

## Isaak Markovich Khalatnikov (on his 100th birthday)

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October 17 marked the centenary of the birth of Isaak Markovich Khalatnikov, the outstanding Soviet and Russian theoretical physicist. I M Khalatnikov's scientific activity is diverse and covers the majority of areas of modern theoretical physics — from the theory of superfluidity to quantum field theory and the theory of relativity. Isaak Markovich was an initiator of the foundation of the Landau Institute of Theoretical Physics of the USSR Academy of Sciences (now the Russian Academy of Sciences — RAS), which he headed from 1965 to 1992.

Isaak Markovich Khalatnikov was born on October 17, 1919 in the town of Ekaterinoslav (after 1926 Dnepropetrovsk, now Dnepr, Ukraine). He studied at Dnepropetrovsk State University and graduated from there in 1941. When a university student, Isaak Markovich began to take the exams for the theoretical minimum with Lev Davidovich Landau, who invited Isaak Markovich to become his postgraduate student. However, this plan went unfulfilled because of the war, during which Isaak Markovich was in the active army in the air defense forces.

After demobilization, Isaak Markovich entered the postgraduate course of the Institute for Physical Problems of the USSR Academy of Sciences, where, under L D Landau's guidance, he became engaged in the theory of superfluidity. He made an underlying contribution to this field, where he was the leading theoretician for many years. He derived equations describing the dynamics of elementary excitations in superfluid liquid helium, formulated the theory of relaxation processes, considered various hydrodynamic phenomena (including shock waves), studied the hydrodynamics and kinetics of superfluid solutions of helium isotopes, and constructed the theory of temperature jump at the interface between superfluid helium and a solid body (Kapitza jump). All of this work was carried out in close connection with experiment and, undoubtedly, exerted a strong stimulating influence on the development of studies of superfluidity all over the world. In 1953, Isaak Markovich defended his doctoral thesis, in which he summed up his research in the theory of superfluid helium. Rather notable were the names of panel members at this defense: N N Bogoliubov, V L Ginzburg, and I M Lifshitz.

In 1946, I M Khalatnikov was invited to participate, as part of L D Landau's group, in the Soviet Atomic Project. He organized numerical calculations concerning first the nuclear and then the thermonuclear bomb. During this work, he developed original numerical methods, in particular, he constructed implicit numerical schemes and solved the problem of numerical scheme stability. All this allowed successful calculations for the project to be carried out. For



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these achievements, I M Khalatnikov was rewarded with the USSR State Prize.

After the postgraduate course, I M Khalatnikov continued working at the Theoretical Department of the Institute for Physical Problems. In the second half of the 1950s, he implemented studies devoted to the theory of Fermi liquids: he analyzed kinetic phenomena in such a liquid and formulated the theory of light scattering in it. I M Khalatnikov formulated canonical methods (Lagrangian and Hamiltonian) in the hydrodynamics of quantum liquids, convenient for examining nonlinear phenomena. The work of I M Khalatnikov (together with L D Landau) devoted to the theory of sound absorption near second-order phase transition points came to underlie the dynamic theory of phase transitions. Isaak Markovich summarized his studies of the physics of quantum liquids in the monograph, *An Introduction to the Theory of Superfluidity*, which was published in 1971 and has been a handbook for all physicists engaged in this subject. The work on mixtures of superfluid Fermi liquids and superfluid Bose liquids (together with G E Volovik and V P Mineev) proved to be useful in experimental studies of quantum gas mixtures obtained through laser cooling.

I M Khalatnikov, together with L D Landau and A A Abrikosov, obtained fundamental results in quantum electrodynamics in the second half of the 1950s. The question concerning the asymptotic behavior of the main quantities of the theory (the photon and electron Green's functions) for large momenta was for the first time put forth and solved in this work. An original method of summation of the principal sequence of Feynman diagrams was also developed and then found wide applications in both statistical physics and quantum field theory. I M Khalatnikov was the first to formulate the methods of functional integration over Fermi fields that further on became an everyday apparatus of theoretical studies.

We should specially note I M Khalatnikov's studies in cosmology and astrophysics. His many years of work (together with E M Lifshitz) led to the discovery in cosmological models of the oscillatory regime of behavior of the initial singularity. This type of behavior turned out to be universal and underlay the construction of the general solution of Einstein's equations with time singularity, known as the Belinskii–Khalatnikov–Lifshitz singularity. These results were widely applied in astrophysics in the analysis of the early stages of the Universe's evolution. I M Khalatnikov and some of his co-authors found a solution to the problem of the stochastic properties of the Universe's evolution in homogeneous models. Later on, Isaak Markovich returned many times to cosmological problems.

Without an exhaustive review of I M Khalatnikov's research work, we cannot but mention the series of his studies in relativistic hydrodynamics (the results of which were then applied to the theory of multiple particle production), superconductivity (together with A A Abrikosov), as well as the analysis (together with V L Pokrovskii) of reflection above a barrier in quantum mechanics.

The scientific achievements of Isaak Markovich were rewarded with his receiving the L D Landau Prize (1974). He was awarded medals and orders, among which was the Order of the Badge of Honor (1950), three orders of the Red Banner of Labor (1954, 1956, 1975), the Order of the Great Patriotic War (II class) (1975), two orders of Friendship of Peoples (1979, 1994), the order of the October Revolution (1986), and the Order for Services to the Fatherland (II class). Isaak Markovich also has several prestigious foreign awards.

In 1972, I M Khalatnikov became a corresponding member and in 1984 a full member of the USSR Academy of Sciences. In 1994, Isaak Markovich was elected a foreign member of the Royal Society of Great Britain.

I M Khalatnikov was the initiator of the foundation in the USSR Academy of Sciences of the Institute of Theoretical Physics (ITP), which was named after L D Landau in 1969. He organized ITP in collaboration with the group of L D Landau's disciples (A A Abrikosov, L P Gor'kov, and I E Dzyaloshinskii) and became its first director. He held this post from 1965 to 1992. During these years, the institute became the leading center of theoretical physics, well known all over the world and upholding an exceedingly high reputation. Several generations of Soviet and Russian theoretical physicists were trained at the institute.

We should note I M Khalatnikov's personal traits that played a very important role when he was director of the Institute. They substantially moved forward the successful development of ITP. A distinctive trait of Isaak Markovich is wholehearted and quite selfless sympathy for any entry-level theoretician who comes out with an interesting idea. He

managed to distinguish and attract the most talented and effective theoretical physicists and mathematicians. Isaak Markovich is known to be democratic: he can listen to and appreciate the opinion of his colleagues; he demonstrates a quick reaction and an immutable sense of humor, which has allowed him to nip any conflict in the bud.

The scientific and organizational activity of I M Khalatnikov is fairly diverse. He organized annual conferences in Odessa and Bakuriani that played an important role in the development of Russian theoretical physics. I M Khalatnikov did much to establish international relations of the institute and to organize joint working meetings of Russian scientists with top scientists from the USA and other countries. In the 1980s–1990s, I M Khalatnikov organized several programs of scientific exchange with centers at the forefront of theoretical physics.

In 1954, I M Khalatnikov became a professor at the Moscow Institute of Physics and Technology (MIPT), where he delivered lectures and trained students and postgraduates first at the Chair of Low Temperatures at the Institute for Physical Problems and then at the Chair of Problems of Theoretical Physics at L D Landau ITP. He trained a whole cadre of disciples, with members of the RAS among them.

It is difficult, or practically impossible, to describe in a jubilee paper (with formal limits) devoted to Isaak Markovich Khalatnikov his uncommon life, filled with great scientific achievements, participation in historic events, meetings with outstanding people, and other notable moments. It is fortunate for us that Isaak Markovich himself described wittily and brilliantly many escapades of his rich life in the sensational book, *Dau, Centaur and others (Top Nonsecret)*, issued by Fizmatlit in 2008 on the centenary of L D Landau. The book has been in several editions in the Russian language and is now on sale in large Internet shops as a bestseller. A somewhat extended translation of this book into the English language was published by Springer publishers in 2012 under the title *From the Atomic Bomb to the Landau Institute. Autobiography. Top Non-Secret*. So, all those who wish to can get acquainted with the events of Khalatnikov's life in his own interpretation.

Isaak Markovich is brisk and full of energy as always. He is well informed about academic affairs, takes part in RAS enterprises, gives talks and interviews, takes an active part in the life of the institute founded by him, and has by right the title of its honorary director.

We wish Isaak Markovich health, happiness, and further achievements.

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