber elasticity, the elastic force F is given by:

$$F = T\frac{\partial S}{\partial r}, \quad S = k\log W, \quad \Rightarrow \quad F = kT\frac{\partial \log W}{\partial r} \tag{5}$$

where T is the temperature density as the energy density, S is the entropy, r is the distance, W is the number of microstates, k is Boltzmann's constant.

Suppose the entropy structure of the space–time continuum, since the statistical entropy is the logarithm of the number of states (i.e., degeneracy of system), it is necessary to consider what kinds of physical state exist. Fig. 5(b) and (c) show that the open strings cling to the field of space. Fig. 5 (b) shows the state of the present cosmic space in ultra-low temperature, and Fig. 5(c) shows the state of the early universe in ultra-high temperature. The excitation of space implies that the ordered phase of open strings clinging to space in Fig. 5(b) is transferred to the disordered phase of open strings that clings to space in Fig. 5(c) by some trigger. It corresponds to that the number of twined open strings is transferred from ordered phase (small entropy) to disordered phase (large entropy). This picture indicates that these states can be interpreted as entropy [6].

3.3. Energy source for field propulsion

Any propulsion systems, i.e., not only conventional propulsion but also field propulsion, require huge energy sources due to their performance for producing high acceleration and high speed. This energy problem is common to all propulsion systems if high speed is required to the stars. In general, a spaceship (mass of M) traveling at a speed V needs the kinetic energy of $E_K = (1/2)MV^2$. For instance, a spaceship traveling at a speed equal to 0.1c has a specific kinetic energy equal to 450 TJ/kg (of spaceship mass). The required energy of spaceship of 100 t at a speed of 0.1c is 4.5×10^{19} J. Its power source in any propulsion system must provide huge energies, that is, $E=Pt$ (P is power in watts, t (s) is acceleration and deceleration time). Although this energy problem is common to all propulsion systems, field propulsion is not based on negative rest mass matter but allowable new technology.

Discovery and further investigation of new energy methods to power these propulsion systems is warranted.

4. Conclusions

The notions of substantial physical structure of space are discussed from the standpoints of both General Relativity in the view of macroscopic structure and Quantum Field Theory in the view of microscopic structure. The engineering technology to excite space at localized spatial area required for space travel may most likely require using some means of field propulsion in the near future.

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