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Landau Institute for Theoretical Physics turns 60

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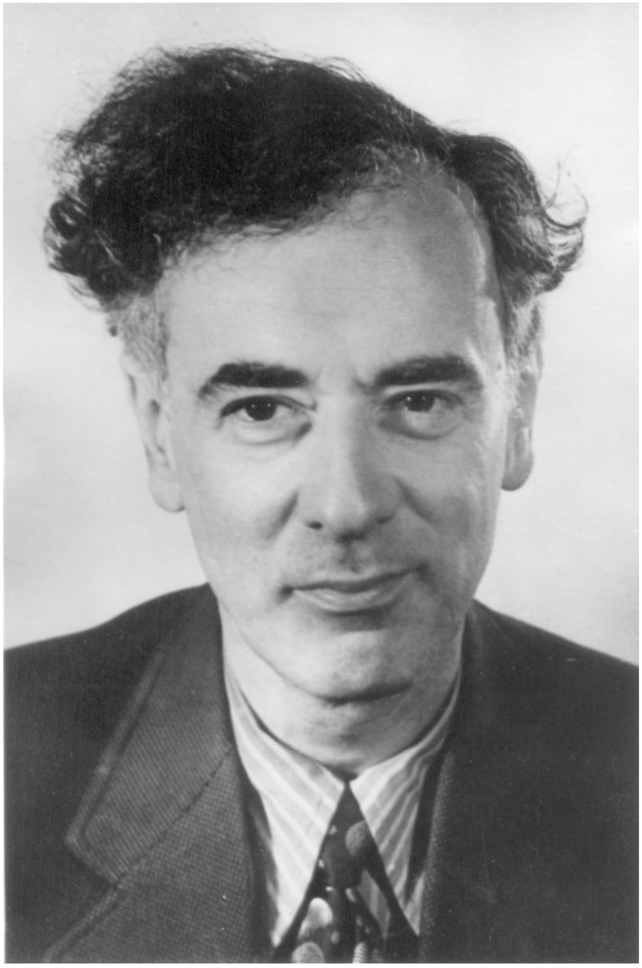
The decree establishing the Institute for Theoretical Physics (ITP) of the USSR Academy of Sciences was signed on September 14, 1964. The initiators of the Institute were I.M. Khalatnikov, the first director; A.A. Abrikosov, the future Nobel Laureate in Physics; and L.P. Gor'kov and I.E. Dzyaloshinskii, outstanding Soviet scientists. All of them were students of L.D. Landau, and so the ITP rightfully bears his name. In 1968, the institute's name was changed to the Landau Institute for Theoretical Physics. The ITP has always been characterized by a high scientific level and universalism characteristic of the Landau school. Thanks to the efforts of the 'founding fathers,' the ITP cultivates a unique creative atmosphere, fostering effective scientific work.

Since its founding, ITP scientists have followed L.D. Landau's principles; Landau perceived theoretical physics as a unified whole. Accordingly, a wide variety of theoretical physics fields are represented at the ITP. We will list the main ones.

A traditional topic studied at the ITP is the physics of disordered systems. Many papers published at the Institute are devoted to kinetic phenomena in metals with various impurities and defects. The pioneers in this field are A.A. Abrikosov, L.P. Gor'kov, and A.I. Larkin. Subsequently, Yu.N. Ovchinnikov, D.E. Khmelnitskii, K.B. Efetov, A.M. Finkel'shtein, P.B. Wiegmann, and O.N. Dorokhov made a significant contribution to this topic. Noteworthy is the fact that scientists at the ITP have developed the theory of weak localization and derived the replica and supersymmetric nonlinear sigma models. Currently, the physics of disordered metals is still one of the main research areas at the ITP, with I.S. Burmistrov and M.A. Skvortsov among the leaders in this field.

Semiconductors have a very rich physics. At the ITP, this topic was studied by E.I. Rashba and I.B. Levinson. Also noteworthy is A.S. Ioselevich's work on disordered semiconductors. Nowadays, the ITP is conducting research on quasi-two-dimensional electron systems, which are realized in semiconductor heterostructures. Related to this topic is the physics of various quasi-two-dimensional materials, including graphene. I.S. Burmistrov is a leader in this area of research.

The theory of superconductivity has been comprehensively developed at the ITP. A.A. Abrikosov and L.P. Gor'kov obtained fundamental results in this field, the former having been awarded the Nobel Prize in Physics for the discovery of quantum vortices, now known as the Abrikosov vortex lattice. Gor'kov's equations form the basis of the modern theory of superconductivity. A significant contribution to the theory of superconductivity was made by G.M. Eliashberg, A.I. Larkin, Yu.N. Ovchinnikov, V.B. Geshkenbein, and N.B. Kopnin. M.V. Feigel'man extensively studied the physics of high-temperature and highly disordered superconductors. Currently, V.P. Mineev, Ya.V. Fominov, and M.A. Skvortsov are leaders in superconductor physics research at the ITP.



Lev Davidovich Landau, Moscow, 1957

I.M. Khalatnikov is a leading theoretical physicist of superfluidity theory. S.V. Iordanskii studied various aspects of the physics of superfluids. The role of quantum vortices in the physics of two-dimensional superconductors was first elucidated by V.L. Berezinskii. Following the discovery of

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superfluid phases of helium-3, intensive work on developing a theory of this phenomenon began at the ITP. The work of G.E. Volovik and V.P. Mineev is particularly worthy of note.

Interest in the theory of magnets at the ITP dates back to the works of I.E. Dzyaloshinskii and A.I. Larkin. Subsequently, many Institute researchers turned to this topic. Of particular note is the work of A.I. Larkin, Yu.N. Ovchinnikov, and V.L. Pokrovskii on complex ferromagnet–superconductor systems. Mention should also be made of the work of S.E. Korshunov and Yu.A. Bychkov on two-dimensional degenerate magnets and strongly magnetized metals, respectively. At present, ITP researchers are actively studying the effects associated with topological defects (skyrmions) in two-dimensional magnets. The work of I.S. Burmistrov and S.S. Apostoloff has made a significant contribution to this research.

Interest in the role of quantum effects in mesoscopic systems arose quite early at the ITP. In this area, noteworthy is L.S. Levitov's work devoted to the statistics of quantum systems and the research by A.Yu. Kitaev, who formulated the ideas that laid the foundations for the theory of topologically secure quantum computing. Currently, the leader in the quantum computing field at the ITP is Yu.G. Makhlin.

Research at the Institute in the field of phase transition theory dates back directly to L.D. Landau. This topic, particularly the role of fluctuations, was extensively and fruitfully studied by V.L. Pokrovskii, as well as A.I. Larkin and D.E. Khmel'nitskii. Phase transitions play a significant role in the physics of liquid crystals, the theory of which was studied at the ITP by E.I. Kats and V.V. Lebedev. S.A. Brazovskii developed a fluctuation theory of weak first-order phase transitions and obtained a number of results in the theory of quasi-one-dimensional systems. L.N. Shchur devoted his work to the numerical simulation of effects in the vicinity of phase transitions. Nowadays, phase transition theory is a relevant topic at the ITP, primarily related to understanding the physical properties of new materials.

Perhaps the most intriguing topic for humanity is the origin of the Universe. The theory of the initial cosmological singularity and inflationary scenarios, the basis of modern cosmology, were laid down at the ITP by I.M. Khalatnikov and A.A. Starobinskii. A.Yu. Kamenshchik and G.E. Volovik continue cosmological research at the ITP.

Developing a theory of the behavior of matter under extreme conditions, particularly during its interaction with high-power electromagnetic pulses, is important from both fundamental and practical perspectives. Since the emergence of this field, it has become clear that the development of the theory of extreme states of matter is impossible without extensive numerical simulation, which was organized at the ITP by S.I. Anisimov. Now, the leader in this field is N.A. Inogamov.

The theory of interaction of an electromagnetic field with atoms has also been studied at the ITP, particularly by A.P. Kazantsev and V.L. Pokrovskii.

Another extensive area of research at the ITP is related to nonlinear wave phenomena. First and foremost, we should mention V.E. Zakharov, who made fundamental contributions to the kinetic theory of wave interaction. He extensively studied practical topics such as the statistical properties of ocean waves. His disciples continue this research at the Institute. E.A. Kuznetsov worked extensively on the theory of nonlinear phenomena in plasma. S.V. Nazarenko made significant contributions to the theory of nonlinear wave interaction. I.R. Gabitov, who, together with I.V. Kolokolov and V.V. Lebedev, studied the role of inhomogeneities in the transmission of these signals, was involved in the development of the theory of optical signal propagation in optical fibers.

Among the models used to describe nonlinear phenomena, so-called integrable systems stand out. These systems are nonlinear equations with an infinite set of integrals of motion. Such equations arise in surprising ways in a wide variety of fields of physics, for example, in plasma physics and fiber optics. Groundbreaking work in the analysis of integrable models has been performed at the ITP. Most notably, we should mention the work of V.E. Zakharov, A.B. Shabat, and S.V. Manakov.

The theory of strong interactions is being developed at the ITP. This line of research dates back to V.N. Gribov. Currently, the leaders in this field are N.N. Nikolaev and B.G. Zakharov.

The work carried out at the ITP in quantum field theory is undoubtedly a gem of theoretical physics. The modern development of the theory of fundamental interactions is based on the ideas of instantons, conformal invariance, and bosonic and fermionic strings — ideas first proposed by ITP researchers (A.A. Belavin, A.M. Polyakov, A.A. Zamolodchikov, and V.G. Knizhnik).

The Institute is also renowned for its school of mathematical physics (S.P. Novikov, Ya.G. Sinai, I.M. Krichever, B.A. Feigin, E.B. Bogomol'nyi, V.V. Sokolov, V.A. Kazakov, K.M. Khanin, A.V. Mikhailov, and P.G. Grinevich) with its fundamental results in topology, the theory of integrable systems, algebraic geometry, the theory of dynamical systems, ergodic theory, and other fields. The collaboration of mathematicians and physicists has led to unique results that would not have been possible with any other combination.

In recent years, a school of statistical hydrodynamics (V.V. Lebedev, I.V. Kolokolov, and S.S. Vergeles) has emerged at the ITP, which has received worldwide recognition. A theory of transport and mixing in turbulent and chaotic flows has been developed, and effects arising during the flow of complex fluids, particularly polymer solutions, immiscible liquids, and other processes, are being studied. The physics of light signal propagation in turbulent media, closely related to problems of information transmission through the atmosphere, is also related to these phenomena, which all require extensive numerical computations. In this regard, a specialized computing cluster for the numerical simulation of highly nonequilibrium physical processes has been constructed and is operating effectively at the ITP.

The Institute is well-known in Russia and abroad and, despite certain difficulties, has maintained scientific ties with leading global research centers. Institute researchers publish co-authored papers with international colleagues, and the Institute regularly hosts international conferences and research schools. The achievements of the Institute are recognized worldwide by the scientific community, and many of the obtained results are forever associated with the names of its scientists in the literature. The Institute is alive and well, as evidenced by the work carried out there in recent years. It remains one of the world leaders in theoretical physics.

I.S. Burmistrov, I.V. Kolokolov, V.V. Lebedev