

# The engine " Em Drive " for space flights, and the laws of physics.

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The article is a development of article Burago SG "On the nature of the engine thrust EmDrive". In this paper, it was proposed a theoretical justification of nature thrust of EmDrive engine. This study is within the concepts of mechanics about reactive force and representations about gaseous dark matter. It was determined the value of pressure increase and the speed of the jet of gaseous dark matter that arises into space for the micro waves, generated by the resonator of the engine, which converts electricity into microwaves. However, in this work was not understood the mechanism of transition of the power of electricity into pressure and into the traction of EmDrive engine. In this article, this mechanism has been understood and described. The formulas for calculating the pressure increase and traction was obtained, if we know the power supplied to the electric motor. The calculation with these formulas showed good agreement with the experimental data.

Drafts NASA of the article in which reaffirms the operability of engine EmDrive [1], had flowed into the Internet and caused a stir. This engine allegedly requires no fuel. According to the experts of Eagleworks laboratory, the engine develops a thrust of 1,2 milliNewtons per kilowatt. And it works is probably using a vacuum energy. Should we believe this? (The big supporter of engine Phil Wilson (Phil Wilson) had published on this site of forum NASA post Spaceflight under the name The Traveller. However the moderators removed it, explaining that the article should be published by the American Institute of Aeronautics and Astronautics officially in December 2016. However, the site "the Next Big Future" has provided access to documents and diagrams, contained in them. It finally do its available to the public).

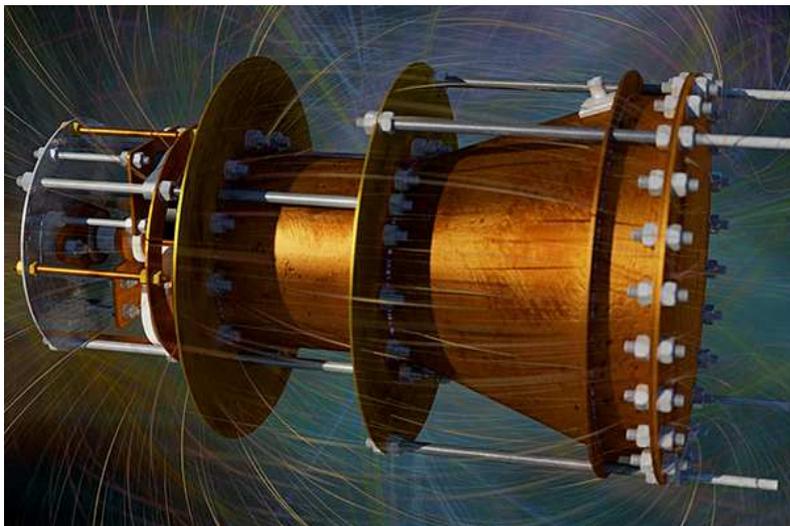


Fig.1

The NASA researchers have reported the successful repetition of the experiment conducted by the British engineer Roger Scheuer in 2006 year. He managed to create a rotary engine that produces no emissions, and to show that the device is subject to the laws of Newtonian mechanics. According to the developer, the device converts the electricity into microwaves. Their energy is stored in the resonator. A little thrust of the engine is the result. Since then, scientists are try to understand the mystery EmDrive: if it works, and if so, why? After all, according to the law of conservation of momentum, the thrust is due of jet stream. In other words, in order to the object moved forward, it is necessary that from him something bounced in the opposite direction.

In the study used a torsion pendulum - aluminum construction, mounted on a slippery table in a vacuum chamber. Such a device is capable of measuring even very weak engine thrust. On one arm of the pendulum was EmDrive, and as a result it is a series of tests at 40, 60 and 80 watts power showed in 1,2 milliNewtons per kilowatt in vacuo. The tests did not reveal any unaccounted sources of motion, but experts have recognized the need for additional research to eliminate distortion from factors such as thermal expansion.

The last version of the engine was patented by inventor Roger Scheuer at the end of October 2016. The new modification is characterized by the presence of superconducting plate. According to the scientist, this can reduce the relatively casual observer the change the frequency of the electromagnetic wave as it propagates in the engine cavity and thus increase the traction EmDrive.

The scientists, which are trying to understand the principles of operation of the engine, is believed that the law of conservation of momentum is maintained, but easy to explain it is quite difficult. So, Michael Makkalosh from the University of Plymouth (UK), admits the existence of photons with mass, and changing the speed of light inside the device. Another hypothesis suggests repayment of microwaves, resulting the pairs of photons is born and transfer momentum. This can happen only in the cone-shaped cavities.

Some scientists suggest the existence in the space around us of quantum vacuum environment that supports the acoustic oscillations, and that the components of any such medium is capable of exchanging by the momentum. So, you can to make a work into the vacuum and extract from it the energy that determines the performance of the engine. However, these assumptions are beyond the scope of modern concepts of physics, which is rejecting the presence of a continuous space of the gaseous medium, and are unlikely they may to convince other professionals.

Contrary to this view the article NASA states that the engineers have achieved a positive result. It is assumed that these engines can be used on spacecraft for interplanetary missions. Theoretically, the flight to Mars with this engine would only lasted ten weeks.

We also believe that modern physics, rejecting the existence in the space of continuous gaseous medium, itself creates the own problems. By this the physics impoverishes its tools to solve these problems. Author of this article has shown in his works [2,3], that the recognition by the physics of the presence in the surrounding space of a gaseous dark matter allows to reveal the nature of gravity, inertia, or differently to look at the nature of the "Big Bang" and many other mysterious phenomena in physics and astronomy. In these papers it was theoretically determined the physical parameters of the interstellar gaseous of dark matter. It is shown in particular that it has a density, a mass inertia interacts with ordinary baryonic matter and may exert force effect on a baryonic body.

Next, based on the ideas of [2,3], we will consider the nature of the forces thrust EmDrive from the standpoint of the theory of the interstellar gas of dark matter that fills all the space around us. For this we turn to Fig.2. If at a point O a small change in pressure occurs, then this the change will spread further from the source O in the form of a spherical wave of compression or vacuum (weak perturbation) thanks to the elasticity of gas.

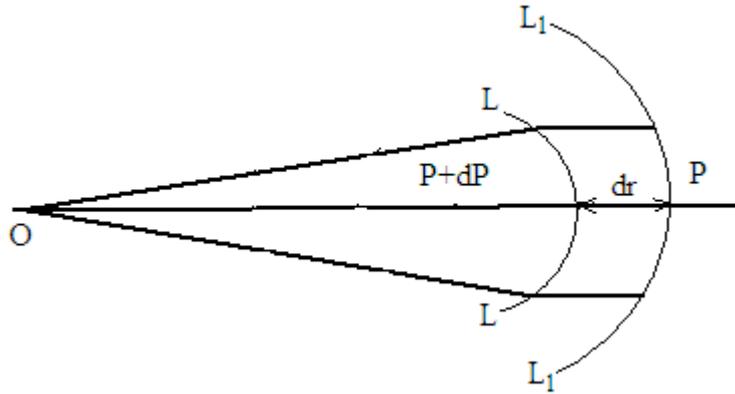


Fig.2

Assume that L is the position of the wave at time t, and  $L_1$  is position at time  $t+dt$ . If the wave propagation speed of weak perturbation is equal to the speed of light in vacuum  $C=3 \cdot 10^8$  m/s, then the distance between L and  $L_1$ , is equal to  $dr = C \cdot dt$ . Assume further that  $p_e + dp_e$  is pressure to the left of the line L, and p is pressure to the right of the line  $L_1$ , then the composition

$$dp_e \cdot \Delta s \cdot dt$$

will give us the momentum of pressure forces acting along the radius r on the considered column of gas during the time dt. Under the influence of this impulse the mass of column gas  $dm = \rho_e^* \cdot \Delta s \cdot dr$ , expressed in units of baryons [2,3], will get in the direction of radius r the speed dw and the corresponding the amount of the movement

$$dm \cdot dw = \rho_e^* \cdot \Delta s \cdot dr \cdot dw$$

Equating the pressure pulse forces to a change of momentum and taking into account that  $dr = C \cdot dt$ , after minor cuts we get

$$dp_e = \rho_e^* \cdot C \cdot dw,$$

from where the velocity of gaseous dark matter, induced by wave in the direction of its movement, will

$$dw = dp_e / \rho_e^* \cdot C.$$

where  $C = 3 \cdot 10^8$  m/s - the speed of light (in a vacuum). The density of gaseous dark matter  $\rho_e^* = 3,54 \cdot 10^{-9}$  kg/m<sup>3</sup> expressed in terms baryonic matter [2,3]. The density was obtained in [2,3]. The previous expression in the finite-difference can be written as

$$V_e = \Delta W = \frac{\Delta p_e}{\rho_e^* \cdot C}, \quad (1)$$

The pressure force in one direction accelerates the gaseous particles of dark matter, and in the opposite direction the pressure force acts on the elements of engine design EmDrive and creates thrust force

$$F = \Delta p_e \cdot S \quad (2)$$

As the area  $S$  we will take the area of the resonator engine EmDrive. In the absence of accurate data about the size of the engine we will take  $S = 1 \text{ m}^2$ . The force applied to the design elements of the engine is equal to the pressure multiplied by the cross-sectional area, which is equal to  $S = 1 \text{ m}^2$ . Of course, the pressure is not created by a single wave. As noted in [1], the device of engine continuously converts electricity into microwaves, their energy is stored in the resonator. The pressure of all the microwaves around the cross-section of the resonator of the engine remains the same as in the case of a single wave. As a result of this pressure on the engine design elements is a slight force of the engine thrust.

This power (on 1 kilowatt) according to [1] is equal to

$$F = \Delta p_e \cdot S = 1,2 \cdot 10^{-3} \quad [\text{N}] \quad (3)$$

From this the excess pressure behind the wave will

$$\Delta p_e = 1,2 \cdot 10^{-3} = 0,0012 \quad [\text{N/m}^2] \quad (4)$$

According to the formula (1), we define the speed of the gaseous dark matter behind the wave

$$V_e = \frac{1,2 \cdot 10^{-3}}{3,54 \cdot 10^{-9} \cdot 3 \cdot 10^8} = 0,113 \cdot 10^{-2} = 0,00113 \quad [\text{m/c}] \quad (5)$$

These pressure and velocity gaseous dark matter after a wave is provide the emergence of the force acting on the elements of engine design. (The value of this force was given by NASA considered in the article). These values of velocity, and force pressure are not large. But in [2,3] shown, that a small radial velocity gas streams of dark matter  $V_r = 9,8 \text{ m/s}$  to the Center of the Earth creates the power of the Earth gravity.

If beforehand we would have known the value of the differential pressure  $\Delta p_e$  in the wake of weak disturbances, emitted by the engine device, which converts electricity into microwaves, it would be possible to determine the speed of gaseous dark matter and traction of engine. It is unclear how, regardless of the NASA article about EmDrive engine to find the pressure drop and the speed of dark gaseous matter after wave, obtained in [4] ? In [1] correctly notes that according to the law of conservation of momentum, the thrust is due to the jet stream. To object moved forward, it is necessary that from him something "bounced" in the opposite direction. The cork of mass of a gaseous of the

dark matter, which is moving behind the wave, "bounces" in this case. Under the influence of the pressure inside the engine nozzle has local gas jet stream of dark matter. Thus, it is clear that the engine EmDrive can create traction, without violating the laws of physics.

The invention EmDrive engine from our point of view, is have more than the practical significance of the invention of a new economical propulsion. For physics, this is a great ideological breakthrough in the understanding of the world order, which is opening the way to use the inexhaustible dark energy of the cosmos [2,3].

As a working hypothesis to the problem of definition the pressure  $\Delta p$  we can bring our assumption that the power of electric current, entered to engine EmDrive, spent on acceleration of the mass  $m$  of gaseous dark matter with a velocity

$$V_e = \frac{\Delta p}{\rho_e^* \cdot C} \quad (6)$$

As the mass of the product we will take volume of circular the segment (Fig.3) with a radius  $r = C \cdot \Delta t$  and a width  $l$ , multiplied on the density of the gas in the dark matter [2,3]. The width  $l$ , is equal to the nominal size of the resonator

$$m = 0,00873 \cdot C^2 \cdot \rho_e^* \cdot \theta^o \cdot (\Delta t)^2 \cdot l, \quad (7)$$

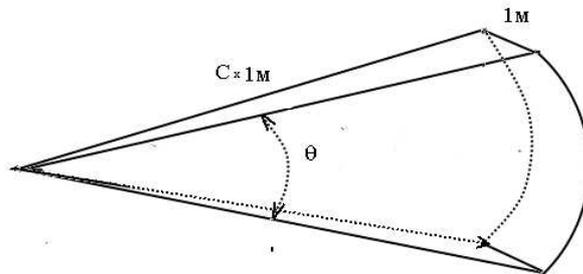


Fig.3

In this case, the energy, which was supplied during a every second in the resonator  $E = N \cdot 1s = 10^3 J$  should be equal to kinetic energy of the gaseous mass of dark matter inside the segment under consideration

$$E = \frac{m \cdot V_e^2}{2} = 0,00873 \cdot C^2 \cdot \rho_e^* \cdot \theta^o \cdot (\Delta t)^2 \cdot l \cdot \frac{1}{2} \frac{(\Delta p)^2}{(\rho_e^*)^2 \cdot C^2}, \quad (8)$$

From this the pressure increase can be expressed by the formula

$$\Delta p = \sqrt{\frac{2 \cdot E \cdot \rho_e^*}{0,00873 \cdot \theta^o \cdot (\Delta t)^2 \cdot l}} \quad (9)$$

The calculation on this formula allows to obtain the required growth of the value pressure after front of the microwaves, emitted by the engine resonator. The density of gaseous dark matter is  $\rho_e^* = 3,54 \cdot 10^{-9} \text{ kg/m}^3$  [2.3]. As the width of the circular segment we assume  $l=1\text{m}$  (equal to the nominal size of the resonator). As interval of the time we take value  $\Delta t=1\text{s}$ , because the power  $N=1 \text{ kW}$ , which supplied in the motor, represents the energy supplied for one second  $\Delta t=1\text{s}$ . (Fig. 3)

$$\Delta p = \sqrt{\frac{2 \cdot E \cdot \rho_e^*}{0,00873 \cdot \theta^o}} = \sqrt{\frac{2 \cdot 10^3 \cdot 3,54 \cdot 10^{-9}}{0,00873 \cdot 180^o}} = \sqrt{4,5 \cdot 10^{-6}} = 2,12 \cdot 10^{-3} \text{ [N/m}^2\text{]} \quad (10)$$

Here we choose the angle 180 degrees due to the fact, that, the waves of weak perturbation and the bung of gaseous dark matter was distributed only in a direction opposite to the direction of the engine thrust. The pressure force in one direction accelerates the gaseous particles of dark matter, but in the opposite direction affects on the engine design of EmDrive and creates a traction force

$$F = \Delta p_e \cdot S \quad (11)$$

As a result, the pressure  $\Delta p$  after the microwaves acts on all elements on the design of the engine and creates a slight pull. This force of traction ( on 1 watt) by carrying out the calculation is

$$F = \Delta p_e \cdot S = 2,12 \cdot 10^{-3} \text{ [H]} \quad (12)$$

This value is only twice the value obtained in the experiment for EmDrive engine. If you reduce the area of the resonator to a value  $S = 0,566 \text{ m}^2$ , the force will be equal to the value obtained in the experiment  $F = 1,2 \cdot 10^{-3} \text{ [H]}$ . Perhaps a loss of input power to the engine there is when converting it into kinetic energy of traffic jams of the gaseous dark matter behind the front of the microwaves. Therefore, the coincidence can be considered satisfactory.

We are in this case not so much interested in complete agreement with the experimental results of calculations as the validity of our assumption that the engine thrust occurs due to the reactive action of gaseous jets of dark matter from the nozzle EmDrive engine. At the same time we must note that the formula (9) is obtained based on the idealized model shown in Figure 3. In the actual design of the engine the pressure, which was determined by this formula, will retain its value only in the vicinity of the resonator, and the engine nozzle. As the distance waves of weak perturbation from the engine the pressure will decrease back to the square of the distance. Nevertheless, the formula (9) may be used for the constructing of the engines of type EmDrive. It can be seen that the higher power value is supplied to the engine, the more pressure will increase and therefore the thrust. However, this increase in pressure and thrust is the proportionality to the square root of the energy input every second, i.e. power.

## Bibliography :

1. Sucked into a pacifier. The good operation of engine EmDrive, by which was violated the physics laws, was confirmed . <https://lenta.ru/articles/2016/11/09/emdrive/>
2. Burago S.G. Gravity, dark matter and dark energy balance. The General Science. April, 25.2014

3. Burago SG The space objects in the ocean of interstellar dark matter. ResearchGate.  
DOI: 10.13140/RG.2.2.21497.88160
4. Burago S.G On the nature of the engine thrust EmDrive. ResearchGate. Working Paper  
DOI: 10.13140/RG.2.2.32133.55527. 11.2016

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