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Energodynamic Theory of the Shawyer's Engine

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I. Introduction

In August 2013, the official website of NASA, there was a report on testing the model of the space engine "Cannae Drive" American inventor Guido Fett [1]. A year later, at a conference on the reactive movement, a report was made by a group of NASA employees who experienced this engine for 8 days in various modes and was convinced of its efficiency. Test tests showed that Fett's microwave engine generates a thrust of (30-50)·10-3 N.

The author of the idea of creating traction due to directed microwave radiation, British engineer Roger Shawyer in 2003, designed a series of demo-tion devices called "EmDrive" and did his best to attract attention to his invention [3-6]. In 2006, his electromagnetic engine was introduced to the world and during the demonstration created a thrust of 16·10-3 Newton. R. Shawyer even received a state grant for his EmDrive, but nothing convinced the critics: they denied the theoretical part of the work and insisted that the EmDrive engine is a closed system and, according to the law of conservation of momentum, can not work. The appearance of the generator Shawyer is shown in Fig.1. Its device is quite simple: the magnetron generates microwaves, and the energy of the oscillations accumulates in a high-Q copper resonator. The resonator is made in the form of a copper container in the form of a truncated cone and closed on all sides. The microwave generator (from the left) directs the radiation into the resonator, where it is repeatedly reflected from the walls of the hollow vessel and, due to the effect of the light pressure, creates a thrust from the side of the base of the cone. Thanks to this engine do not need traditional rocket fuel. Microwave radiation is generated solely by electric energy, which will feed the EmDrive engine from solar batteries, from thermoelectric radioisotope generators or from miniature nuclear reactors.

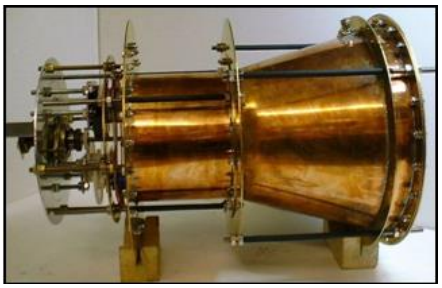

Fig. 1: Appearance of "EM DRIVE"

In 2009-2010, a Chinese research team from North Western Polytechnical University (Xi'an, China) built an analog "EmDrive" and confirmed that the thrust of the engine reached 720·10-3 N [7]. This is quite enough to practically use the device to adjust the orbits of communications satellites and other spacecraft. However, these experiments did not attract convincing physicists, the overwhelming majority of which recognize this idea as unscientific. Indeed, classical mechanics argues that to create a movement it is necessary "to push something off". Since the Scheuer engine "does not leave anything," its momentum must remain zero. This explains why the experts literally took up arms against Shawyer, calling his idea unscientific and even fraudulent. This reaction put the EmDrive testers in a difficult position, forcing them to express very vague considerations, such as the fact that the device Shawyer "demonstrates the interaction with the quantum vacuum of virtual plasma" [8]. The objections of Shawyer, based on the fact that the laws of physics, and their interpretation by physicists, are not mistaken, were not taken into account, as usual. He is meanwhile right, and this can be justified from the standpoint of energodynamics [9] as a more general theory from the viewpoint of which the Shawyer's device is not a closed system.

II. Energodinamics As A Unified Force Theory

Energodynamics generalizes the thermodynamic method of investigation to nonthermal forms of energy and continuous media with distributed parameters. The specificity of this method consists in

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considering the system as a whole, without the usual division of such a system into an infinite number of conditionally equilibrium elementary volumes. This required the introduction of specific "heterogeneity parameters" of the systems under study, capable of repelling the removal of them as a whole from an equilibrium of any kind. These parameters are the moments of the distribution $\mathbf{Z}_i = \Theta_i\Delta\mathbf{R}_i$ of the known thermodynamic parameters Θi (mass M, entropy S, charge $\mathcal{Z}$, number of moles k-th substances N_k, their momentum $\mathbf{P}_k$, its moment $\mathbf{L}_k$, etc.). These moments arise when the system deviates from a homogeneous state due to the displacement $\Delta\mathbf{R}_i$ of the radius vector of the center of these extensive $\mathbf{R}_i$ values from its equilibrium position $\mathbf{R}_{io}$. This position is determined in a known way

$$\mathbf{R}_i = \Theta_i^{-1}\int\rho_i(\mathbf{r},t)\,\mathbf{r}dV\,;\ \mathbf{R}_{io} = \Theta_i^{-1}\int\overline{\rho}(t)\,\mathbf{r}dV, \qquad (1)$$

where $\rho_i(\mathbf{r}, t)$, $\overline{\rho}(t)$ - - size density Θ_i and its average value; $\mathbf{r}$ - the "running" (Euler) coordinate of a point of the field; $i = 1,2,\ldots, n$ – the number of forms of energy in the system; t – time.

From here directly follows that the shift of energy carriers Θi is followed by the emergence of "the distribution moments" [9]:

$$\mathbf{Z}_i = \Theta_i\Delta\mathbf{R}_i = \int_V\left[\rho_i(\mathbf{r},t) - \overline{\rho}_i(t)\right]\mathbf{r}dV. \qquad (2)$$

with the arm $\Delta\mathbf{R}_i = \mathbf{R}_i - \mathbf{R}_{io}$, which we called the "displacement vector" [10].

Thus, the moment of distribution $\mathbf{Z}_i$ of each i-th form of U_i can change in the course of two independent processes, the coordinates of which are the parameters Θ_i and $\Delta\mathbf{R}_i$. This means that the total energy differential of the system $U = \Sigma_i U_i(\Theta_i, \Delta\mathbf{R}_i)$ can be represented in the form of the identity [9,10]:

$$dU \equiv \Sigma_i\Psi_i d\Theta_i - \Sigma_i\mathbf{F}_i\cdot d\mathbf{R}_i, \qquad (3)$$

where $\Psi_i \equiv (\partial U/\partial\Theta_i)$ are the averaged over the system values of its generalized potentials (absolute temperature T and pressure p, chemical μ_k, electric φ and gravitational ψ_g potentials, the components υ_α and ω_α ($\alpha = 1,2,3$) of the vectors speed of translational and rotational motion $\boldsymbol{\upsilon}$ and $\boldsymbol{\omega}$, etc., $\mathbf{F}_i \equiv -(\partial U/\partial\mathbf{R}_i)$ - forces in their general physical meaning.

In this expression, the terms of the first sum characterize the effects that do not violate the distribution of the parameters Θ_i in the volume of the system V, including the nonequilibrium heat transfer, the all-round deformation of the system, its mass exchange with the environment, the diffusion of kx substances through its boundaries, the electrization of the system, the translational and rotational acceleration of it as a whole, etc. The second sum of this expression, on the contrary, characterizes the work connected with the redistribution of the parameters Θ_i by the volume of the system and performed by the forces $\mathbf{F}_i$ "against equilibrium" in it. In isolated systems, where all processes are internal, identity (4) vanishes, but its terms still describe the energy exchange between its parts (components) and its interconversion. This allows us to expand the scope of the applicability of thermodynamic methods to isolated systems.

Fundamentally important for the energodynamic determination of the energy U is the uniform dimension of forces of any nature $\mathbf{F}_i$ and a unified method for their determination as functions of the nonequilibrium state of the system. This allows directly summing up forces of a different nature, determining their resultant, finding equilibrium conditions from the condition of their balance, and so on. This energy dynamic differs from other fundamental disciplines operating in terms of the electric and magnetic fields $\mathbf{E}$ and $\mathbf{H}$, the thermodynamic forces $\mathbf{X}_i = \mathbf{F}_i/\Theta_i$, surface tension, etc. Since the partial derivative $(\partial U/\partial\mathbf{R}_i)$ is in the constancy of all variables Θ_i and in the absence of displacements $\Delta\mathbf{r}_j$ of all other energy carriers ($j \neq i$), then $dU = dU_i$ and $d\mathbf{R}_i = d\mathbf{r}$. Consequently, the forces $\mathbf{F}_i = -(\partial U_i/\partial\mathbf{r})$ are gradients of the "partial" energy U_i taken with the opposite sign. Thus, the notion of force known as mechanics as a gradient of potential energy extends not only to inertial forces and centrifugal forces, but also to any (scalar, vector and tensor) fields, including vortex fields and temperature fields, pressures, chemical potentials, velocities, etc. [11]. These force fields are not reducible to the four known types of interaction. This, in particular, is the "spin-spin" and "orientational" interaction that causes the ordering of spin systems and rotation axes of celestial bodies [12], or an interaction that generates attractive or repulsive forces between rotating bodies [13].

It is in this unity of forces and interactions of a different nature that the "key" is to understand the "mechanism" of the interaction of the vortex electromagnetic field in the resonator of the Shawyer propulsor with a gravitational field, from which, as is known, no isolation exists.

III. How To Create Traction In The Shawyer's Engine

From the point of view of energodynamics, the Shawyer's engine is a device whose magnetron, with the help of a waveguide, creates a vortex electromagnetic field (EMF) in the resonator that has a certain kinetic energy of the vortex motion $dU\omega = \boldsymbol{\omega}\cdot d\mathbf{L}\omega$. This energy is distributed unevenly in the resonator due to the difference in its diameter and the angular velocity $\boldsymbol{\omega}$. As a result, the EMF acquires an inhomogeneous "vorticity" inside the resonator, characterized by a gradient of the angular velocity $\nabla\boldsymbol{\omega}$. The non-uniform distribution of the

amount of rotational motion (angular momentum) in the installation causes the displacement of its center $\Delta\mathbf{R}\omega$, which generates the "vorticity distribution moment" $\mathbf{Z}\omega$. It is one of the parameters of the spatial inhomogeneity of the system considered above and characterizes the removal of the system from the state of "homogeneous vorticity. If we are only interested in the component of the tensor $\mathbf{Z}\omega = \Delta\mathbf{R}\omega \times \mathbf{L}\omega$, which is directed along the resonator axis, then the value of $\mathbf{Z}\omega$ can be found from the expression analogous to (2):

$$\mathbf{Z}_\omega = L_\omega \Delta\mathbf{R}_\omega = \int[\rho_\omega(\mathbf{r}, t) - \bar{\rho}_\omega(t)]\mathbf{r}dV, \qquad (4)$$

where $\rho\omega(\mathbf{r}, t)$, $(t)\bar{\rho}_\omega(t)$ is the local and average density of the amount of this motion in the resonator; $L\omega$ is the axial component of $\mathbf{L}\omega$.

As in other cases, the appearance of an inhomogeneous vorticity produces a force

$$\mathbf{F}_\omega \equiv -(\partial U/\partial \mathbf{R}_\omega), \qquad (5)$$

called earlier *gyroscopic* due to the fact that it appears in gyroscopes and any other rotating bodies [13]. It is directed toward the base of the cone since the angular velocity of the vortex EMF rises with distance from it. Thus, we come to the conclusion that there is another kind of force in media with an inhomogeneous vorticity that is not reducible to its known species.

We now apply the identity (3) to the set of electromagnetic and gravitational fields of the Universe (i = 1,2), referring the terms with i = 1 to the EMF, and the terms with i = 2 to the gravitational field. Then it becomes obvious that for the universe as a whole, $\Sigma_i \mathbf{F}i \cdot d\mathbf{R}i = 0$ for the isolated system, since $dU = 0$ and $d\Theta i = 0$. Hence, the forces $\mathbf{F}i$ are interrelated, so that the interaction of electromagnetic and gravitational fields is inevitable, even if the eddy EMF is enclosed in a cavity closed for him. Thus, the appearance of thrust in experiments with the engines of Shawyer and Fett does not contradict any laws of physics [14]. It remains to confirm the reality of gyroscopic forces.

IV. Experimental Confirmation Of The Existence Of Gyroscopic Forces

Back in 1974, E. Latewaite (Eric Laithwaite) publicly demonstrated a spiral rotation of a gyroscope weighing 10 kg, suspended at one end of the rotor [15]. A very important addition to its results was the experiments of GA. Golushko [16], in which the gyroscope was isolated from the environment by paper screens of conical shape. In these experiments, thanks to a laser pointer attached to the free end of the gyroscope, it was possible to fix the trajectory of the gyroscope's rotational motion and to detect oscillations of the gyroscope rotation speed caused by a change in the direction of the gyroscopic traction vector. These experiments confirmed that the gyroscope is an open system whose vector of thrust is directed along the axis of the gyroscope.

Another effect - the apparent "weight loss" of rotating masses - was confirmed by precision measurements of the weight of rotating gyroscopes, performed in 1989 by Japanese physicists H. Hayasaka and S. Takeuchi [17]. Their studies showed that at speeds of $\sim 12 \cdot 103$ rpm the 175 g gyroscope loses in weight up to 10 milligrams, and the gyroscope, rotating clockwise, is lighter than the counter-clockwise gyroscope by an amount of the order of $7 \cdot 10^{-8}$ %.

In 2001, in the experiments of A.L. Dmitriev and her co-workers [18] found a systematic increase (up to 10 ± 2 cm/s^2) of the free fall acceleration of the container with two coaxial gyroscopes with a horizontal axis rotating at an angular velocity of 20,000 rpm.

S.V. Plotnikov performed very detailed studies of the interaction of rotating masses [19]. In his experiments, a smooth increase in weight was observed as the standard aviation gyroscopic autopilot with a mass of 540 grams was rotated to $20 \cdot 10^3$ rpm, and the difference in weight gain with the rotation of the gyroscope in the direction coinciding with the direction of rotation of the Earth and against it (520 and 430 mg, respectively).

The presence of the interaction of rotating bodies was demonstrated by a series of experiments by V.N. Samokhvalov [20] with two closely spaced (with a gap of 2-3 mm) discs 165 mm in diameter, fixed at the ends of the rotors of two coaxial DC motors. In his experiments, the appearance of torque during the unscrewing of one of the disks was measured by the magnitude of the braking torque of the other electric motor. These experiments revealed an increase in the torque of the "driven" disk by two orders of magnitude as the vacuum deepened in the container containing the device. This seemingly unexpected result also follows from the identity (5), according to which the potential of any force $\mathbf{F}i \equiv -(\partial U/\partial \mathbf{r}i)$ is determined under conditions of constant volume of the system V. In this case, the specific value of the force $\mathbf{F}i/M = \mathbf{x}i$ in [14, 15] by the thermodynamic force, can be expressed in terms of the density $\rho u = (\partial U/\partial V)$ of the energy of the system U by the simple expression:

$$\mathbf{X}_i = -\nabla\rho_u/\rho \qquad (6)$$

According to this expression, the intensity $\mathbf{x}i$ of any force field increases as the density ρ of the material medium decreases with the same value of the energy gradient. This consequence of the energy dynamics is directly related to the Shoyer's engine, indicating that its thrust in outer space can be even higher than that achieved in laboratory experiments.

Thus, the recognition of the existence of hidden matter as an all-pervasive environment from which all forms of matter of the Universe were formed, makes it possible to explain the appearance of thrust in the engine of Scheuer, without going beyond the framework of classical physics. The existence of gyroscopic forces may be an alternative to the reactive motion. Together with the lowering of the launch weight of spacecraft, more than 90% of which is fuel, the possible acceleration will also increase by an order of magnitude. The duration of flights, even within the solar system, will be reduced. It will become easier and cheaper to adjust the orbits of satellites and orbital stations. All this opens up new prospects for the exploration of outer space.

V. Conclusion

1. The apparent violation of the law of conservation of momentum by the Shawyer's engine is due to the limited nature of the concepts of classical mechanics about closed systems. There are no closed systems for gravitational systems.
2. Introduction of parameters of spatial heterogeneity of the studied systems finds the dependence of any form of internal energy of such systems on the position of the center of her material carrier. It allows finding the internal forces and the moments characterizing their nonequilibrium state earlier not giving in to the definition.
3. In non-closed systems, the appearance of such forces is equivalent to the acquisition by the system of additional external energy, which becomes, therefore, dependent on the internal state of the system. A consequence of this is the existence of a new form of interaction with the external environment, not accounted for by mechanics. This, in particular, is the interaction of rotating bodies.
4. Among the additional forces of interaction with the external environment, arising from the inhomogeneity of the system, there is a gyroscopic force due to the inhomogeneity of the vortex electromagnetic field created in the Shawyer's engine by the magnetron. This force also generates its thrust, found in the experiment.
5. The validity of the conclusions of energodynamics is confirmed by the fact of the existence of gyroscopic forces, found in a variety of experiments and observations. This allows us to explain the thrust of the Shawyer's electromagnetic motors, without going beyond the framework of classical physics.

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