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Conservative Diffusion as a Physical Mechanism for Quantum Mechanics and Gravitation

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Abstract

The theory of conservative diffusion and its main applications are reviewed. A basic model for the theory is diffusion of a cold light gas in a warm heavy gas before relaxation when light gas remains cold and mean energy of its particles conserves. Unlike the Lorentz gas, where thermal energies of light and heavy atoms are equal, here the same order are their thermal speeds. Such conservative diffusion is described by two equations – the Hamilton-Jacobi and continuity equations, nonlinear under the probability density. They can be linearized by introduction of a complex probability amplitude, transforming them to the Schrödinger equation where one must add not probabilities, but probability amplitudes of alternatives. Mean free path and the corresponding momentum determine an elementary phase volume and a diffusion coefficient. The theory predicts a number of quasiquantum effects in classical systems. The formalism of quantum mechanics thus describes a classical conservative diffusion and quantum mechanics is only a special case of such diffusion in the vacuum, when the elementary phase volume is equal to the Planck constant. A conservative thermodiffusion at nonzero temperature gradient is studied also. Its properties, such as decreasing of intensity of fluctuations of particles (including redshift of frequencies), drift of particles to colder region and their thermodiffusive acceleration, not depending on the mass of particles, are similar to properties of gravitation. This allows us to identify gravitation by thermodiffusion in the physical vacuum. In the diffusive picture fluctuations of energy-momentum of classical particles due to interaction with vacuum lead to increasing of their mean energy, which appears as quantum phenomena, while corresponding local decreasing of vacuum energy density reveals as gravitation. The diffusive treatment of quantum theory thus leads to the thermodiffusive treatment of gravitation too with natural synthesis of theories of both phenomena. Observable effects following from the new theory are discussed.

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Content

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Introduction

In theories of random processes and condensed media mainly *dissipative diffusion* of suspended particles in thermal equilibrium with medium has been studied.

In the paper [1] diffusion in classical systems with very small dissipation of energy of diffusing particles has been studied. It was shown that a mechanism of such almost conservative diffusion significantly differs from a mechanism of usual diffusion and there appear analogs of quantum effects (*quasiquantum* effects). It is realized at diffusion of a cold light gas in a warm heavy gas during short time before relaxation where in the ideal gas approach the mean energy of a light particle conserves at quite large number of collisions with heavy particles.

The existence of a mean free path and also the statistical reversibility of the process due to conservation of light particle's mean energy lead to two evolution equations – the Hamilton-Jacobi and continuity equation, to which the probability density $\rho(x,t)$ and a particle's action function $S(x,t)$ enter non-linearly [3]. At combining of two real functions S and ρ into one complex probability *amplitude* $\psi = \rho^{1/2} \cdot \exp(S/2mD)$, where D is the diffusion coefficient, the equations linearizes and transform to the Schrödinger equation.

As a result, at classical conservative diffusion it holds the probability *amplitudes* addition law for alternatives as in quantum mechanics, the mean free path and corresponding momentum are related by the uncertainty relations, and also determine D and an elementary phase volume $\Gamma_D = 2mD$. The formalism of quantum mechanics thus appears as the description of classical conservative diffusion at $D = const$. The theory predicts a number of quasiquantum effects in classical systems with $\Gamma_D \gg \hbar$.

Quantum mechanics appears here as a description of a particular case of conservative diffusion of classical particles in the physical vacuum at $\Gamma_D = \hbar$. By this, therefore, a long history of searching of an adequate physical interpretation of quantum mechanics finishes.

Another fundamental consequence of the diffusive mechanism of quantum theory appears the fact that properties of conservative thermodiffusion in vacuum occur as identical with properties of gravitation [2]. In the diffusive treatment an increasing of particle's mean energy at quantum fluctuations should be compensated by lowering of physical vacuum's energy to the same value. An influence of one particle to the vacuum energy density ρ_V is negligible, but at high density of particles a local decreasing of ρ_V becomes sufficient.

Such local lowering of ρ_V , equivalent to "cooling", generates a thermodiffusion flux of light particles from regions with higher ρ_V to this regions with lower ρ_V , i.e. high concentration of light particles effectively attracts other light particles. Due to conservativity, the flux speed will increase with each shift and there appears a thermodiffusive acceleration, depending on properties of medium, but not depending on the mass of accelerating light particles. In the "cold" region there occur also the decreasing of intensity of fluctuations and the thermal contraction of sizes, i.e. proper times slowing down and scales contract.

All these are characteristic properties of gravitation and the fact that they follow from quantum theory at large concentration of particles makes gravitation as one of quantum phenomena. Thus, from the diffusive treatment of quantum processes follows the thermodiffusive treatment of gravitation.

Since this treatment of gravitation is based on quantum notions, it therefore realizes unexpectedly close synthesis of gravitation and quantum theory. From two basic hypotheses of modern physics - quantum fluctuations and gravitation - the diffusive treatment leaves as a hypothesis only the first one, while the second one appears as its consequence, i.e. the theory of gravitation becomes a part of quantum theory.

Basics of the theory of conservative diffusion are presented in Part 1 of the paper. In Part 2 the diffusive treatment of quantum mechanics is discussed. In part 3 conservative thermodiffusion and analogs of gravitational effects are considered and in Part 4 the diffusive treatment of gravitation is presented.

1. Theory of conservative diffusion

1.1. A physical mechanism of conservative diffusion

Diffusion of light gas in heavy at *thermal equilibrium* of mixture's components allows one to simplify the kinetic equations and for this reason it represents one of well studied phenomena of the theory of condensed media [4].

However, diffusion of a *cold* light gas in a *warm* heavy gas at initial times *before relaxation*, as it appeared, qualitatively differs from the usual dissipative diffusion. In the ideal gas model here mean energy of light particles approximately conserves and the process is very close to the *conservative diffusion* [1].

At collision with heavy particles of the medium in the rest frame of the latter light particle's speed changes direction, while its module remains practically unchanged. In the laboratory frame, where a binary gas is resting, fluctuations of light particle's speed are of order of mean thermal speed of heavy particles V :

$$\delta v_D \sim V = (6kT / M)^{1/2} \quad , \qquad (1)$$

where T is medium's temperature, M is heavy particle's mass and k is Boltzmann constant.

The trajectory of light particles represents a set of sections of free pass between collisions and their mean kinetic energy, initial and due to acceleration in external fields, conserve at quite large number of collisions $n_D \sim M / m$, where m is light particle's mass. In the first order such process is statistically reversible and there is a symmetry under time reversal.

Thus, we consider diffusion of light particles in a dilute medium of massive particles, where by averaging in an ensemble of light particles at any moment t we find the mean free path l_D, mean free path time τ_D and mean free path speed $v_D = l_D / \tau_D$. The last one gives corresponding momentum and kinetic energy: $p_D = mv_D$, $E_D = mv_D^2 / 2$.

During conservativity time (i.e. before relaxation) the ensemble of light particles is not in thermal equilibrium with medium. Unlike the Lorentz gas, where thermal energies of light and heavy atoms are equal, in our case only their thermal speeds are the same order. Therefore, thermal energy of light particles, as well as temperature of light gas T_l, remain sufficiently less than of heavy gas, i.e. relatively long time (w.r.t. τ_D) light gas remains cold $T_l \ll T$.

Due to the existence of classical sections of light particle's trajectory with the mean characteristics l_D, p_D and conservation of mean energy, we can enter a mean value of the abbreviated action S in the time interval $t' - t = N\tau_D$, $N \gg 1$. It represents sum over the classical sections of trajectory:

$$\Delta S = N\, S_D, \qquad S_D = p_D l_D\,, \tag{2}$$

where S_D is the *elementary abbreviated action* for a particle in this medium.

However, the statistical mechanics deals with not by the action function along trajectories, but with an element of phase volume $\Delta\Gamma = \Delta p \Delta x,$ where the particle locates during time Δt. In our case there is an *elementary phase volume*:

$$\Delta\Gamma = p_D l_D = m l_D^2 / \tau_D = \Gamma_D, \tag{3}$$

which coincides with S_D.

Since Γ_D plays such important role, it is more natural to take it as a basic quantity and to express through it other characteristics of the system. Particularly, from (3) and definition of the diffusion coefficient $l_D^2 = 2D\tau_D$ it follows:

$$\Gamma_D = 2mD, \qquad D = \frac{\Gamma_D}{2m}, \tag{4}$$

i.e. in fact the diffusion coefficient $2D$ in our system is equal to Γ_D for a unit mass particle.

1.2. Dynamics of conservative diffusion

The theory of usual dissipative diffusion in equilibrium mixture for a random walk of a light particle leads to the Brownian motion formalism. For conservative diffusion it is more natural the formalism of *hydrodynamics*.

The *drift speed* $\mathbf{v}$ is that part of mean speed in ensemble of light particles which is sum of initial speed relative to the medium and of speed due to acceleration in an external field. Since particle's trajectory between collisions is classical, thus, according to the canonical formalism, a drift component of momentum $\mathbf{p}_\mathbf{v} = m\mathbf{v}$ can be presented as a gradient of a "drift" action function $S(x,t)$:

$$m\,\mathbf{v}(x,t) = \nabla S(x,t). \tag{5}$$

Let in some region of space of volume ΔV a concentration of light particles c_D be higher than outside of this region. In any time interval a mean number of leaving ΔV light particles exceeds a mean number of incoming particles, i.e. there is a diffusion flux of light particles $\mathbf{j}_D = \mathbf{u}\, c_D$ from ΔV to external region, where $\mathbf{u}$ is the *speed of diffusion flux*. In the isothermal medium ($T = const.$), in the first approximation, this flux is proportional to the negative of concentration gradient [4]:

$$\mathbf{j}_D = \mathbf{u} c_D = -D \cdot \nabla c_D, \tag{6}$$

which gives:

$$\mathbf{u} = -D\frac{\nabla c_D}{c_D} = -D\frac{\nabla n_D}{n_D}, \tag{7}$$

where n_D is number density of light particles.

If we consider in the medium any light particle independently, in (7) instead of n_D we may use the probability density $\rho(x,t)$, which is normalized:

$$\int \rho(x,t)\, d^3x = 1, \tag{8}$$

and, due to conservation of probability, satisfies the continuity equation:

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\mathbf{v}\rho) = 0. \tag{9}$$

The relationship (7) in this case takes the form:

$$\mathbf{u} = -D\frac{\nabla \rho}{\rho}. \tag{10}$$

The mean on ensemble from $\mathbf{u}$ vanishes, while the mean square value is non-zero:

$$\bar{\mathbf{u}} = \int \mathbf{u}\,\rho\, d^3x = 0, \quad \int \mathbf{u}^2 \rho\, d^3x \neq 0. \tag{11}$$

Corresponding momentum $\mathbf{p}_u = m\mathbf{u}$ satisfies the *uncertainty relation* (at $\bar{\mathbf{x}} = 0$):

$$\sqrt{\overline{\mathbf{p}_u^2} \cdot \overline{\mathbf{x}^2}} \geq \left|\overline{\mathbf{p}_u \cdot \mathbf{x}}\right| = m\left|\int \mathbf{u}\cdot\mathbf{x}\,\rho\, d^3x\right| = mD\left|\int \nabla\rho \cdot \mathbf{x}\, d^3x\right| = \frac{\Gamma_D}{2}. \tag{12}$$

A part of energy of a light particle related by this diffusion flux is:

$$U_u = \frac{\mathbf{p}_\mathbf{u}^2}{2m} = \frac{\Gamma_D^2}{8m}\left(\frac{\nabla\rho}{\rho}\right)^2. \tag{13}$$

This energy, which is in fact the kinetic energy of the flux flattening concentrations, or probability densities, of light particles at different points, formally appears as a certain potential energy since depends only on $\rho(x,t)$ given at one moment of time. Therefore, further we may consider U_u as some effective potential energy. In this case the Lagrangian of the system takes the form**:**

$$L = \int \left(\frac{m\mathbf{v}^2}{2} - \frac{m\mathbf{u}^2}{2} - V\right)\rho\, d^3x, \tag{14}$$

where V is particle's potential energy in an external field. Then, by expressing $\mathbf{v}$ and $\mathbf{u}$ through S and ρ in L, we can derive equations of motion by variation under these functions.

However, in quantum theory the Hamiltonian approach is more convenient and we also will use it. Total kinetic energy of the flux of light particles is the sum of drift and diffusive parts, and thus the Hamiltonian has the form:

$$H = \int \left(\frac{\mathbf{p}_\mathbf{v}^2}{2m} + \frac{\mathbf{p}_\mathbf{u}^2}{2m} + V\right)\rho\, d^3x, \tag{15}$$

which, taking into account (5) and (13), can be rewritten in terms of S and ρ as:

$$H = \int \left(\frac{1}{2m} (\nabla S)^2 + \frac{\Gamma_D^2}{8m} \left(\frac{\nabla \rho}{\rho} \right)^2 + V \right) \rho \, d^3x. \tag{16}$$

In this "hydrodynamic" Hamiltonian the role of canonical pair play the functions $S(x,t)$ and $\rho(x,t)$. Poisson's brackets in their terms have the form [5]:

$$\{A, B\} = \int \left(\frac{\delta A}{\delta \rho} \frac{\delta B}{\delta S} - \frac{\delta B}{\delta \rho} \frac{\delta A}{\delta S} \right) d^3x,$$
$$\{\rho(x,t), S(x',t)\} = \delta(x - x'). \tag{17}$$

Corresponding canonical equations:

$$\frac{\partial S}{\partial t} = \{S, H\} = -\frac{\delta H}{\delta \rho}, \qquad \frac{\partial \rho}{\partial t} = \{\rho, H\} = \frac{\delta H}{\delta S}. \tag{18}$$

give the Hamilton-Jacoby equation and the continuity equation [3]:

$$\frac{\partial S}{\partial t} + \left(\frac{(\nabla S)^2}{2m} + V \right) - \frac{\Gamma_D^2}{8m} \frac{\Delta \sqrt{\rho}}{\sqrt{\rho}} = 0, \tag{19}$$

$$\frac{\partial \rho}{\partial t} + \frac{1}{m} \nabla \cdot (\rho \nabla S) = 0. \tag{20}$$

The probability density ρ enters to this system of equations non-linearly and for two alternatives $\rho_{12} \neq \rho_1 + \rho_2$. But these equations can be linearized at the canonical transformations to a new canonical pair ψ_1, ψ_2:

$$\psi_1 = \sqrt{\rho} \cos(S / \Gamma_D), \quad \psi_2 = \sqrt{\rho} \sin(S / \Gamma_D), \tag{21}$$

which can be combined to one a complex probability amplitude ψ:

$$\psi = \psi_1 + i\psi_2 = \sqrt{\rho} \exp(iS / \Gamma_D). \tag{22}$$

The equations (19)-(20) then turn to the Schrödinger equation for $\psi(x,t)$:

$$i\Gamma_D \frac{\partial \psi}{\partial t} = \left(-\frac{\Gamma_D^2}{2m} \Delta + V \right) \psi. \tag{23}$$

Here it takes place the superposition of states: $\psi = c_1\psi_{(1)} + c_2\psi_{(2)} + \ldots$ and, therefore, at classical conservative diffusion one must add not probabilities of alternatives, but their probability *amplitudes*. Here the Markov condition is satisfied for the *complex transition amplitudes,* which allows us to formulate the theory in terms of the path integrals. The physical meaning of the wave behavior consists in the periodic reappearance of classical pieces l_D along particle's trajectory and also in the existence of the related elementary phase volume Γ_D.

Thus, conservative diffusion in classical systems under above mentioned conditions is described by the mathematical formalism of quantum mechanics with replacement $\hbar \to \Gamma_D$. In this case quantum mechanics appears only as a special case of classical conservative diffusion at $\Gamma_D = \hbar$.

Therefore, known quantum effects should appear in other cases of conservative diffusion too with $\Gamma_D > \hbar$. From this we conclude that in classical systems, where such diffusion could be realized, also should be analogs of quantum effects or *quasiquantum effects*

[1]. Particularly, here the interference effects and other wave properties should appear for probability distributions, the discreteness of energy levels and angular momenta will appear also. Special interest represent the effects of quantum statistics which will be discussed below.

1.3. Quantum statistics in classical systems

Above we considered an ensemble of light particles, assuming that any light particle collides with heavy particles only, i.e. in fact it was a *one-particle* problem. Let us consider a *multi-particle* problem when concentration of light particles is not small, collisions between them are essential and there is a real *ideal gas* of light particles diffusing in heavy gas. Since at collisions of light particles with each other their energy redistributes, they will achieve thermodynamic equilibrium among themselves quite faster than with the medium.

For our purposes it is interesting the fact that gas of light particles in medium of the heavy will be described *by quantum statistics*, where the Γ_D plays the role of Planck's constant. From various effects of quantum statistics we consider only some of them which demonstrate main distinctions of quantum statistics from classical one.

The first property is indistinguishability. If in multiparticle system energy levels have *equal probability* and particles are assumed *distinguishable*, we have *the Boltzmann distribution*:

$$n = n_0 e^{-E_n/kT}\,. \tag{24}$$

If the levels have *equal probability*, but particles are *indistinguishable*, there appears the Bose-Einstein distribution:

$$n = \frac{n_0}{e^{E_n/kT} - 1}. \tag{25}$$

In diffusion treatment of quantum processes there is a question how in a system of classical *distinguishable* particles it can appears a quantum statistics based on indistinguishability?

The solution to this problem has been discovered by Terzoff and Bayer [6] and consists in that the assumption about *equal probability* of levels was too strong limitation. In fact, as Bose did from the beginning, here it is enough an assumption that *sum of probabilities of all alternative ways of filling is equal to unity* and that system's total energy, obviously, does not change at all such possible fillings:

$$E = \sum_n N_n E_n\,. \tag{26}$$

At such general assumptions, as it has appeared, in a gas of *distinguishable* particles *the Bose-Einstein distribution* generally takes place and only at additional restriction to *equal probability* states it becomes narrowed to the Boltzmann distribution [6]. Thus, the indistinguishability of particles in the quantum statistics appears *effectively*, being a consequence of certain limitations for the system of distinguishable particles.

Another in principle new property is the *Pauli's exclusion principle* for systems of particles which are described by wave functions antisymmetric under transposition of particles. Still neglecting details of connection of spin and statistics, here we notice only that the theory of conservative diffusion *generally admits such states* irrespective of the reasons of their origin. Thus, if one provides the conditions for the conservative diffusion with such wave functions, it will be possible to observe as well consequences of *the Fermi-Dirac statistics* and Pauli's principle.

1.4. Conservative thermodiffusion and concentration in cold region

Still we considered the isothermal mixture and diffusion caused by the concentration (or probability density) gradient. Let us consider the thermodiffusion flux in this mixture caused by the temperature gradient ∇T of heavy gas. This flux is directed from warmer region to colder and equates temperatures.

In kinetic theory of binary gas a case of local thermal equilibrium of mixture is usually considered when light gas concentrates in regions with *higher temperature* [4]. This property is often used in practice, in particular, at separation of isotopes. In this model thermal speeds of light atoms sufficiently exceeds speeds of heavy atoms and even a small gradient of thermal speeds of the last ones leads to a large gradient of thermal speeds of light atoms. This leads to thermodiffusion of light particles and increases concentration in colder region, but this amplifies the opposite diffusive flux equating concentrations. An equilibrium of two opposite fluxes is achieved when concentration of light gas in warmer region is higher.

In our case of conservative thermodiffusion there arises *an opposite* effect and light gas concentrates in *colder* region. At the same temperature gradient the low temperature of light gas amplifies the thermodiffusion flux and weakens the opposite diffusion flux. As a result, the thermodiffusion flux becomes dominating and light gas concentrates in colder region.

As for usual Brownian motion, at random walk of a single particle instead the concentration $n(x,t)$ we deal with the probability density $\rho(x,t)$ in the ensemble, and the diffusion flux $\rho\mathbf{u}_\rho$ flattens the probability density. The thermodiffusion flux $\rho\mathbf{u}_T$, as usual, is proportional to $-Dk_T\nabla T/T$, where k_T is the thermodiffusion ratio [4]. Since the diffusion flux with drift $\mathbf{u}_\rho$ weaker than the thermodiffusion flux with drift $\mathbf{u}_T$, the total flux of light particles, due to dominating of the thermodiffusion, is directed to colder region:

$$\rho\mathbf{u} = \rho(\mathbf{u}_\rho + \mathbf{u}_T) = -D\left(\nabla\rho + k_T\frac{\nabla T}{T}\right) \to -Dk_T\frac{\nabla T}{T}. \tag{27}$$

Thus, in the binary gas at thermal equilibrium the light gas concentrates in warmer region, whereas at conservative diffusion, due to domination of the thermodiffusion flux, the light gas concentrates in colder region. This difference is the new effect predicting by the theory of conservative diffusion and it allows one to check the theory in experiment.

1.5. Conservative thermodiffusion as a model of gravitation

In general case of thermodiffusion one describes a flux of light particles independently on an origin of the temperature gradient in the medium. Here we consider a particular case when this temperature gradient is appeared due to an influence to the medium's energy of large local concentrations of the light particles.

Let in binary gas there is non-zero gradient of initial concentration ∇n_l of cold light gas. Since a part of thermal energy of heavy gas will paid out for heating of light gas up to temperature T_l, when thermal velocity of light atoms become of order of thermal velocity of heavy, then the initial concentration gradient of light gas generates medium's temperature gradient.

In regions with higher concentration of light gas temperature of the medium becomes lower than in regions with smaller concentration. An appearing temperature gradient ∇T will proportional to initial concentration gradient and directed opposite:

$$\nabla T \sim -\nabla n_l. \tag{28}$$

Then this temperature gradient leads to the thermodiffusion flux of other light particles to the colder region, thus, to the region with higher concentration of the initial light particles:

$$\rho \mathbf{u}_T \sim -\nabla T \sim \nabla n_l . \qquad (29)$$

As a result, on the outside process looks like that a cluster of light particles "attracts" other light particles and how large was initial mass of the cluster, so stronger will its effective "attraction".

This fact allows one to consider this effect as the process modeling gravitation. In Parts 3-4 of the paper this property will be used for treatment of gravitation as thermodiffusion in physical vacuum.

2. Diffusive treatment of quantum mechanics

2.1. Conservative diffusion as a physical basis of quantum mechanics

The considered in the Part 1 properties of conservative diffusion allow us turn to a treatment of quantum mechanics as a description of conservative diffusion of classical particles in physical vacuum, where $\Gamma_D = \hbar$ and $D = \hbar / 2m$. In this treatment all objects are described classically, but with accurately accounting of vacuum's influence, which is sufficient for microobjects and negligible for macroobjects.

The mathematical formalism of quantum mechanics (in various formulations) is a consistent tool for the description of the physical phenomena. However a *physical interpretation* of this formalism up to now has remained as one of main unsolved fundamental problems of physics.

Standard interpretations of quantum mechanics were reduced to avoidance from a direct answer by division of reality on macro - and microobjects and postulating of the formalism of quantum mechanics for the last ones without explanations. For this reason here were remained a number of open questions:

(1) Why quantization is necessary?

(2) Why there occur quantum fluctuations and what they mean?

(3) What in fact fluctuates: a background or a particle by itself?

(4) Why one must add probability amplitudes, but not probabilities?

(5) What principally distinguishes quantum particles from the classical ones?

(6) If energy and momentum of a particle fluctuate, then what is a source of these additional energy and momentum at any short time interval and where they disappear after?

(7) Is such temporary violation of energy and momentum conservation compensated by decreasing or increasing of energy and momentum of something?

(8) Are fluctuations related to structure of spacetime or not?

Contrary to the former interpretations, the diffusive treatment naturally answers to most of these questions. It is based on the physical fact that influence of physical vacuum leads to the specifically, inversely proportional to their mass, fluctuations of classical particles.

In the diffusive treatment answers to the questions (1)-(3) are follow from the fact of the existence of the physical vacuum as an active medium conserving mean energy of particles, which only has been taken as fact.

To problems 4-5, the key and most mysterious ones in all previous treatments, an answer is simple and clear. As it has been shown in Part 1, from the non-linear equations of conservative diffusion, relating a probability density and action function of classical particles, there follow the linear Schrödinger equation for a complex probability amplitude.

Answers to other three questions 6-8, requiring consideration of a thermodiffusion in vacuum, we will discuss in the last two Parts of the paper.

2.2. Energy of localization in the nonrelativistic theory

"Quantization" thus is reduced to description of a classical particle, which in classical (empty) space and an external potential V would have energy $\mathbf{p}_{\mathbf{v}}^2/2m+V$, being embedded into the physical vacuum fluctuates and there appear diffusive contributions to its momentum and energy. Let energy of such fluctuations are denoted as U.

The state of a free particle usually is represented as a plane wave**:**

$$\psi = const\cdot \mathrm{e}^{i(\mathbf{px}-Et)/2mD} \tag{30}$$

where $S(\mathbf{x},t)=\mathbf{px}-Et$ and $\rho=const.$, so in this case $\mathbf{u}\sim\nabla\rho=0$ and there are no diffusive parts in nonrelativistic momentum $\mathbf{p}_u=0$ and energy $E_u=0$. Here $U=U_0=const.$, the probability amplitude of a particle is periodically distributed on entire space and interaction with vacuum is revealed in the “wave” behavior of this amplitude, when energy and momentum of drift are expressed through frequency and wave vector.

For bounded states $S(t)=-Et$ and $\rho(x)$ provides particle’s localization at a vicinity of the centre of inertia with $\mathbf{u}^2>0$. It testifies that the speed $\mathbf{u}$ of diffusion flux and corresponding energy U_u are related with particle’s *localization* in a finite volume and that the last one is that part of U which has been transferred to the particle at narrowing of its probability distribution (by means of walls of a box or a force etc.). A part of energy of fluctuations of particle U, which has been generally “smeared” on entire space, at restriction of particle’s free diffusion became concentrated in smaller volume. Thus, as a localization region is less, as high the localization energy U_u, and this is shown by the uncertainty relation (12).

2.3. The rest energy as particle’s thermal energy in the vacuum

The relativistic theory has entered into physics a new additive constant to energy of any finite mass particle – the rest energy $E_0=mc^2$, which played an important role in physics, though its physical meaning remained unclear. From the diffusive treatment the rest energy follows naturally and thus its origin becomes clear.

Really, at diffusion a part of medium’s energy is paid out for heating of a light gas and this thermal energy of light gas’s particles $\sim kT_l$, as a mean kinetic energy of their thermal fluctuations, is proportional to light particle’s mass. Thus, at diffusion treatment of quantum theory we should take into account that for quantum fluctuations of any particle the vacuum also “expends” an energy $U\sim m$.

As it was already discussed, the total energy of fluctuations U can contain a localization energy U_u, which is present in the nonrelativistic theory too, but is absent for free particles. Therefore, if we exclude U_u from U and also turn to a rest frame of the particle for excluding kinematic corrections, here it remains only the energy of interaction with vacuum. As at any diffusion process, this constant residual contribution is the thermal energy in the medium.

Thus, in the physical vacuum it should exist an energy of fluctuations proportional to mass of particles:

$$U_0 = m\varphi_0. \tag{31}$$

Here U_0 should exist for localized and free particles, moving and resting ones. Such part of particle's energy should be appeared earlier both in the theory and experiment, and in the former treatments, not including vacuum as an active participant of processes, it should be unexplainable and mysterious.

A unique known part of energy of particles, obeying to these requirements and having the same properties, is the rest energy E_0 of relativistic theory and, thus, we have a right to identify this part of energy with the constant part of the energy of fluctuations in the vacuum $U_0 = E_0$. It allows one to define the constant in (31) from coincidence by relativistic kinematics and to take: $\varphi_0 = c^2$.

Thus, the energy of fluctuations of a finite mass particle, due to the influence of physical vacuum, contains a constant part which reveals as the rest energy:

$$U_0 = m\varphi_0 = mc^2. \qquad (32)$$

Here the physical vacuum appears as a certain external field with a potential $\varphi_0 = c^2$, where the role of a "charge" plays particle's rest mass. Continuing this analogy we can interpret U_0 as an energy level which the particle occupies in the "vacuum field" φ_0.

Below it will be shown that a logical development of this picture for systems of large number of diffusing particles leads to non-trivial observable consequences, allowing one better understand some fundamental phenomena, particularly, gravitation.

3. Conservative thermodiffusion and quasigravitational effects

3.1. A cluster of light particles as an attraction center for light particles

As it was discussed in section 1.4, if in isothermal heavy gas there was initial non-zero concentration gradient of light gas $\nabla n_l \neq 0$, then, as a result of initial inhomogeneous heat transfer to light gas, here quickly appears a temperature gradient of heavy gas $\nabla T \sim -\nabla n_l$ and at regions where light gas was denser, there temperature becomes lower.

This further generates a thermodiffusion flux of light particles $\rho \mathbf{u}_T \sim -\nabla T \sim \nabla n_l$, directed toward appeared colder region. As a result, the initially denser region of light gas effectively attracts other light particles from regions with lower density.

In fact, if to abstract from the presence of the medium and to watch only light particles, the process looks so as if a large cluster of light particles effectively attracts other light particles.

In addition, the temperature gradient and thus thermodiffusive speed, i.e. speed of "falling" of remote light particles to the cluster, are proportional to total mass of the cluster of light particles.

3.2. Thermodiffusive acceleration toward cold region

In case of usual dissipative diffusion friction is large and in thermodiffusion flux the particles are not accelerated, but only drift by the flux speed $\mathbf{u}_T \sim -\nabla T$.

However, in the case of conservative thermodiffusion increments of drift speed of light particles from earlier stages practically conserves during the conservativity time. For this reason these increments of the drift speed at each shift accumulate and there appears a thermodiffusive acceleration $a_D(x)$ directed from warmer region toward colder. This acceleration is proportional to the negative of the mean square speed gradient:

$$a_D(x) \sim -\nabla\overline{\mathbf{v}^2} \sim -\nabla\overline{\mathbf{V}^2}. \tag{33}$$

Then this thermodiffusive acceleration is proportional to the temperature gradient and directed to the colder region:

$$a_D(x) \sim -\nabla T. \tag{34}$$

Thus, because of conservativity of thermodiffusion, i.e. due to practical absence of friction, the light particles not only drift, as usual, but also accelerates toward colder region.

3.3. Independence of thermodiffusive acceleration of a particle on its mass

Another new and important property of conservative thermodiffusion - independence of acceleration of different kind of light particles on its mass.

At thermodiffusion in Lorentz's gas, because of thermal equilibrium with medium, mean square speeds of light atoms *depend* on their masses and are inversely proportional to them. Respectively, in such mixture the speeds of thermodiffusion flux, proportional to the gradient of the mean square speeds, also is inversely proportional to mass of light particles:

$$\frac{\overline{\mathbf{v}_1^2(x)}}{\overline{\mathbf{v}_2^2(x)}} \sim \frac{m_2}{m_1}, \qquad \frac{\mathbf{u}_{T1}(x)}{\mathbf{u}_{T2}(x)} \sim \frac{m_2}{m_1}. \tag{35}$$

At conservative diffusion thermal speeds of all light particles are of order of the thermal speed of heavy particles, i.e. depend only on medium's temperature and mass of heavy particles and do not depend on masses of light particles. For this reason, as it follows from (33), thermodiffusive accelerations of the different kind light particles are the same and do not depend on their masses:

$$\frac{\overline{\mathbf{v}_1^2(x)}}{\overline{\mathbf{v}_2^2(x)}} \sim \frac{\overline{\mathbf{V}^2(x)}}{\overline{\mathbf{V}^2(x)}} = 1, \qquad \frac{a_1(x)}{a_2(x)} \simeq 1. \tag{36}$$

Moreover, a cluster of light particles will be accelerated as other cluster with different number of particles and, therefore, the independence on mass of thermodiffusive acceleration will hold for clusters of light particles too. From this property it follows the *thermodiffusive effect of equivalence*, analogous to the principle of equivalence. This specifically property of conservative thermodiffusion also can be checked experimentally.

3.4. Thermodiffusive delay of processes and contraction of sizes

Decreasing of thermal speed in colder region leads to relative decreasing of intensity of all processes related by fluctuations of a light particle. Particularly, it decreases a frequency $\omega = E / \Gamma_D$ in "diffusive wave function" (30) of ensemble of light particles.

Such thermodiffusive delay of rate of fluctuations in mixture of gases with "redshift" of frequencies, associated by energy of light particles, should take place in diffusive treatment of quantum mechanics also. In this case relative larger density of particles in some region leads here to relative lowering of the energy density of vacuum and delay of intensity of quantum fluctuations with decreasing of all frequencies with respect to other regions.

This diffusive delay of rate of fluctuations then can be interpreted by distant observers as a *delay of proper times* of light particles in their high concentration region. This effect of diffusive delay of fluctuations, applied to quantum processes, is an analog of the gravitational delay of proper times.

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Relative decreasing of thermal speed in colder region leads also to decreasing of the mean free path and increasing of density of the medium and clusters of light particles. From outside all these look like as a relative *contraction of sizes*.

A classical example of changing of scales in condensed media is the change of volumes with temperature. At conservative diffusion the properties of the medium remain the same, so these examples belong to our case too.

Thus, an extrapolation of the known thermal effects, such as delay of fluctuations and contraction of sizes at cooling, on the physical vacuum at the thermodiffusive treatment of gravitation can lead to simple and evident physical explanation of such puzzle phenomena, as time delay and contraction of lengths in gravitational field.

4. Gravitation as a conservative thermodiffusion in vacuum

4.1. Basic ideas of thermodiffusive treatment of gravitation

At conservative thermodiffusion a large local concentration of light particles decreases here energy density (temperature) of the medium, which then locally reduces intensity of fluctuations. As a result, light particles from other regions with faster fluctuations will drift toward this slower fluctuations region (thermodiffusion) with growing speed of drift and this thermodiffusive acceleration does not dependent on their mass.

All these are characteristic properties of gravitation which allow us, in order to develop the diffusive treatment of quantum phenomena, to treat gravitation as a conservative thermodiffusion of classical particles in the physical vacuum [2].

Such model of thermodiffusive gravitation naturally follows from the energy conservation in the “particle+vacuum” system, that at random increasing of particle’s energy vacuum’s energy locally decreases to the same value and vice versa. Here the rest energy of a finite mass particle appears as a main part of the energy of quantum fluctuations. Then a magnitude of decreasing of vacuum energy density in each point, after averaging in time, is related by a gravitational potential created by this particle in this point.

The energy of gravitational field then appears as a local deficit of mean energy of vacuum which has arisen because a part of vacuum’s energy has passed to the particle as mean energy of its fluctuations, including energy of diffusion flux and the rest energy. This fact will becomes clear at the thermodiffusive derivation of simple gravitational potentials in the next Section.

The described diffusive treatment naturally explains also the fact that gravitation appears as a variation of spacetime geometry. In GR this fact has been postulated, whereas in the diffusive approach the effective metrics and effective curvature of spacetime follow from the behavior of particles and their world lines at inhomogeneous vacuum energy density.

At large local concentration of light particles their total influence to local vacuum becomes essential, since if for quantum fluctuations of each particle it has been utilized vacuum’s energy equal at least to $U_0 = mc^2$, the presence of N particles lowers vacuum’s energy at least to Nmc^2.

However, the balance of energies in the “particle+vacuum” system gives only total change of vacuum’s energy, but it generally does not allow one to determine a spatial distribution of vacuum’s energy density. In the presence of many light particles the vacuum energy density depends on total probability density of the system of particles. Since the last one depends on a *relative location* of particles, to different configurations there will correspond different vacuum energy density distributions.

It in general case complicates the situation, but the presence of symmetries in a configuration can simplify the solution and below some of such simple solutions are presented

4.2. Thermodiffusive derivation of simplest gravitational potentials

If gravitation is thermodiffusion in vacuum, by consideration of simplest symmetric configurations of light particles we should come to the same experimentally found gravitational potentials which then have been derived in GR geometrically. In this Section we will consider standard non-relativistic problems.

a) Uniform potential between two plates

Let two thin and flat dust plates of area S are rested at large distance and the rest energy of N particles of each of plates is equal to $E_0 = \bar{M}c^2$, where $\bar{M} = Nm$. Between the plates the vacuum energy density decreasing due to fluctuations of the particles is deeper than outside of this region.

Thus, with respect to the external regions the internal region appears as colder. For this reason there appears a thermodiffusion flux by acceleration of each of particles of both plates toward to internal region and both plates begin approaching.

At drift to Δx a part of vacuum energy in internal region transforms to the increased kinetic energy of plates related with drift speed increasing Δv. In the layer Δx and internal region the vacuum energy decreases to the value of the transferred kinetic energy, so the vacuum energy densities near and between the plates becomes lower than before this drift.

At drift to the same Δx internal volume decreases to the same value $\Delta V = S \cdot \Delta x$. As a result, the vacuum energy decreasings are the same too. At any x they are proportional to the mass of the accelerating particles and shift Δx. As a result, at shifting to the same Δx at two values of x the ratio of the kinetic energy increments is constant:

$$\frac{v^2(x_1+\Delta x) - v^2(x_1)}{v^2(x_2+\Delta x) - v^2(x_2)} = const. \tag{37}$$

By introducing the acceleration as

$$a_0 = \frac{dv}{dt} = \frac{dx}{dt}\frac{dv}{dx} = v\frac{dv}{dx} = \frac{1}{2}\frac{d(v^2)}{dx} = \text{const.}, \tag{38}$$

we see that the proportionality coefficient in Eq. (37) is equal to $2a_0$ and at the acceleration in the positive direction from the rest at x_0 we obtain:

$$\frac{1}{2}v^2(x) = a_0(x - x_0). \tag{39}$$

A potential φ_h for such effective uniform field is:

$$a_0 \equiv -\frac{d\varphi_h}{dx}, \quad \varphi_h(x) = -a_0 x. \tag{40}$$

The total energy of the particle of mass m on the plate, beginning to diffuse from the rest at x_0, is thus equal to:

$$E = \frac{mv^2(x)}{2} + m\varphi_h(x) = m\varphi_h(x_0). \tag{41}$$

This is nothing but as the energy of a particle in a uniform and constant gravitational field.

b) The Newtonian potential of a thin dust shell

Let a thin spherical dust shell was rested at “infinity” and the sum of rest energy of its particles was equal to $E_0 = \bar{M}c^2$. At finite values of its radius the vacuum energy density inside the shell is lower than outside and the interior of the shell appears as “colder”, i.e. here the quantum fluctuations are less intensive than beyond the shell.

This leads to radial thermodiffusion flux of particles of the thin shell toward the centre and the shell contracts. At drift to Δr a part of vacuum energy in the internal region transforms to the increasing of shell’s kinetic energy related with the drift speed increasing Δv. In the layer Δr and interior the vacuum energy decreases to the value of this transferred kinetic energy, so the vacuum energy densities near and in the shell become lower than before the drift.

The vacuum energy decreasing, as in the case of plates, is proportional to mass of the shell and the shift Δr. However, now the shell’s area $S(r) = 4\pi r^2$ decreases with decreasing of r and thus at shrinking of the shell to Δr a swept by it volume element is equal to:

$$\Delta V = 4\pi r^2 \Delta r. \tag{42}$$

If now to compare growth of the shell’s kinetic energy at shrinking to Δr and corresponding vacuum energy decreasing around and in the shell to the same value, we may conclude that:

a) for acceleration of the same number of particles the vacuum energy is paid out from more and more decreasing volume of the layer;

b) as the result, the same value of energy, which was transformed to the kinetic energy of particles, at each contraction to Δr leads to larger decreasing of the vacuum energy density than previous one;

c) the increasing difference of vacuum energy densities at the same contraction to Δr leads to additional strengthening of the drift speed, thus decreases the vacuum energy density even more.

As a result, the vacuum energy density decreasing becomes inverse proportional to shell’s area at given radius. Then the ratio of kinetic energy increments of a diffusing particle for two values of radius at drift on the same Δr is not constant, as in the uniform field, but is inversely proportional to the ratio of swept volumes, i.e to the areas of shells at these radii:

$$\frac{v^2(x_1+\Delta x) - v^2(x_1)}{v^2(x_2+\Delta x) - v^2(x_2)} = \frac{4\pi r_2^2 \Delta r}{4\pi r_1^2 \Delta r} = \frac{r_2^2}{r_1^2}, \tag{43}$$

As for the uniform field, it is also the ratio of accelerations, which means that now the accelerations also are inversely proportional to r^2. This thermodiffusive acceleration is directed toward the centre, i.e. has the negative sign, and also is proportional to mass of the shell $\bar{M}$, since the vacuum energy decreasing is proportional to the number and mass of accelerating particles. Thus, taking into account (38) and (43), we obtain:

$$a(r) = -\frac{G\bar{M}}{r^2} \equiv -\frac{d\varphi_g}{dr}, \tag{44}$$

where the gravitational constant *G* in principle may be calculated and expressed through parameters of thermodiffusion. Then the potential of the thermodiffusive gravitational field arising around the shell takes the form:

$$\varphi_g(r) - \varphi_g(\infty) = -\frac{G\bar{M}}{r}. \quad (45)$$

A total energy of a particle of mass m on the shell falling from the rest at x_0 is:

$$E = \frac{mv^2(r)}{2} + m\varphi_g(r) = m\varphi_g(r_0). \quad (46)$$

Thus, the thermodiffusive mechanism for gravitation in the nonrelativistic case reproduces the Newtonian potential $\varphi_g(r)$.

4.3. A physical meaning and normalization of the gravitational potential

Transition to relativistic theory of thermodiffusive gravitation assumes a certain combination of quantum, gravitational and relativistic methods. Due to obvious difficulty of it, at first we consider some simple physical facts allowing us to define contours of the theory.

The Newton potential $\varphi_g(r)$ in Eq. (45) is defined up to a constant $\varphi_g(\infty)$ which, for convenience, has been chosen as vanishing $\varphi_g(\infty) = 0$. As the result, the energy of a gravitational field, as well as a total energy of a particle, rested in this field at r_0, were appeared as negative defined.

The thermodiffusive treatment gets clarity in this question, since here the constant $\varphi_g(\infty)$ is nothing but as a value of energy of a unit mass particle in the vacuum at $r \to \infty$, identified by its rest energy, i.e. $\varphi_g(\infty) = \varphi_{vac}(\infty) = c^2$. Then the gravitational potential of dust shell's static field appears as the difference between local vacuum energy levels of the unit mass sample particle at given radius $\varphi_{vac}(r)$ and at spatial infinity $\varphi_{vac}(\infty) = c^2$:

$$\varphi_{vac}(r) - \varphi_{vac}(\infty) = \varphi_{vac}(r) - c^2 = \varphi_g(r). \quad (47)$$

Then the total energy of a sample particle of mass *m*, as in the nonrelativistic limit of the relativistic theory, includes the rest energy too and takes the form:

$$E = m\varphi_{vac}(r) + \frac{1}{2}mv^2, \quad (48)$$

$$\varphi_{vac}(r) = c^2 + \varphi_g(r) = c^2 - \frac{GM}{r}. \quad (49)$$

As a result, now not only particle's energy, but also the vacuum's potential $\varphi_{vac}(r)$ are positive defined everywhere outside the source.

Thus, the redefined potential $\varphi_{vac}(r)$, on the one hand, is maximal at infinity, where tends to c^2, and, on the other hand, vanishes at the gravitational radius $r_g = 2GM / c^2$ of the source: $\varphi_{vac}(r_g) = 0$.

At the same time, in the thermodiffusive picture the intensity of fluctuations at any point determines a local temporal rate of processes with sample particles. Therefore, the ratio of $\varphi_{vac}(r)$ to $\varphi_{vac}(\infty)$, showing how the local vacuum energy density lower than a normal one at spatial infinity, is also shows delay of proper times at this point.

In the geometrical treatment of GR this measure is given by a time component of the metrics $g_{00}(r)$. In this regard we can enter also an *effective thermodiffusive metric*, by defining it as the ratio of vacuum's "energy level" in this radius to the "level" at spatial infinity:

$$g_{00}(r) = \frac{2\varphi_{vac}(r)}{2\varphi_{vac}(\infty)} = \frac{2\varphi_{vac}(r)}{c^2} = 1 + \frac{2\varphi_g(r)}{c^2}. \tag{50}$$

The geometrical structures induced by thermodiffusion, including the metrics, are discussed in the following two Sections.

4.4. The metrics and connection induced by thermodiffusion in the vacuum

In GR basic properties of a gravitational field were postulated, and then they were represented as properties of spacetime geometry. After discussion that these properties of gravitation, such as independence of acceleration of sample particles on their mass and energy-momentum of matter as a source of the field, follow from conservative thermodiffusion in vacuum, for transition to their geometrical form one can follow on the standard methods of GR.

Independence of thermodiffusive acceleration on the mass of a sample particle leads to equal acceleration of particles and their macroscopic collections, including the local reference frames too. But equal acceleration of objects and local reference frames is indistinguishable from the existence of a nontrivial metrics and connection of spacetime.

At thermodiffusion in vacuum the mean trajectories of free particles are not geodesics in flat spacetime and contain some deviations from the geodesics. For their description in relativistic kinematics the curvilinear coordinates $x^{\mu}(x^a, t)$ and basis vectors e^a_{μ} along *mean trajectories* of free particles should be introduced, the differentials of which are related by local intervals of physical coordinates dx^a at a point M as $dx^{\mu} = e^{\mu}_a dx^a$ ($\mu, \nu = 0,...,3$ $a, b = 0,...,3$).

Then thermodiffusion can be described as a motion of the particle in an effective Riemannian manifold with a metric tensor $g_{\mu\nu}(x,t)$, where mean trajectories of thermodiffusive drift are geodesics. This allows us to enter a thermodiffusive *parallel transport* of tensors in flat spacetime along the mean trajectory of free drift:

$$de^{\mu}_a(x,t) = -\Gamma^{\mu}_{\nu\lambda} e^{\lambda}_a dx^b(t), \tag{51}$$

where $\Gamma^{\mu}_{\nu\lambda}$ is an effective connection. Then corresponding to this connection an effective Riemann curvature tensor $R_{\mu\nu\lambda\sigma}$ can be entered as usual.

The thermodiffusive treatment of gravitation then can be build as quantum mechanics in effective (pseudo) Riemannian spacetime. Therefore, here we may use various methods of description of diffusion in curved manifolds.

Thermodiffusion in physical vacuum, therefore, induces a nontrivial effective metrics $g_{\mu\nu}(x,t)$ which define a spacetime interval between events:

$$ds^2 = \eta_{ab} dx^a dx^b = g_{\mu\nu} dx^{\mu} dx^{\nu}. \tag{52}$$

For a sample particle an action function then takes the form:

$$S = -mc \int ds = -mc \int \sqrt{g_{\mu\nu} dx^{\mu} dx^{\nu}}. \tag{53}$$

Thus, the first postulate of GR, the principle of equivalence, and also its direct consequence that gravitation can be described as a nontrivial metrics and connection in spacetime, now appear as a consequence of thermodiffusion in vacuum at large concentration of matter.

4.5. Thermodiffusive curvature and derivation of the Einstein equations

Let's pass to the second of postulates of GR that gravitation is generated by energy-momentum of a source. In thermodiffusive treatment energy of vacuum around a source is lower to a value of energy of quantum fluctuations of its particles, including the rest energy and kinetic energy received from vacuum during thermodiffusive formation of the source.

In principle, it follows from the thermodiffusive treatment that the total energy of a particle is equal to an energy to which the energy of vacuum has decreased. Therefore, the sum of particle's total energy and a value of decrease of the vacuum energy in entire space is equal to zero, which in terms of an energy density ε_m (for the rested particles) gives:

$$\int(\rho_{vac}^{(0)} - \rho_{vac})dV = \int \varepsilon_m dV. \tag{54}$$

Decreasing of the vacuum energy density near a source and its smooth restoring by distance, appeared in the left side of Eq. (54), can be described as in terms of thermodiffusion, as in terms of the gravitational potential or corresponding metrics, connection and curvature of spacetime.

The curvature tensor has been used in a more suitable for physical problems form as composed to the Einstein tensor $G_{\mu\nu} \equiv R_{\mu\nu} - g_{\mu\nu}R/2$. By choosing at each point a definite local basis with 4-speed u^μ on some hypersurface of simultaneity and by projecting of tensors to this basis, at each point we can obtain corresponding scalars. In thermodiffusive treatment such scalar projection of $G_{\mu\nu}$ on the hypersurface with a unit time-like normale n^μ can be identified by the local deficit of physical vacuum's energy-momentum density:

$$\rho_{vac}^{(0)} - \rho_{vac} = \frac{1}{\kappa} G_{\mu\nu} n^\mu n^\nu. \tag{55}$$

In general case the balance of energies of a local source and vacuum around it should be written locally and in the tensor form, i.e. through a energy-momentum tensor of the source $T_{\mu\nu}$, which then leads to the Einstein equations:

$$\frac{1}{\kappa} G_{\mu\nu} = T_{\mu\nu}. \tag{56}$$

At possibility to integrate scalars over all space on hypersurfaces of simultaneity, the obtaining total energies of the source and its gravitational field, according to (54), will equal to each other. As the result of a clear physical picture, there is no problem with the energy of the gravitational field.

Thus, in comparison with GR the theory of thermodiffusive gravitation is a next step in understanding of the nature of gravitation. From this theory, as they have been shown, naturally follow both the principle of equivalence and relation of the field variables by the energy-momentum of matter. For this reason the new theory naturally reproduces the formalism of GR, but not as a formal mathematical construction, bus as a geometrical method of description of thermodiffusive gravitation without deepening to its microscopic mechanism.

Conclusion

Thus, at beginning of diffusion of a cold light gas in a warm heavy gas there is a small, but quite long, with respect to the free pass time, period before relaxation when the diffusion is practically conservative.

In this conservativity time the diffusion process is described, in addition to the continuity equation, by the equation of motion too, including the speeds of drift, diffusion flux and thermodiffusion flux. There is also the elementary phase volume $\Gamma_D = p_D l_D$ of mean free path and momentum of a light particle and a diffusion constant then is equal to $D = \Gamma_D / 2m$. There is also a uncertainty relation for dispersions of coordinate and momentum in ensemble of particles connecting them with Γ_D. At $\Gamma_D = const.$ the system of nonlinear diffusion equations linearizes and turn to the Schrödinger equation for a complex probability amplitude. Thus, in this theory one should add the probability amplitudes for alternatives.

Thus, it has appeared that the formalism of quantum mechanics has wider area of applicability than especially quantum systems and describes in fact a classical conservative diffusion. Quantum mechanics is only a particular case of such diffusion with the elementary phase volume $\Gamma_D = \hbar$.

Most fundamental consequence of conservative diffusion appears the new mechanism of gravitation which succeeded to identify by thermodiffusion in the physical vacuum. This circumstance does the theory of gravitation as a part of quantum theory and solves the problem of synthesis of theories of these two phenomena.

As problems for further research remain origins and mechanisms of fluctuations of physical vacuum, whereas their acceptance as the observational fact leads to a simple and clear physical picture of both quantum and gravitational phenomena, by sufficiently simplifying the situation in foundations of physics.

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