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Energy Theory: the Vortex Nature of Quantum Physics

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В работе утверждается, что помимо энергии, описываемой функцией состояния взаимодействующих систем, существует и вездесуща дополнительная к ней энергия, и определяются ее принципы и критерии. Эта энергия существенна для устойчивости материи, но не вписывается в законы термодинамики и энтропии и традиционные теории фазовых переходов и броуновского движения. Она имеет вихревую природу, связана с релаксацией и порождает все квантовые явления с их сверхтоками, стабилизируя коллапс состояний. Дается критика устоявшихся представлений, влияющих на поиск новых состояний материи и энергии.

This work states the existence and ubiquity of the energy form complementary to the energy given by the function of states of interacting systems, and substantiates its principles and criteria. This energy form is critical to matter stability but does not conform to the thermodynamics and entropy laws and the traditional theory of Brownian motion and phase transitions. It is of vortex nature related to relaxation and gives rise to all quantum realm with its super currents stable against state collapse. Conventional views detrimental to search for new states of matter and energy are exposed.

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1. Introduction

The gist of physics is in the unifying guideline of energy bound to its conservation and transformations in the evolution of all things existent. The meaning of all is vague and better determined via perception of phenomena through the energy exchange between systems given by a function of their states. Such is the energy concept of mechanics by Euler and Lagrange and that of equilibrium thermodynamics by Gibbs and more general statistics of states. This energy concept has found ways in all pores of physics, but is limitted. Taking it for granted leads to circular theories and fallacies.

Let us recall the forces called circulatory or vortex with all their cumulative impact beyond the energy function concept that can be huge, and the term "dry water" coined by von Neumann stuck to viscosity-neglect hydrodynamic studies as inadequate, see [1]. Also since the 19th century, e.g. [2,3], it was exposed in mechanics and other fields the invalidity of the concept due to the reaction forces of ideal non-holonomy, performing no work on the system, as is the case of rigid bodies rolling without slipping on a surface. Recall also a general symmetry argument provoked by the H-theorem of Boltzmann and showing the Loschmidt's fundamental paradox [4] of reversibility on the way to conform the real world with the energy function concept.

Physics nowadays in line with quantum mechanics bridged to Lagrangian mechanics has a commanding influence on both fundamental and applied research. It looks just the way things are, but is heuristic and narrows the reach of thought about the energy and stable matter in vast realm of statistical equilibria. This is what the present work is about. It is based on the idea of complementary energies we introduced in [5] and now clarify. We begin with outlining the validity domain of the traditional energy concept, then consider the principles of complementary energies, dwell on things it opens up, and rest our case on quantum physics.

2. The existence domain of energy function concepts

Let us think of energy concepts in terms of generalized thermodynamic potential commonly accepted in the study of phase transitions, transport through barriers, and many other things. The generalized potential of a system relaxing in steady conditions to a density distribution $\rho_{\rm st}$ connects to it by

$$\rho_{\rm st}(z) = Ne^{-\Phi(z)}, \quad N^{-1} = \int e^{-\Phi} d\Gamma \tag{1}$$

where the integral is over the volume Γ of system phase space variables z and the reversible motion is on surfaces

$$\Phi(z) = const. \tag{2}$$

The properties of the system mainly depend then on the local properties of the minima of Φ. Also, it gives insight from the observed symmetries of a physical system. An analogous approach to systems under high frequency fields is in terms of the picture where the hf field looks fixed or its effect is time-averaged. In all this, Eq. (1) can be viewed as merely redefining the distribution $\rho_{\rm st}$ in terms of function Φ, whereas, taking this function as the energy integral of reversible motion provides the physical basis of the theory, but implies rigid constraints.

Commonly, going back to Boltzmann and Onsager, to mention a few, the constraints are reasoned based on microscopical reversibility. It corresponds to detailed balance of transition probabilities between each pair of system states in equilibrium. The balance of transition probalities implies system descriptions within the framework of autonomous Fokker-Planck equations and analysis, see [6], via division the system parameters into odd and even with respect to time reversal, with a reserve on factors like magnetic field. In so doing the logic of time reversal is model-bound, and the reserve rule can be easily broken, e.g., in nuclear processes and where spin-orbit interactions are a factor, particularly near surfaces, interfaces, dislocations. So, a problem arises even with this model-bound case.

A different approach to outlining the overall domain of generalized thermodynamic potential validity was suggested in [5]. Its basis is in keeping with invariance under transformations of variables. On doing so the energy integral of reversible motion implies the invariance under univalent transformations $z \to Z$, of Jacobian

$$|\det\{\partial Z_k(z,t)/\partial z_i\}| = 1 \tag{3}$$

where i, k run through all components of z and Z. $\Phi(z)$ (1) satisfies this condition, for then not only $\rho d\Gamma$ is invariant (being a number) but also $d\Gamma$. The environment as a diffusion/dissipation source for the system brings in another invariance. Connecting Φ to the system's energy function implies scaling this function in terms of environmental-noise energy levels. The energy scales set this way are fixed but must vary proportionally with the energy function in arbitrary moving frames $Z = Z(z,t)$ to hold Φ invariant. Since the energy function changes in moving frames, this constraint can hold only for the systems *entrained* - carried along on the average for every system's degree of freedom with the environment causing irreversible drift and diffusion.

Also account must be taken where the limit of weak background noise poses as a structure peculiarity – transition to modeling of evolution with possible irreversible drift without regard to diffusion. This means motion along isolated paths. The entrainment constraint then keeps its sense as the weak irreversible-drift limit. Such mechanics allows for the ideal non-holonomic constraints that do not perform work on the system but reduce the number of its degrees of freedom, which violates the desired invariance of $\Phi(z)$. Hence, the invariance necessitates the domain of entrainment free of that, termed ideal entrainment or just ideal below.

We have discussed all conditions on $\Phi(z)$, and the reasoning holds for any one-to-one functions $\rho_{\rm st}(\Phi)$. For the systems describable by a time-dependent density distribution $\rho(z,t)$, the adequacy of energy function formalism also requires the entrainment ideal. The arguments used above for the systems of steady $\rho_{\rm st}(z)$ become applicable there with univalent transformations of $\rho(z,t)$ into t-independent distribution functions.

The converse is also true: the behaviors governed by a dressed (due to the environment) Hamiltonian $\mathrm{H}(z,t)$ imply the entrainment ideal and the existence of a density distribution $\rho(z,t)$. The velocity function $\dot{z} = \dot{z}(z,t)$ of underlying motion is then constrained by $\dot{z} = [z, \mathrm{H}]$ with $[,]$ a Poisson bracket, so the divergence $div\,\dot{z} = div[z,\mathrm{H}] = 0$ and $div(\dot{z}f) = -[\mathrm{H}, f]$ for any smooth $f(z,t)$. It implies, if a smooth distribution $\rho(z,t)$ exists,

$$\partial\rho/\partial t = [\mathrm{H}, \rho] \tag{4}$$

and that $\rho(z,t)$ satisfies Eq. (4) from given initial conditions and the boundary conditions taken natural at $|z| \to \infty$ (ρ and its derivatives vanish) to preserve the normalization $\int \rho d\Gamma = 1$, for all other constraints are embodied in H. Such solution to (4) cannot cease to exist as smooth, unique and non-negative over the phase space of z where $\mathrm{H}(z,t)$ governs the behaviors. The entrainment ideal there takes place since the solution turns into a function $\rho(\mathrm{H})$ in the interaction picture where H is t-independent. This completes the proof.

Thus, *the necessary and sufficient conditions where the energy function concept is duly* *adequate to the evolution described by the distribution function of system states come down to the entrainment ideal.*

This theorem of [5] lays down the overall domain of energy function validity. It includes the systems isolated or in thermodynamic equilibrium, as well as entrained in steady or unsteady environments generally of non-uniform temperature or indescribable in temperature terms so long as the diffusion, irreversible drift, and ideal nonholonomy can be neglected.

3. Incompleteness of energy function concepts

The concepts of energy as a function of system states give rise to the fundamental notion of reversibility. But along comes the following dilemma:

On the one hand, the irreversible forcing generally cannot be consistently referred to smoothing of reversible microscopy over irrelevant variables and random conditions. On the other, insofar as the true physics of phenomena is perceived through the interactions given by energy functions of states, so should be the physics of irreversible phenomena.

The approach to irreversiblity from microscopy can mislead in the question of both statistical and dynamical (over fast motion) averaging. First, it is impossible to come to the irreversible behaviors from a many-body Hamiltonian system unless resorting to the methods of averaging and truncations irreducible to the separation of variables within the framework of canonical transformations. Secondly, the arising inaccuracy accumulates with time, which is essential for the notion of energy as a conservative measure of the evolution in stationary conditions. Also the perception of myriad of outer influences, even treated within the Hamiltonian dynamics as frequently alternating interactions, is possible only through averaging, which practically cannot be presented as the exact averaging given by canonical transformations, hence, leads to irreversible influences that may significantly accumulate for long times.

The other way around, as the averaging in point is then to provide evolution to ideal entrainment, it inevitably means relaxation towards a macro state of rest, hence, rigid constraints following from nowhere, i.e., circular theories.

The formulated dilemma is inherent in the perception of energy exchange in terms of the energy function concepts and brings in fundamental inexactness and incompleteness. There is no other way to account for the energy exchange incompleteness but to integrate the concept with a tentative (statistical) measure of energy blur/relaxation rates. The more it matters as the ideal entrainment as an asymptotic limit in the parameter space of modeling is inherent in a boundary layer and intermittency where the limit trend can be deprived of evidential force in the close vicinity of the ideal. Let us now go over to introducing the principles and criteria of consistent energy measure that put the issue of dilemma by.

4. The whole energy measure and its vortex element

Let us agree on terms. The systems will be defined as describable by a smooth evolution of the density distribution function $\rho(z,t)$ of phase space z. z is a set of continuous variables $z = (x,p)$ - the generalized coordinates $x = (x_1, \dots x_n)$ and conjugated moments $p = (p_1, \dots p_n)$ taken in neglect of the constraints breaking the energy function formalism; z may include sets of normal mode amplitudes of waves in media. The smoothness of $\rho(z,t)$ will be understood to mean

$$\partial\rho/\partial t = -div(\hat{v}\rho) \tag{5}$$

with $\hat{v}\rho$ the $2n$-vector flux of phase fluid at z, t; $\hat{v}\rho$ is a smooth functional of ρ. Eq. (5) turns into the evolution equation for $\rho(z,t)$ with $\hat{v}$ treated as a proper operator that accounts for all constraints on the phase flows under the boundary conditions taken natural for the z components set unbound. Generally the constraints are non-local in z and non-anticipating in t. Let us consider the conditions of stationary environment, when Eq. (5) is autonomous and describes relaxation of systems to a stable distribution of ρ in response to perturbations.

In this general approach, a measurable property, and nonmeasurable are off physics, presumes conservation of its measure judged by the solutions $\rho(z,t)$ to Eq. (5), its Cauchy problem as a function of t in space z. In our case this is the conservation of system energy in outer stationary conditions. The general principles of work on the system and the law of energy conservation, with the energy determined by the work, are to be taken as prime as so the material world is perceived. This base fully and by far covers the basics given by the notion of energy conservation of reversible processes, as shown below.

It is customary to formulate the principles of work in terms of isolated trajectories $z = (p,q)$ as functions of t without account of diffusion and retardation in $\hat{v}$ independent of ρ. The motion $z(t)$ from an initial $z(0)$ reduces then to delta-function $\rho(z,t) = \delta(z - z(t))$ in

(5) where $\hat{v}$ is a function $v = \{v_i(z)\}$, and is given by the set of equations

$$dz_i/dt = v_i(z), \quad i = 1, \ldots 2n. \tag{6}$$

But already in this explicit mechanics the notion of energy as a function of system states much narrows the conditions of energy conservation for the case. The conservation over closed paths of system motion $z(t)$ means

$$\oint v_i dz_i = 0 \tag{7}$$

assumed summing over dummy indeces. The criterion (7) is satisfied for the ideal, for then v is to be divergence-free. However, the equilibrium states to be stable require irreversibility in the vicinity of such paths, that is $div\, v \neq 0$. Absorbing the energy means $div\, v < 0$. An archetype example is Rayleigh dissipation function, then $div\, v = k$ with $k = const < 0$, so the irreversible contribution to the drift v represents viscous forces linear in system velocity in terms of Lagrange variables of physical space. These forces disappear in the states of rest and it realizes in the minima of potential forces of the system, a point or their set depending on the potential shape.

The phenomenon of stable motion, rather than rest, in conditions of energy conservation, is considered impossible in classics. Obviously, we are talking about the equilibrium phenomena - steady motions governed by autonomous equations in conditions without supply of energy. However, nothing contradicts to the principles of work in such conditions, if we take into account that the sign of $div\, v(z)$ may vary so that the work can be irreversibly absorbed on some parts of motion $z(t)$ and gained on other parts. The quadratic form vdz in the regions of motion satisfying (7) where $div\, v(z) \neq 0$ then includes vortex forces, and the work due to them depends on the path of motion, becomes not the function but a functional of system states. The conserved energy as determined through the work over the whole path of motion is thus a functional embodying vortex forces. For the systems described by a retarded $\hat{v}$, Eqs. (7) are integrodifferential and the existence conditions for such integral energy measure diversify.

Certainly, the phenomenon of motion in point is negated if we associate the energy conservation with the work on an imaginable Hamiltonian system, rather than a real, *physical* system determinable by Eq. (5) of measurable parameters. The possibility to overrun the narrow framework of energy as a function of system states much widens further with account of diffusion, which means nonlocality in z of action $\hat{v}$ on $\rho(z,t)$. For the general conditions of modeling within Eq. (5) where

$$div(\hat{v}\rho) = (div\,\hat{v})\rho + \hat{v}\,grad\rho, \tag{8}$$

the criterion of energy conservation (7) extends into that the integral in (7) is replaced by a multidimensional integral of $\hat{v}\rho d\Gamma$ over the volume of steady phase fluid flows. For $\hat{v}\rho$ modeled linear in ρ and not retarded, the limit $(div\,\hat{v})\rho = 0$ in the volume corresponds to the ideal of total, over space z, self-compensation of irreversible drift forces and diffusion, whereas, the stability requires such conditions near the compensation to be violated with predominance of viscous forces; clearly the domain of that is limited. Diffusion contributes significantly to irreversibly gaining the energy, as this creates mass new possibilities for changing the sign of $(div\,\hat{v})\rho$, hence, for the equilibrium states of system motion and its energy beyond customary notions of reversible physics phenomena.

So, *the utmost wide energy measure of stable systems in the above-outlined general conditions of work includes the integral energy that embodies the vortex forces of drift and diffusion.*

The measure extends much beyond the ideal, which is a low dimension limit where $(div\,\hat{v})\rho = 0$, depending on the character of irreversible drift and diffusion. The energy of equilibrium system off the ideal aria represents its ρ state of motion in t, and the motion may be not necessarily slow, since the compensation of irreversible drift forces and diffusion is broken locally also by emerging motion. For all that, the stability of motion states corresponds to the inseparable balance of all forcing - the reversible and irreversible drift and diffusion for the case.

5. The canonical property of irreversible kinetics

The general kinetic equations (5) acquire the form

$$\partial\rho/\partial t = [\mathrm{H}, \rho] + I \tag{9}$$

where $\mathrm{H} = \mathrm{H}(z,t)$ is, unlike in (4), an arbitrary Hamilton function, if we take for the term I the expression

$$I = -div[(\hat{v} - \dot{z})\rho] \tag{10}$$

with $\dot{z} = [z, \mathrm{H}]$ the local velocity of Hamiltonian phase flows governed by H. An important feature of presentation (9) noted in [5] is

The canonical invariance of I holds as in as off the entrainment ideal, i.e. stands for all drift and also diffusion.

To prove, note that a canonical (univalent) transformation $z \to Z$ implies not only the invariance of ρ and Poisson brackets but also the constraint

$$\partial Z(z,t)/\partial t = [Z, G] \tag{11}$$

with G a scalar function of z, t. Herein $\partial Z(z,t)/\partial t$ is the relative velocity of reference frame Z at (z,t), so the function $G(z,t)$ plays the role of a Hamiltonian governing this relative motion. The canonical invariance of $\partial\rho/\partial t - [\mathrm{H}, \rho]$ in (9) follows and, hence, of the I term whatever its functional form may be. This formulation generalizes our theorem IV in [5a]. It follows important consequences.

In the domain of ideal, I reduces to a $[\mathrm{H}, \rho]$-like Poisson bracket since the evolution is then to be governed by a dressed Hamiltonian. Beyond the ideal, the entrainment theorem implies that I is not reducible to a $[\mathrm{H}, \rho]$-like bracket and cannot keep invariance, hence, both the $\partial\rho/\partial t - [\mathrm{H}, \rho]$ and $[\mathrm{H}, \rho]$ of (9) cease to be invariant in the process of actual evolution for any choice of $\mathrm{H}(z,t)$.

In disregard for the evolution, the state of ρ at any given instant $t = t_i$ can be taken for ideally entrained by fitting. Due to this and since ρ is assumed smooth in t, the effect of the irreducibility of I and $[\mathrm{H}, \rho]$ to invariants is weak for t's close to t_i. So, it may seem reasonable to judge about their figure of merit for not small $t - t_i$ by popular perturbation methods of dynamical systems, e.g. [7]. But this insight is insufficient and fails in the long run beyond the domain of ideal to match the future with the past. As the reliance on such perturbation theories conforms to the trends of ρ in line with a dressed Hamiltonian, it conduces to the belief in this energy function theory beyond its above-established rigid constraints.

By virtue of the canonical feature, its consequences in point, the system's behavior in externally applied fields changes generally in a non-conservative way. It shows up vigorously in systems under fields of high frequencies, e.g. laser optics, particularly near resonances, including parametric and combinational. The averaged effect of hf fields in the lowest, quadratic order in field amplitude results in static vortex forces along with strong forces of effective potential. Thereat, the quasi-steady states, fluctuations and stability of systems at resonances appear quite different from what the theories of quasi-energy and generalized thermodynamic potential prescribe. Various essential effects of this kind, their general features and methods of analysis were elucidated in our work cited in [5a] (e.g. [8]).

6. Extended equilibrium and measurements

In the above, along with the new notion of energy, we have come to a new notion of equilibrium states - its extension from the habitual stereotype of system states of rest to the equilibrium states of motion that take place in an immensely wider area of autonomous conditions. The conclusion is immediate from the equation (5) for irreversible kinetics with $\partial\rho/\partial t \neq 0$ and allows for the stable states of fast motion. Importantly, the macromotion in point relates to the physics of systems in equilibrium states in outer fairly stationary conditions when the energy is conserved, rather than concerns non-equilibrium statistical physics. Is there then a derogation from stationarity?

The question is not so academic as principal for the measurements and understanding of the claimed principles. The stationarity for the case is the invariance of behaviors with respect to time translation from the time of perturbation, and it is inherent as in the states of rest as in the states of steady motion. The difference between the two displays itself in comparing the temporal correlations between the pictures of steady distributions of ρ for the system. Determining these correlations or the power spectra corresponding to them for these or those forms of motion gives one an insight into the phenomena in point, including the region of rest-motion transition. The approach within the framework of Eq. (8) or (9) governs the trends already smoothed over frequently alternating influences on the system. More detailed correlations are described by more detailed kinetics and energy measures; we shall not dwell on that.

For the systems relaxing in stationary outer conditions to equilibrium distributions of states close to the states of rest, in the sense of limit $\partial\rho/\partial t \to 0$, we get in terms of Eq. (9)

$$[\mathrm{H}, \rho] + I = 0. \tag{12}$$

The energy of systems is then conserved with the branch I acting on a par with $[\mathrm{H}, \rho]$ in jointly keeping the circulation and transformations of conserved energy. To similar trends we come for the energy of stable equilibrium states of fast motion in the picture of canonical transformations where the steady ρ is roughly t-independent. It is clear that the conditions of such energy circulation and transformations in systems include the whole domain of ideal, but are not limited by it at all and can stretch beyond the ideal vastly.

While in the domain of ideal (whether Eq. (12) holds or not) the energy is a function of system states given by a dressed Hamiltonian with its potential and kinetic energies, both of regular and/or chaotic origin, the conserved energy of systems beyond the ideal includes or comprises the energy of a different form, complementary to all those types given by Hamiltonian, since stands for both reversible and irreversible drift forces and diffusion in their inseparable balance. This is just our integral vortex energy of equilibrium states. It is not related to the principles of detailed balance and habitual trends of relaxation, which is to the minimum of energy as a function of systems' states, hence, the trends of stability and preference relations in phase transitions - all that based on the theory of generalized thermodynamic potential.

7. On the macromotion and vortex energy criteria

Look first at a Brownian particle on a reflecting plate. Gravity tends to press the particle down and chaotic influences of the environment keep it hopping on the plate in stationary conditions. For the particle charged and placed in a field of a permanent magnet, its drift arises across both the magnetic and gravity force fields. The drift modifies but not disappears for the plate rolled into a closed pipe or box. The energy of steady drift is conserved, hence, contains a vortex form not given by a function of the system states;. the same picture is for a number of interacting charged particles between reflecting walls. We raised the issue in [9] but established the point in [5].

It will be observed that there are many studies of various directed Brownian motion phenomena, e.g. [10] and recent reviews [11-14]. Paradoxically, the conventional wisdom relates the phenomena to non-equilibrium statistical physics. As it does, this is nothing else but stable equilibrium states of systems and stored energy of integral vortex form previously missed in equilibrium physics of sight.

Let us formulate a general criterion on this score, considering as before the systems described by a distribution function in stationary outer conditions. For the case of stable ideal, the systems relax to the state of rest determined by a dressed Hamiltonian $\mathrm{H}(z)$ bound from below, commuting with the generalized thermodynamic potential $\Phi(z)$, $[\mathrm{H}, \Phi] = 0$, and being its monotonic function, for unambiguity. Thereat, the condition of vanishing irreversible forcing on the average for every component i of variables z implies according to (12) the following $2n$ constraints

$$\left(f_i - d_{ik}\frac{\partial}{\partial z_k} + \ldots\right)\rho_{\mathrm{st}}(z) = 0 \tag{13}$$

where $f = \{f_i(z)\}$ is the irreversible drift forces, $d = \{d_{ik}(z)\}$ a symmetric non-negative definite (for stability) matrix of diffusion and ellipsis stands for the higher order diffusion terms of expansion of I into a series in $\partial/\partial z$. As I is generally an integrodifferential form in z, so the operator bracket of (13) is. The constraints of (13) generalize the conditions of detailed balance.

Neglecting the higher order terms in the bracket, reduces Eq. (13) to the algebraic fluctuation-dissipation relations

$$f_i = -(d\Phi/d\mathrm{H})d_{ik}\dot{z}_k \tag{14}$$

with $\dot{z} = [z, \mathrm{H}]$ and $d\Phi/d\mathrm{H} > 0$. For the distribution ρ_{st} of Maxwell-Boltzmann form and general Gibbs form, $d\Phi/d\mathrm{H} = \beta$ is independent of H, which reduces (14) to

$$f = -\beta d\dot{z} = -\beta d[z, \mathrm{H}]. \tag{15}$$

$\beta^{-1} = \Theta$ is the energy scale of absolute temperature whose meaning expounds the known equipartition theorem: for every component of z (coordinate or momentum) whose contribution to H reduces to a square term, say, $k_1(z_j - k_2)^2$ with $k_1 > 0$ and k_1, k_2 independent of z_j but may depend on other components of z and t, its mean over the Gibbs statistics comes to $\langle k_1(z_j - k_2)^2\rangle = \Theta$.

It is easily seen that the ρ_{st} taken a Gibbs rules out persistent currents since for any $\langle \dot{z}_i\rangle$, a function of z_i averaged over the phase subspace off z_i, one gets on integrating by parts (no summing over i in the integral)

$$\langle \dot{z}_i\rangle = N\int [z_i, \mathrm{H}]e^{-\beta\mathrm{H}}(d\Gamma/dz_i) = 0 \tag{16}$$

by virtue of natural boundary conditions for $\rho_{\mathrm{st}}(z)$. The theorem $\langle \dot{z}_i\rangle = 0$ holds not only for Gibbs but for the Bose-Einstein, Fermi-Dirac and other statistics, provided the system relaxes to a stationary distribution $\rho_{\rm st}(z) = \rho_{\rm st}({\rm H}(z))$ satisfying natural boundary conditions. The conditions of all that are limited by the entrainment ideal. So the states of stable macro-motion like persistent currents are thus a Litmus test of conserved vortex energy. A distinctive feature of the phenomenon is the fact of relaxation and reverse in response to perturbations.

Thereby, the paradigm of Brownian motion caused by eternal chaos as non-directional extends to that of directional, and it concerns phase transitions. While any system at a certain standing can be taken via fitting as ideally entrained, governed by an energy function of its states, the theories of transition under a shift of parameters to a stable macromotion beg a question whenever the emerging macromotion state is also treated as a state governed so. The macromotion is then attributed to spontaneous symmetry breaking, topological defects, and what-not, which is problematic as it implies the conditions (13) to be somehow miraculously restored. Anyhow, in the end one faces the above theorem banning a stable macromotion within this beaten path down-the-line.

In contrast to the essence of pattern formation as a process that makes the Cauchy problem of kinetic equation (9) [even its quasi-static ($\partial/\partial t \to 0$, not just $\partial\rho/\partial t = 0$) limit (12)] the corner stone of the theory of energy, as we do, the theory of phase transitions in question makes the boundary value problem imposing the evolution trend given by the energy function concept the corner stone. The imposition results in the geometrization beauty of kinetics, but rules out the formation intrinsic to a stable non-entrained state in equilibrium, hence, the macromotion and vortex energy.

8. Thermodynamic laws in the light of vortex energy

Let us look into equilibrium thermodynamics. It proceeds from the existence of internal energy E of thermodynamic system as a function of external parameters $a = \{a_k\}$ and temperature Θ so that the differential dE in space (a, Θ)

$$dE = \frac{\partial E}{\partial \Theta} d\Theta + \frac{\partial E}{\partial a_k} da_k = \delta Q + \delta W \tag{17}$$

expresses the first law by introducing the heat transfer Q as the difference between the internal energy and the work on the system W defined for any processes as purely mechanical, for Θ fixed. For the processes to proceed the parameters are assumed to vary in time, but slowly - in the quasi-static limit $|d(a,\Theta)/dt| \to 0$. Whereas Q and W may freely depend on the path chosen in (a,Θ) with δQ and δW not bound to be exact differentials, Eq. (17) implies for any cyclic process

$$\oint \delta Q = -\oint \delta W. \tag{18}$$

Therein lays the principle of equivalence between the work and heat. The principle of first law in the form (17) is tantamount to that of (18). This being for any closed paths in (a,Θ), the vortex energy is thereby completely excluded.

Not only the first law appears to be the law of energy conservation bound to the framework of energy a function of system states for the case, but also it implies, since the thermodynamic equilibrium is treated as a stable state, relaxation to be exactly towards the minimum of energy function of system states in terms of (a,Θ) without introducing any entropy function.

The second law of thermodynamics in this regard specifies the equation of system state, its caloric-thermal relations - by assuming that the energy function is additive with respect to the partition of system volume, a one-dimension external parameter, in independent small parts. It best fits the ideal gas confined by rigid walls, is in line with Gibbs statistics of ρ_{st}, and poses the energy E and forces $A_k = -\partial E/\partial a_k$ as the averages

$$E = \int \mathrm{H} e^{(\varphi - \mathrm{H})/\Theta} d\Gamma, \tag{19}$$

$$A_k = \int (-\partial \mathrm{H}/\partial a_k) e^{(\varphi - \mathrm{H})/\Theta} d\Gamma \tag{20}$$

with

$$\varphi = -\Theta \ln N, \quad N = \int e^{-H/\Theta} d\Gamma \tag{21}$$

and the Hamiltonian H assumed a function of z and slowly varying parameters a but not Θ, to avoid ambiguity. These equations show $\varphi(a,\Theta)$ as the Helmholtz free energy determining the work of forces $A = \{A_k\}$ and also the expression $\Theta \partial\varphi/\partial\Theta$ as the binding energy function. The entropy function, which is introduced in pure thermodynamics as $S(a,\Theta) = \int(\delta Q/\Theta)$ by postulating the existence of the integrating multiplier of δQ with $1/\Theta$, amounts by Eqs. (19), (21) to

$$S = -\frac{\partial\varphi}{\partial\Theta} = \frac{E - \varphi}{\Theta}. \tag{22}$$

So, all physics of Gibbsian thermodynamics is given on the base of energy function φ. Also it shows entropy as not a self-sustained notion for that matter and that the second law, just as the first law, is not reflective of vortex energy and its trends.

The latter assertion is to be common to any entropy a function of system states treated not only on the base of first law but also on the base of any its generalization within the framework of entrainment ideal. Indeed, the entropy function and the generalized potential must then commute, for the ideal entrainment holds where this potential for the system is its energy integral. The violation of entropy conservation law would mean that the entropy is not a function of parameters entering in the potential for the case. Moreover, the assertion is also true in stationary conditions where the law of energy conservation holds beyond the entrainment ideal, which is the area of vortex energy, for the opposite would then mean the existence of the energy integral of the system there. As to the conservation law of entropy in conditions where the energy of system is not conserved, the entropy function again cannot be related to the energy of system, for such notion ceases to exist then. Thus, the notion of entropy, however defined and by which statistics, does not add physics to the vortex energy.

Of various statistics linked to the second law, only Gibbs statistics assigns to the thermodynamics the meaning given by the equipartition theorem. But at that, only a small area of Gibbs statistics domain fits the thermodynamics, as particularly evident from the paragraph with Eqs. (13)-(16). Namely, it implies $\mathrm{H}(z)$ to be bound from below and the additivity postulate to limit its long-ranged interactions, and the interactions and parameters entering into H should not depend on Θ and statistical factors – to preserve the very separating principle between the balances of reversible and irreversible forcing and avoid ambiguity in its definition.

In this light, the known Landau theorem [15], often referred to as the outright ban on classical routes to persistent currents, should not be treated so. The theorem states that a closed system of interacting parts in thermal equilibrium admits only uniform translation and rotation as a whole. The proof proceeds from the system's entropy S taken in the form of a sum $\sum S_i$ where each summand S_i is a function of the difference $E_i - P_i^2/2m_i$ between the total and kinetic energy only of part i, and the arguments and calculations do not go beyond the first and second laws. So, it cannot stand for the outright ban in general. The theorem does make allowances for a difference between the macromotion of parts in thermodynamic equilibrium (otherwise, it is not a theorem), but the natural next step - to the idea of vortex energy form critical for stable macromotion states in equilibrium - involves freedom from entropy argument and was not made then a days.

The questions of this sort arise first of all in connection of stability of matter, its element based on Gibbsian thermodynamics for Coulomb systems. By the rigorous theory, see [16,17], and mean-field theories going back to Debye, the screening of long-range Coulomb potential $1/r$ between moving charges of opposite sign at large distances r in matter makes the potential short-ranged, so the free energy per unit volume is bound below and tends to a finite limit as the system volume increases. Our point here is that the sufficient conditions of such equilibrium states should include the stability with respect to the factor of vortex energy, especially as the very screening arises due to the diffusion and relaxation of gradient of charge-particle density under Coulomb field perturbations. The stability criterion (13) then transits into that where f comprises both reversible and irreversible drift forces, which is accessible for measurements.

The vortex form of energy has a direct bearing also on phenomena related to boundaries and interfaces. The equilibrium thermodynamics of particle systems confined or self-confined in a finite volume abstracts away of surface effects, and it may not realize because of vortex energy. It fits into this group our example of Brownian particle and many systems with surfaces, interfaces, dislocations, domain walls. It may concern, e.g., superconducting topological insulators. Recall also the instability of electron fluid suggested by Vlasov [10] by analogy with the physics of capillary waves going back to Stokes and Rayleigh [18] - the attraction of surfaces particles to the bulk of fluid gives a negative contribution to the potential energy of ripple wave motion on the surface of fluid, so such states can evolve into a steady ripple that transports mass and charges. Our point here - there is no other way for the phenomenon to exist as robust in equilibrium but to imply stabilization due to stored vortex energy.

9. General questions of vortex energy physics

The energy principles of interacting systems set forth represent a consistent causality approach to the conservation of energy that departs from the conventional energy concept. Both energy concepts, conventional and set forth, rest on the ability of systems to produce work, but conventional proceeds from the notion of work determined by the function of system states. The energy measure then implies the ideal entrainment, hence, corresponds to the systems behaviors within the framework of boundary value problem imposing the conditions of ideal. Unlikely, we proceed from the notion of work measurable by the evolution of distribution function of system states according to the Cauchy problem of kinetics governing the evolution. The departure is thus from the physics of basically predetermined world to that of real, diverse world where nothing happens by itself but depends on circumstances.

The difference is like transition from the world of integers to that of reals and deeper, being on a functional level. Within the framework of the law of energy conservation given by the function of system states, the states in equilibrium are isolated, determined on gratings, for the transitions between each pair of states are determined by balance of reversible drift forces and a separate balance of irreversible forces of drift and diffusion. Meanwhile, the separation of balances should not be postulated, follows from nowhere and does not cover all effect of irreversible forcing, and it generally matters no less to provide stability. The system's states are then not isolated, have open vicinities. So, it is important for the energy as measure of forcing able to produce work to include the forces of whole drift and diffusion.

A self-sustained action of irreversible forcing, with diffusion or not, is behind this unconventional energy measure we came to and called integral vortex or just vortex. It is for the first time that the energy measure incorporates the irreversible forcing. Its effect, as evident from previous sections, can be crucial in clearing the hurdles of potential barriers in autonomic conditions, so the stable states of macromotion can take place. Just as important from a general physics standpoint, the conventional and vortex energies are complementary forms comprising the total energy measure in equilibrium.

Thereat, we proceed from physics as science perceiving all phenomena exclusively through the notion of energy and work on the basis of cause-effect relations. The notion of entropy, as shown, adds no physics to the energy duality in point and has no relation to the vortex energy form. The conventional form of energy is behind the states of rest and emerges as a low-dimensional limit in the parameter space of vortex form generating the states of macromotion. In all, it is all about stability in small and finite with regard to the vortex forcing as the very issues of equilibrium states and inseparable balance are resolved through its principles and criteria we formulated above in terms of kinetics.

The vortex energy of systems is obviously ubiquitous as inherent in the phenomena of material world of stable macromotion states. This complementary energy being essentially integral and of vortex nature characterizes behaviors that do not follow the principles of equilibrium statistical mechanics and the first and second laws of thermodynamics. So the existence domain of matter stability can as extend as shrink compared with the predictions of theory of energy as a function of system states. This provides also a wider insight into Brownian motion as its unidirectionality becomes allowable. Besides Maxwell's, a unidirectional demon may fit for equilibrium.

10. Extension to relativistic and continuous systems

Just as the approach based on energy function concepts extends to incorporate general relativity and also systems of infinite degree of freedom, so the approach based complementary energies does. To conform the energy function concept to the relativity conditions, one starts off with an action integral

$$\int L(x, \dot{x}) dt \tag{23}$$

with a function $L = L(x, \dot{x})$ being the Lagrangian of the coordinates and velocities of the system, and requires this action integral to be motion invariant. Passing from Lagrangian to Hamiltonian involves then singling out one particular observer and making the formalism refer to the time t for this observer. By analogy, our analysis set forth can be viewed so in the limit of ideal entrainment, while beyond may include retarded terms - for $\hat{v}$ modeled suitably. The principle of least action $\delta(\int L dt) = 0$ yields the Lagrangian equations $\dot{p}_i = \partial L / \partial x_i$ with the momentum defined by

$$p_i = \frac{\partial L}{\partial \dot{x}_i} \tag{24}$$

and $p = \{p_i\}$ assumed usually independent functions of $\dot{x}$, but imposing relativistic constraints makes these momenta not independent functions of the velocities. The Hamiltonian defined as $H = p_i \dot{x}_i - L$ then can still be made (being not uniquely determined) independent of the velocities, which modifies the Hamiltonian equations of motion but can be written concisely in the Poisson bracket formalism with H called the total Hamiltonian, see Dirac [19]; in [9] one finds also its extension from the case of a finite number of degrees of freedom $i = 1, \ldots, n$ to the case of their continually infinite number. The extension is by taking n infinite, with all values of i in a continuous range. For the equation generalizing (24) to define the momenta, it is to be treated as a process of partial functional differentiation, which is to vary the velocities by $\delta \dot{x}_i$ in the Lagrangian and then put $\delta L = \int p_i \delta \dot{x}_i$ as defining p_i's.

By analogy with this pattern, we come to desired extensions proceeding with the continuity equations (4), (5) and others of previous sections but treating there the partial derivatives of density distributions in z as partial functional derivatives. This leads to evident extension of the theorems and other conclusions formulated above regarding the integral vortex energy. At that, while the conventional theory of relativity is bound to the order of things given by Lagrangian dynamics, the physics behind the complementary vortex energy, being not bound so, may not comply to that theory in various aspects, e.g., Lorentz symmetry.

11. The vortex nature of quantum physics

The concept of vortex energy we established and clarified above within the framework of classical physics description does not rely on any postulates of quantum physics, its particle-wave notion, quantization, energy transfer by quanta. However, the two physics are not complementary but competing. Whereas in outer stationary conditions the quantum concept admits super currents in and of itself, from the standpoint of our complementary energies all kinds of stable macromotion states then emerge due to the irreversible kinetics. The same is true for all other non-classical features which we formulate as the following energy theorem or principle of the classical footing of quantum physics

The observable quantum phenomena are exclusively of vortex nature - pertain to the existence domain of vortex energy form.

Indeed, quantum theory implies existing an ideal where the evolution of system is described by a wave function $\psi(z,t)$ governed by a quantum Hamiltonian $\hat{H}$, an Hermitian operator having terms of non-commutativity bound to Planck's constant. With the observable values of $\hat{H}$ defined in this quantum ideal as the averages

$$\langle \hat{H} \rangle = \left\langle \psi \left| \hat{H}(\hat{z},t) \right| \psi \right\rangle \tag{25}$$

and the observable system's properties defined via ψ by the rule (25) where $\hat{H}$ is replaced by Hermitian operators $\hat{A}$ associated with observables, the eigen spectrum of $\hat{H}$ is assigned the observable energy measure. But the non-commutativity terms make this energy measure different from that of given by a classical Hamiltonian. Accordingly, the behaviors governed so acquire features unusual from that classical perspective. Thereby, in conditions of energy conservation they fall into nothing else but the realm given by the integral vortex energy measure.

The quantum ideal in point fits the observations perturbing the system in a way of transitions between its pure states. Beyond this ideal, the quantum phenomena must also fall into the vortex-energy category, for the states of quantum system are then assumed to be a mixture of pure states each given a statistical weight in the sense used in the classical physics. The proof is immediate while reasoning in terms of density matrix as well as the Feynman's path integral approach.

So, all phenomena attributed to quantum physics represent classical irreversible phenomena. It is not just one more interpretation, but basic - if to proceed from the fully consistent theory of energy. To attribute the quantum phenomena to an uninterpretable sort of reversible processes, constrained in the sense of Eq. (2), then turns out to be inadequate. This our conclusion is in marked contrast with the conventional wisdom. In-depth quantum theories proceeding from research via Koopman-von Neumann approach [20,21], path integral [22], and other methods are presently in intensive works of many researchers, e.g. [23-26], but to find real, on the basis of energy measure for physical systems, classical routes of quantum phenomena, one then needed to come up to, or rely on the general idea of complementary energy measures substantiated in the present work.

The principle of the classical footing of quantum physics we claim is not obligatory an equal footing, for the existence domain of the concept called quantum is unknown - a fundamental problem of quantum mechanics is how a quantum state is protected against the state collapse from a measuring apparatus. Stabilization of states is required, and we see no other way based on the notion of energy to that but to identify it with the integral vortex energy. In fact, it is on this energy basis the very existence of quantum physics becomes established rigorously, while its previous support was by the rule of thumb. The Einstein-Podolsky-Rosen paradox and the quantum entanglement and quantum nonlocality as measured by Bell test experiments are then appear resolved, but with the clue in point. A novel insight and possibly paths of research open up in quantum developments of thermodynamics, electrodynamics, gravity etc so far as they are based on quantum mechanics.

Unlike the conventional approach, we do not augment validity to the quantum concept by resorting to the concept of entropy and a semi-classical approach to the irreversible kinetics, but acquire it exclusively due to this kinetics. The principle of complementary energies with its vortex energy covers all aspects of that in a self-sustained way in terms of measurable kinetics adequate to the reality of inseparable balance between the reversible and irreversible forcing. In this light, the established principles of integral vortex energy inherent in stable systems unravel the inventions of quantum mechanics and place them on a tangible ground of the inseparable balance to test and unveil their potential for actual use.

12. Conclusions

It has been shown in this work that the total measure of energy comprises of two principally dierent forms one of which presents the traditional standard - the energy of interacting systems given by a function of system states. The other form has an integral vortex nature related to relaxation and diusion. It is critical to the stability of matter, and does not conform to the equilibrium thermodynamics and entropy laws and the traditional theory of Brownian motion and phase transitions. The idea of two energy forms was introduced by the author and has been now substantiated and given its key features.

It is essential that the two forms of energy, standard and revealed, are complementary, comprise the whole energy of interacting systems, and that the established principles of two-form energy admit direct generalizations and extensions to the caseof relativistic and continuous systems. Just as important practically, the traditional concept of energy is incomplete, its validity is limited by the ideal entrainment outlined in the work. The conventional wisdom based on the traditional concept appears detrimental to search for new states of stable matter and energy.

The more reason for general and applied research to rethink of faith in the conventional energy concept, for all quantum phenomena appear, as shown, bound to the vortex energy. Not only it refutes the beliefs banning classical routes to quantum physics. Vice a versa, now we have got quantum physics on fully consistent basis of two-form energy theory. Merging of reversible and irreversible kinetics via the vortex energy is its gist. It widens perspectives, hence, may materialize into new directions, from physics of supercurrents to quantum computers up to puzzles of blackholes and states of dark matter and energy.

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