TRANSFORMING THE ENERGY OF VACUUM BY USING THE OSCILLATOR BASED ON CASIMIR EFFECT

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Abstract. The article shows the possibility of extracting energy from vacuum using an electric oscillator model based on Casimir's effect with split mirrors rotating relative to each other. Since, according to existing physical concepts, unilateral extraction of energy from vacuum is impossible, the task goes into experimentally detecting tangential forces in Casimir's effect during the relative rotation of the mirrors that slows down this rotation.

Keywords: Casimir's effect, vacuum energy, rotating mirrors, tangential forces.

Conflict of interests. The authors declare no conflict of interest.

ПРЕОБРАЗОВАНИЕ ЭНЕРГИИ ВАКУУМА С ПОМОЩЬЮ ГЕНЕРАТОРА НА ОСНОВЕ ЭФФЕКТА КАЗИМИРА

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Аннотация. Показана возможность извлечения энергии из вакуума с использованием модели электрического генератора на основе эффекта Казимира с вращающимися относительно друг друга разделенными зеркалами. Поскольку, согласно существующим физическим представлениям, одностороннее извлечение энергии из вакуума невозможно, задача состоит в экспериментальном обнаружении тангенциальных сил в эффекте Казимира при относительном вращении зеркал, замедляющих это вращение.

Ключевые слова: эффект Казимира, энергия вакуума, вращающиеся зеркала, тангенциальные силы.

Конфликт интересов. Авторы заявляют об отсутствии конфликта интересов.

Introduction

Vacuum is a state of quantum fields (bosons: electromagnetic photons, fermions: electron-positron "Dirac sea") with the lowest energy density [1–3] and this lowest energy density does not equal zero in accordance with modern physical concepts. Indeed [2, 3], the spectrum of possible particle states, taking into account the Heisenberg uncertainty principle, is defined as

$$E_n = \hbar\omega\left(n + \frac{1}{2}\right), \; n = 0, 1, 2, ...,$$ (1)

where E_n are the permissible energy values $\hbar$ (the reduced Planck constant); $\omega = 2\pi f$; f – the particle frequency.

The lowest energy state ("zero energy") corresponds to $n = 0$, and it gives the final energy value

$$E_n = \frac{1}{2}\hbar\omega.$$ (2)

If a certain volume V in a vacuum is limited by the walls, then the zero-point energy in it depends on the size and shape of the volume boundaries [2, 3] due to the admissible ω set depends on them and corresponding them virtual particles. And as a result of above, then changing the size and shape of the walls drives to ones does the work and certain the forces act on the walls [2, 3]. One example of such forces is the attraction force between two parallel conducting mirrors in Casimir's effect, predicted by Heinrich Casimir in 1948. The formula [4] presents this attractive force

$$F_c = \frac{c\hbar\pi^2}{240d^4}S,$$ (3)

where F_c is the attraction force of the mirrors directed normally to their surfaces; c is the speed of light in a vacuum; S is the area of the mirrors; d is the distance between the mirrors.

Formula (3) was confirmed experimentally with high accuracy, and in 2011 the dynamic Casimir's effect was discovered: when vibrating one of the two mirrors generated electromagnetic radiation [4].

Casimir's force phenomenon opens up the application possibility of vacuum energy in creating the new engine design. One can be the following: a sector-separation mirror (equal sectors with spraying and voids) is sprayed onto a piezocrystal plate. The same mirror is mounted on a rotating disk underneath the first mirror. When the disk rotation frequency and the piezocrystal resonant frequency equals, elastic vibrations are excited in upper disk and is generated piezoelectricity due to periodically appearing Casimir' forces. This scheme is practice one, but difficult to analyze and calculate. Therefore one considers an analog design circuit in which the piezoelectric crystal is replaced by a mechanical oscillating design with an induction coil.

The scheme of oscillator design analog

The oscillator construction scheme presents Fig. 1, *a* (cross section), where: 1 – the top mirror; 2 – the lower mirror is driven by motor 3; 4 – the elastic spring; 5 – the axial pin with locking device 6; 7 – the induction coil is excited by the axial magnet vibrations 8 mounted on axis 5; 9 – the oscillator housing. Mirror 1, spring 4, axial pin 5 and magnets 8 attached to it represent a mechanical one-dimensional (only in the axis direction) oscillatory system, the losses in which are caused by braking magnet movement 8 by the induced magnetic fields in coil 7. Mirror 2, fixed in the axial direction, is driven into rotation by motor 3. Thus, the movement direction of mirrors 1 and 2 are mutually orthogonal (without related). The sector-cut mirror structures are identical and are presented on Fig. 1, *b*. When rotating mirror 2, the complete alignment moments of the mirror surfaces and zero alignment are repeated.

The modeled oscillator

To describe one-dimensional mechanical vibrations in the oscillator, one takes the direction of the vibration axis X from mirror 1 to the mirror 2 (downwards – according to the drawing). Due to it the system oscillates 1–4–5–8 (Fig. 1, *a*) in accordance with [5] is described by the following equation:

$$m\frac{d^2 X}{dt^2} + \beta\frac{dX}{dt} + kX = F_c(t),$$ (4)

where m is the mass of the oscillatory system; β is loss coefficient in the exciting induction system 7–8; k is spring stiffness coefficient; $F_c(t)$ is variable Casimir's force.
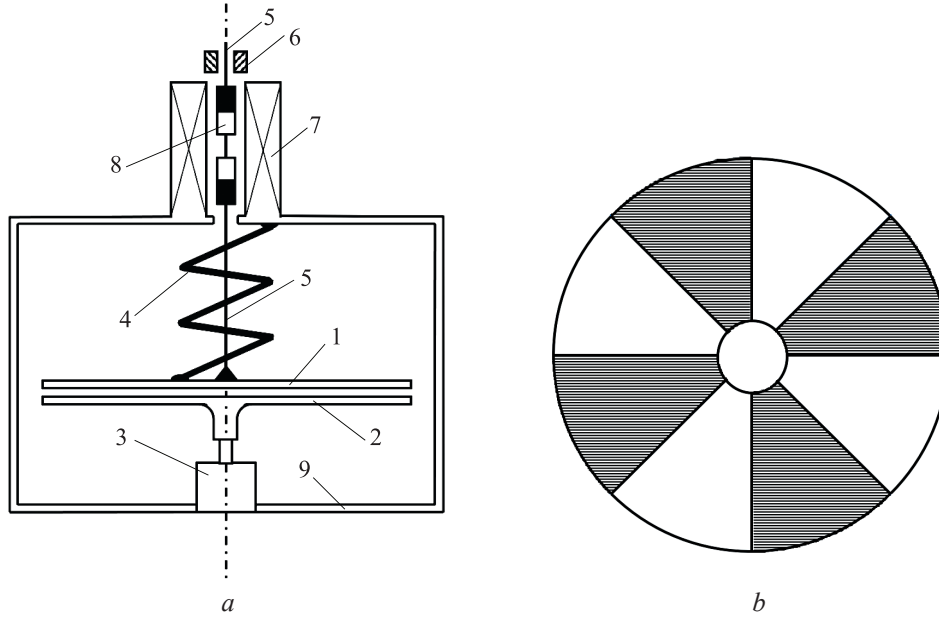
Fig. 1. Construction scheme of the oscillator

Dividing both sides of (4) by m, one obtains the standard vibration equation

$$\frac{d^2 X}{dt^2} + \alpha \frac{dX}{dt} + \omega_0^2 X = \frac{F_c(t)}{m},$$ (5)

where $\alpha = \frac{\beta}{m}$ is the damping coefficient; $\omega_0 = \sqrt{\frac{k}{m}}$ is the eigen system frequency.

Next, one introduces dimensionless variables and parameters: $y = \frac{X}{d}$, d is the distance between the mirrors in the neutral relative position of the split mirrors, i. e. when the mirror overlap area is zero (in (3) $S = 0$), $\theta = \omega_0 t$, $p = \frac{\omega}{\omega_0}$, ω is the rotation frequency of the lower mirror, $\bar{\alpha} = \frac{\alpha}{\omega_0}$. Then, taking into account (3), one obtains the final dimensionless vibration equation of the system:

$$\frac{d^2 y}{d\theta^2} + \bar{\alpha} \frac{dy}{d\theta} + y = \frac{A}{(1-y)^4} F_n(p\theta),$$ (6)

where $A = \frac{c\hbar\pi^2 S_m}{240 d^5 \omega_0^2 m}$; $F_n(p\theta) = \begin{cases} \dfrac{2(p\theta - n\pi)}{\pi}, & \theta \in [\pi, n\pi + \dfrac{\pi}{2}]; \\ 1 - \dfrac{2(p\theta - n\pi)}{\pi}, & \theta \in [n\pi + \dfrac{\pi}{2}, (n+1)\pi]. \end{cases}$

The initial conditions for (6) have the form

$$y(0) = 0, \quad \frac{dy}{d\theta}(0) = 0.$$ (7)

In accordance with [5, 6], the energy obtained in the oscillatory system load for one period given notation is expressed as: $\Delta E = \bar{\alpha} m d^2 \omega_0^2 I$, $I = \int\limits_0^{2\pi} \left(\frac{dy}{d\theta}\right)^2 d\theta$. Accordingly, obtained the power P is calculated as

$$P = \frac{\Delta E}{T_0} = \frac{\bar{\alpha} m d^2 \omega_0^3}{2\pi} I.$$ (8)

The calculation data

The calculation carries out for four oscillator cases:
1) $A = 0,112$; $\bar{\alpha} = 0,35$; $p = 0,4$; $I = 0,243$;
2) $A = 0,112$; $\bar{\alpha} = 0,65$; $p = 0,3$; $I = 0,09$;
3) $A = 0,112$; $\bar{\alpha} = 0,1$; $p = 0,5$; $I = 0,154$;
4) $A = 0,112$; $\bar{\alpha} = 0,35$; $p = 0,5$; $I = 0,059$.

The plots for the first three options are shown in Fig. 2. In all cases can see the dependences $y(p\theta)$, the oscillation modes are stable.
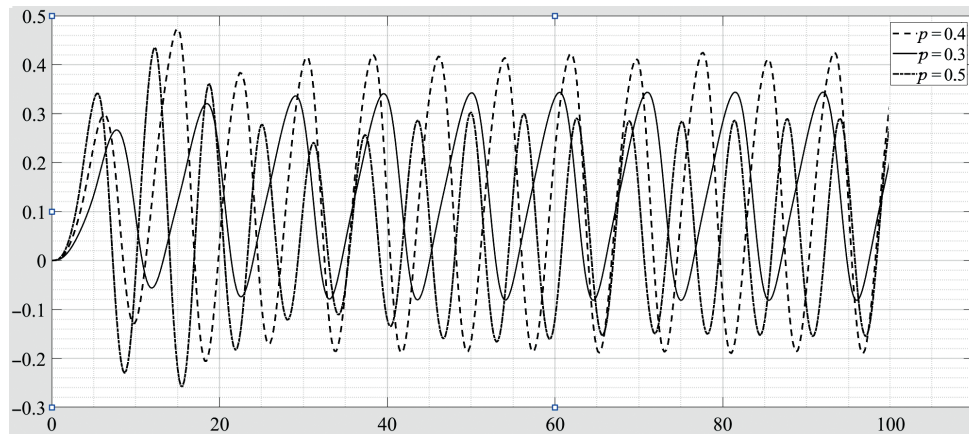

Fig. 2. Dependence plots $y(p\theta)$

Let us turn to the calculation of the powers extracted from the vacuum in presented the three cases. To do this, one uses formula (8), and for given A, $\bar{\alpha}$, I remain free to choose a combination of parameters: S_m, m, d, ω_0. If one takes into account the original design of the piezoelectric crystal oscillator [7, 8], then the permissible values f_0 $(\omega_0 = 2\pi f_0)$ can reach $10^3 \div 5 \cdot 10^4$ s^{-1} (ultrasonic range). So, the possible options for parameters are presented in Tab. 1.

Table 1. Generator parameters

Parameter	S_m, m^2	m, kg	d, m	f_0, Hz	P, W
1.1	0,53	0,100	10^{-6}	100	$3,36 \cdot 10^{-7}$
1.2	0,10	0,100	$0,7 \cdot 10^{-6}$	105	$1,9 \cdot 10^{-7}$
1.3	0,01	0,010	$0,7 \cdot 10^{-6}$	105	$1,9 \cdot 10^{-8}$
1.4	0,01	0,019	10^{-7}	10^4	$6,38 \cdot 10^{-4}$
2.1	0,53	0,100	10^{-6}	100	$2,31 \cdot 10^{-7}$
2.2	0,10	0,100	$0,7 \cdot 10^{-6}$	105	$1,31 \cdot 10^{-7}$
2.3	0,01	0,010	$0,7 \cdot 10^{-6}$	105	$1,31 \cdot 10^{-7}$
2.4	0,01	0,019	10^{-7}	10^4	$4,4 \cdot 10^{-8}$
3.1	0,53	0,100	10^{-6}	100	$6,1 \cdot 10^{-8}$
3.2	0,10	0,100	$0,7 \cdot 10^{-6}$	105	$3,45 \cdot 10^{-8}$
3.3	0,01	0,010	$0,7 \cdot 10^{-6}$	105	$3,45 \cdot 10^{-9}$
3.4	0,01	0,019	10^{-7}	10^4	$1,16 \cdot 10^{-4}$

The resulting values P are quite noticeable and measurable. However, if one adheres to modern physical views, unilateral energy extraction from vacuum is impossible [3]. This energy must come from outside. In the device considered, such a source can only be the energy required to rotate the lower mirror 2 relative to mirror 1 in a vacuum. In other words, in a vacuum, one can arise only braking forces tangential to the surface of the mirrors.

There is no information about such forces. Therefore, the data presented the article pose a very relevant task for experimental research: to detect and study the tangential forces that arise during parallel mirror displacement in a vacuum. These studies can be carried out both on special installations

and in the circuit of oscillator proposed the article to measure the power of motor 3 necessary to ensure the rotation of mirror 2.

Conclusion

Thus, the article substantiates the formulating an actual experimental problem for detecting and studying tangential forces arising in a vacuum with a parallel mirror shift due to Casimir's effect. If these forces are not discovered, the possibility of direct using vacuum energy opens up, which is denied at the present time.

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Authors' contribution

The authors contributed equally to the writing of the article.

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