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A joint scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics of the USSR Academy of Sciences was held on February 24–25, 1982, at the P. N. Lebedev Physics Institute of the USSR Academy of Sciences. The following papers were presented:

February 24

1. *V. I. Talanov,* Stimulated diffusion and cooperative behavior of components in distributed kinetic systems.

2. *G. A. Smolenskii, E. I. Golovenchits, and V. A. Sanina,* Magnetic phase transition induced by high-power optical pumping.

3. *V. L. Gurevich,* Dielectric relaxation and the thermopolarization effect in crystals.

February 25

4. *I. M. Dremin,* Hadronic analogs of Cherenkov, transition, and bremsstrahlung radiation.

5. *L. A. Khalfin,* The instability of the proton and the nonexponential character of the decay law.

Brief summaries of these papers are given below.

V.I. Talanov. *Stimulated diffusion and cooperative behavior of components in distributed kinetic systems.* Certain further possibilities of the phenomenological description of cooperative effects in nonlinear distributed systems with diffusion are discussed.[1] The cooperative properties of such systems can be analyzed in terms of simple but sufficiently universal mathematical models. A clear idea of the principles underlying such models is provided by theoretical biology in the context of studies of the kinetics of physiochemical and sociobiological processes at different levels of life.[2-4]

The basic mathematical model of distributed kinetic systems is based on the parabolic-type evolutionary equations[2]:

$$\frac{\partial m_i}{\partial t} = F_i(m_1, m_2, \ldots, m_n, \mathbf{r}, t) + \operatorname{div} \sum_{j=1}^{n} D_{ij} \nabla m_j, \qquad (1)$$

where D_{ij} are the coefficients of linear (self and mutual) diffusion of the components. The functions F_i describe local transformations of the components and are usually constructed in accordance with the type characteristic for chemical-reaction kinetics.

Equations (1) do not take into account effects associated with the interaction between the system elements in space. For systems that are not in equilibrium, the inclusion of this interaction together with the linear terms $\mathbf{J}_i^L = -\sum_{j=1}^{n} D_{ij} \nabla m_j$ gives rise to nonlinear currents of the components as well. For paired interactions between the elements, and when the interaction range is much smaller than the characteristic scale of variations in the concentration of the components, these currents can be written in the form

$$\mathbf{J}_i^{NL} = \sum_{k,j} \chi_{ikj} m_k \nabla m_j, \qquad (2)$$

or, in more specialized form,

$$\mathbf{J}_i^{NL} = m_i \sum_{j} S_{ij} \nabla m_j. \qquad (2')$$

Equations (1) are then replaced with the more general system

$$\frac{\partial m_i}{\partial t} = F_i(m_i, \ldots, m_n, \mathbf{r}, t) + \operatorname{div} \sum_{j=1} D_{ij} \nabla m_j - \operatorname{div} m_i \sum_{j=1} S_{ij} \nabla m_j. \qquad (3)$$

The linear transport processes that are represented by the second term on the right of (3), and are due to the "Brownian" motion of the elements under the influence of random impacts due to the main medium, can be referred to as spontaneous diffusion. Nonlinear diffusion, which is represented by the last term in (3) and is due to the regular interaction between the elements, can be interpreted as stimulated or forced diffusion, since the corresponding nonlinear current (2′) is proportional to both the component concentration gradients and the concentrations themselves. In the absence of extraneous influences, spontaneous diffusion tends to return the system to the homogeneous state. Stimulated diffusion, on the other hand, disturbs this state. In physical systems, the coefficients of stimulated diffusion, S_{ij}, can be determined from the energy of interaction between the elements, whereas in "nonphysi-

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cal" systems (for example, in ecology), appropriate choice of these coefficients enables us to describe the nature of the spatial interaction between the elements, provided only it extends over scales that are much smaller than the characteristic scales of variation in the component concentrations. Of course, this substantially extends the possibilities of (3) as compared with (1).

Even in the simplest case represented by (2′), stimulated diffusion introduces fundamentally new elements into the behavior of the system. For example, in the two-component system with nonlinear mutual diffusion ($S_{12} \neq 0$, $S_{21} \neq 0$), in which there is no local interaction ($F_i = 0$), it is possible to observe states of consistent behavior that disturbs the original homogeneous structure: spatial cooperation between the components arises for ($S_{12} > 0$, $S_{21} > 0$), whereas differentiation appears for ($S_{12} < 0$, $S_{21} < 0$) and, moreover, linear diffusion makes this process look into a phase transition which occurs when a certain definite level of component concentration is exceeded. Examples of such cooperative pairs are: radiation and matter in physics, concomitant population types in ecology, resources and manufactured products in economics, and so on. For multicomponent systems one can, in principle, construct a sequential or branched-sequential scheme for the stimulation of the components in which differentiation (cooperation) will involve an increasing number of new components as they grow. The idea of stimulated diffusion is found to be useful, for example, in the devlopement of mathematical models for biological phenomena such as chemotaxis and photoaxis. From the standpoint of thermodynamics, stimulated diffusion leads to a reduction in configurational entropy with a simultaneous reduction in the free energy of the system.

[1]V. I. Talanov, Doklady Akad. Nauk SSSR **258**, 604 (1981) [Sov. Phys. Doklady **26**, 522 (1981)].

[2]V. A. Vasil'ev, Yu. M. Romanovskiĭ, and V. G. Yakhno, Usp. Fiz. Nauk **128**, 625 (1979) [Sov. Phys. Uspekhi **22**, 615 (1979)].

[3]H. Haken, Synergetics- an Introduction, Springer-Verlag (1978) Russ. Transl. Mir, M. 1980.

[4]G. Nicolis and I. Prigogine, Self-organization in nonequilibrium systems, Wiley (1977) Russ. Transl. Mir, M. 1979.