About polarization nature of Newtonian fluid viscosity

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The paper considers a polarization mechanism of viscosity in Newtonian fluid that gives viscosity coefficients of the both signs in the Navier-Stokes equation derived from the Euler equation. Their value range is demonstrated to agree with variation of viscosity of known Newtonian fluids. A possibility of obtaining and utilizing negative friction is discussed.

1. Introduction.

It is known from experience that isolated non-equilibrium nucleonic matter known to us behaves as a dissipating system, its entropy increases monotonically. This entropy law (the second law of thermodynamics) was discovered by R. Clausius, and its statistical justification was provided by L. Boltzmann. This is one of the fundamental tenets of current physics and technology supported by a wealth of experimental and technical experience. Many tried to refute it, or, to be more exact, limit its scope by finding conditions under which a perpetuum mobile can be built. The science rejects all such attempted refutations.

Is it correct?

To answer this question, the paper considers origination of viscosity in fluids due to the non-linear polarization mechanisms and presents derivation of the Navier-Stokes equation from the Euler equation. In classical mechanics the Navier-Stokes equation is derived by means of phenomenological introduction of viscosity through the viscous stress tensor [1]. And the physical nature of viscosity remains unclear.

At present fluid structure and properties are most successfully described in the perturbation theory where a hard-sphere model is taken as the zero-order approximation, and attractive forces are treated as perturbation [2]. The statistical theory of kinetic processes in fluid is based on non-equilibrium distribution function studies for systems of different number of molecules. If paired forces act in a system, these functions satisfy a system of Bogolubov self-consistent integro-differential equations [3]. These equations are reversible in terms of time, and in order to obtain solutions describing irreversible kinetic processes the distribution functions are averaged or “smeared” over appropriately chosen small time intervals. Kinetic equations irreversible in time are obtained as a result [2]. However the fundamental physical nature of the irreversibility remains unclear in this case also.

Why is that?

In the modern theory all four fundamental interactions are potential. In this case any fundamental explanation of viscosity development should involve potential interaction of fluid particles. However, with the vortex fluid flow the friction force due to viscosity does not have potential since it depends on the directed fluid velocity. That is why an interaction between electron shells of atoms moving in a fluid with different velocities cannot result in dissipation. Similarly, electrons in an atom do not experience mutual friction in spite of different velocities. How then viscosity develops in fluid?

The single possibility to answer the question of the viscosity nature at the fundamental level is to seek for an interaction that gives rise to viscosity and does not possess a real potential. To this end we shall step over the bounds of the theory with four fundamental interactions. Such an approach is implemented in the polarization theory (PT) where the polarization derivation of the Navier-Stokes equation was obtained [4]. This paper discusses the polarization mechanism of viscosity that allows describing its variation range in actual fluids. The polarization theory (PT) postulates provided the basis for the results obtained; four of the postulates are essential to understanding of the results and are cited below.

1. All physical quantities, including space-time (ST) coordinates, are complex in the general case. Their emergence is described by polarization relationships of the following type:

$$a+b=0; \quad a^2+b^2=0; \quad \vec{a}+\vec{b}+0; \quad \vec{a}^2+\vec{b}^2=0. \tag{1}$$

2. Three types of worlds that differ in the type of spatial symmetry exist in nature. In the worlds with translational symmetry (*c*-worlds) and axial symmetry (*h*-worlds) time is reversible. Gravitation develops in spatial inclusions having central symmetry that are formed in *h*- and *c*-worlds. These are *G*-universes where time is irreversible and dissipative processes take place.

3. In addition to the world visible to us and our instruments where particle properties (charge, spin, rest mass) do not change, there exists a hidden world where particles and fields form and disappear as a result of polarization processes. This world is called a polarization world (PW). It is not studied by the modern science. Real physical quantities may arise in this world, such as forces manifesting themselves in our nucleonic world (NW) and causing phenomena that are not understood by the science.

4. In the PW real and imaginary components of ST coordinates have two directions. Therefore, for a *d*-dimensional complex ST the number of ST-structures differing in at least one direction of the actual or imaginary coordinate equals

$$k_d = 2^{(2^d)}; \quad k_1 = 4; \quad k_2 = 16; \quad k_3 = 256; \quad k_4 = 65536\text{, etc.} \tag{2}$$

2. Dissipation and anti-dissipation.

From the perspective of the polarization theory the entropy increase law cannot have an absolute meaning, i.e. unlimited scope of application, since a matter with anti-dissipative properties shall exist. This follows from the non-dissipativity of the *c*- and *h*-worlds that produce gravitating matter. Anti-dissipating matter possessing a property of substance structuring accompanied by an entropy decrease shall exist in the Universe along with the dissipating matter. Otherwise it is hard to imagine how the Universe or living matter could evolve. A dead body decays, while a live one grows and develops, i.e. an anti-dissipative process of cell differentiation is implemented in the latter. Other examples can also be given to show that anti-dissipative processes do exist in nature. As far as physics and technology are concerned, similar data exist there too, but they are not so self-evident that the second law of thermodynamics could be overturned: closedness of an experimental system is always a matter of doubt. Closedness conditions are formulated for the nucleonic matter we know, but the question of its association with the PW has never been raised since this world does not appear in the modern physics.

The second law of thermodynamics is based on the possibility of existence of a closed system with dissipation hence rejecting non-locality of dissipative mechanisms, though this cannot be done if we proceed from quantum mechanics properties of substance. For a non-local PT, dissipation in a closed system is meaningless. If a closed system is possible, it shall be non-dissipative.

For an understanding of the nature of dissipation and anti-dissipation, let us consider a polarization mechanism of viscosity development in an ideal liquid that can exist in the PW. As is known, the viscous flow of the Newtonian fluid (where shear viscosity is independent of the strain rate) is described by the Navier-Stokes equation with a positive friction coefficient. Its negative value is reported very seldom. There is a pronounced asymmetry of experimental data on dissipating and non-dissipating states of the nucleonic matter.

A non-local mechanism is required to give rise to such an effect as friction. Therefore we will consider development of friction due to non-linear polarization of action in a ideal (non-dissipative) fluid.

3. Derivation of the Navier-Stokes equation.

An ideal fluid moves by a potential mechanism, i.e. velocity of its particles is described by the velocity potential φ_v :

$$\vec{\mathrm{v}} = grad\varphi_{\mathrm{v}}$$

As known from hydrodynamics [1], the potential flow equation has the first integral

$$\frac{\partial \varphi_{\mathrm{v}}}{\partial t} + W + \frac{\mathrm{v}^2}{2} = \dot{F}(t), \qquad (3)$$

where *F(t)* is an arbitrary function, the enthalpy of the fluid unit mass $W=\varepsilon+p/\rho$, ε is the unit mass internal energy, p is pressure, and ρ is fluid density that varies slightly compared to the pressure. Integral (3) allows determining action Σ of a fluid particle with mass m:

$$\frac{\Sigma}{m} = c^2\tau = \int \vec{\mathrm{v}} d\vec{r} - \int (\varepsilon + \frac{\mathrm{v}^2}{2})dt = \int dt(\frac{d\varphi_{\mathrm{v}}}{dt} - \dot{F} + \frac{p}{\rho}) \qquad (4)$$

This relationship pertains to the nucleonic world that has a polarization association with the PW where a viscous friction mechanism should be sought for. In that world force may have a real value and not manifest itself in the NW. However, since coordinates of the polarization space are imaginary, the force potential proves to be imaginary too and has no effect on variations of the real energy taking place in the NW and satisfying the law of energy conservation in the latter. This is a possible mechanism of appearance of “non-potential” forces at the fundamental level.

We are interested in the force of friction proportional to the value of the local fluid velocity and having a polarization origin. Let us consider a force that develops at birth of truly neutral scalar particles acquiring the velocity of a fluid particle being reactively acted upon by the force while its mass is increasing. As demonstrated in [4], such a particle does exist and play an important role in many natural phenomena, including confinement of quarks in hadrons. This particle is called a plenon. According to [4], its mass equals

$$m_0 = \frac{m_P}{k_6}\cos\frac{\pi}{4} \approx 0{,}468 \text{ GeV}, \qquad (5)$$

where m_P is the Planck particle mass. Let us assume that the plenon mass distributes among polarizing particles of mass m_ν ($\nu-$particles) filling the k_4-plet of ST-states. When it is completely filled, the number of particles, according to [4], equals $\pi k_4 \approx 2\cdot 10^5$. The increase of the particle mass in the birth process produces reactive thrust

$$\vec{f} = -\frac{dm}{d\tau}\vec{\mathrm{v}},$$

where multipliers v and $\frac{dm}{d\tau}$ are real values. Since action Σ_ν of polarizing ν- particles increases in proportion to its mass, and we are considering the process of polarization of action between ν-particle and fluid particle having constant mass, the polarizing quantity is action related to the unit mass of interacting particles. The corresponding polarization relationship for these particles belonging to different worlds but to the same STS takes the form:

$$\frac{\Sigma_\nu}{m_\nu} = \pm i\frac{\Sigma}{m}. \qquad (6)$$

The action of ν-particles is imaginary and is implemented in one of the STS. The two signs in (6) appear due to polarization of plenon together with nega-plenon that has a negative mass and implements its own action polarization channel.

Let us assume that in the PW each fluid is characterized by its own set of STS. The number of particles in the set is denoted by *s*. In this case the plenon (or nega-plenon) breaks down into *s* ν-particles with mass

$$m_\nu = m_0/s. \tag{7}$$

And if the plenon does not break down but is born in each of the *s*-states with equal probability, any of them on the average accounts for the same polarization mass that may be considered as the mass of a notional ν- particle that takes part in the polarization process (6).

Since fluid particles are outside the PW, the mass conservation law expressed by the equation of continuity holds for them:

$$\frac{d\ln n}{dt} = -\Delta\varphi_{\mathrm{v}}\,. \tag{8}$$

The density of polarizing ν-particles n_ν is defined by their wave function $\Psi_\nu \sim e^{i\Sigma_{\mathrm{v}}/\hbar}$. In view of (6), we arrive at

$$n_\nu \sim \left|\Psi_\nu\right|^2 \sim e^{\pm 2\frac{\Sigma}{\hbar}\frac{m_{\mathrm{v}}}{m}}. \tag{9}$$

The density of plenons and ν-particles is proportional to the density of fluid particles, hence

$$\frac{d\ln n}{dt} = \frac{d\ln n_\nu}{dt}, \tag{10}$$

i.e. in view of (4),(8), (9) and (10) we obtain an equation for velocity potential φ_{v}

$$\frac{d\varphi_{\mathrm{v}}}{dt} - \dot{F}(t) + \frac{p}{\rho} = \pm\frac{\hbar}{2m_\nu}\Delta\varphi_{\mathrm{v}}\,. \tag{11}$$

Introducing the kinematic viscosity

$$\nu(s) = \pm\frac{s\hbar}{2m_0};\;\; s = 1,\, 2,\, \ldots \pi\, k_4\,, \tag{12}$$

and applying operator $\vec{\nabla}$ to the both sides of (11), we arrive at the Navier-Stokes equation for incompressible fluid:

$$\frac{\partial\vec{\mathrm{v}}}{\partial t} + (\vec{\mathrm{v}}\vec{\nabla})\vec{\mathrm{v}} = -\frac{\vec{\nabla}p}{\rho} + \nu\Delta\vec{\mathrm{v}}\,. \tag{13}$$

Thus viscosity appears when the fluid is still free of vorticity. This is a quantum polarization effect causing vorticity. Vortexes are new macroscopic formations, and they shall have polarization origin as everything new.

The form of the kinematic viscosity coefficient (12) is independent of the strain rate and shall describe the Newtonian fluid viscosity. In view of (5) we obtain the viscosity variation range:

$$\nu(1) \approx 0.6\; 10^{-3}\,\mathrm{S};\;\; \nu(\pi k_4) \approx 125\,\mathrm{S}. \tag{14}$$

Below are some experimental values of viscosity expressed in S (cm^2/s) taken from [5]: mercury – 0,0011 (15C); ester – 0,00327 (15C); benzine – 0,0093 (15C); water – 0,01 (20C); ethyl alcohol – 0,0154 (20C); kerosine – 0,027 (15C); anhydrous glycerin – 11,89 (20C); syrup – 600 (18C).

According to [5], the shear viscosity of low-molecular fluids, molten metals and salts is no greater than several tens of Pa·s. At higher viscosities fluids no longer behave as Newtonian ones and their behavior should be considered using the common rheology and viscoelasticity approach. The latter shall be implemented through different polarization mechanisms. The kinematic viscosity corresponding to the boundary between Newtonian and non-Newtonian fluid is close to the upper value of the range (14). Therefore we may speak about approximate correspondence of this range with viscosity of actual Newtonian fluids and hence about a possible polarization mechanism that forms their internal friction. The theory presented has not yet considered the question as to how a fluid "chooses" its value of *s* and how the latter depends on the fluid temperature and pressures.

4. About negative viscosity

We considered viscosity as polarization excitation of the superfluid state. For all substances except for helium this state is only implemented in the *h*-world and disappears in transition to the *G*-world due to the change in the symmetry of space: there are no translational degrees of freedom in the centrally symmetric space of the *G*-world, hence the equilibrium velocity in the nucleonic world

$$V=0. \qquad (15)$$

This implies positive-valued viscosity in the latter and its dissipativity. We observe this in the majority of experiments and technical devices, where no association between nucleonic and polarization worlds manifests itself.

However a different situation is also observed in nature and some experiments if rotation takes place and in the $h \to G-$transition there is preserved the symmetry of the *h*-world where dissipation is lacking and the equilibrium velocity

$$V>0. \qquad (16)$$

An example is rotation of electrons in an atom already mentioned above.

If the speed of revolution of a nucleonic macrosystem is higher than the equilibrium value, the developing friction slows it down, and vice versa, at the speed of revolution lower than the equilibrium value the negative friction develops that increases the speed of revolution. This case is important in practical terms: an increase in the rotor kinetic energy occurs through extraction of energy from the PW. The most well known of self-spinning systems are Searl generator which theory is presented in [4], Testatika, and Roschin and Godin generator [7]. The friction sign in them depends on the rotor speed of revolution. A self-spinning mode is attained when a certain relatively low critical velocity is exceeded. This allows converting the derived kinetic energy into electric one. However, creation of conditions at which an effective link of the NW with the PW is implemented is a problem that has not been theoretically elaborated. This causes difficulties in reproducing such a link in similar rotor systems. However, no such problem arises in K. Chukanov's systems [8] where artificial stationary "ball lightning" is produced.

Hence the friction sign (in general case the dissipation sign) depends on the degree of association between nucleonic world and PW. In the PT antidissipation has the same status as dissipation, merely their manifestations require different conditions. Rotation shall promote development of antidissipative manifestations. If nucleonic substance rotates, than at the $h \to G$-transition the movement symmetry is not broken, and in the presence of sufficiently efficient polarization processes the effective friction may prove to be negative, and the substance will spin up. In space all bodies rotate, and this should be treated as a consequence of antidissipative processes of the Universe matter structuring. Living matter is also a manifestation of antidissipation. The existence of the latter can be illustrated by such polarization atmospheric phenomena as tornados and whirlwinds, and concentration of minerals on land. Everything that is born shall have polarization nature. Utilization of dissipation in technology is possible and will become a new stage of its development.

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