The interaction of rotating masses in vacuum: Samokhvalov experiment and rotation of spiral galaxies.

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In addition to the Casimir effect, which describes the forces arising between the two plates due to selecting the vacuum fluctuations between plates, there may exist also moments of forces. They are caused by the formation of vortices in the vacuum because of self-organization a giant number of fluctuating 'particle-antiparticle' pairs rotating around their common center of mass of such a pair. These vortices can transmit torque from one spinning disk to another initially immobile. Also, this torque can be responsible for the flat dependence of the orbital velocities of the spiral galaxies, instead the notorious dark matter. The Navier-Stokes equations, with slightly modified internal forces (the pressure gradient and the fluctuating viscosity in the superfluid vacuum medium), give a clear picture of the formation of such vortices.

I. INTRODUCTION

The concluding phrases of M. Osipov, given in his article "Interaction of rotating bodies and the general principles of symmetry" [17], are as follows: "also it should be noted that this discussion has two important effects. First, in the experiments of V. N. Samokhvalov interaction occurs no immediately, but with some (macroscopic) time-delay, i.e. there exist very strong effects of temporal nonlocality. Similar interactions in traditional physics are unknown. Only simple analog may be a resonance phenomenon, when the energy injected into the system gradually. Secondly, it is unclear why this interaction is shielded in sufficiently rarefied medium, i.e. in air."

Taking this statement as a call to continue the discussion, we shall continue it from a slightly different perspective. It is assumed that in Samokhvalov experiment [20] between two ferromagnetic disks there exist a good vacuum. We shall not dwell on the details of this experiment. The reader can directly turn to the description of the experiment in Samokhvalov's article [20], if there is an acute need.

We shall assume that the interaction between disks is achieved by mechanisms of self-organization of elementary vortices that exist in physical vacuum due to giant number of pairs of particles and antiparticles [22]. Due to this, the torque is transmitted from one rotating disk to another, which is not rotating. As a result, there occurs a capture of the nonrotating disk into a uniform rhythm with the rotating disk.

Samohvalov experiment described in the article [20] in details, opens horizons much broader than it may seem at first glance. Perhaps the most interesting problem affected by the experiment may be a question about the so-called "dark matter". It is a obscure substance, which is allegedly responsible for the constancy of the orbital motion of spiral arms of the galaxies around the nucleus [4]. Really, here there is a capture of star clusters in an unified rhythm. What is reflected in the stabilization of the orbital motion of the stars up to those lying on the edges of the galaxy.

The paper is organized as follows. Chapter II starts with description of the well-known Casimir effect [14]. An important role here belongs to scalar modes of the vacuum fluctuations which stem with involving the scalar potential. Totally different situation occurs in the case of rotational modes of the vacuum fluctuations. For understanding of the role of the rotational modes, we refer to the study of vortex beams in liquid helium [7]. The fact is that the liquid helium can be a perfect model of the

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physical vacuum [5, 25]. In Chapter III we declare, that behavior of the physical vacuum in the non-relativistic approximation can be quite strictly described by the modified Navier-Stokes equations [22]. There are two slight modifications. They lead to two important outcomes: (a) the scalar potential is the basis of obtaining the Schŕodinger equation; (b) whereas the vector potential leads to the equations describing the vortices.

Looking ahead, it is important to emphasize that the second modification (fluctuating about zero viscosity of the vacuum medium) leads to: (i) an arbitrarily long period of existence of the vortices; (ii) the vortex has a finite core radius; (iii) the trembling of the vortex in time. In Chapter IV we discuss the facts of steady rotation of the spiral arms of the galaxies in the light of exchange of the rotational energy of baryonic matter with the zero-point fluctuations of the vacuum. It is shown that there is no need to involve dark matter to explain the stationarity of rotation. Chapter V is final and here we involve a brief characterization of the philosophical issues about the problems raised in this article.

II. INFLUENCE OF THE PHYSICAL VACUUM ON THE BARYONIC MATTER.

Baryons (protons and neutrons) are bricks from which the majority of the observed matter of the universe are built. Here we can also add the leptons, among which there is such a long-lived particle like electron. These three particles, proton, neutron and electron, are basic particles of the matter given us in sensation. We can guess that these particles are long-lived excitations of the vacuum. In other words, the physical vacuum is a basis of all, against which a drama unfolds being contemplate by the human mind, who himself is a party to this drama.

Not going to continue this philosophical thought further. We can suppose only that such an ephemeral medium, previously called ether, is present everywhere. Baryonic matter is under the constant influence of this medium. Not always this assumption was welcomed good. At the beginning of the 20th century the ether was rejected. It did not withstood experimental verification. All observable matter evolves in a vacuum. For a long time the vacuum was a synonym of emptiness, filled with atoms of Democritus. They are facing, exist for a while together, and then diverge apart again [18].

On the other hand, at the beginning of the 20th century the foundations of quantum mechanics were laid. In agreement of its findings, the space cannot be empty. But here there happens all possible zero-point quantum fluctuations. On a short time particles are born from nothingness and next they disappear again. This constant emergence and disappearance of particles can't pass without a trace for the objects that inhabit the space. An example would be the Casimir effect [2].

A. The Casimir effect: scalar modes of vacuum fluctuations

In 1947, the Dutch physicist Hendrik Casimir predicted the possibility of attraction of two uncharged plates separated by the empty space, at the expense of energy of fluctuations of the physical vacuum [14]. Later this effect was confirmed experimentally. According to the quantum field theory, physical vacuum is not absolutely empty. Here there happens constant creation and annihilation pairs of virtual particles and antiparticles. This medium is a perfect superfluid liquid, represented as an ensemble of virtual pairs, susceptible to any movements in it. These pairs, in fact, are Bose particles. Simply put, particles with zero spin, which may represent scalar oscillatory modes.

The wavelengths of these modes can be laid between the two plates multiple times (as it takes place in the resonator). Only a finite number of such modes can be between plates. While outside this limited space the number of modes is not restricted. This difference in number of modes between the plates and outside of them is the reason of the force of attraction of the plates. It is called the Casimir effect. Outwardly, it resembles the same effect of attraction of the two ship hulls floating next to each other on a parallel course. The Casimir effect manifests itself owing to the selection of the simplest oscillation modes (scalar waves), confined in the space between these plates.

B. Twisted vortex bundles

On the basis of scalar waves discussed above, it is impossible to explain the observed capture of a disk by the torque in the experiment Samokhvalova [20]. Here we need to involve the mechanisms responsible for emergence of the torque. The right-hand rule representing the chirality that is a visual image of the torque, see Fig. 1.

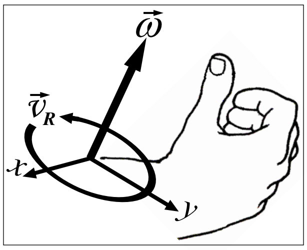

FIG. 1: The right-hand rule: four fingers of the right hand indicate the direction of rotation, the thumb shows the direction of the vorticity vector $\vec{\omega}$.

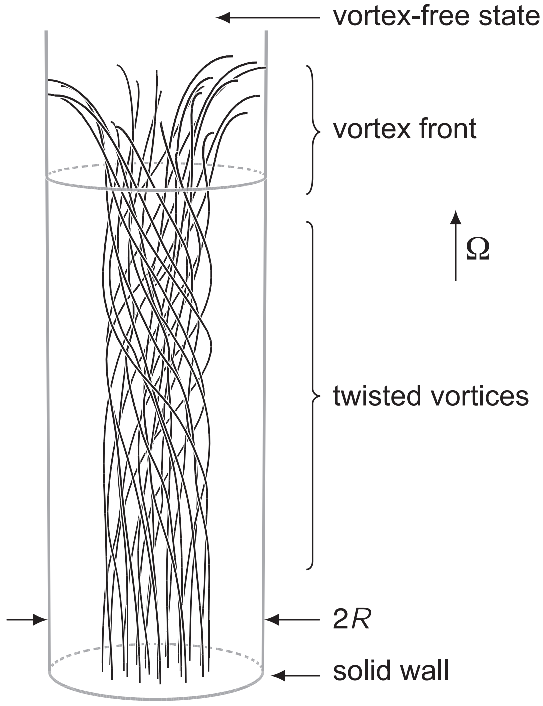

FIG. 2: The formation of the twisted vortex state [7]. A bundle of vortex lines is slowly growing up with the rotation of the cylinder. Here Ω is angular velocity, R is the radius of the rotating cylinder. Picture placed with kind permission of E. Thuneberg.

It is noticed, that liquid helium is a particularly good model of the physical vacuum [25]. Therefore, results of the experiments conducted on liquid helium may give food for thought about what might happen in the physical vacuum. As is known, in liquid helium the electrons form Cooper pairs. They are particles with zero spin, and in the ensemble representing the Bose-Einstein condensate. In the physical vacuum such a condensate is formed due to pairing of particles and antiparticles. It should be borne in mind that vacuum fluctuations are represented by sporadic annihilation and creation of particles and antiparticles. Such an exotic pair mutually is annihilated and generated again on lower Bohr orbit. So in the vacuum there are always natural elementary vortices formed by rotating around a common center of mass.

Each elementary vortex gives a negligible contribution. But since there are a lot of such virtual vortices, they may give noticeable macroscopic effect. A joint team of physicists from Finland, Russia and Japan have carried out model calculations with the formation of the twisted vortex beams [7], which are formed in the liquid helium ^{3}He-B because of the rotation of the cylinder, see Fig. 2. It is found that as the rotation of the cylinder, on the bottom plane begins to be formed a vortex bundle, which slowly grows upwards until it reaches the upper plane. Each vortex filament in this ensemble is represented by a number of elementary vortices forming a holistic formation and entering into a synergistic relationship with other filaments. In the result, a twisted vortex bundle is formed, which can have a macroscopic effect on the upper disk, see Fig. 3.

In a similar manner twisted vortex bundles can be formed in the physical vacuum where the elementary vortices are represented by virtual pairs particles and antiparticles. These pairs are annihilated and then are created again, perhaps in a different place (the uncertainty principle does not guarantee creation of the pair in the same place where the annihilation occurred). Since these fluctuating pairs are bosons, their birth takes place in the same vortex bundle with the same orbital angular momentum and the chiral-

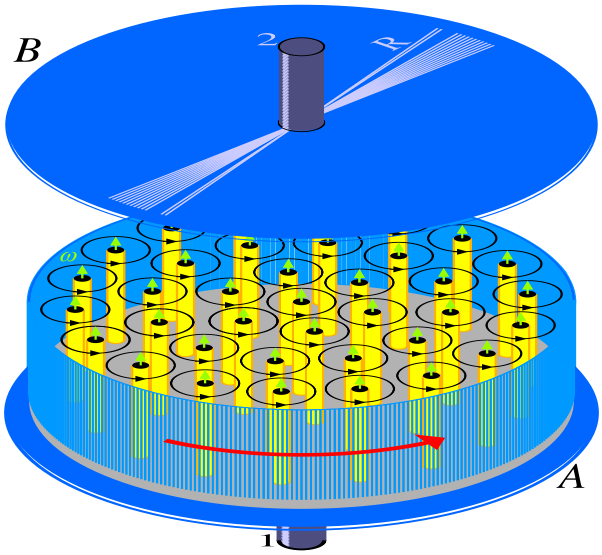

FIG. 3: The rotation in the superfluid special medium, which is the physical vacuum, leads to the formation of a lattice of quantized vortices [13, 22]. The vortex cores painted in yellow are parallel to the axis of rotation. Green arrows show the vorticity ω. Small arrows on the black circles indicate the direction of the orbital velocity $\vec{v}_R$ around vorticity. The technical vacuum is maintained between non-ferromagnetic disks A and B. The both have radius R impaled on unbound axes **1**, and **2**. Disk A rotates and causes the formation of a vortex beam. Once the vortex beam reaches disk B, it begins to rotate in a single rhythm with the disk A [20].

ity according to the law of conservation.

Twisted vortex bundles are not homogeneous but form a lattice of quantized vortices with the vorticity parallel to the axis of rotation [13]. Fig. 3 shows such a lattice of vortices, drawn by yellow bars. Vorticity, ω, is shown by a green arrow, oriented upwards.

Such a vortex bundle arising in a special superfluid medium, such as the physical vacuum, grows from the bottom of the rotating disk A to the top. Once the bundle reaches the upper disk B, fixed initially, this disk begins to rotate in the same rhythm as the disk A. This experiment was fulfilled by V. Samokhvalov [20] (see figure 4) and demonstrated that the capture disk B occurs if and only if between the disks A and B is supported a good technical vacuum (~ 0.02 Torr). Otherwise, there are no conditions for the formation of the vortex bundle.

Thus, in addition to the Casimir effect conditioned by the selection of vibrational modes (scalar waves), that are confined in a confined space between two plates, there is another effect caused by reproduction of the twisted vortex bundle due to the rotating disk. The vortex bundle is formed from a synergistic ensemble of elementary vortices, presented by virtual pairs of particles and antiparticles, which fluctuate on the lower Bohr orbit around the common centre of mass. Once the vortex bundle reaches the upper nonrotating disk, this disk begins to rotate with the same rotation rhythm.

Now the challenge is to give a clear mathematical picture of this phenomenon.

III. THE NAVIER-STOKES EQUATION CAN DESCRIBE MOTION OF THE SPECIAL SUPERFLUID MEDIUM

Newton's second law describes the accelerated motion of a rigid body under the influence of the applied external force $\vec{F}$:

$$m\frac{d\vec{v}}{dt} = \vec{F}. \qquad (1)$$

Here m is the mass of the body, $\vec{v}$ is the current velocity of the body, and the right part of the equation presents the force $\vec{F}$.

However, if the body is a deformable body, then when describing the motion of such body, along with the external force it is necessary to take into account the internal forces leading to deformations of the body as it moves in space. In the first place there are two internal forces. One force is due to the pressure arising inside the body. And the second force is owing to friction of different body parts against each other as the body moves. The last force is dissipative force that dissipates the energy to a heat at moving the body.

In fact, we come to extension of Newton's second law for motion of deformable media. The equation describing such a motion is the Navier-Stokes equation:

$$\rho_M\frac{d\vec{v}}{dt} = \frac{\vec{F}}{\Delta V} - \nabla P + \mu\nabla^2\vec{v}. \qquad (2)$$

Since this equation describes the motion of a deformable medium instead the mass M we write the density distribution $\rho_M = M/\Delta V$ of this mass within the small volume ΔV. Also, we keep

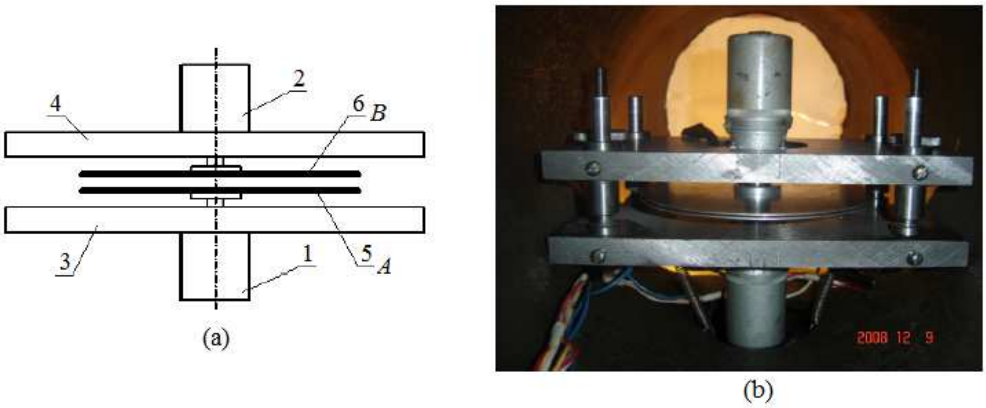

FIG. 4: Schematic diagram (a) and general view of the device (b) for research of the mass dynamical effect: **1**, and **2** - axis with impaled on them electric motors; **3**, and **4** - steel boards with fortified them electromagnetic brakes; **5**, and **6** (A and B, see the previous illustration) are non-ferromagnetic disks, rigidly attached to the flanges of the rotors of electric motors. Picture is placed with kind permission of V. Samokhvalov.

in mind that the external force is distributed through the whole body. So, we need to write the density of the external force $\vec{F}/\Delta V$. The two other terms describe the action of internal forces. A term ∇P describes the pressure gradient at each point of the medium. As for the term $\mu\nabla^2\vec{v}$, as we see, it is the diffusion flux. It describes a dissipation rate due to the viscosity of the medium. The coefficient μ is called the dynamic viscosity.

As one can see, the Navier-Stokes equation is a specific form of Newton's second law, which describes the classical motion of a compressible, viscous fluid. This equation has a wide class of solutions, ranging from simple laminar fluid flows, up to complex flows such as turbulent. The latter give such interesting solutions, as the emergence, evolution, and dissipation of vortices. Because of the presence of dissipative term $\mu\nabla^2\vec{v}$, any vortex motion with time fades.Therefore, in that form in which this equation is presented, it may not qualify for the description of any quantum phenomena.

It is possible in principle to abandon dissipative term. Then heat dissipation in any form will be absent. It will be a perfect equation describing the superfluid medium. This equation is called Euler equation.

It would seem that this equation is able to describe any motions in the superfluid medium, which is the physical vacuum. However, problems arise with the description of the vortex motions. In principle, the vortex, as a solution of the equation, could exist as long as possible. But the vortex has that disadvantage that the vorticity ω is centered at the central point of the vortex. In order to describe such a vortex we have to involve the Delta function. What does this mean physically? This means that near the localization of the vorticity, the orbital speed tends to infinity. This leads to divergences in the subsequent calculations, with all the ensuing consequences, like forced renormalization of the solutions, etc. From this point of view, the Euler equation has a low efficiency.

Let us assume two modifications in the original Navier-Stokes equation [22]:

$$\rho_{_M}\frac{d\vec{v}}{d\,t} = \frac{\vec{F}}{\Delta V} - \rho_{_M}\nabla\left(\frac{P}{\rho_{_M}}\right) + \mu(t)\nabla^2\vec{v}. \qquad (3)$$

Here we see that the modified terms are the internal forces of the deformable medium. The first force is described by the pressure gradient takes the form $\rho_{_M}\nabla(P/\rho_{_M}) = \nabla P - P\nabla(\ln(\rho_{_M}))$. The additional term $P\nabla(\ln(\rho_{_M}))$, as can be seen, absents in the original Navier-Stokes equation: in accord with the principle of Occam's razor, its presence introduces an unnecessary entity. But this essence allows us to derive the quantum potential, without which we can't obtain the Schr´odinger, which is a basic equation of non-relativistic quantum mechanics. Now we will output the quantum potential. As for the time-dependent dynamic viscosity $\mu(t)$, this issue will be considered in the next phase.

A. Quantum potential

First of all, we define a mass density, ρ_M through the density of the number of particles, ρ, occupying the volume ΔV:

$$\rho_M = \frac{M}{\Delta V} = \frac{mN}{\Delta V} = m\rho. \qquad (4)$$

Here the total mass M of the deformed medium in the volume ΔV is represented as the product of the mass of elementary carriers m by the number of these carriers N in the same volume [9].We also believe that the elementary carriers in this medium perform the Brownian motion [16]. In this regard, it is necessary to have a diffusion coefficient of such walkings. Let us admit that this coefficient has the form [15]

$$D = \frac{\hbar}{2m}, \qquad (5)$$

where $\hbar$ is the Planck constant divided by 2π. It should be noted that the Brownian motion is empirical simulant of the uncertainty principle [21]. Namely, at collision of two particles, their positions become localized accurate to their sizes. Therefore, according to the uncertainty principle, their impulses, in a result of the collision, become indeterminate (in other words, they gain indefinite angles of scattering after collision).

Observed that the energy of the elementary carrier is $E = mc^2$, where $c = 1/\sqrt{(\epsilon_0\mu_0)}$ is the speed of light in the physical vacuum, and ϵ_0 and μ_0 are the absolute permittivity and permeability of the vacuum, respectively. On the other hand, the same energy can be expressed as $E = \hbar\omega/2$. Here ω represents the frequency of the wave radiation that corresponds to the elementary carrier. From the above drawn formulas, the hypothesis of the wave-particle dualism is defined in explicit form as representation of the mass through the frequency of the radiation

$$m = \frac{\hbar}{2c^2}\,\omega = \frac{\hbar}{2}\,\epsilon_0\mu_0\,\omega. \qquad (6)$$

This ratio indicates that material bodies, under certain circumstances, behave like waves, demonstrating interference effects [21].

Now, by substituting the expression (6) in equation (5), we obtain another representation of the same diffusion coefficient

$$D = \frac{c^2}{\omega} = \frac{1}{\epsilon_0\mu_0\omega}. \qquad (7)$$

This formula is the diffusion coefficient for radiation of virtual particles that populate the lower energy level of the vacuum.

Postulate: the quantum potential [1, 12] is proportional to the pressure P, which occurs in a liquid medium under the action of forces that cause stress in this medium. We believe that the pressure P can be represented by the sum of the two pressures, P_1 and P_2. The first Fick's law states that the diffusion flux $\vec{J}$ is proportional to the negative magnitude of gradient of the mass density, $\vec{J} = -D\nabla\rho_M$, where the constant of proportionality, D, is the diffusion coefficient defined above. Since a term $D\nabla\vec{J}$ has the dimension of pressure, we say

$$P_1 = D\nabla\vec{J} = -\frac{\hbar^2}{4m^2}\nabla^2\rho_M. \qquad (8)$$

Observe further that the kinetic energy of the diffusion flux can be defined as $(m/2)(\vec{J}/\rho_M)^2$. From here it follows, that there can be another pressure, P_2, defined as the average momentum transfer, per unit surface and per unit time:

$$P_2 = \frac{\rho_M}{2}\left(\frac{\vec{J}}{\rho_M}\right)^2 = \frac{\hbar^2}{8m^2}\frac{(\nabla\rho_M)^2}{\rho_M}. \qquad (9)$$

Finally, we obtain that the sum of the two pressures, $P_1 + P_2$ divided by $\rho = \rho_M/m$, see (4), represents the quantum potential

$$Q = \frac{P_1 + P_2}{\rho} = \frac{\hbar^2}{8m}\left(\frac{\nabla\rho}{\rho}\right)^2 - \frac{\hbar^2}{4m}\frac{\nabla^2\rho}{\rho}. \qquad (10)$$

Now, in order to come to the Schrödinger equation it is necessary to supplement the Navier-Stokes equation by the continuity equation. And then perform a number of transformations with the Navier-Stokes equation, to extract from it the Hamilton-Jacobi loaded by the quantum potential [22].

We will not perform these transformations. We note only that the solution of the Schrödinger equation has a complex-valued function, the wave function, which to be represented in the polar form

$$\psi(\vec{r},t) = \sqrt{\rho}\exp\{-\mathbf{i}S/\hbar\}. \qquad (11)$$

Here ρ represents the probability density of finding the particle (the elementary carrier of energy) in the vicinity of the point $\vec{r}$, at time t. And the function S, called by the action function, characterizes mobility of this particle. The mobility is the momentum of the particle $\vec{p} = \nabla S$, or it can be expressed through the velocity of the particle

$$\vec{v}_S = \frac{1}{m}\nabla S. \qquad (12)$$

Here the subscript S emphasizes that velocity is the derivative of the scalar function S. The rotor applied to this velocity vanishes.

The wave function $\psi(\vec{r},t)$ describes the motion of the special superfluid medium, of the physical vacuum, It presents innumerable set of different virtual pairs of particles and antiparticles. They are at the lower energy level, and only the zero-point fluctuations of the vacuum can declare about their existence.

B. The vortex motions

Remarkably, the Navier-Stokes equation provides a broad set of solutions, covering simple laminar flows and up to such complicated solutions, as turbulent ones. It means, that the velocity $\vec{v}$ appears to be a superposition of at least two velocities [11] - cruising velocity $\vec{v}_S$ and an orbital velocity $\vec{v}_R$. Here the subscripts S and R indicate the cruising velocity following from the gradient of the scalar field S and the orbital velocity relating to the rotation about the central point. They satisfy the following equations::

$$\begin{cases} (\nabla\cdot\vec{v}_S) \neq 0, & [\nabla\times\vec{v}_S] = 0, \\ (\nabla\cdot\vec{v}_R) = 0, & [\nabla\times\vec{v}_R] = \vec{\omega}. \end{cases} \qquad (13)$$

Here $\vec{\omega}$ is called the vorticity.

Let us apply the operator of the rotor to the modified Navier-Stokes equation (3). But first we imagine the full derivative of the velocity $\vec{v}$ by time (the time derivative along the trajectory) using partial derivatives (the derivatives in the current point $(\vec{r},t)$):

$$\frac{d\vec{v}}{dt} = \frac{\partial\vec{v}}{\partial t} + (\vec{v}\cdot\nabla)\vec{v}. \qquad (14)$$

After applying the rotor operator to equation (3), we obtain equation for the vorticity $\vec{\omega}$:

$$\frac{\partial\vec{\omega}}{\partial t} + (\vec{\omega}\cdot\nabla)\vec{v} = \nu(t)\nabla^2\vec{\omega}. \qquad (15)$$

Here and further we will not write the subscript R at the orbital velocity $\vec{v}$, since we will deal with this velocity hereinafter only. This equation describes a state of the vortex in the local frame of reference attached to the center of the vortex. The right term describes dissipation of the energy stored in the vortex. The coefficient $\nu(t) = \mu(t)/\rho_M$ is the kinetic viscosity coefficient. Its dimension is [length^2/time]. As mentioned earlier, this coefficient is a fluctuating function of time.

To simplify the analysis of this equation, we shift the coordinate system to the center of the vortex so that the vortex axis would directed along the axis z, and the vortex would be lying in the plane (x,y). The vortex equation, rewritten in this coordinate system has the view

$$\frac{\partial\omega}{\partial t} = \nu(t)\left(\frac{\partial^2\omega}{\partial r^2} + \frac{1}{r}\frac{\partial\omega}{\partial r}\right). \qquad (16)$$

Here we do not write the sign of the vector over ω, since the vorticity is accurately oriented along z-axis. The general solution of this equation has the following form

$$\omega(r,t) = \frac{\Gamma}{4\Sigma(\nu,t,\sigma)}\exp\left\{-\frac{r^2}{4\Sigma(\nu,t,\sigma)}\right\}, \qquad (17)$$

$$v(r,t) = \frac{1}{r}\int\limits_0^r \omega(r',t)r'dr' = \frac{\mathit{\Gamma}}{2r}\left(1 - \exp\left\{-\frac{r^2}{4\mathit{\Sigma}(\nu,t,\sigma)}\right\}\right). \tag{18}$$

Here $\mathit{\Gamma}$ has the dimension [length^2/time], and the denominator $\Sigma(\nu,t,\sigma)$ has the form

$$\mathit{\Sigma}(\nu,t,\sigma) = \int\limits_0^t \nu(\tau)d\tau + \sigma^2. \tag{19}$$

The parameter σ is an arbitrary constant, due to which the denominator stays always positive. This parameter is due to assumption of the existence of a stationary Gaussian "cloud" [10], supported by the field pressure.

Consider the case where the coefficient of viscosity is a positive constant, $\nu = \text{const} > 0$. In this case, there is an irreversible energy dissipation of the vortex. The solution (17)-(18) degenerates into the form

$$\omega(r,t) = \frac{\mathit{\Gamma}}{4(\nu t + \sigma^2)}\exp\left\{-\frac{r^2}{4(\nu t + \sigma^2)}\right\}, \tag{20}$$

$$v(r,t) = \frac{\mathit{\Gamma}}{2r}\left(1 - \exp\left\{-\frac{r^2}{4(\nu t + \sigma^2)}\right\}\right). \tag{21}$$

When $\sigma = 0$ this solution is known in the literature as the Lamb-Oseen vortex [26], which describes decay of the vortex with time due to the viscosity. As is clear from (20)-(21), when $t \to \infty$ both the vorticity $\omega(r,t)$ and the angular velocity $v(r,t)$ go to zero in the whole space.

Consider the case of a perfect fluid with $\nu = \text{const} \to 0$. In this case, the solution of (20)-(21) reveal a stationary Gaussian "cloud" [10]. Non-zero constant σ has a meaning of the average radius of this cloud. The vorticity gradually decreases, but the orbital speed grows from zero up to some maximum value with increasing the radius r from the center of the cloud to σ. Then it drops to zero when $r \to \infty$.

The return to the formulas (17)-(18) shows that at fluctuations of the viscosity $\nu(t)$ around zero, the exchange of the vortex energy with zero-point fluctuations of the vacuum occurs, Fig. 5. Let the viscosity $\nu(t)$, for the sake of simplicity, have the following form

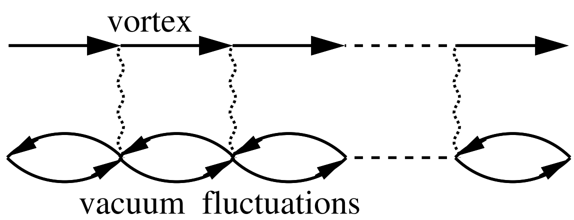

FIG. 5: Exchange of the vortex energy with zero-point vacuum fluctuations.

$$\nu(t) = \nu\cos(\Omega t) = \nu\,\frac{e^{\mathrm{i}\Omega t} + e^{-\mathrm{i}\Omega t}}{2}. \tag{22}$$

Then, calculating the integral (19), we find that in the formulas for the vorticity (17) and for the orbital velocity (18) the function $\mathit{\Sigma}(\nu,t,\sigma)$ will be as follows

$$\mathit{\Sigma}(\nu,t,\sigma) = (\nu/\Omega)(\sin(\Omega\,t) + n) \tag{23}$$

Here $(\nu/\Omega)n = \sigma^2$ and $n > 1$. These solutions for given parameters $\mathit{\Gamma} = 1$, $\nu = 1$, $\Omega = 2\pi$, $n = 16$ are shown in figure 6. The vorticity $\omega(r,t)$ reaches maximal values in the center of the vortex ($r = 0$), and then decreases to zero as $r \to \infty$. While the orbital speed vanishes in the center of the vortex, then grows with increasing r, and after reaching a maximum value begins to decrease monotonically to zero as $r \to \infty$. The both functions do not to decrease with time, as seen, but retain some statistical average level at their maximal values. It is evident, that both the vorticity $\omega(r,t)$ and the orbital speed $v(r,\,t)$ oscillate around this level. These fluctuations are due to exchange of the stored energy of the vortex with the vacuum fluctuations.

Qualitative view of the vortex in a cross-section is shown in Fig. 7. In the center of the vortex is well visible a light spot, representing the core of the vortex. Turning to the macroscopic images it is best to give an example with a tornado. In this sense, the light spot represents the eye of the tornado, where the wind speed is minimal. As distance from the center of the tornado grows, the wind speed increases until it

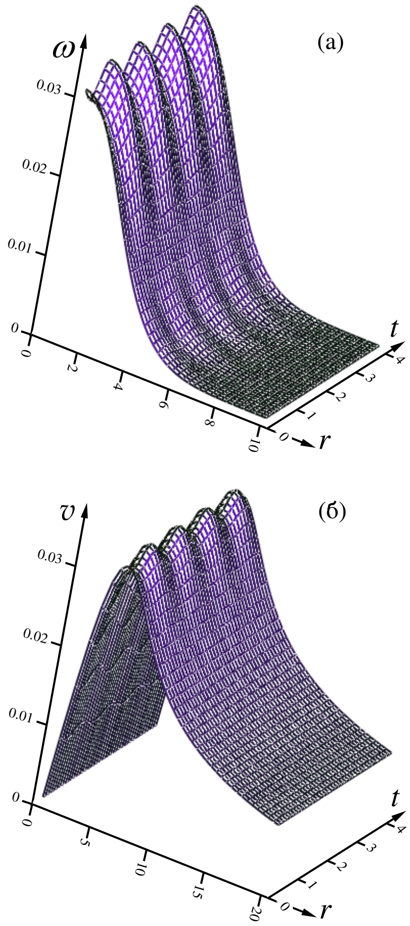

FIG. 6: Solutions (17)-(18) with the function $\Sigma(\nu, t, \sigma)$ inserted in formula (23); $\nu = 1$, $\Omega = 2\pi$, $n = 16$ and $\Gamma = 1$: (a) the vorticity $\omega(r, t)$, (b) the orbital speed $v(r, t)$.

reaches a crushing force on the wall of the eye. Moving away from the wall of the eye outward, the wind speed begins to fall. And far from the tornado, the wind slackens.

Fluctuations of the vorticity dencity and the orbital speed represent a breathing of the tornado, which is most clearly felt when the tornado is formed in the ocean. It is known that it is a source of infrasound oscillations acting on animals and humans long before its onset on a coastline. The infrasound causes discomfort in animals and they try to leave a region with its high level. As for humans, the infrasound can also provoke phantom visions and auditory hallucinations.

Returning to the transfer effects from one disk (rotating) to another (fixed) through the self-organizing vortex bundle in the vacuum, mentioned at the beginning of the article, we came to the Navier-Stokes equation, with modified in-

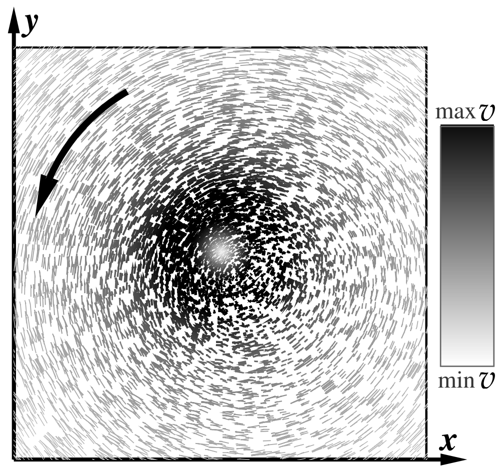

FIG. 7: The cross-section of the vortex in the plane (x, y). Values of the orbital speed v are represented in gray, ranging from light gray (min v) to dark gray (max v). The pixel density reflects the intensity of the vorticity.

ternal forces (the pressure gradient and the viscosity). This equation describes motion of the special superfluid medium that is the physical vacuum. This equation gives solutions for the vortices, which involve many pairs of particles and antiparticles, fluctuating in a vortex dance around the center of mass. Circling each such pair has a negligible angular momentum, but myriad of couples involved in a single rotating dance is able to transfer the kinetic moment to a stationary disk and capture it in the general rotation. Surprisingly, but such a process of capture through the self-organizing vortex bundles is the basis of stabilization of the orbital speed spiral galaxies [23].

IV. ROTATION OF SPIRAL GALAXIES: THE DARK MATTER IS AN ILLUSION

It would seem that spiral galaxy looks like a tornado in its cross-section. And therefore a speed of rotation of the spiral galaxy around the axis, would have to obey the same regularities as the orbital speed of the tornado. Namely, in the center of the galaxy the rate is minimal, then it grows as distance from the core of the galaxy increases, and once it reaches a certain maximum speed, begins to subside slowly when you are removing on a periphery of the galaxy.

Real measurements of the orbital speeds of galaxies show that this is not so. After reaching the maximum speed, by subsequent removing from the galactic center, the speed remains at a constant level, or even increases slightly [4].

To try to deal with this fact, scientists introduced a concept of the dark matter [3, 6, 19]. It is believed that its presence in the galaxy contributes to the stabilization of the rotation of the spiral arms. Imagine that all the stars and interstellar gas "tightly glued" into a some hard substance which does not interact with the baryonic matter, except gravitational interaction. Such "strange dark matter", rotating around the axis, holds all the stars in those places where they were "firmly affixed". Since the dark matter does not manifest itself, its presence is not possible to detect by devices based on known interactions such as electromagnetic, strong, and weak. Remain only indirect evidences through gravitational interaction.

However, there are opinions in the scientific literature [8, 18, 24], denying the dark matter as a false tool for solving this delicate problems.

A question arises, whether is the abovementioned effect of steady rotating the spiral arms of galaxies, similar to that that have been observed and described in the articles of Samokhvalov? In other words, there is not any dark matter, but stationary rotation is conditioned by stabilization of the self-organized vortex bundles in vacuum, by involving into a single vortex dance of stars and the interstellar gas of the spiral arms. In article [23] the author suggests the mechanism of stabilization of the orbital rotation of spiral galaxies, based on the above idea.

Suppose that there exists a wide range of the viscosity coefficients. For the sake of simplicity of presentation, we assume a discrete spectrum, with the localization of components in each frequency band according to the law $1/f$ (flicker range):

$$\nu_n(\,t\,) = \frac{c^2}{\Omega_n}\cos(\Omega_n t). \tag{24}$$

Here c is the speed of light. Note that the coefficient c^2/Ω_n is equivalent to the diffusion coefficient (7). So that the different frequency modes has its own the viscosity coefficients. At that, the viscosity coefficient, ν_n, converges to infinity when Ω_n tends to zero. This spectrum of excitability of the vacuum fluctuations gives the largest contribution on the frequencies near zero:

$$\Sigma_n(\,t\,) = 4\left(\frac{c^2}{\Omega_n^2}\sin(\Omega_n t) + \sigma_n^2\right). \tag{25}$$

For each vibrational mode, as can be seen, there is the Gaussian vortex cloud with its own average radius

$$\sigma_n = \frac{4c}{\Omega_n}. \tag{26}$$

From here it follows, in particular, that when Ω_n tends to zero, the cloud covers the whole universe and the viscosity of the clouds tends to infinite value. It is possible, the cloud represents an universal halo.

Subsequent calculations are based on calculations similar to the calculation of the function of canonical distribution, which represents the statistical sum over all possible states of the thermodynamical system. In our case, the statistical sum is given by superposition of the solutions of equation (16) for all orbital modes. As a result, we obtain a general function of the vorticity

$$\omega(r,t) = \frac{\mathit{\Gamma}}{N}\sum_{n=1}^{N}\frac{1}{\Sigma_n(\,t\,)}\exp\left\{-\frac{r^2}{\Sigma_n(\,t\,)}\right\} \tag{27}$$

and a general function of the orbital speed

$$V(r,t) = \frac{\mathit{\Gamma}}{2rN}\sum_{n=1}^{N}\left(1-\exp\left\{-\frac{r^2}{\Sigma_n(\,t\,)}\right\}\right). \tag{28}$$

With aim of illustration, the curves (27) and (28) are calculated for $\mathit{\Gamma} = 4\cdot 10^{27}$ m^2/h, $\Omega_n = 10^{-11}n^{-1}$ 1/h, and $N = 25$. Fig. 8 shows the evolution of the orbital velocity for a typical spiral galaxy for t changing in a range of about 1000 light years (time is generally measured in units of tc, where c is the speed of light). It is seen that the dependence of V vs. r, when r exceeds the radius of the galactic core, is almost unchanged on the whole time interval. Still, that catches the eye, it is the presence of small fluctuations of the speed around some its average

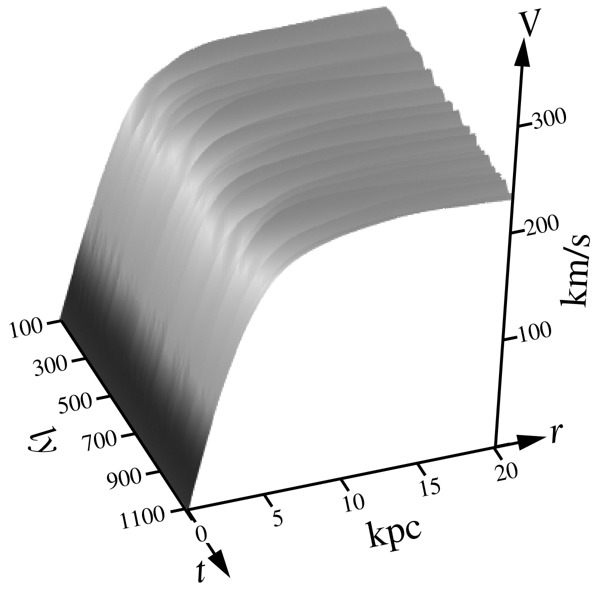

FIG. 8: The orbital velocity V as function of radius r from the galactic center (is given in kiloparsecs), is shown for time t for a period of about 1,000 years.

value. Galaxy breathes. This breathing is conditioned by exchange of the rotation energy of the galaxy with the fluctuations of virtual particle-antiparticle pairs at very low frequencies, that is, at wavelengths commensurate with sizes of the galaxies. Most likely these pairs are gravitational dipoles. Dragan Hajdukovic in this regard, writes [8]: "dark matter does not exist but is an illusion created by the polarization of the quantum vacuum by the gravitational field of the baryonic matter. Hence, for the first time, the quantum vacuum fluctuations, well established in quantum field theory but mainly neglected in astrophysics and cosmology, are related to the problem of dark matter."

An existence of the Gaussian vortex of clouds with an average radius of $\sigma_n \sim \Omega_n^{-1}$ ensures the stability of galaxies. Perhaps, these clouds represent the galactic halo, where there are globular clusters stars, dust, and gas surrounding the galaxy. As follows from the formula (26), the radius of the vortex cloud tends to infinity at Ω_n going to zero. For this reason, the halo can extend well on significant distances beyond the galaxy.

V. CONCLUSION

Self-organization of huge amount of gyroscopes presented by virtual pairs of particles and antiparticles and involved in a single rotating dance leads to a significant macroscopic effect. This effect is observed in the Samokhvalov experiment [20] as the grasping in the technical vacuum of the initially unmoved disk by the rotating disk. On the cosmic scale this effect exhibits itself in stabilization of the orbital speeds of spiral arms of galaxies. As a result, all stars rotate around the central core of the galaxy with almost equal speed, independently of how far from the center of the galaxy they are placed.

This effect, like the Casimir effect, is a manifestation of amazing properties of the physical vacuum, which was previously called ether and which is responsible for forwarding interactions at distances (as for example, the interaction of electric charges, masses, or the influence of magnetic field on remote solids).

It is curious that the rejection of the ether as an ubiquitous special substance, at the initial stage of creation of the general theory of relativity (GTR), has led to the series of false hypotheses. Some of these hypotheses are the dark matter and dark energy. The both concepts are based on assumption of the absolute correctness of the equations of GTR and the hasty conclusions drawn from early astrophysical observations. The first one had somehow to explain stabilization of the orbital speeds of the spiral arms of galaxies. And the second one is to explain the discrepancies found in the Hubble's law, also called the law of expanding the universe. As a result, on the light there were assumptions about the existence of hitherto unknown substances, called dark matter and dark energy.

Above only two controversial hypotheses are mentioned. Scientific society recognizes that modern science is experiencing an ontological crisis [18] - the crisis conditioned by existence of false premises that are accepted by the next generations of scientists for the truth. The contemporary crisis in science resembles the clash of geocentric and heliocentric points of view -

whether the Sun revolves around the Earth, or the Earth revolves around the Sun. The history shows that the struggle between these points of view has been very dramatic. It is quite possible that the resolution of the current crisis in science, can have a dramatic scenario also, when on a fire line will be problems of the inflationary cosmology that are based on perfect recognition of the Big Bang.

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