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New energy sources for space exploration

Abstract

Fuel for the energy supply in space travel must be elevated by other fuel, requiring more fuel for its elevation. The consequence is a limit to the size of space transporting systems and to the duration of travel. This limitation can be removed, if an energy supply can be constructed, which doesn't need to combust ponderable matter. A possible appropriate energy source is the zero point energy of the quantum-vacuum (ZPE). The necessary research is the development of an energy converter, which can tap ZPE-energy from the quantum vacuum. An electrostatic rotor presented here, which the author analyzed at the Otto-von-Guericke-University in Magdeburg, demonstrates a verification that ZPE-energy can be converted into classical mechanical energy. Due to the small amount of converted power (150 nanowatts), the experiment is regarded as a fundamental scientific proof, not as an engineering construction of a ZPE-motor. Additionally, computer-simulations of a powerful ZPE-engine are developed in theory, arising the expectation to operate in the range of several hundred watts or some kilowatts – with the future perspective to build a prototype of a useful engine. If energy can be gained from the quantum-vacuum, the recoil of photons can be used for propulsion techniques.

Keywords

Space travel techniques; Energy supply; Propellant for space exploration; Photon recoil propulsion; Energy from the quantum-vacuum.

INTRODUCTION

The energy supply for space travel techniques, for satellites in earth's orbit as well as for deep space travel, arises several requirements, which are not necessary for the energy supply on earth. One very important central aspect is the minimization of the ponderable mass of the propellant, i.e. the fuel necessary for the energy supply. Therefore it is highly recommendable to avoid transportation of fuel at all, and to gain the necessary energy directly at the position, where it is needed. Solar cells might solve this problem. An alternative solution is the utilization of the zero point energy of the quantum-vacuum (ZPE), which is the topic of the present paper.
Several theoretical approaches to ZPE-conversion are under investigation, most of them not available for public discussion, due to confidentiality reasons[1]. One rather new principle is the "Principle of the Finite Propagation Speed of the Interacting Fields" (FPSIF)[2], which is mostly based on the retarded potentials by Liénard and Wiechert[3,4]. One of its main consequences is the fact that alterations of electrostatic and magnetic fields propagate with the speed of light. This gives the possibility to move electrical charges, and to compare the motions of the charge and of the field in a way, that the real value of the field (at a given point of observation) strength is different from its value, as it would be in the (quite widespread and usual) approximation of infinite propagation speed of the interacting fields. The difference of the exact consideration, taking the finite propagation speed of the field into account, and the approximation, not taking this speed into account, will provide the possibility, to extract energy from the quantum-vacuum[5]. Details are explained in section 3 of the preceding paper.
A very first approach to verify this theoretical concept experimentally, and to prove its capability to convert energy from the quantum-vacuum into classical energy, was given by the author as a research guest at the Otto-von-Guericke-University in Magdeburg in 2008 and 2009, as being reported in section 4 of the preceding article[6,7].

Based on this successful verification, which converted a power of 150 nanowatts, a further theoretical development of powerful ZPE-engines has been performed, and the construction principles are explained in the section 5. Additionally, in section 6 an interesting alternative is added.

ZPE-CONVERSION REPORTED IN LITERATURE

Small light-emitting diodes operating above unity efficiency are reported by the Massachusetts Institute of Technology[8]. Under appropriate conditions, the coefficient of performance (COP) can be brought up to a value of more than 200%, with respect to the conversion of electrical energy into the energy of the emitted light. The discussion is, in how far thermodynamical effects play a role, namely the additional conversion of thermal energy into light energy. If this would be really the case, the question arises, in how far a violation of the second law of thermodynamics must be discussed in this case – or in how far some conversion of entropy of the quantum-vacuum is responsible for the explanation of the experiment. Nevertheless, for the sake of clean energy supply, a converter of entropy of the quantum-vacuum is the same acceptable as a source of energy. It should be mentioned, that the power being converted in this MIT-experiment is in the picowatt-range.

Larger power being converted (namely in range of several watts) from unknown and invisible source, is reported by Lutec[9] in Australia. Information about the official testing report, done by the Société Générale de Surveillance SA (the world's largest certifying agency, coming from Geneva, Switzerland) can be seen at[10]. According to this analysis and report, the Lutec-device converts electrical energy back into electrical energy again, obtaining COP-values in the surprising range between 289% and 1440%, depending on the mode of operation of the device. Due to reasons of confidentiality, Lutec does not explain the working principle nor the underlying theory of physics. The only information about these topics can be found in the US-patent by Ludwig Emma Brits and Victor John Christie[11]. A photograph of the experimental setup and the inventors is displayed at[12].

Another electromechanical converter, consuming about 200 watts of electrical energy, and producing a bit more than 600 watts of mechanical energy in the output, is reported by Terawatt Research LLC – also with the capability to gain some additional energy from an unknown and invisible source[13]. The testing procedures with official certificates are made by the German inspection agency of TÜV Rheinland of America Inc. and by the American Underwriters Laboratories Inc. from the USA.

There are many other ZPE-converters or devices being generally known, even if the theoretical background is still not explained sufficiently. A book with an overview about such facilities can be found at[14], giving an overview over nearly 50 different such methods, to tap such energy from unknown sources. Nevertheless all these devices have in common, that the inventors did not elaborate their theoretical fundaments completely, but they developed their devices more or less experimentally respectively practically. The unique feature of my work reported in the present paper is, that it describes a theory of ZPE-conversion. The work began with a theoretical analysis, and after the theoretical investigations came to a certain point of results, the experiment was performed to verify the theory.

FUNDAMENTAL THEORY

The very fundament of a possible theory of ZPE-conversion (as it is applied by the author of the present paper) is the FPSIF-principle as mentioned in the intro-duction, indicating that the fields (and forces) of all fundamental interactions in physics can propagate only with finite speed, at least maximum with the speed of light, which is at natural limit to speed at all, due the speed limit of the theory of relativity. This is the case by principle, for all four fundamental interactions of physics, such as gravitation, electromagnetic interaction, strong and weak interaction. In the present work, this principle is applied to the electromagnetic interaction, namely to the electrostatic field and to the magnetic field. In the example of the electrostatic, the magnetic and the electromagnetic field, we know from the mechanism of the Hertz'ian dipole emitter, that the propagation speed of the fields really reach the full speed of light, when those fields propagate in the vacuum free from other fields[15-17].

This FPSIF-principle has two aspects, a static one and a dynamic one, to be explained separately in the sections 3.1 and 3.2.

The static FPSIF-principle

The static FPSIF-principle can be understood, based on the field flux being emanated into the space, originating from an electrostatic charge or from a magnet. It occurs due to the mere existence of an electrostatic charge or of a magnet as the source of an electrostatic field or a magnetic field, and it does not require any motion of the field-source.

The static FPSIF-principle shall be explained now on the example of Coulomb's force. From the moment on, when an electrical charge is being created (no matter whether this happened at the big bang or later, for instance at a process in elementary particle physics, such as pair-production or some other process), the charge emits an electrostatic field. The situation can be understood in perfect analogy for a (permanent) magnet, which begins to emit a magnetic field from the moment on, at which it has been magnetized.

Let us tend our attention to an electrostatic charge Q which has (at the moment "now") the age of t_1 (compare figure 1). In the moment "now", the field fills a spherical volume with the radius of $x_1 = c \cdot t_1$, due to its propagation speed "c". If we wait for an interval of time $\Delta t = t_2 - t_1$, until t_2 will be reached, the radius of the sphere filled with field will be grown up to $x_2 = c \cdot t_2$. And we pose the question: From where does the field's energy originate, which is necessary to fill the additional volume with field – as given in equation (1).

$$\Delta E = \int_0^{2\pi} \int_0^{\pi} \int_{x_1}^{x_2} \frac{\varepsilon_0}{2} \cdot \left|E\right|^2 \cdot r^2 \sin(\vartheta)\, dr\, d\vartheta\, d\varphi$$

(spherical shell in spherical coordinates) (1)

(with $\frac{\varepsilon_0}{2} \cdot \left|E\right|^2$ being the energy-density of the electrostatic field).

It is clear that this emitted energy cannot be permanently created by the electrostatic charge Q. At least there is no alteration of the mass of the charged (elementary) particle (which is the field-source). Consequent-ly there must be some other energy supply. Because the phenomenon is observed even in the vacuum, this energy can be supplied only by the empty space, for this is the only entity of physics, with which our charge Q is in contact. This logical consideration (regard it as a hypothesis now, which will be verified experimentally soon) identifies the quantum-vacuum as a source of energy. And some of the energy of the quantum-vacuum is permanently being converted by every charged elementary particle into field's energy.

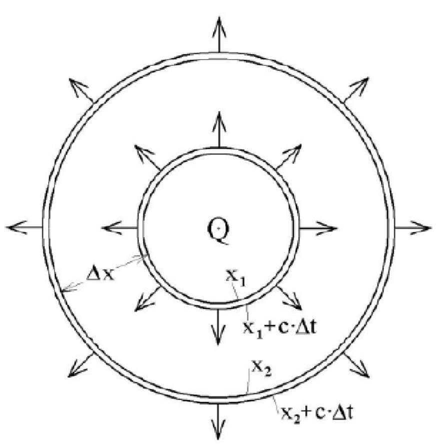

Figure 1 : Illustration of a spherical shell, containing field energy, which is propagating into the space.

Because of energy conservation, it is clear that every charge Q permanently extracts some energy from the quantum-vacuum and converts it into energy of an electrostatic field. But there is a second part of energy conversion, being understood as following: For this consideration let us fix a new time scale with the time t = 0, at the moment, when the electrostatic field fills exactly the sphere with the radius x_1. At the moment $\Delta t > 0$, at which the field (with its finite speed of propagat-ion c) fills a sphere with the radius $x_1 + c \cdot \Delta t$, we can state that the energy which the charge emitted during the time-interval Δt is the energy within the spherical shell from x_1 to $x_1 + c \cdot \Delta t$, because this is the amount of energy, by which the total energy of the field was enhanced during the time interval Δt. This energy is calculated in equation (2).

$$\begin{aligned}
E_{\substack{inner\\shell}} &= \int\limits_{\substack{spherical\\shell}} u(\vec{r})\,dV = \int_{\varphi=0}^{2\pi} \int_{\vartheta=0}^{\pi} \int_{r=x_1}^{x_1+c\cdot\Delta t} \frac{Q^2}{32\pi^2\varepsilon_0 r^4} \cdot r^2 \cdot \sin(\vartheta)\, dr\, d\vartheta\, d\varphi \\
&= \frac{Q^2}{32\pi^2\varepsilon_0} \cdot \int_{\varphi=0}^{2\pi} \int_{\vartheta=0}^{\pi} \underbrace{\int_{r=x_1}^{x_1+c\cdot\Delta t} \frac{1}{r^2} \cdot dr}_{=\frac{c\cdot\Delta t}{(x_1+c\cdot\Delta t)\cdot x_1}} \cdot \sin(\vartheta)\, d\vartheta\, d\varphi \\
&= \frac{Q^2}{32\pi^2\varepsilon_0} \cdot \frac{c\cdot\Delta t}{(x_1+c\cdot\Delta t)\cdot x_1} \cdot \underbrace{\int_{\varphi=0}^{2\pi} \underbrace{\int_{\vartheta=0}^{\pi} \sin(\vartheta)\, d\vartheta}_{=2}\, d\varphi}_{=4\pi} \qquad (2) \\
&= \frac{Q^2}{32\pi^2\varepsilon_0} \cdot \frac{c\cdot\Delta t}{(x_1+c\cdot\Delta t)\cdot x_1} \cdot 4\pi = \frac{Q^2}{8\pi\varepsilon_0} \cdot \frac{c\cdot\Delta t}{(x_1+c\cdot\Delta t)\cdot x_1}
\end{aligned}$$

We now follow the namely field-package (the spherical shell under observation) until to the moment t_2, which is later than $t_1 = 0$; and from there on, let us add the time interval Δt, so that the spherical shell from x_1 to $x_1 + c \cdot \Delta t$ had developed itself into the spherical shell from x_2 to $x_2 + c \cdot \Delta t$. If the field's energy is kept within the spherical shell during its propagation, the energy from the shell x_1 ... $x_1 + c \cdot \Delta t$ has moved into the shell x_2 ... $x_2 + c \cdot \Delta t$, thus both shells should contain the same energy. This question can be checked easy by calculating the field's energy within the outer shell from x_2 ... $x_2 + c \cdot \Delta t$, as done in equation (3), and comparing the result with the result of equation (2). Of course the energy-density in (3) is smaller than the energy-density in (2), but the volume of the spherical shell in (3) is larger than the volume of the spherical shell in (2) – but its total energy contents must be expected to remain constant, as long as the energy within the propagating spherical shell is constant.

$$\begin{aligned}
E_{\substack{outer\\shell}} &= \int\limits_{\substack{spherical\\shell}} u(\vec{r})\,dV = \int_{\varphi=0}^{2\pi} \int_{\vartheta=0}^{\pi} \int_{r=x_2}^{x_2+c\cdot\Delta t} \frac{Q^2}{32\pi^2\varepsilon_0 r^4} \cdot r^2 \cdot \sin(\vartheta)\, dr\, d\vartheta\, d\varphi \\
&= \frac{Q^2}{32\pi^2\varepsilon_0} \cdot \int_{\varphi=0}^{2\pi} \int_{\vartheta=0}^{\pi} \underbrace{\int_{r=x_1+\Delta x}^{x_1+\Delta x+c\cdot\Delta t} \frac{1}{r^2} \cdot dr}_{=\frac{c\cdot\Delta t}{(x_1+\Delta x+c\cdot\Delta t)\cdot(x_1+\Delta x)}} \cdot \sin(\vartheta)\, d\vartheta\, d\varphi \\
&= \frac{Q^2}{32\pi^2\varepsilon_0} \cdot \frac{c\cdot\Delta t}{(x_1+\Delta x+c\cdot\Delta t)\cdot(x_1+\Delta x)} \cdot \underbrace{\int_{\varphi=0}^{2\pi} \underbrace{\int_{\vartheta=0}^{\pi} \sin(\vartheta)\, d\vartheta}_{=2}\, d\varphi}_{=4\pi} \qquad (3) \\
&= \frac{Q^2}{32\pi^2\varepsilon_0} \cdot \frac{c\cdot\Delta t}{(x_1+\Delta x+c\cdot\Delta t)\cdot(x_1+\Delta x)} \cdot 4\pi = \frac{Q^2}{8\pi\varepsilon_0} \cdot \frac{c\cdot\Delta t}{(x_1+\Delta x+c\cdot\Delta t)\cdot(x_1+\Delta x)}
\end{aligned}$$

The observation is: The total energy sum within the propagating spherical shell is not constant. There is field's energy being lost during the propagation of the field into the space. For the field is in contact only with one entity of physics, namely with the quantum-vacuum, the fact must be that field's energy is being converted into some energy of the quantum-vacuum. Although this is still only a theoretical finding, which will have to be verified in section 4 experimentally, we face an energy-circulation: The field source (an electrostatic charge in the same way as a magnet) converts energy from the quantum-vacuum into field's energy and the field during its propagation performs the analogous conversion back from field's energy into energy of the quantum-vacuum.

But this circulation is not active for the complete energy of the field, because there is always some field's energy being left, and not being converted back into vacuum-energy. This can be easily understood, because the diameter x of the sphere filled with field's energy is growing permanently, as we saw its increase from x_1 to x_2, and of course this growth is not finished at x_2. This means that our circulation always converts more energy from the vacuum into field's energy than back into the quantum-vacuum.

If the described energy circulation is real, it should be possible, to extract some energy from the explained circuit. The practical realisation of this possibility, as described in section 4, is to be understood as the required experimental verification (of the described theoretical conception). For this energy extraction from the quantum-vacuum can be done everywhere, even in deep space, the research work is to be understood as an investigation of a new energy source for deep space travel.

The dynamic FPSIF-principle

The dynamic FPSIF-principle has its reason in the alteration of the field flux being emanated from an electrostatic charge or from a magnet, occurring due to the motion of the field-source, i.e. only if the charge or the magnet is in motion. If somebody mounts a field-sensor at a given position, measuring the field-strength produced by a field-source in a well-defined distance, the sensor will notice any motion of the field source, because the field-strength (vector) depends on the distance between the field-source and the sensor.

In the classical approximation (as shown for instance for Coulomb's law in equation (4)), not taking the propagation speed of the field into account, i.e. working with the limit of infinitely fast propagation speed of the field, the sensor measures the motion of the field-source immediately in the same moment, when it occurs.

$$\vec{F}_C = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 \cdot q_2}{|\vec{r}|^2} \cdot \vec{e}_r \tag{4}$$

In reality, the sensor measures the motion of the field-source with some delay, so that it is noticed somewhat later than at the moment, when it occurs. The reason was described first by Liénard and Wiechert[3,4], under the name of the "retarded potential", stating that the field propagates with finite speed (in the case of the electrostatic or/ and of the magnetic field, this is the speed of light "c"), so that the propagation of the alteration of the field-strength needs some given amount of time, to move from the field-source to the sensor. The propagation time t_{prop} of the alteration of the field-strength is given in equation (5), where "x" is the distance between the field-source to the sensor.

$$t_{prop} = \frac{x}{c} \tag{5}$$

Thus, for the full and complete computation of the field-strength, measured at the sensor, we have to replace the distance $\vec{r}$ in equation (4) by the retarded distance $\vec{r}\,'$ in equation (6). The expression of "retarded distance" was first introduced by Liénard and Wiechert.

$$\vec{F}_C = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 \cdot q_2}{\left|\vec{r}\,'\left(\vec{x}_1(t), \vec{x}_2(t), \vec{v}_1(t), \vec{v}_2(t), t\right)\right|^2} \cdot \vec{e}_{\vec{r}\,'\left(\vec{x}_1(t), \vec{x}_2(t), \vec{v}_1(t), \vec{v}_2(t), t\right)} \tag{6}$$

The classical approximation is good, as long as the speed of motion of the field-source along its trajectory is negligibly small in comparison to the velocity of the field "c", i.e. it is an approximation of infinitely fast speed of light. For classical electrical engineering purpose, this is a very good approximation (for instance, when electrical engineers construct electromotors). But as soon as the speed of the field-source reaches a real percentage of the speed of light, this approximation loses its quality. It should be remarked, that $\vec{r}\,'$ depends on the trajectories of the partners of interaction (the sensor and the field-source), namely as $\vec{r}\,'\left(\vec{x}_1(t), \vec{x}_2(t), \vec{v}_1(t), \vec{v}_2(t), t\right)$.

The retarded potentials according to Liénard and Wiechert can be utilized to convert energy from the quantum-vacuum into classical energy, as soon as the speed of motion of the field-source reaches a serious percentage of the propagation-speed of the field. This utilization is, what I want to entitle the principle of the "Finite Propagation Speed of the Interacting Fields (FPSIF-principle). An illustration is given in figure 2, regarding two electrical charges q_1 and q_2, following the trajectories $x_1(t)$ in red colour from the top left to the bottom left, and $x_2(t)$ in blue colour from the top right to the bottom right. At the moment t_a, the charge q_1 passes the position $x_{1,a}$ and the charge q_2 passes the position $x_{2,a}$. We now regard the coulomb-force at a moment later than t_a, namely at the time t_b, at which the charge q_1 is at the position $x_{1,b}$ and the charge q_2 is at the position $x_{2,b}$. (Meaning of the indices: "1/2" = number of the partner of interaction, "a/b" = moment of time.) In order to calculate the Coulomb-force with which q_1

acts onto q_2 at this time t_b, we have to follow the history of the trajectories back to the time t_a, at which the charge q_1 had produced the coulomb-field (component) being indicated by 8 small vectors (in black colour), representing flux lines emanating radially from the charge at $x_{1,a}$. We want to follow one of these vector-arrows at its course through space *and* time, seeing that it propagates with finite speed from $x_{1,a}$ to $x_{2,b}$ during the time-interval from t_a to t_b. This is the distance in space and time, which the field of interaction has two pass from $\left(\vec{x}_{1,a},t_a\right)$ to $\left(\vec{x}_{2,b},t_b\right)$, where it arrives at the partner of interaction q_2. The real distance of interaction from q_1 to q_2 thus is $\vec{r}=\vec{x}_{2,b}-\vec{x}_{1,a}$, defined by the FPSIF-principle. Obviously this distance of interaction is different from the interaction-distance according to the mere classical consideration, whose approximation is the negligence of the propagation-time of the field, where the interaction-distance would be approximated by $\vec{r}=\vec{x}_{2,b}-\vec{x}_{1,b}$, following the green arrow in figure 2.

Additionally we compare the force, with which q_2 acts onto q_1 at the time t_b. It is different from the force with which q_1 acts onto q_2 at the same moment t_b. This distance of interaction is $\vec{r}=\vec{x}_{2,a}-\vec{x}_{1,b}$. We see that the FPSIF-consideration introduces a time-shift (i.a. a delay-time) into Newton's axiom of "actio = reactio". Furthermore we can state, that q_2 at the time t_x emitted a field of interaction, which had to pass the distance of the purple arrow, to reach q_1 at the time t_b, so that force and counter-force acting onto q_1 are not identically the same at the moment t_b. If we want to compare the forces of Newton's "actio" ($\vec{F}_{1,2}$) and "reactio" ($\vec{F}_{2,1}$) we have to take into account the interaction-forces at different moments of time. The situation reminds (with a smile) to "borrow the force as the action" and to "give it back alter as the reactio".

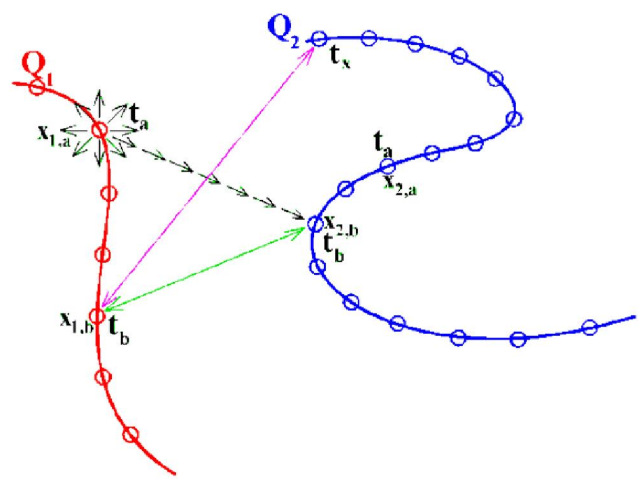

Figure 2 : Fundamental interactions in the FPSIF-conception, following the retarded potential of Liénard and Wiechert.

One possible method to utilize the FPSIF-principle is the following. Let two electrostatic charges (or in analogy two magnets) approach to each other along their trajectories, as shown in figure 3 (left side) or run away from each other, as shown in figure 3 (right side), where we see each motion represented by three snapshots with increasing time from line to line along $t_a < t_b < t_c$. Thus the left part of figure 3 describes two partners approaching to each other, and the right part of figure 3 describes two partners running away from each other. At the moment t_a, partner no.1 emits a field of interaction, among which we have also the component marked by a little red arrow, running towards partner no.2. The time-dependent development of the situation can be understood from the second line on, which is at the moment t_b, finally up to the third line, representing the moment t_c. At t_c, the regarded field-component (red arrow) of the interaction reaches partner no.2. And now we pose the question about the distance of interaction (which is the distance to be passed by the field-component), which determines the absolute value of the force of interaction. According to the classical approximation of the infinitely fast field, the distance would follow the length of the green arrow, but in reality, taking the propagation speed of the field into account, the distance follows the length of the blue arrow, which is the

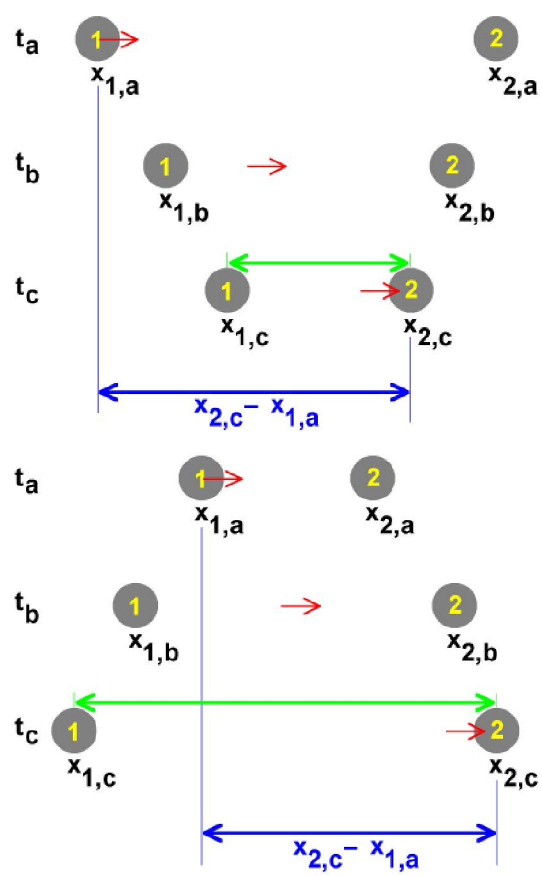

Figure 3 : Two electrical charges (or magnets) moving relatively to each other, indicating the distances of interaction, being determined by the propagation distances of the field.

distance, that had to be passed by the field-component marked by the little red arrow.
The consequence can be summarized rather short:
- When the two partners approach to each other, the FPSIF-interaction-distance is larger than the classical approximation, so that the force of interaction is reduced, relatively to the classical approximation.
- When the two partners run away from each other, the FPSIF-interaction-distance is smaller than the classical approximation, so that the force of interaction is enhanced.

On this basis, an imaginable utilization of the FPSIF-principle for the conversion of vacuum-energy into classical energy can be realized as following (please see the illustration of figure 4). We regard two magnets, passing by each other in course of time from $t_A < t_B < t_C < t_D < t_E$. Within the classical approximation of the infinitely fast propagating field, there is finally no conversion of energy. From t_A to t_C, we had to push the magnets against their repulsive force, and from t_C to t_E, the repulsive magnetic force pushes (and thus accelerates) the magnets, so that we get back the same amount of energy, as we had to insert in the interval from t_A to t_C.

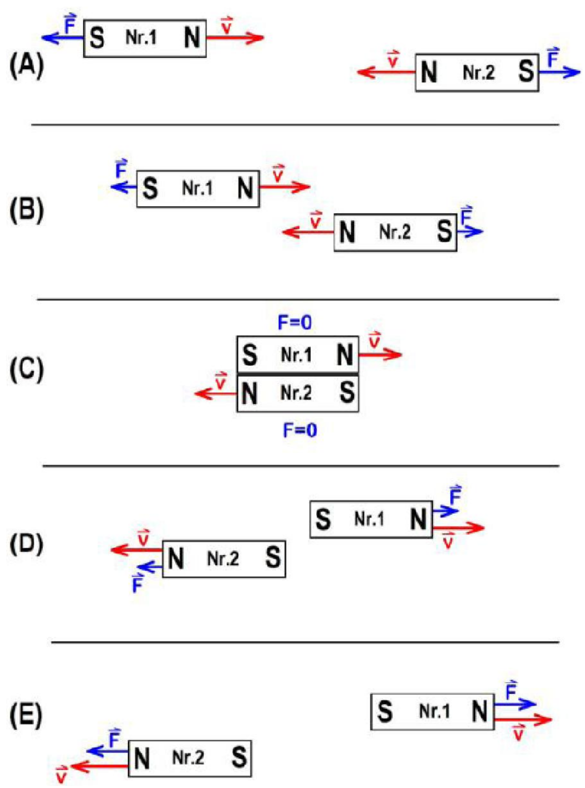

Figure 4 : Illustration of one magnet-passage, of two magnets passing each other. The system is a candidate to convert energy from the quantum-vacuum, if the velocity of the magnets is large.

Totally different from the classical approximation, the FPSIF-principle leads to an alteration of the classical kinetic energy of the magnets, as soon as the magnets are moving fast enough (in comparison to the speed of light). The fundamental reason is traced back down to quantum-electrodynamics in a former publication[5]. The crucial point is, that the sum of classical kinetic energy plus classical potential energy of the magnetic field plus energy of the quantum-vacuum (being converted), is constant – namely as following. During the phase of approach (and deceleration) of both magnets (from t_A to t_C), the magnetic force is reduced, (relatively to the classical approximation), and during the phase of acceleration (and departing), the accelerating force is enhanced, due to the same reasons. The consequence is, that the enhancement of (kinetic) energy (during the phase of acceleration) is larger than the reduction of (kinetic) energy (during the phase of deceleration). Finally, the speed of the magnets grows permanently from magnet-passage to magnet-passage (being compared at positions with the same distance between the magnets and thus at the same potential energy).

The development of a construction for a real setup will be described in section 4, going back to the fundamental differential equations of motion, and back to the FPSIF-principle. For this is expected to give a rather powerful energy extraction from the quantum-vacuum, being possible everywhere, also in deep space, the work is to be understood as an investigation of a new energy source for deep space travel.

Further additional opportunities

All methods discussed up to now for the conversion of vacuum-energy, are traced back to Coulomb's forces (between electrostatic charges) or to Lorentz' forces (in the magnetic case). The question arises, whether there are additional opportunities to tap energy from the quantum-vacuum ? Up to now, we do not have a final answer to this question, but we know from Feynman[4], that the field produced by a point charge q in motion follows equation (7).

$$\vec{E} = \frac{q}{4\pi\varepsilon_0} \cdot \left[\frac{\vec{e}_{r'}}{r'^2} + \frac{r'}{c}\frac{d}{dt}\left(\frac{\vec{e}_{r'}}{r'^2}\right) + \frac{1}{c^2}\frac{d^2}{dt^2}\vec{e}_{r'} \right] \tag{7}$$

The rectangular bracket contains three summands, and it is consequent that Feynman always uses the retarded distance $\vec{r}'$ to describe the space between the "emission-point" and the "field-point", which the field has to pass (with finite speed) in order to cause its interaction. Up to now, in the present paper, only two of these three summands have been taken into account, as can be seen from the following interpretation:

- The very first summand in the rectangular bracket represents Coulomb's law, together with the retarded potential (according to Liénard and Wiechert). This is exactly the term, which is the fundament of the FPSIF-conception with regard to electrostatic charges.

- The second summand stands for the explicit consideration of the particle's velocity, because it contains the first derivative of the position-vector to time. It is to be seen in connection with the term of the "magnetic field". Its consequence is also known under the name of Biot-Savart and the Lorentz-force. This term, is the fundament of the FPSIF-theory with regard to magnets.
- The third summand contains the second derivative of the position-vector to time, and thus it refers directly to the acceleration of the charge q. This one is rather seldom under discussion, but it has the extremely surprising feature, that it does not decrease with the distance of the partners of interaction. Only the direction, but not the absolute value (the length) of the vector from the "emission-point" to the "field-point" takes the geometry of the setup into account, thus it allows interaction over arbitrary distances. This summand might allow everybody, to contrive the construction of further other vacuum-energy converters, exceeding the range of discussion of the present paper.

EXPERIMENTAL VERIFICATION

The central experimental

The preparation of the experiment was done by designing a setup, which can be driven by the energy of the quantum-vacuum, being transferred by the Coulomb-forces of an electrostatic field. The arrangement is shown in figure 5.

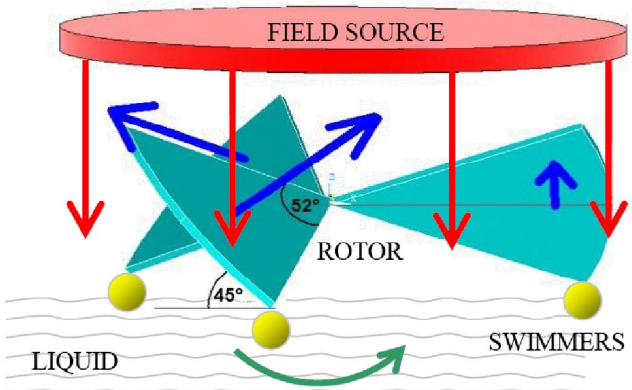

Figure 5 : Electrostatic rotor, consisting of a field source (red) and a rotor (blue)

The metallic disc (drawn in red color) in the top of the image has the purpose to produce an electrostatic field (symbolized by flux lines in red color), therefore it is charged up electrically. The rotor (drawn in blue color) experiences a Coulomb-force (blue arrows), in the electrostatic field, which drives the rotor. The consideration of this force in cylindrical coordinates leads us to the following three components:

- A vertical (z-) component, which lifts the rotor by a small amount, as soon as the electrical charge is being brought onto the field source.
- A tangential (r-) component, which shifts the rotor horizontally, to bring its center under the middle of the field source. This is an automatic adjustment-mechanism, bringing to rotor to an optimum position.
- A radial (φ-) component, which makes the rotor spin.

The very first approach to this setup was done by theory, namely with two different types of Finite-Element-Algorithms. The first algorithm was self-made[18]; it calculates the forces on the basis of finite charge elements (on the surface of the field source) and finite image-charge elements on the rotor blade, using Cou-lomb's forces between all those pairs of charges. The second algorithm

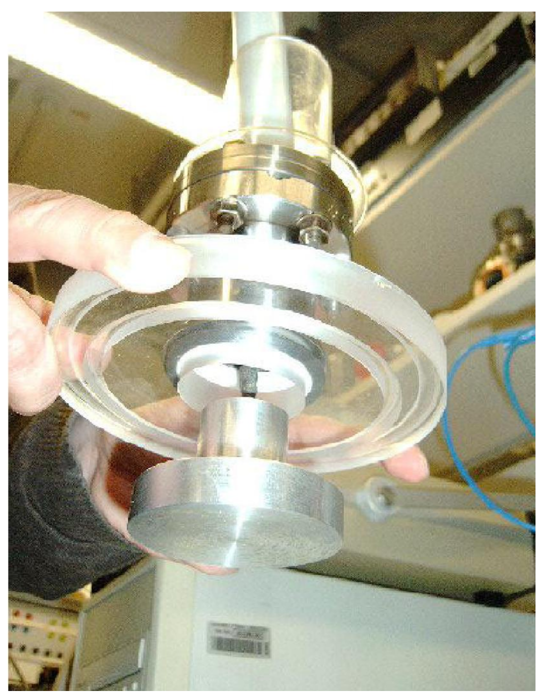

Figure 6 : Left side: Electrostatic rotor inside the vacuum chamber, swimming on vacuum-oil; Right side: Field-source being mounted on the (transparent) top flange

was the commercial FEM-program ANSYS[19], whose working is based on potential theory. Both computer-simulations follow different methods, and they both come to the same result: A rotor with a diameter of 46 cm under a voltage of 10 kV is expected to take up a torque of $M \approx 1.2 \cdot 10^{-5}$Nm. After ANSYS confirmed my self-made considerations, I decided that the setup is worth being tested experimentally.

The very first tests had been performed under air pressure, confirming a rotation at all. The next step was a verification under vacuum (with a pressure of $6 \cdot 10^{-5}$ mbar), in order to exclude the risk that ionized gas molecules of the air, might give rise to a classical energy transportation from the field source to the rotor, which would be the well-known Biefeld-Brown effect[20,21]. The setup is shown in figure 6.

The final verification of the conversion of energy from the quantum-vacuum was done with a kilovolt-meter and picoamperemeter (for the measurement of the electrical power-input) on the one hand, and a micro torsion-balance (for the measurement of the mechanical power-output) on the other hand. Therefore (due to technical reasons), the rotor was replaced by another one, as shown in figure 7. The rotor was driven electrically, and the power-input consumed, was measured to be $P = U \cdot I = 29.7 \cdot 10^{3}\text{V} \cdot (0.100 \pm 0.030) \cdot 10^{-12}\,\text{A} = (2.97 \pm 0.89) \cdot 10^{-9}\text{W}$. The experiment was performed at the Otto-von-Guericke University in Magdeburg[7].

Figure 7 : The rotor in the experiment under control of mechanical and electrical power.

The mechanical power-output was measured with a torsion balance as shown in figure 8. The produced mechanical power, was the power necessary to surmount the friction of the rotation of the rotor on the vacuum-oil (Ilmvac, LABOVAC-12S), which was used as a liquid for the bearing of the rotor[22].

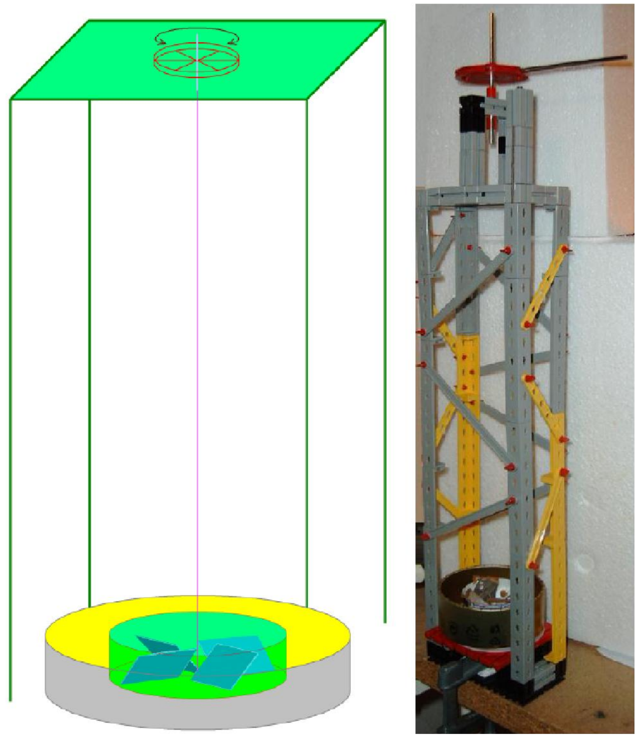

Figure 8 : The torsion balance for the measurement of the mechanical power-output.

From the torque and the angular velocity of rotation, the mechanical power of the rotation was determined, as it is plotted in figure 9. The blue rectangles represent the measured values of the mechanical power-output as a function of the angular velocity of the rotation. Width and height of the rectangles represent 1σ-uncertainty intervals according to a Gauss'ian distribution of the measuring uncertainties, the red curve is a compensating curve for the mechanical power-output (as a function of the angular velocity of the rotor) regarding the rotation of the rotor on the oil.

The red curve of the mechanical power-output has to be compared with the green rectangle of the electrical power-input (the green rectangle also follows an estimation of a 1σ-uncertainty interval). The green rectangle is plotted at the location of the time-scale corresponding to the duration of one rotation, as it has been observed via optical control, by watching the rotation through the transparent acrylic top-flange. If we have the double logarithmic scale of the diagram in mind, we see that the mechanical power-output is larger, than the electrical power-input by a factor of 150nW/2.97nW = 50.5. This means that maximal 1/50.5 = 1.98%≈2% of the produced mechanical energy can be explained by electrical energy supply (from the power-input), and minimal 98% of the produced mechanical energy must be explained by an invisible source of energy. (More likely, the 2% of energy loss is only due to imperfections electrical isolators.) From the preceding chapters, we have the clear expectation, that this invisible energy is the zero-point-energy of electromagnetic waves of the quantum-vacuum.

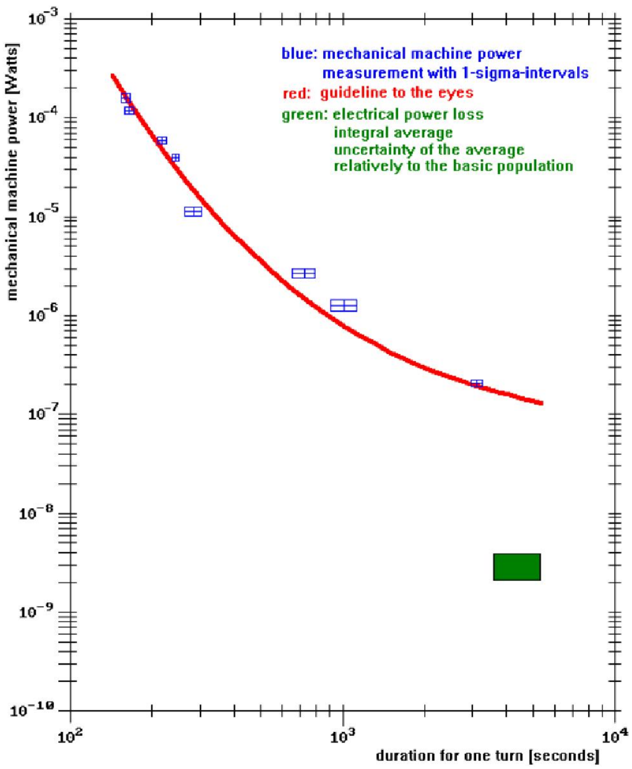

Figure 9 : Comparison of the electrical power-input (red curve) with the produced mechani-cal power-output (green rectangle)

DISCUSSION ABOUT IMAGINABLE RECOIL AT THE QUANTUM-VACUUM

From the fact that energy can be extracted from the quantum-vacuum, the question arises, whether it is also possible to produce a utilizable recoil at some invisible entities of the quantum-vacuum, perhaps even in the context with the extraction of energy. The extraction of energy might correspond to a measurable force. This would be a great help for deep space travel. Thus, I investigated, whether the electrostatic rotor of figure 5 might be a good candidate for the production of such a recoil on the quantum-vacuum. Unfortunately it turned out, that this is not the case.

For this testing-experiment, the setup of figure 5 was expanded by mounting the field source within a micro torsion-balance, i.e. the field source was hanging at the bottom of a copper wire with a diameter of 50 μm. If Newton's axiom "actio = reactio" is active directly between the rotor and the field source, the angular momentum on the rotor should be the same, as the angular momentum on the field source, and both should rotate into opposite directions, being accelerated with the same torque. But – on the other hand – if the some invisible entities of the quantum-vacuum will play an additional role within Newton's axiom "actio = reactio", some torque and some angular momentum should be transferred to the quantum-vacuum, so that the field source and the rotor do not experience the same angular momentum of rotation. In order to make the setup most easy, the rotor was mounted on toe bearing, so that the rotor and the field-source are as shown in figure 10.

Figure 10 : Electrostatic rotor and field-source for the test of a potential recoil at the quantum-vacuum.

The rotor was designed to rotate with almost negligible restoring force (due to a toe-bearing), whereas the field-source was designed to rotate with restoring force, due to the copper wire of the torsion-balance. Thus, the rotation of the rotor was determined by its angular acceleration and by a small (negligible) amount of friction, but the rotation of the field source was determined by its angular acceleration and by a remarkable restoring force coming from the copper filament on which it was hanging.

The result is that the torque acting on the rotor is identical with the torque acting on the field-source within a measuring certainty of 5%, confirming that there is no recoil at the quantum-vacuum. On the one hand, this has the advantage to demonstrate again that there is no remarkable momentum-transfer by any gas ions, but on the other hand, the analyzed electrostatic rotor is not a device for any recoil at the quantum-vacuum.

Nevertheless, this is not an exclusion criterion for our ZPE-system as an energy-source for space travel,

because - energy is required not only for recoil,

and - if energy is available without ponderable mass of propellant, the recoil can be made separately, as for instance by producing and emitting photons, with the use of some other device.

CONSTRUCTION OF POWERFUL ENGINES

For the Magdeburg's electrostatic rotor (of section 4) converted a power only 150 nW, this device is to be regarded as a fundamental scientific experiment, but not as powerful energy-supply, which is really capable for technical application. The device demonstrates, that the idea of the FPSIF-principle is capable indeed, to gain energy from the quantum-vacuum, but some other system must be found for technical purpose, which is capable to convert a utilizable amount of power from the quantum-vacuum.
The Magdeburg's electrostatic rotor had been designed according to the static FPSIF-principle, but the conception of a powerful vacuum-energy converter, will now be designed in section 5, according to the dynamic FPSIF-principle. The main reason for this difference is, that the use of the magnetic field allows to build engines with much higher energy-density, than the use of the electrostatic field.
In principle a very simple setup according to figure 11 might illustrate, how the dynamic FPSIF-principle can be applied to convert vacuum-energy: If m_1 and m_2 are two magnets, oriented in such way that they act with repulsive forces onto each other (as for instance both north-poles point towards each other, or both south-poles point towards each other), we can modulate the magnetic forces by a very fast motion of the magnet due to the dynamic FPSIF-principle, namely as following: We have a spring, which allows a harmonic oscillation of the both magnets, and in addition to the inertial forces of the magnets' masses and to the Hooke's forces of the spring, we have the repulsive forces between the magnets. These magnetic forces have to be included in addition, into the differential equation of the harmonic oscillation of the magnets (equation 8), and they make the oscillation inharmonic.

$$m \cdot x_1 + D \cdot x_1 + \frac{C_{\text{magnet}}}{\text{distance}^2_{\text{magnets}}} = 0$$

$$\textit{resp. } m \cdot x_2 + D \cdot x_2 + \frac{C_{\text{magnet}}}{\text{distance}^2_{\text{magnets}}} = 0 \qquad (8)$$

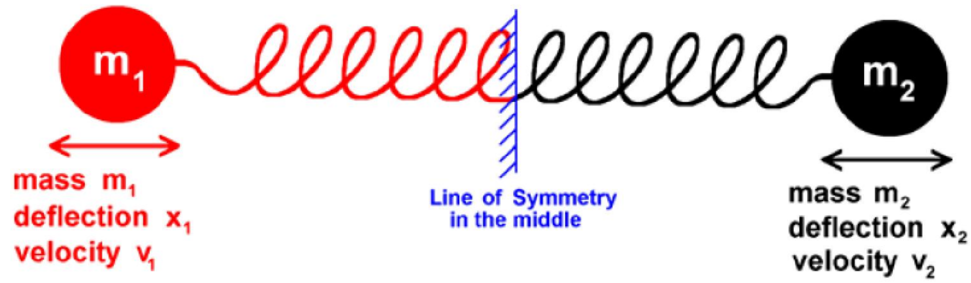

Figure 11 : Two magnets attracting each other, converting vacuum-energy according to the FPSIF-principle.

And the crucial aspect of the FPSIF-principle is, that the repulsive magnetic forces depend on the motion of the magnets, namely during the part of the oscillation, when the magnets approach to each other (with very high speed), the magnetic forces are reduced due to the FPSIF-principle (in comparison to the classical approach, which does not take the finite propagation speed of the field into account), but during the phase of the oscillation, when the magnets are running away from each other, the magnetic forces are enhanced (in comparison to the classical approximation) due to the FPSIF-principle. This has the consequence that the resonance frequency of the mechanical motion, can be adjusted appropriately to the runtime of the fields, so that under proper mode of operation, the spring will always be compressed with reduced force and be expanded with enhanced force, so that the amplitudes of the oscillation (as well as the expansion of the spring) will grow as a function time from phase to phase of the oscillation, being supported from some invisible source of energy, going back to the FPSIF-principle.
Nevertheless we face the problem that the motion of the magnets has to be accelerated and decelerated twice during each period of oscillation – and this acceleration (same as the deceleration) must be extremely strong, because it is to be done from standstill to a serious percentage of the speed of the propagating fields (which is the speed of light), back and forth. This condition leads to the consequence that the power conversion is somewhere in the picowatt-regime, otherwise the forces necessary for acceleration and deceleration would exceed all limits, given by a real engine (due to the stability of its material). Thus, the conception of figure 11 is just acceptable for the development of an idea, how to use the dynamic FPSIF-principle.
In order to find a way how to convert a utilizable amount of energy, several modifications are necessary. The modified and realistic setup for a utilizable amount of power is shown in figure 12. For instance, the oscillation must be replaced by a rotation, in order to avoid the permanent acceleration and deceleration of the magnet. Another modification is the idea, to replace one of the both magnets by a coil, which is included into an electrical LC-oscillation-circuit, and this oscillation-circuit has the pur-

pose to provide the oscillation of the magnetic field. This means that one magnet is rotating, and the other one is replaced by an electromagnetic coil, so that the magnetic fields between the rotating magnet and the coil interact with each other. The fast motion, which is necessary for the FPSIF-principle, is performed by the rotation of the magnet.

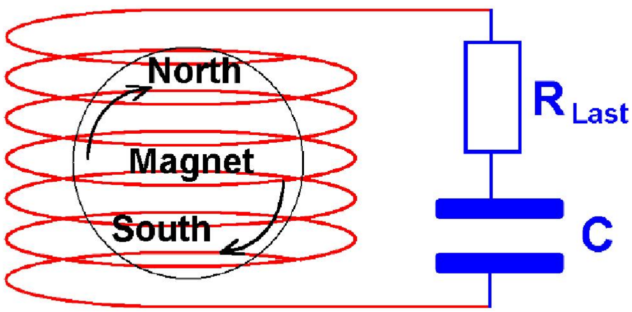

Figure 12 : Modified setup for the interaction between two magnetic fields, converting energy from an invisible source (vacuum-energy) according to the FPSIF-principle.

The differential equations of the system are calculated in[23-27], coming to the result that a realizable dimension of the system, leading to utilizable amount of power can be constructed. The setup, as shown in figure 13, contains a magnet with a thickness 2 cm and a length of 10 cm (in red color), rotating within a coil (in blue color), made of rather thick copper wire (10 mm material-thickness), because the electrical current goes up to several 100 A, and the Ohmic resistance should very low. The amount of power being convertible (from the quantum-vcuum) with the use of such a device is expected to be 528 W of mechanical power plus 52 Watts of electrical power at a rotational speed of 30100 rpm. Probably (according to detailed verification computations), the angular velocity expected to be necessary, might be even higher that this value. Finally the limitation of the power density of the engine is given by the mechanic stability (the tensile strength) of the magnet's material.

Figure 14 shows one of the solutions of the differential equations, describing the rotation of the magnet and the oscillation of the electrical charge within the LC-circuit, both motions being connected with each other via the magnetic interaction. The operation of the system is started with the capacitor and the coil being uncharged; and the motion is started mechanically, by bringing the rotation of the magnet to an angular velocity not far below the necessary value for a permanent operation of the engine. At the very first begin of the rotation, the magnet induces electrical voltage (and with it energy) into the coil, and thus its rotational speed is reduced somewhat. But rather soon, the electrical energy being induced into the LC-circuit, comes back into the coil and accelerates the magnet's rotation according to the FPSIF-principle. After few oscillations,

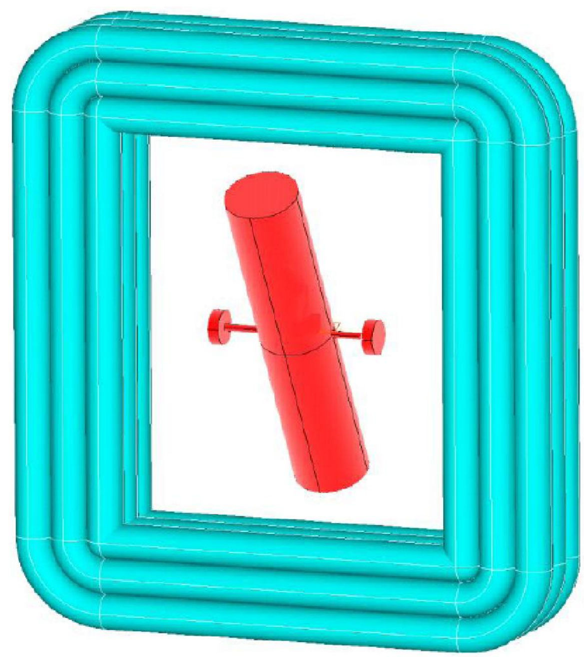

Figure 13 : Imagination of an "Electro-mechanic double-resonance" converter (EMDR), to convert a useful amount of power from vacuum-energy into electrical and mechanical energy.

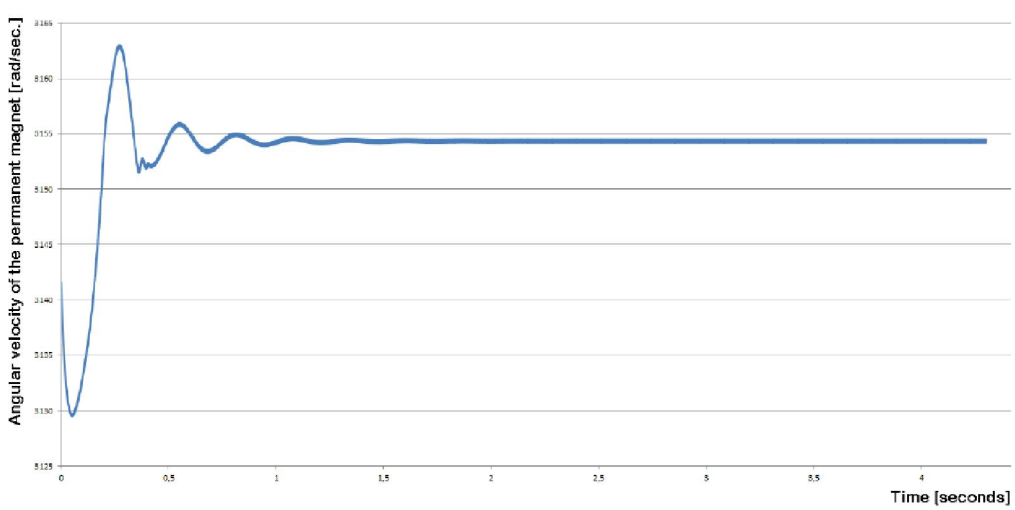

Figure 14 : Result of a theoretical computation of the angular velocity of the magnet, during the starting mode of the engine.

the engine runs into a stable mode of operation with constant rotational speed, delivering electrical energy via the resistor (R_{Last}, see figure 12) and via mechanical extraction of energy from the rotating shaft. The engine can only work under constant operation, as soon as there is permanent extraction (with constant average over each period) of electrical and mechanical energy, and both types of energy have to stand in a given relation with each other.

INTERESTING ALTERNATIVE: A MAGNETIC ROTOR ACCORDING TO THE STATIC FPSIF-PRINCIPLE

Similar as the electrostatic rotor (of section 4.1 and 4.2) was driven by electrostatic forces on the basis of the static FPSIF-principle, it should be possible to drive a magnetic rotor by magnetic forces on the basis of the static FPSIF-principle. This would be a pendant to the Magdeburg's electrostatic rotor, but with a permanent magnet as field-source instead of the red disc in figure 5. Furthermore, the metallic rotor-blades (in blue color in figure 5) will have to be replaced by a magnetic shield. The metallic surfaces of the rotor-blades have the purpose to shield the electrostatic field, so that the image-charge on the metallic surfaces (of the rotor-blades) causes a Coulomb-force between this image-charge and the electrostatic charge-carriers on the field-source. A magnetic shield, acting analogously with the magnetic field, is a superconductor, of which the capability to shield magnetic fields, is described by a susceptibility of χ = -1 (see for instance[29]). For superconductors, the Meissner-Ochsenfeld-effect on the surface of the material, can be understood as complete magnetic analogy with the transportation of charge-carriers on the surface of electrical conductors in electrostatic case, giving rise to the image-charge method, as being used in the discipline of electrical engineering[16,30,31]. In the superconductor, image-current elements in the surface of the superconductor, have the consequence to avoid, that external magnetic fields can penetrate the superconductor's surface, so that no field can come into the bulk material of the superconductor. The magnetic interaction is then to be calculated, between the image-current elements on the surface of the superconductor, and the external magnetic field, causing these image-current elements.

One of the main difference in the consequence, between the image-charge method for electrostatic charges, and an image-field method for magnetostatic fields is, that the electrostatic forces are attractive, whereas the magnetostatic forces are repulsive. The consequence is that a superconductive rotor spins into the opposite direction, than the electrostatic rotor. Furthermore, and this is the important technical problem, the self-adjustment mechanism, caused by the lateral forces (tangential (r-) component, shifting the rotor horizontally), turns into the opposite direction, to become a self-deadjustment mechanism in the magnetic case. This causes the problem, that the mechanical precision of the magnetic rotor must be far better than in the electrostatic case, and the field homogeneity of the magnetic field must be by orders of magnitude better than field homogeneity of the electrostatic field in the electrostatic case.

Nevertheless, a magnetostatic rotor, as shown in figure 15, was brought into the computer-simulation, with the force of the magnetic interaction between every finite element of the magnet (disc on top) and every finite element of the image-field of rotor-blades, being calculated according to equation (9).

$$\vec{F}_{12} = 4\pi\mu_0 \cdot \left|\vec{r}_{12}\right|^2 \cdot \left(\vec{e}_{12} \times \vec{H}_1\right) \times \vec{H}_2$$

with $\mu_0 = 4\pi \cdot 10^{-7} \frac{\text{Vs}}{\text{Am}}$,

$\vec{r}_{12}$ = vector from the field-source to the rotor-blade

$\vec{e}_{12}$ = unit-vector from the field-source to the rotor-blade (9)

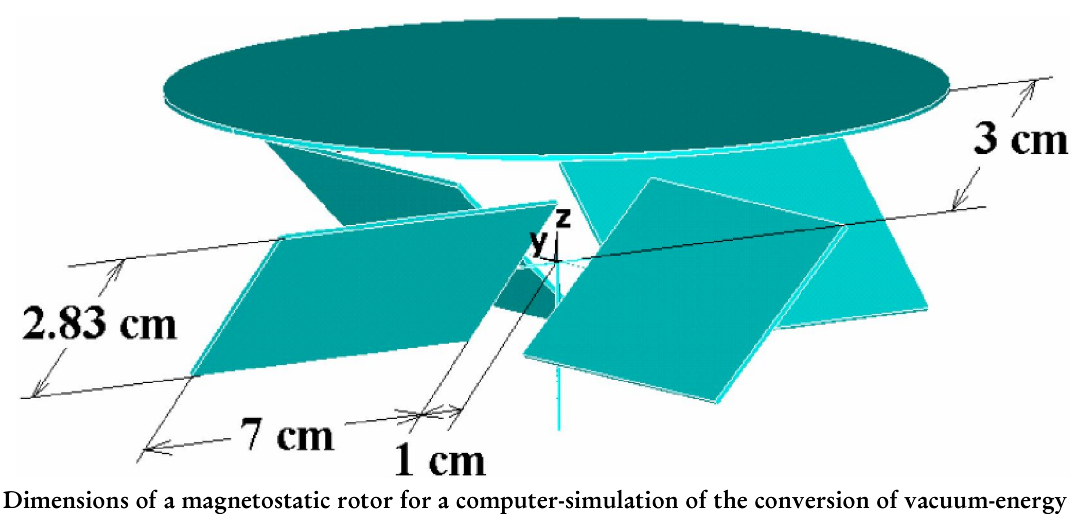

Figure 15 : Dimensions of a magnetostatic rotor for a computer-simulation of the conversion of vacuum-energy according to the FPSIF-principle.

For a field of $\left|\vec{H}_1\right| = 10^3 \frac{\mathrm{A}}{\mathrm{m}}$, the computer-simulation of the rotor in figure 15, achieves a torque of $\left|\vec{M}\right| \approx 4.8 \cdot 10^{-5}\,\mathrm{Nm}$, which should be noticeable in analogous way, as the torque in the electrostatic case was noticeable. The restriction to the absolute value of the field strength is given by the fact, that the high-T_c-superconductors forming the rotor-blades ($Y\,Ba_2\,Cu_3\,O_7$ being operated under liquid nitrogen) should not be brought into the Shubnikov-Phase, in order to maintain, that they really remain superconductive on their surfaces.

For the real experiment, a setup as shown in figure 16 was built up, filled with liquid nitrogen and positioned under a permanent rare-earth magnet. Unfortunately, the rotation could be observed only for three quarters of one turn, so that a permanent rotation could not yet be proven. The problem is the spatial field's inhomogeneity, which is estimated to be about $\frac{\Delta H}{H_{max}} \approx 10 \ldots 15\,\%$ (according to the manufacturer's information [private communication with the manufacturer]). Following the laboratory experiences, known from the electrostatic rotor, this inhomogeneity is far too much for any permanent rotation. The problem is intensified by the fact that the repulsive magnetic force, does not allow any self-adjustment mechanism (as it has been extremely helpful in the electrostatic case), so that the axis of the rotor must be fixed rigidly in the magnetic case, which enhances the effort to the mechanical manufacturing of the magnetic-rotor remarkably, in comparison with the electrostatic case.

Figure 16 : Real setup of a magnetostatic rotor with rotor-blades of high-Tc-superconductor, mounted under a rare earth magnet

The resumeé of section 6 is, that the magnetostatic rotor is an interesting candidate for the conversion of energy from the quantum-vacuum in deep space travel, because low temperatures as being necessary for superconductors, are available in space without the necessity to transport or to handle liquid nitrogen. This makes the magnetostatic system rather versatile as an energy-supply, because it only needs an array of permanent magnets (optimized for a homogeneous magnetic field better then $\frac{\Delta H}{H_{max}} \approx 10^{-2} \ldots 10^{-3}$) and a superconducting rotor.

CONCLUSIONS

It is well known that the quantum-vacuum contains energy. Under discussion is the question, whether this energy can be converted into a classical type of energy, such as electrical or/and mechanical energy, for technical utilization. If this is the case, the quantum-vacuum is an ideal energy source for space exploration, because it is available everywhere, without the necessity to transport any energy-carrying matter within the space-ship.

The present paper introduces a theory, which explains a possibility, how to tap some part of the energy of the quantum-vacuum, namely the concept of the "Finite Propagation Speed of the Interacting Fields", which has a static and a dynamic possibility of application. For both types of application, possible devices of energy-conversion are analyzed by computer-simulation.

For the static variant, an experimental verification has been demonstrated. This is a fundamental scientific experiment, which shows the usability of the quantum-vacuum as an omnipresent and massless propellant – not to forget, that the extraction of energy from the quantum-vacuum changes the fundamental structure of the vacuum (by a small amount).

For the dynamic variant of the FPSIF-principle, a practical engine to verify the theory, has been developed by computer-simulation. The next step of investigation should now be the hardware-realization of a prototype of this engine, working according to the dynamic variant of FPSIF-principle, because the dynamic variant has a much higher density of power, than the static variant. This should provide the possibility to build ZPE-converters for powerful application, especially for deep space travel, because no ponderable propellant has to be transported.

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