THE DESCRIPTION OF SELF-OSCILLATION PROCESSES OF ENERGY TRANSFER-CONVERSION AS A LINEAR APPROXIMATION

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ABSTRACT

It is pointed out that the partial direct energy conversion transported by heat conduction in heavily non-equilibrium systems which are characterized by the unattainability of local thermodynamic equilibrium in them is possible. The methods of description of this complex process with the help of the bounds of the applicable law and the expediency of their combined use are emphasized. With heat conduction in non-equilibrium systems taken as an example, one can show the possibility of adequate substitution of the nonlinear heat transfer equation with a limited velocity for a linear differential equation of a higher order. This equation is based on a wider use of dynamic laws which gives the opportunity to describe the complex processes of energy transfer-conversion with the help of a simpler theory.

INTRODUCTION

Development of a new energy source, including those based on the cold nuclear fusion phenomenon, is closely connected with solution of the problem of energy transfer, in particular, by heat conduction, accompanied by energy dissipation. Apparently heat conduction processes are most logically investigated in the book [1] devoted to heat propagation with a finite rate. However, with highly intensive transfer processes in non-static systems in which local thermodynamic equilibrium becomes unfeasible [2], energy is transferred not only as heat but as some other forms, for example, as a mechanical displacement work or electric current. These transfer-conversion processes are typical of direct energy conversion into the work of random types. This conversion is possible, for example, with the help of thermionic converters [3,4]. In these cases modern energy transfer and conversion theories are based on the idea that statistical laws (SL), determining ambiguous causal relationships in structurally complex many-particle systems play the main role. As for dynamic laws (DL) which can, together with the given initial conditions, correctly predict all subsequent states of global non-equilibrium systems, they are given a secondary part.

Indeed, though DL are comparatively simple and easily understood to be physically interpreted, it is evident that to also interpret SL is impossible mainly because it is difficult to adequately take into account the fact that in open structurally complex systems there come into being qualitatively new states and the tendencies for their development. That is why when describing complex phenomena in macroscopic, multi-particle systems one can consider DL to be only approximate. On the other hand, the non-ambiguity of DL affirms their heuristic value. In connection with this, the methods of solving complex problems of energy transfer and conversion which are based on the use both of SL and DL prove to be most effective. Depending on the character and specific aims of the problems being solved, the boundaries between SL and DL can be markedly different.

PURPOSE

The purpose of this paper is to try to show the possibility of formulating linear differential equations for description of the self-oscillating process of energy transfer-conversion in heavily non-equilibrium systems of neutral and charged particles. The realization of such a possibility depends on the use mobility of the boundaries between SL and DL, at which nonlinear effects responsible for self-oscillations are taken into consideration by increasing the order of the differential equations. The best known example of the combined use of SL and DL is the method of solution of the Boltzmann integro-differential equation [5]

$$\frac{\partial f}{\partial \tau} = -\frac{\vec{p}}{m_0}\vec{\nabla}_r f - \vec{F}'^{*}\vec{\nabla}_p f + \left(\frac{\partial f}{\partial \tau}\right)_{col}, \tag{1}$$

by its linearization and presentation in the relation form

$$\frac{\partial f}{\partial \tau} = -\frac{\vec{p}}{m_0}\vec{\nabla}_r f - \vec{F}'^{*}\vec{\nabla}_p f + \left(\frac{f - f_0}{r}\right) \tag{2}$$

where f_0, f are equilibrium and non-equilibrium distribution functions; m_0, $\vec{p}$, $\vec{F}'^{*}$ are the unmovable [sic] particles mass, their momentum and external force respectively; $(\partial f/\partial \tau)_{col}$ is the collision integral non-linearly related to $f'f'_1$-ff_1, where f′, f'_1 are the distribution functions after mutual collision of the particles, τ_r is the relaxation time characterizing the velocity of the non-equilibrium system coming back into equilibrium state after the force $\vec{F}'^{*}$ stops acting on it.

In this case the substitution of non-linear equation (1) by model linearized equation (2) can be considered not only as one of the ways of the simplification of the problem at the cost of the loss of some important information contained in this equation, for example, the possibility of the description of non-elastic collision of particles. In reality the field of applications of [2] can be defined and substantially expanded, regardless of equation (1), if the distribution function f and especially the parameters are provided with new values, made suitable for the character of the phenomena studied and taking into account the practice of analyzing and solving equation (1). This approach to the solution of this equation is well known; however, the approach, used in [6], cannot be excluded. Its author considers the solution of Boltzmann's model equation in his statement and interpretation to be accurate.

When formulating Boltzmann's model equations, it is important to try to use DL as much as possible because they substantially expand the range of applicability of equations, based on CL, and simplify their physical interpretation. Therefore, it is not a coincidence that it is the law of energy degradation but not Boltzmann/s H-theorem that is widely used to explain an experimental fact. This fact, as a basic assumption acting as a dynamic principle, in the development of irreversible theories, in synergetics, and in a recent Prigogine's publication -- see monograph [7]. In any case there are no reasons to neglect the heuristic role of DL, when developing new theories for the description of complex phenomena even if one can successfully use the methods of statistic physics.

Unlike paper [6] in which Boltzmann's model equation is solved by Lorentz diffusion approximation [5], in which the parameter τ_r is taken as the mean time τ_L between the particles collision, $\tau_r \equiv \tau_L$. In [3,4] this parameter is defined with the help of DL and in a more complicated way depending on a concrete statement of the problem. This method makes it possible to obtain more precise results for a specific problem solution and make them more valuable from the information point of view. For example, the intensity and qualitative peculiarities of energy transfer processes during the period of time $\tau \gg \tau_L$ (which is much longer than the mean time of the particles path τ_L under conditions of stationary heat conductivity in non-static systems of neutral particles) depends not only on the kinetic energy exchange between the adjacent L-subsystems, measuring the mean-free-path length (L) of particles in the period of time $\tau_\epsilon > \tau_L$, but also on the dynamic exchange of particle momentum in the period of time $\tau_p < \tau_\epsilon$ and also on the diffusion exchange of the particles themselves in the period of time τ_L, where $\tau_L < \tau_p < \tau_\epsilon$.

The hierarchy of the periods of time, which is expressed by the latter inequality (which can be easily substantiated with the help of DL in the presence of interaction of neutral particles in the L-subsystems) is the cause of the self-oscillation in them during the period of time τ_{pr}. This period is equal in its value to the relaxation time τ_ϵ of the slowest process responsible for the temperature formation. However, it is due to the complex multichannel energy transfer process in L-subsystems occurring in the direction of temperature decrease and realizing not only in the form of the heat Q_L to the time τ_ϵ, and not only in the form of the heat Q_L to the time τ_ϵ, but also in the form A_L, for the time $\tau_A \to (\tau_A(\tau_L, \tau_p)$ approx. $< \tau_\epsilon)$ what in the L-subsystems self-oscillations arise and local thermodynamic equilibrium (LTE) in the non-static system is, in principle, unattainable. It follows from this that the energy transfer therein only as heat is impossible and one must consider there is a complex process of energy transfer-conversion, which can be only approximated by the equilibrium temperature T. The exact integral mean temperature at period $\tau_{pr} \sim \tau_\epsilon$ of non-static system is found in reactions of the form [3,4].

$$\frac{d\theta}{d\tau} = -\frac{t - T}{\tau_\epsilon}, \quad t = \int_{\tau}^{\tau + \tau_\epsilon} \theta(\tau)\, 0 \tag{3}$$

where $\theta(\tau)$ is the temperature depending on the time; $T = \theta_{(\tau_\epsilon \to 0,\ L \to 0)}$ is the equilibrium temperature, it is strongly dependent on the co-ordinates used (or not used).

The statement of unattainability of LTE in non-static systems, discussed above, was used in [3,4] for formulation and solution of the generalized equation of energy transfer-conversion

$$\frac{\partial t}{\partial \tau} + \tau_\epsilon \frac{\partial^2 t}{\partial \tau^2} = a\left(\frac{\partial^2 t}{\partial x^2} + L\frac{\partial^3 t}{\partial x^3}\right) \tag{4}$$

This equation describes the process approximately as completely as the non-linear heat conductivity equation in paper [8].

$$\frac{\partial T}{\partial \tau} \quad a \frac{\partial}{\partial x} T^n \frac{\partial T}{\partial x}, \quad n \lessgtr 1 \tag{5}$$

and has the advantage of linearity. This advantage was achieved at the cost of the order increase of the differential equation. This approach essentially keeps the information which can be obtained from a non-linear equation and allows one to solve such problems with the help of the well-developed methods of linear analysis.

The important element of the method based on the unattainability of LTE within the limits of equation (4) is the conclusion that the finite value of the relaxation time τ_ϵ, approximately equals the period of self-oscillation in L-subsystems. This coincides with one of the necessary conditions of the mixing formulated by N.S. Krylov [9]. It was done with the help of the analysis of probability processes when substantiating the logical bases of statistical physics. Moreover, the preliminary analysis proved the expediency of the additional study of feasibility of LTE, not only as a necessary, but also as a sufficient condition of the systems mixing according to N.S. Krylov.

Thus, the method taking into account both a statistical and dynamic conformity in L-subsystems of non-static system of charged particles, can be considered to be prospective. Such systems with the *a priori* assumed the inequality of the relaxation times $\tau_L \neq \tau_p \neq \tau_\epsilon$ in their L-subsystems can tend to self-oscillations which is a consequence of unattainability of LTE or local electrodynamic stability in them. Practical application of the results can be especially useful for mere logical solution of traditional problems of vacuum and semiconductors electronics, including the problem of thermoelectronic energy conversion. Apart from the above problems, we may mention the following:

1. The determination of the hierarchy of the relaxation time values τ_L, τ_p and τ_ϵ in non-static systems of charges particles;

2. The formulation of a set of linear differential equations for the description of a multichannel process of energy transfer-conversion in such systems;

3. The presentation of the process of energy transfer-conversion on non-static systems of neutral and charged particles as a simple model of a self-organization process of non-equilibrium systems.

FUTURE PLANS

In the future the proposed method is supposed to be applied to the solution of the problem of high temperature superconductivity and to try to substantiate the possibility or impossibility of the practical application of a cold nuclear fusion in energetics. It is supposed to use the method, proposed by de Broglie [10, 11] and developed by his followers - Bohm [10, 12], Vigier [10, 13], Lochak [14] and others. The essence of this method lies in the taking into account of complex natural phenomena on the sub-quantum level of matter. This, in turn, demands a more precise definition of modern ideas about the concept of a "particle" and a "field".

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