Scientific session of the Division of General Physics and Astronomy, USSR Academy of Sciences (26–27 October 1977)

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A scientific session of the Division of General Physics and Astronomy of the USSR Academy of Sciences was held on October 26 and 27, 1977 in the Conference Hall of the P. N. Lebedev Physics Institute of the USSR Academy of Sciences. The following papers were presented at that session:

1. *E. A. Grebenikov and Yu. A. Ryabov*, Problems of the dynamical evolution of planetary systems.

2. *A. M. Fridman*, Origin of the spiral structure of galaxies.

3. *A. S. Borovik-Romanov, N. M. Kreĭnes and V. G. Zhotikov*, Scattering of light by thermal and UHF-excited magnons in antiferromagnetic substances.

4. *V. G. Zinov, A. D. Konin, and A. I. Mukhin*, X-ray spectra of negative muons in chemical compounds.

Below we briefly review the contents of these papers.

E. A. Grebenikov and Yu. A. Ryabov, *Problems of the dynamical evolution of planetary systems*. One of the main problems of planetary cosmogony can be formulated as follows: Is the present dynamical structure of the solar system a static reflection—a copy—of the system's initial state, or has the solar system changed so much during the course of several billion years of evolution as now to be entirely different from what it was in the days of its youth?

Are the planetary configurations stable or unstable?

No complete answer to this question can be given at present, but theoretical methods of research have made it possible to obtain interesting new results. When we speak of the dynamical evolution of the planetary system we have in mind an analysis of the motion of each component separately and of its configuration as a whole during long (sometimes infinitely long) cosmogonic periods of time.

Mathematical formalism makes it possible to reduce the cosmogonic problem to the study of the solutions of Hamiltonian or quasi-Hamiltonian systems whose Hamiltonians have a complex analytic structure.

The study is conducted under the following assumptions:

1) Time is Newtonian, i.e., it is uniform.

2) The gravitational field is Newtonian, and it is of course invariant under time reversal.

3) There exists an extremely tenuous medium that gives rise to dissipative forces that are small compared to the Newtonian forces.

There exists a rigorous mathematical theory of conditionally periodic solutions of Hamiltonian systems (the KAM theory) which, developing the "metric" theory of differential equations, asserts that "almost all" (in the sense of Lebesgue measure) solutions of Hamiltonian systems (having negative total energy) are conditionally periodic functions of time. This rich manifold of solutions consists of nonresonance trajectories. From this it follows that almost all initial conditions generate planetary-system configurations that are stable on infinite time intervals, so that from the point of view of the metric theory, planetary systems do not undergo dynamic evolution. Unfortunately, this elegant mathematical theory cannot be applied to any realistic planetary or satellite system because of its limitations.

According to a second point of view, which is winning more and more adherents, the planetary system has undergone a great deal of evolution during the long cosmogonic time interval since its origin, and its present state, which is characterized by a large number of resonances, is not a copy of its initial state.

Modern methods of modeling have made it possible to calculate the dynamical evolution of a large number of planetary and satellite systems and thus to acquire a large mass of statistical material. As a result of theoretical study and numerical analysis, Ovenden, Feagin, and Graff were able to announce a principle of least interaction that is analogous to Lagrange's theorem of minimum potential energy for the case of perturbation theory. According to this principle, planetary and satellite systems evolve toward a resonance state even without the influence of dissipative forces. In this case the time average of the perturbing function due to the mutual attraction of the planets has a minimum value.

The cited authors believe that the dynamical evolution of planetary and satellite systems takes place in accordance with the following hypothesis. During its lifetime, any planetary system may pass through several resonance and nonresonance states, tidal and dissipative forces playing the important part when the system is close to a resonance state, and the gravitational field of point masses, when the system is in a nonresonance state. The number of such states depends essentially on the initial values of the parameters describing the system. Some calculations tend to indicate that at pres-

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ent our solar system is "close" to the first resonance state. The times of remaining in resonance states may be widely different and depend on the quantitative relation between the dissipative forces and gravitational perturbations. The "older" the system, the less time it spends in nonresonance and resonance states.

In any case the cosmogonic hypothesis advanced above is not in conflict with the present state of science.

E. A. Grebenikov and Yu. A. Ryabov, Rezonansy i malye znamenateli v nebesnoĭ mekhanike (Resonances and small denominators in celestial mechanics), "Nauka", Moscow, 1978.

V. I. Arnol'd, Usp. Mat. Nauk **18** (6) 92 (1963) [Russ. Math. Surveys **18** (6) 86 (1963)].

M. M. N'eto, Zakon Titsiusa-Bode (The Ticius-Bode Law) "Mir", Moscow, 1976.

M. W. Ovenden, T. Feagin, and O. Graff, Celest. Mech. **8**, 455 (1974).