International Journal of Pure and Applied Physics
ISSN 0973-1776 Volume 4 Number 1 (2008) pp. 53–63

http://www.ripublication.com/ijpap.htm

New Approaches to Equilibrium Thermodynamics

Fathollah Ommi[1] and Koros Nekofar[2]

[1]Faculty of Engineering, Department of Mechanic
Tarbiat Modares University, Tehran, Iran
[2]Iranian Space Agency, Tehran, Iran
**Corresponding author: fommi@modares.ac.ir*

Abstract

The problem of quantum gravitation is transferred in the field macro-quantum gravitation and there is resolved within the framework of the non-local version of classic thermodynamics. Last one makes provision for elimination the "model" traces of continuous medium from thermodynamic phenomenology and transition to the discrete space- time metric. Such routine together with usage of physical initial principles is equivalent to macro - quantization of gravitational fields for classic, homogeneous and isotropic thermodynamically equilibrium material medium. It is established that a state, which one the classic thermodynamics accepts for equilibrium. Actually is only very good approximation of description the spontaneous process of temperature fall and entropy. In a usual term it is the strongly braked process, so the realization of "perpetuum mobile" on this basis is possible only in space - time scale of Universe. The opening opportunities of a new methodological fundamental are illustrated on the examples from a cosmology. (The nature of Big Bang, the arrow of time, black holes, etc.) The data of experiments and observations for the benefit of the viewed version are presented.

Keyword: Thermodynamic, Quantum, Physics

Introduction

Last years in the field of applied macroscopic physics it was detected a physical niche free from investigations. Nobody posed before himself the purpose - to improve classic equilibrium thermodynamics, by liberating it from model elements, bound with acceptance of the concept of a continuous medium. Eventually the speech was about a problem non-locality, in which one the correctness of usage differentially of small in "conversation with the Nature" was posed under doubt.

The problem of non-locality has arisen in physics together with the birth of quantum mechanics. Apparently first who converted on it a close attention was " Henry Poincare", who wrote by the beginning of century: "It is well known, to what hypothesis the Planck has come, investigating the laws of radiation. Hardly is it necessary to underline how much these ideas differ from the conventional concepts: the physical appearances, apparently, cease to obey to the laws, which can be expressed with the help of the differential equations, and it is probably, most major and most deep shock in philosophy of natural sciences from time of Newton." [1]

It is known also that A. Einstein guessed transition to the non-local concept in the scientific program. In the letter to "Наше Musam" (1944) he so set up a common intention of the uniform theory: "The purpose is served by relativistic performance of physical space, but without the differential equations. Last does not give in reasonable comprehension of quantum and matter. Basically it is possible without usage of a statistical method, which I always considered as a rotten exit." [2] If it takes into account, that the creator the theory of relativity sceptically fell to potentials of a quantum mechanics, and, on the first view, hi scientific program looked paradoxical: quantum gravitation: but without a quantum mechanics, without the differential equations and without statistical method. Running forward, it is necessary to tell that the problem of non-locality in quantum gravitation really appears decisive.

Let's present almost popular statement of physical substance for a problem of non-locality, by making use one of the recent reviews of the Russian journal "Successes of physical sciences": [3] "The principle of localization used at build-up, both classic thermodynamics of irreversible processes, and many other thermodynamic theories, guesses, that the fundamental laws of a mechanics are valid not only for system as a whole, but also for each of its parts, as what small it was.

From here follows, that in integrated conservation laws for such systems it is possible to commit a passage to the limit at rushing volume of an integration to zero point and to gain the equivalent laws of saving in the shape of differential partial equations. From the physical point of view such procedure is improper, as medium consists of microscopic objects (atoms, molecules, clusters, etc) which one has qualitatively new properties incompatible to classic introducing of continuum mechanics". And further: "Recently, the author writes, the concern to models of a discrete type increases, which as against of the classic continuum approaches, guess, that space and time are not continuous, but discrete variables. Differently, it is considered, that the system consists of interacting discrete plants, which state is changing through the final time intervals".

To say it is necessary to add, that at the continuum approach from exposition the properties of a physical vacuum as structural component any material medium fall out. If in the separate physical theories these properties manage to be entered by padding model reasons in the deductive theory, which the thermodynamics is, such system of initial principles is indispensable, which initially enveloped a problem in. On the language of physics, it means the necessity of potential insertion of macro-quantum field theory at the initial axiomatic of thermodynamics. Such principles were retrieved in the extended (no local) version of classic thermodynamics [4-9].

The non-local thermodynamics, being deductive, is built on the assertion, that by

analogy with discrete energy of mechanical genesis $\hbar\omega$ ($\hbar$ - quantum of action, Planck constant; ω - the circular frequency) exists macroscopic discrete energy of the thermodynamic nature kT (k - (macro) quantum of entropy, Boltzmann's constant; T-thermodynamic temperature).

The non-local thermodynamics considerably differs from the present thermodynamics, and even it is more than the quantum mechanics differs from the classic analogue, as the extended version of thermodynamics is not only quantum, but also relativistic.

It is interesting to note, that in last investigations the western cosmologists also come to the conclusion about existence of discretization not dependent from a quantum mechanics. So, the cycle of lectures recently was published, which has preceded controversies between known physicists "S. Hawking" and "R. Penrose". The status of this controversy was introduced as a prolongation of a historical controversy between "Bore" and "Einstein". In the lecture of "S. Hawking" the speech was about applying some positions of thermodynamics to comprehension of black holes and singularities features. "S. Hawking" starts one of his lectures so: "In the second lecture I want to talk about a quantum theory of black holes. It seems that it carries on to a new level of unpredictability in physics over customary uncertainty, bound with a quantum mechanics". [10] "R. Penrose" yields with the opponent, terming new quantum uncertainty "padding". In the non-local version of thermodynamics [4] this uncertainty is named macro-quantum.

The procedure of macro-quanting together with usage of physical initial principles, including relativistic character, is equivalent to quantization of a gravitational field for classic, homogeneous and isotropic thermodynamically equilibrium material medium. The discrete space - time metric is considered. It is important to mark, that thus the theory not only saves, but also boosts initial thermodynamically phenomenological style of statement

The non-local approach, explicated in the report, being phenomenological (in thermodynamic sense) naturally, can not claim for description of those or diverse mechanisms, as it is accepted in customary model (numerological) theories. The obtained results can put in correspondence a series of "explanatory" mechanisms. It is important, that the results thus do not vary. The author did not consider for himself possible sequentially to realize such "explanatory" link between macro and micro descriptions, behind elimination, perhaps, cases, when this link is rather transparent. Here it is necessary to mean, that the conceptual mechanism of any theoretical concept only approximately can be translated to the language of diverse approach. Physics, working in the field of gravitation, without effort can make out in thermodynamic results the present model introducing with establishment of "domain walls", "the fifth measuring", "multivariate spaces", "plankeons", etc.

The solution of (macro) quantum gravitation problem away from the basic direction of physics hampers its estimation and prompt advancement of the basic results in the field "of normal science". The greedy phenomenological style of thermodynamics is generally alien to physicists, attempting by all means to open " mechanism" of phenomenon. Nevertheless, as it will be visible from the report, the thermodynamics changes the status and essentially dress as the scientific

methodology. From here the purpose of the report to attract attention of the specialists to the non-local version of thermodynamics as to the not mastered physical niche of macroscopic physics with major potentials on methodological resorts and on subjects of investigation.

For the best comprehension the features of work it is necessary from the very beginning to understand its place in modern partitions of physics. Thus it is useful to pay attention also to partitions, which one in the theory will not be utilized.

The viewed approach accepts equilibrium thermodynamics as the launching theory with its concepts of temperature and entropy. The work is not rest on a Hamilton mechanics. In it the problem of transition from a mechanics to thermodynamics is not considered.

The used procedure of macro-quantisation does not require applying the mechanism of quantum mechanics. However from the last one, two uncertainty principle will be borrowed as phenomenological initial principles for introduction of uncertainty.

Uncertainty is considered as an illegibility of a common type (not necessarily statistical). Therefore the mechanism of statistical physics doesn't utilize. In the work affirms the determinative style, though in extreme small slice of times the absence of causal links is enabled.

By virtue of the non-local concept, in theoretical outputs practically will not be utilized the mechanism of infinitesimal.

The report explicates and partly improves original positions of non-local thermodynamics explained in the monograph [4]. The opportunities of new methodological fundamentals are demonstrated in the report on problems of a modern cosmology. If to lower some details, in the report the speech, in basic, goes about thermodynamic exposition of cosmological expansion process of a physical vacuum and its interaction with a material medium, being in relative rest. The examples of experimental affirming the new approach in the field of fundamental physics are contained in [4], in the field of application problems see [7- 8].

Allowing that the classic thermodynamics as a matter of fact is a thermostatic, further for brevity under the term the thermodynamics frequently will be implicated its extended version. With the same purpose it is meant their macro quantum analogue under quantum effects.

First law of thermodynamics as a dynamic state

Let's esteem how it is possible to enter into thermodynamics already evocative " padding" uncertainty of macroscopic character not disturbing, but reinforced the phenomenological style of the thermodynamic theory.

Initial positions

It is known, that the classic theories lie in a basis practically of all non-classical approaches. Sometimes such reception terms as inoculation classic model. In non-local thermodynamics similar "seeding agent" serves physical initial purpose, formulated differentially.

Essence of a used method – transition from classic differentially small to physical extreme to small on the basis of initial parameters obtained from uncertainty relations of a quantum mechanics.

Let's note whit reference to dynamically equilibrium system, the quantum - mechanical uncertainty relations in the shape adequate to a sign of equality:

$$\Delta\varepsilon\Delta t=\hbar/2 \qquad (1.1)$$

$$\Delta x\Delta p=\hbar/2 \qquad (1.2)$$

The record of uncertainty relations in the minimum shape treats, as is known, to coherent state, the initial formalism of which one was included still by "Schroedinger" . The coherence is representative macroscopic property, therefore relations (1) and (2) can be referred to micro systems. Further will be demonstrated, that in a divided into parts thus elementary macro systems should be proper both, classic, and quantum properties.

If the system is in equilibrium state, the allocation of probabilities for dynamic variable does not depend on time. From this apparent position "L. Mandelchtam" and "I. Tamm" have made a conclusion concerning existence of a common relation between uncertainty of energy and variations in time of coordinates, impulses etc. In their treatment in the ratio (1) Δt - "standard time" - least time, during which one a medial value anyone observed (for example coordinate) varies on magnitude of its uncertainty [11].

If the slice of time in the ratio uncertainty (1) is somewhat universal, similar property should have and magnitude $\Delta\varepsilon$, as uniquely defined at fixed Δt. It is known, that in physics the Boltzmann constant is considered as fundamental, first of all because it inlets reference thermodynamic energy $\Delta\varepsilon = kT$. This phenomenological introduced energy (outside of link with the molecular kinetic theory of a model genesis) was adopted as defining in the extended version of equilibrium thermodynamics. Then from the relation (1) the universal minimum macroscopic time scale is discovered:

$$\Delta t=\hbar/2\,kT \qquad (1.3)$$

For example, at T=300K, Δt = 1, 27.10 $^{-14}$c. As the results show, obtained in [4], the interval of time Δt inlets a phenomenon of a time discretization and erects the boundary of classic causal links existence. It is important to note, that as against known attempts of introduction the discrete space-time metric, the interval Δt initially is not bound to one fundamental gauge. It is more then, further will be demonstrated, that most frequently Planck scale, used in such attempts, is only special case of the interval Δt.

Macro cell

The energy $\Delta\varepsilon= kT$ can be put in correspondence to an equivalent mass $\Delta m = kT/ c^2$ with adequate to some pseudo-particle. The uncertainty of coordinate and impulse for such particle will be:

$$\Delta x = c'\Delta t = c'\hbar/2\,kT ,$$

$$\Delta p = c'\Delta m= c'kTl\,c^2$$

From (2) we shall be convinced that this particle, naturally, should have fundamental velocity with $c' = c_S$

The introduced pseudo-particle should be refereed to a virtual photon, i.e. such particle, for which one is not executed customary (for free particles) link between energy, impulse and mass $\varepsilon^2 \neq p^2c^2+m^2c^3$.

Utilizing obtained before expressions, really is discovered, that:

$(kT)^2 \neq (kT)^2 + (kT)^2$

As $\Delta\varepsilon = kT = \hbar\omega$, where ω -some average circular frequency then:

$\omega = kT/\hbar = (2\Delta t)^{-1}$

Similarly to minimum time scale there correspond the $\omega_c = \Delta t^{-1}$ frequency and wavelength: $\lambda = c/\omega_c$

Let's input the reference radius r and volume V, adequate to time scales Δt and energy $\Delta\varepsilon = kT$:

$$r = c\Delta t = \frac{c\hbar}{2kT} \tag{1.4}$$

$$V = (4/3)\pi r^3 = (\pi/6)(c\hbar/kT)^3 \tag{1.5}$$

It is easy to note, that reference radius $r = \lambda = c/\omega_c$ depends only on temperature. For example, at T=30OK, r=3, $9*10^{-6}$ м.

Volume V, which one we shall term as *macro cell*, in standard conditions envelopes rather major number of particles, i.e. is representative macroscopic plant. But also in case of small number of particles isolated cell remains macroscopic, but thus the value of temperature, as thermal characteristics as will be demonstrated below, becomes more and more diffusion, uncertain.

It is possible to consider a macro cell as a short-lived (flickering) physical cluster - peculiar, in usual terms, under molecular level in the hierarchy of macroscopic system. The uniqueness of macro cell as a physical plant is, that on the one side, it is *maximal microscopically volume* and can be used positions of a quantum mechanics, on the other side, at the same time it is *minimum macroscopic volume* and, therefore some classic concepts basically usable can be used for it. This dual character of macro cell also explains occurrence of a Plank constant in a macroscopic exposition, and consequent compatibility of a macro quantisation procedure with the common theory of relativity. Apparently also, that the times $<\Delta t$ can fall into microscopical for requirement data and to belong to only structural units inside macro cell.

Macro-quantum fluctuations

The transition from differential small to physical extreme smells is carried out on the basis of "inoculation" classic initial principles using the gated primary macroscopic parameters: kT, Δt, V, on first steps.

For example, for anyone classic homogeneous isotropic material medium in adiabatic isolation (S = counts) the following thermodynamic relations are valid:

$V(\partial P/\partial V)_s = -K_s$;

$(\partial J/\partial P)_s = V$

where J, P, K_S - enthalpy, pressure and adiabatic compression modulus accordingly. Utilizing as reference volume of macro cell and by exchanging differential

increments final:

$(\partial J)_S \rightarrow (\Delta J)_S = \pm kT;$

$(\partial V)_S \rightarrow (\Delta V)_S;$

$(\partial P)_S \rightarrow (\Delta P)_S$

From the previous expressions is discovered minimally possible increments of pressure and volume of macro cell:

$(\Delta P)_S = \pm kT/V;$

$(\Delta V)_S = \pm kT/K_S$

From other thermodynamic relations:

$V(\partial P/\partial V)_T = -K_T;$

$(\partial G/\partial P)_T = V$

Similarly we obtain:

$(\Delta V)_T = \pm kT/K_T;$

$(\Delta P)_T = \pm kT/V$

here G - free enthalpy, K_T - isothermal compression modulus.

The found minimum possible increments of macro cell parameters, as against known finite-difference magnitudes, are limiting - difference and its appearing by elementary functions only of fundamental constants and classic thermodynamic parameters so can be always scaled.

Thus input a physically extreme small executes the role of macro quantum virtual fluctuations or effects of a surrounding on macro cell, describing dynamically equilibrium material medium. The performances of quantum-thermodynamic fluctuations can be treated as parameters of the relevant pseudo-particles. So, the quantum scatter of a macro cell mass at the expense of a fluctuation of macro cell volume ($\rho, S = const$) will be:

$\Delta m_p = \rho \Delta V = kTpIK_s$

The value Δm_p is necessary to consider only as an effective mass appurtenant to the relevant *pseudo-particle.* To define the nature of a pseudo-particle, we shall discover its velocity, which one we shall designate as c_s. For this purpose use again an uncertainty relation - impulse - coordinate (2). Substituting $\Delta p = c_s \Delta m_p$, $\Delta x = c_s \Delta t$ we discover:

$$c_s = (K_S/\rho)^{1/2} \qquad (1.6)$$

This dependence is known in a mechanics as a Laplacian speed of sound in a homogeneous isotropic medium and, therefore, the particle with an effective mass Δm_p is an acoustics phonon. In equilibrium state it has hypersonic virtual character, i.e. the customary link of particle kinetic energy with its impulse (non-relativistic case) $\varepsilon = p^2/2m$ is not executed for it. Substituting here retrieved values of an effective mass and impulse, we are convinced: $kT \neq kT/2$.

From this example it is visible, how virtual parameters are arisen there in the non-local thermodynamics. *In the classic theory the virtually is, as though latent behind the infinitely small amount of something.* One of the differences of macro quantum fluctuations from classic is that the number of particles in them can not accept involvement, superior number of particles in macro cell.

The parameters of macro cell (temperature, pressure, etc.) at a dynamic equilibrium

for reference time Δt differ from the parameters of its surrounding, and in this sense, any material medium is *thermodynamically non-uniform.* Such dissimilarity gives in occurrence of fluctuating efforts on the macro cell boundary with a surrounding, similar to the nature of surface phenomena. The engaging in a role of "seeding agent" classic thermodynamics of strains displays, that by virtue of spatial and time intervals discretization the volume of macro cell are proper both volumetric and shift strain, disjointed in space and time to macro cell scale . In turn volume strain of medium calls an electric polarization, and shear - magnetic. The polarization gives in occurrence of connected charges both quadruples of an electrical and magnetic type. Last ones call natural macroscopic electrical and magnetic field etc. Thus the thermodynamic viewing is tracked by usage only of relations concerning to the first principles of physics [4].

Here it is necessary to underscore, that the principles of non-local thermodynamics allow computing values of electrical and magnetic fields parameters not resorting to exterior or microscopically fields of material medium. Features of usage the Maxwell equations for this purpose see in [4].

Cycle of a macro cell

The sequent coordination the relations of uncertainty of a quantum mechanics, the initial principles of thermodynamics, classic mechanics and electrodynamics displays, that dynamically equilibrium isotropic classic homogeneous material medium should be considered as plurality of interacting short-lived physical cluster formations of matter and field of virtual character. In such topologically composite formation the elementary cycling process - thermodynamic cycle of macro cell with isotherms and isoentropy is implemented macroscopically, in which one the temperature differences and entropy execute the role of macro-quantum uncertainty. At an isotherm the macro cell exhibits the properties of bosons, and at an isoentropy - the property of famines. These properties are generated by features of macro cell with macro-quantum character, where there isn't a concept of simultaneity. The interaction of material medium (fermion phase of macrocell) with a physical vacuum (boson phase) happens to retardation in space and time. The majority of parameters of a cycle has virtual character and treats to performances of near-surface volume of macrocell [4].

In the book [4] n- and p- conduction currents, displacement magnetizations and currents, proper in near-surface volume of macrocell, are surveyed in detail. Is shown, that the product qv executes a role of quasi-free magnetic charges, and the charge magnetic dipole is similar to current one.

The link between velocity of a hyper sound and surface pull was established, engaging Gelmholtz "electrical pressure" and equation of Laplas [4, p.43]

$$c_s = (\sigma_0 / \rho \Delta t)^{1/3} \qquad (1.7)$$

Is shown, that it is possible to consider a macro cell as a cavity resonator with a capacitance $C=q/Ev\ \Delta t=q^2/kT$. [4, p.42]

And inductance $L = \Phi / J_0 = \pi^2 \hbar^2 / q^2 kT$ [4, p.57], where q - the charge invariant, see is below.

Charge invariant

The macro cell, as the boundary device between micro- and macro-level, has electric charge of a polarization genesis. With the complete right it is possible to consider it as *a fundamental charge invariant.* Such invariant institutes the electric charge of macro cell q of any material medium from a condensed state up to a state of physical singularity [4], $q = \sqrt{\pi\varepsilon_0 c\hbar} = 5.856e_0$.

where e_0 - magnitude of elementary charge; ε_0 - electric constant.

Usage of a charge invariant instead of elementary charge in a fine structure constant a, with reference to a macro cell of any thermodynamic state of a material medium gives one more invariant $q^2 / \pi\varepsilon_0 c\hbar = 1$.

Besides it is possible to show, that the charge q, descent in e of time (q/e), where e - natural logarithm base, responds to a constant of weak coupling $g = e_0 / \sin\theta_w$, where θ_w - experimentally defined magnitude (Weinberg angle). Really, equating $q/e = e_0 / \sin\theta_w$ it is possible to compute a value of Weinberg angle, $\sin^2\theta_w = e_0^2 / g^2 = e^2 e_0^2 / \pi\varepsilon_0 c\hbar = 0.21568$ and to compare with the experimental value $\sin^2\theta_w = 0.215$ [12]. This result follow-up points the fundamentally of invariant q and validity $g = q/e = 2.154e_0$

Temperature and entropy

In non-local thermodynamics the concepts of temperature and entropy take the special place. Temperature apart from the classic function executes here the role of a parameter uniquely assigning the space - time metric of macro cell (see expressions 3-5). As shown in the work the entropy of macro cell is proportional to ratio of thermal phonons energy to mechanical (ordered) energy of collective motion of macro cell particles [4, p.26]

$$S_m = k\frac{T}{(\Delta T)_s} = k\frac{mc_h^2}{mv^2}$$

here $v = (kT/m)^{1/2}$ - velocity of translation (collective velocity of macro cell particles); c_h - velocity of thermal phonons; m - mass of macro cell.

The velocity of translation v is bound to ordered migration of macro cell particles. The expression (9) can be interpreted differently if accounting, that $(\Delta T)_S$ characterizes a discretization of the metric. Then reduced entropy of macro cell S_m/k to number of energy levels in macro cell or number of disrupters of the space-time metric in it. *Thus, the entropy characterizes structural dissimilarity of the metric.*

Conclusion

The waiving of the concept of continuousness and the introduction of macroscopic quantization of physical parameters, as we see, allows featuring the composite hierarchy of material medium states on a uniform methodological basis: from *a pre-*

basis of substances - physical singularity, up to a customary condensed state. Already at a level of available results it is possible to make the conclusion, that with the introduction *of macro-quantization* the physics gains the powerful conceptual apparatus with new opportunities, as on methodological resorts, as on objects of examination.

The development of a thermodynamic method up to self-maintained dilated version of equilibrium thermodynamics, accounting *macro-quantum* and common *relativistic* effects gives rise to the theory of *paradigm* character, demonstrating an opportunity of system generalizing of such fundamental unit of physics as thermodynamics and, as a matter of fact, recognizing a problem of spillover the thermodynamics through the mechanic apparatus as aberrantly delivered. [13]

The thermodynamics becomes not only phenomenological science, circumscribing phenomenon, but also acquires the status of the explanatory theory. Even, if to take into consideration, that the modern physics for a long time "is pregnant" by the ideas of a discretization and non-locality, and in this case, it is necessary to pay attention that the explained approach detects in present partitions of physics almost empty niche, within the framework of which all these ideas are easily drawn up in 'a new *integrated pattern of a world on the basis of non-local thermodynamics*.

Symbols

$\hbar$ - quantum of action
ω - the circular frequency
k - (macro) quantum of entropy, Boltzmann's constant
T- thermodynamic temperature
J, P, K_S - enthalpy, pressure and adiabatic compression modulus accordingly
G - free enthalpy
K_T - isothermal compression modulus
e_0 - magnitude of elementary charge
ε_0 - electric constant
θ_w - experimentally defined magnitude (Weinberg angle)
v - velocity of translation (collective velocity of macro cell particles)
c_h - velocity of thermal phonons
m - mass of macro cell

References

[1] Джеммер М. *Эволюция понятий квантовой механики*.- М: Наука,1985.- С. 171.
[2] Кузнецов Б.Г. *Эйнштейн*.- М.: АН СССР, 1963- С.339.
[3] Соболев С.Л.//*УФН*. 1997.Т.167. №10. - С.1095.
[4] Майков В.П. *Расширенная версия классической термодинамики - физика дискретного пространства-времени*. - М.; МГУИЭ,1997- 160 с.

[5] Майков В.П. *Физика дискретного пространства-времени в расширенной версии классической Владимир*. Тезисы докладов. М.: 1999-С.120.

[6] Майков В.П. *Квантовая макрофизика - альтернатива классической механике сплошной среды*// Вестник РАН 1996. Т.66. №6.-С.566-567.

[7] Майков В.П. *О расширенной версии классической термодинамики* //Теплоэнергетика, 1998. № 9. С.14-19. (Maikov V.P. An Expanded Version of Classical Thermodynamics // Thermal Engineering 1998.Vol. 45, -p. 723-728).

[8] Куликова. Т.А., Майков В.П. Термодинамические минимальные оценки теплопроводности чистых жидкостях// Теор. основы химич. технол.1998. №6.- С. 592-596. (Kulikova T.A., Maikov V.P. *Conservative Thermodynamic Estimates for the Thermal Conductivity of pure Liquids*// Theoretical Foundation of Chemical Engineering. 1998. Vol.32. No.6.pp.537-541)

[9] Майков В.П. *Нелокальная термодинамика газовой равновесной плазмы*. В кн. Тезисы докладов. XXVII Звенигородской конференции по физике плазмы. Звенигород. 2000-С.207.

[10] Хокинг С., Пенроуз Р. Природа пространства-времени.- Ижевск: НИЦ "Регулярная и хаотическая динамика", 2000.- С.48. (Stephen Hawking and Roger Penrose. *The Nature of Space and Time*. Princeton university press, Princeton, New Jersey)

[11] Мандельштам Л.И., Тамм И.Е.// изв. АН СССР. Сер. физич., 1945.Т.9.С.122-128.

[12] Биленький С.М. *Вайнберга угол*. в кн. Физическая энциклопедия. М.: Сов. Энц.,1988.Т.1.С.234.

[13] Некофар К.Х., Майков В.П. Температурное разделение газа как макроквантовый эффект. Журнал “*Техника и технология*”.2005г,№3 (9). Стр. 67-70.

[14] Nekofar K., Maikov V.P. Research of the thermodynamic description of temperature division of gas, with use of discrete parameters. Book of abstracts "Russian International Conference on Chemical Thermodynamics". MSU. Moscow 2005, Volume 1.p.85.

[15] Эйнштейн А. *Собрание научных трудов*. – М.: Наука, 1967.Т.4.- С.286.

[16] Пригожин И. *Конец определенности. Время, хаос и новые законы природы*.- Ижевск: НИЦ "Регулярная и хаотическая динамика". (Ilya Prigojin. *The End of Certainty. Time, Chaos and the New Laws of Nature*. The free press, New York, London, Toronto, Sidney, Singapore.1997)

[17] Новиков И.Д. Космологические модели. в кн. Физическая энциклопедия. М.: Сов. Энц.,1990.Т.2.-С.475.

[18] Надежин Д.К. Нейтронные звезды. в кн. Физическая энциклопедия.- М.:БРЭ,1992.Т.3.С.281.