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ACADEMICIAN IHOR YUKHNOVSKII: PHYSICIST, POLITICIAN, AND NOT ONLY...

On September 1, we marked the 100th anniversary of the birth of one of the founders of the restoration of Ukraine's statehood in the late 1980s and, during the difficult 1990s, an outstanding Ukrainian scientist, the founder of the modern Lviv school of statistical physics, Professor, Academician of the National Academy of Sciences of Ukraine, the full and honorary member of the Shevchenko Scientific Society Ihor Yukhnovskii. At the end of his complicated and eventful life, he reflected, "Now I don't know what was most important to me in my life: physics or politics?" Let us also reflect on this question.

Ihor Yukhnovskii was born in Volyn, in a family of an official. Both of his parents came from ancient families of priests. He studied at the famous Kremenets gymnasium. His studies were interrupted by the war, which actually began in western Ukraine in 1939. He volunteered to join the Soviet army in 1944 because "...I could not calmly walk the streets and look into the eyes of mothers whose sons had joined the army". He fought on the fronts of World War II and met its end in Austria. In 1946, he became a student of the Faculty of Physics and Mathematics at the Ivan Franko State University of Lviv, from which he graduated with honors in 1951. He continued his postgraduate studies at the Department of Theoretical Physics under the supervision of A.Yu. Glauberman. There, he became acquainted with the works by M.M. Bogolyubov, became fascinated with his ideas, and performed several original studies related to the development of the Bogolyubov method of expansion in the plasma parameter and its applications to the description of charged particle systems. These results formed the basis of his Ph.D. thesis "The Binary Distribution Function for Systems of Interacting Particles" (1954) and considerably got ahead of similar studies by foreign scientists. I. Yukhnovskii's thesis was opposed by M.M. Bogolyubov.

In the late 1950s, I.R. Yukhnovskii formulated a new method for studying many-particle systems, the method of collective variables, which opened up new prospects for describing various classical many-particle systems in terms of functional integration. This method was formulated almost at the same time as the Stratonovich–Hubbard integral transformation began to be actively used, but the scope of its applications is much wider. Subsequently, Yukhnovskii generalized the formalism of collective variables to the case of many-particle quantum systems, and the method of displacements and collective variables arose, which turned out to be quite successful in describing quantum Fermi and Bose systems. The obtained results formed the basis of Yukhnovskii's doctoral dissertation "Statistical Theory of Charged Particle Systems", which he defended at the Taras Shevchenko State University of Kyiv in 1965 (the official opponents were D.M. Zubarev, Y.L. Klimontovych, and O.Z. Golyk). Two years later, he was awarded the title of Professor. By that time, I. Yukhnovskii had already been heading the Department of Theoretical Physics at Lviv University for several years.

After defending his dissertation, Yukhnovskii concentrated his main efforts on working with young people; about ten young scientists joined his research under his leadership. His main task at that time was to create a powerful center for statistical physics in Lviv. A favorable moment became the fact that, in 1966, Academician M.M. Bogolyubov organized the Institute for Theoretical Physics (ITP) in Kyiv and

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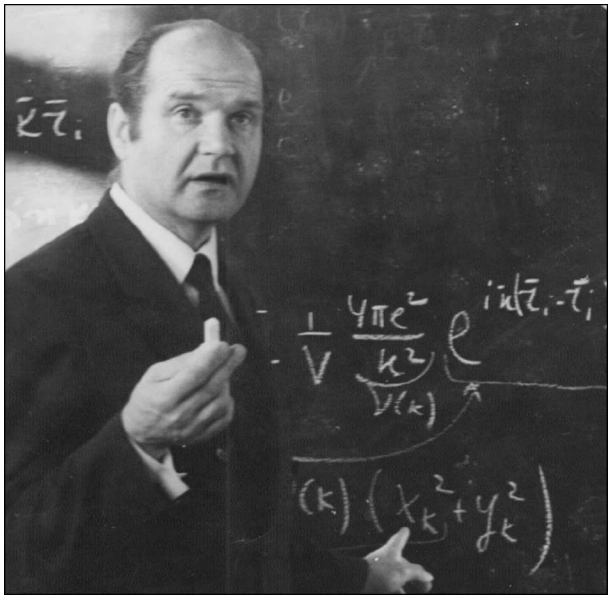
attracted famous theorists and talented young people to work there. After consultations with Mykola Bogolyubov and with his support, in May 1969, the Department of Statistical Theory of Condensed Systems (STCS) of this Institute was created in Lviv. It included two scientists: Ihor Yukhnovskii as the head of the Department (as a part-time employee) and a senior laboratory assistant (on a permanent basis). The newly created Department became the first academic unit in the field of physics in the western regions of Ukraine. A new stage, academic, began in Yukhnovskii's work. All his efforts were concentrated on finding talented youth and working with them. That was how the foundations of the future scientific school were laid.

Perhaps, the most important components of the success in science are competitiveness and the ability to see horizons, because any isolation leads to a transformation into pseudoscience, when closed subsystems acquire certain signs of scientificity, although they are not. Yukhnovskii clearly understood this. During the times of the USSR, he did everything to compare the work that physicists were doing in Lviv with the work performed at the largest scientific centers of the USSR. Already in the 1970s, with the support of M.M. Bogolyubov, he initiated the All-Union Conferences on Statistical Physics, which were gladly attended by scientists from all over the USSR. During the 1970s–1980s, a dozen such conferences were organized and held. In time, the scale of those conferences expanded, and they became international, including, in particular, the International School of Ion Solvation Physics (1983), the 2nd Soviet-Italian Symposium on Mathematical Problems in Statistical Physics (1985), and some others. Owing to Yukhnovskii and his disciples, Lviv gradually began to position itself as a leading center in statistical physics. From the experience of the first working meetings, Ihor Yukhnovskii formulated one of his requirements for formulating new tasks. He said that taking into account that Muscovites have advantages due to the availability of information from Western countries, the Ukrainian scientists should start working on those problems that are complex and have their own history, because this is the main niche for competition with the capital's physicists. At the same time, everything was done to strengthen communications with colleagues from abroad and the level of awareness about the achievements of world science. Surely,



I.R. Yukhnovskii lectures on the method of collective variables at the University of Rostock, Germany, 1972

I.R. Yukhnovskii together with Professor A.Yu. Glauberman (the late 1950s)

the thesis about the "complexity" remains relevant till now.

Most of Yukhnovskii's disciples were the graduates from Lviv University. They were selected from among the best students through postgraduate studies at the Univeristy Department, which Ihor Yukhnovskii continued to head, and, later, at the ITP. He created his own methodology for working with young

In the late 1970s, the Department of Statistical Theory of Condensed Systems at the ITP of the Academy of Sciences of the Ukrainian SSR, which was headed by I.R. Yukhnovskii, already included about twenty scientific officers

people, which allowed him to combine the individual work with them and the so-called "auditions", where everyone had an opportunity to tell others about his/her problem. A seminar began to actively work, where the formulation of new problems was also discussed. Since the beginning of the seminar logs in the early 1970s, almost 1300 seminars have been held till now. Yukhnovskii was demanding as a supervisor; at the same time, he took a "fatherly" care of his disciples, when they had everyday problems. It is worth mentioning the fact that was not immediately obvious. With a very careful professional selection of collaborators, Ihor Yukhnovskii also paid attention to their worldview. The things that were important to him included the family in which his future collaborators were raised, their language of communication among their friends, their attitude to cultural values, and the repertoire of their favorite songs. It seemed that those issues were not very fundamental, but as time has shown, they are strategically significant.

Another feature of Yukhnovskii's school is the concentration of efforts on the most challenging areas. To begin with, the name of the STCS Department was quite innovative. The term "condensed matter" began to be used in scientific circulation in 1963, when the Springer-Verlag publishing house began publishing the journal "Physics of Condensed Matter". This term was first used in the name of scientific subdivision in 1967 by Philip Warren Anderson, the 1977 Nobel laureate in physics, when he changed the name of his group at the Cavendish Laboratory of the University of Cambridge from "solid-state theory" to "condensed matter theory". The Department of Statistical Theory of Condensed Systems appeared in the spring of 1969. In a similar way, Yukhnovskii quickly responded to the emergence and the increasingly widespread application of new computer technologies in science. In the mid-1980s, after his contacts with Karl Heinzinger, one of the pioneers of computer simulation in Germany, he actively supported the idea of a wider use of computer simulation methods in physical research. Today, this is one of the main directions of the activity of Yukhnovskii's school. In 1993, with his active support, the project "Ukrainian Academic and Research Network" was launched. Since then, this initiative, by transforming through a separate laboratory of the Institute, has grown into a separate state enterprise "UARNet"; this is a completely independent structure, which has been the main provider not only for the NAS of Ukraine, but also for a considerable number of institutions in Ukraine for a long time.

In 1972, I.R. Yukhnovskii was elected a Corresponding Member of the Academy of Sciences of the Ukrainian SSR, which was a significant achievement and confirmation of the prospects of both the scientist himself and the scientific unit he headed. The achievements of the scientists of the STCS Department and the availability of sufficient personnel potential made it possible to create the Lviv Division of Statistical Physics of the ITP of the Academy of Sciences of the Ukrainian SSR, with already three scientific departments in its structure. Besides the STCS Department, two new ones arose: the Department of Solution Theory and the Department of Quantum Statistics, which were headed by Yukhnovskii's disciples, M.F. Holovko and I.O. Vakarchuk. In 1973–1987, I.R. Yukhnovskii was a member of the editorial board of the Ukrainian Journal of Physics. In 1982, he was elected an academician of the Academy of Sciences of the Ukrainian SSR. The same year, the monograph by I.R. Yukhnovskii and M.F. Holovko "Statistical Theory of Classical Equilibrium Systems" (Naukova Dumka, Kyiv) was published, which became one of the first books in the world literature on the microscopic theory of liquid state, in particular, electrolyte solutions.

Using the ionic-molecular approach in the theory of electrolyte solutions, it was shown that the characters of the screening of electrostatic interactions by ions and solvent molecules are fundamentally different: the ionic screening leads to an exponential weakening of electrostatic interactions, whereas the screening by polar molecules determines the dielectric properties of the solution. Together with his disciples, I.R. Yukhnovskii analyzed the fundamental role of the solvent molecular subsystem and the nature of ion solvation phenomena, and studied the mechanisms of formation and the specific features of short-range order in solutions. Subsequently, the theory of electrolyte solutions was generalized to the case of spatially confined systems (films and membranes), and it was shown that, owing to the presence of electrostatic image forces in semi-confined systems, which are responsible for adsorption effects at the electrolyte surface, the screening effects in spatially inhomogeneous and bulk systems are qualitatively different. The research in this direction was carried out together with M.F. Holovko, V.S. Vysochans'kyi, I.Y. Kurylyak, O.O. Pizio, Ye.M. Sov'yak, A.F. Kovalenko, and others.

While studying quantum systems, the method of displacements and collective variables was formulated, which allowed Yukhnovskii, together with his disciples, to perform calculations of the average and free energies, the heat capacity, and the binding energy for non-transition metals, as well as derive an equation of state for a degenerate electron gas and analyze the properties of the binary electron distribution function in the case of strong non-ideality. For the first time, a correct short-range asymptotics was obtained for the binary correlation function at electron concentrations typical of metals. Those works were carried out together with M.V. Vavrukh, G.I. Bigun, R.M. Petrashko, and P.P. Kostrobii. The application of the method of displacements and collective variables to the problems in the theory of high-temperature plasma was made together with L.F. Blazhyevs'kyi.

Another direction of research, where the method of displacements and collective variables proved its efficiency, is the theory of interacting Bose particles. Simultaneously, the wave functions of the ground and weakly excited states were obtained, the energy of the ground state and the spectrum of elementary excitations were calculated, the structure functions were found, and the problem of Bose–Einstein condensation was analyzed. This made it possible to develop the microscopic theory of liquid Helium-4, which demonstrated a quantitative agreement of theoretical results with the experiment. These works were carried out together with I.O. Vakarchuk. In the theory of solids, Yukhnovskii's approach to the basic consideration of short-range interactions when describing systems with competing short- and long-range potentials was developed together with R.R. Levitskii. This approach was extended to quantum systems of the order-disorder type (ferroelectrics, magnets, and so forth), which are described by pseudospin models. In this approach, short-range interactions were taken into account in the cluster approximation.

One more direction of Yukhnovskii's research concerned the theory of phase transitions and critical phenomena. His interest to this topic arose in the early 1970s, and he continued to work in this area until his last days. The starting point of the studies was the work on substantiating the form of the basic distribution near the point of the second order phase transition performed together with Yu.K. Rudavskii. It was found that for a successful descrip-

tion of critical phenomena, it is necessary to proceed from higher-order (non-Gaussian) distributions describing fluctuations of a collective variable associated with the order parameter. Using the method of collective variables, recurrence relationships for the coefficients of the basic concentration measure were obtained. The analysis showed that, a special critical regime is observed near the critical point, which is a manifestation of a new type of symmetry, the symmetry of renormalization group, which in turn leads to universality in the behavior of various systems with only a few common characteristics (the space dimension, the number of the order parameter components, the type of interactions, an so on). Those studies were carried out for various systems together with M.P. Kozlovskii, I.O. Vakarchuk, Y.K. Rudavskii, V.O. Kolomiets, Y.V. Holovatch, I.M. Mryglod, I.V. Pylyuk, and others. The main concepts of this theory were published in the monograph by I.R. Yukhnovskii "Phase Transitions of the Second Kind. The Method of Collective Variables" (Naukova Dumka, Kyiv, 1985), which was later published in English by World Scientific (Singapore). It was shown that when calculating the thermodynamic characteristics of a system near its phase transition, it is not enough to take only the critical regime into account. Using the Ising model as an example, Yukhnovskii and his co-authors proposed a scheme that made it possible to carry out sequential calculations of both universal (the critical parameters) and non-universal (the phase transition temperature, the heat capacity, the susceptibility, and others) quantities in the vicinity of the transition point. This approach, verified on the Ising model, became a key to develop a general theory of critical phenomena in three-dimensional systems, and it was applied by Yukhnovskii's disciples to describe critical behavior in various condensed matter models, in particular: the Stanley n-component spin model (together with I.O. Vakarchuk, Y.K. Rudavskii, and Y.V. Holovatch), binary substitution alloys (together with Z.O. Gurskiy), the n-component model of structural phase transitions (together with I.M. Mryglod), Ising systems with anisotropic interactions (together with M.A. Korynevskii), hierarchical models (together with Y.V. Kozyts'kyi), the liquid-gas critical point (together with I.M. Idzyk and V.O. Kolomiets), and classical multicomponent mixtures (together with O.V. Patsahan).

In 1986, I.R. Yukhnovskii, together with M.M. Bogolyubov, Jr. and S.V. Peletminsky, was awarded the M.M. Krylov Academic Prize for the series of works "Mathematical Methods for Studying Systems with Spontaneously Broken Symmetry".

In the late 1980s, Yukhnovskii's biography was very closely intertwined with important social events that took place during the formation of the modern Ukrainian state. As he recalled, "I did not enter the political activity at once. First, it was an objective awareness of the inevitable collapse of the USSR and the creation of independent states. This conviction that the USSR would collapse was nationally logical for me at that time, without anguish... The people, oppressed nationally and socially by the Soviet system, rose up. This explosion was powerful." By that time, Yukhnovskii was already a well-known scientist and an active public figure. He created the Small Academy of Sciences in Lviv, which became the first in Ukraine. He contributed to the revival and development of "Plast". He organized and became the co-chairman of the Lviv Regional Memorial, a historical, educational, and human rights society, which was engaged in preserving the memory of political repressions during the USSR period. He was among the founders of the People's Movement of Ukraine, the first opposition public organization registered by the Council of Ministers of the Ukrainian SSR in February 1990. With a calm and convincing manner of communication, Yukhnovskii was able to convince a crowd of many thousands at a meeting or his opponents in the silence of their offices. Therefore, the natural consequence was the election of I.R. Yukhnovskii in March 1990 as a people's deputy to the Supreme Council of the Ukrainian SSR and, later, to the Supreme Council of Ukraine of the first democratic convocation. The 65-year-old academician began a new and extremely productive period of his state-building activity. This period, in Kyiv, lasted for more than twenty years.

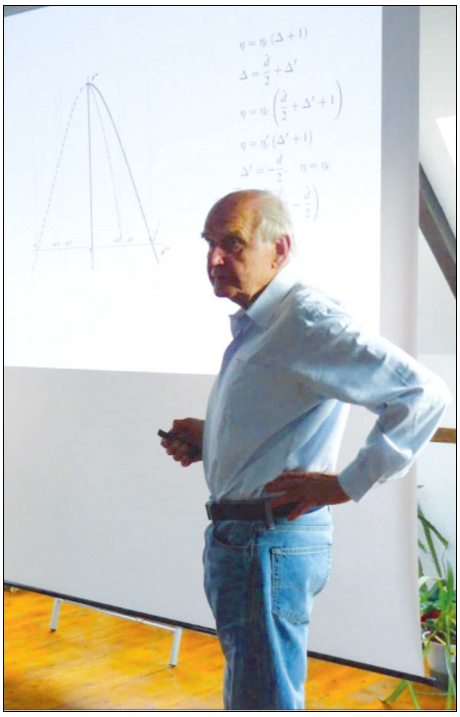
In the Supreme Council of Ukraine of the first convocation, I.R. Yukhnovskii led the opposition as the Chairman of the People's Council; he was an active participant in the adoption of the Declaration on State Sovereignty of Ukraine and one of the authors of the Law "On Economic Independence of Ukraine", the initiator of the All-Ukrainian referendum on the confirmation of Ukraine's independence, which took place on December 1, 1991. At the same time, Ihor

Yukhnovskii continued to be interested, in every free minute, in the life of the team of physicists that he actually created in Lviv.

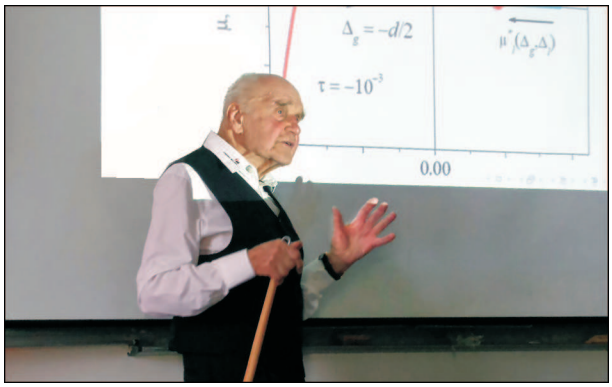
In September 1990, on the basis of the Lviv Division of Statistical Physics of the ITP of the Academy of Sciences of the Ukrainian SSR, the Institute for Condensed Matter Physics (ICMP) of the Academy of Sciences of the Ukrainian SSR was established. It was the first academic institute for fundamental research in the field of physics in Western Ukraine. The ICMP also became the first academic institute that appeared after the adoption of the Law "On Economic Independence of Ukraine" under new rules, according to the decision of the Ukrainian Academy, and without an agreement with Moscow. I.R. Yukhnovs'kyi had headed the Institute and managed it for 16 years. From 2006 till the last days of his life, he was the Honorary Director of the Institute and actively took care of its activities.

In 1993, the Institute for Condensed Matter Physics of the National Academy of Sciences of Ukraine founded the periodical collection (later the journal) "Condensed Matter Physics". Ihor Yukhnovs'kyi had been the Editor-in-chief of this journal for 29 years. During this time, this edition has gone a way from an interdepartmental collection of works to one of the best scientific journals in Ukraine. Now, the journal is included in the most famous scientometric databases, e.g., Scopus and Web of Science.

In 1990–1993, Ihor Yukhnovskii headed the Supreme Council Commission on Science and Education; he was a member of the Presidium of the Supreme Council. In 1992, he worked as a State Counselor of Ukraine and headed the Collegium on Scientific and Technical Policy of the State Duma of Ukraine. In 1992–1993, he was the First Vice Prime Minister of Ukraine in the government of L. Kuchma. In 1994, he was elected a deputy of the Supreme Council of Ukraine for the second time; there, he headed the deputy group "Statehood". Yukhnovskii became one of the key authors and promoters the adoption of the Constitution of Ukraine (1996). At the same time, on his initiative, the Interdepartmental Analytic Advisory Council under the Cabinet of Ministers of Ukraine was created. In 1998, Yukhnovskii was elected a People's Deputy of Ukraine for the third time, and he again became the chairman of the Committee on Science and Education. In 2002, he became a deputy of the Supreme Council of Ukraine for the fourth time, a member of the faction "Our Ukraine", the chairman of the Committee on Science and Education, and the chairman of the Special Temporary Commission on the Issues of the Future.



I.R. Yukhnovskii makes a report at the Anniversary Readings "Statistical Physics in the 21st Century" (Tatariv, August 26–28, 2015)



I.R. Yukhnovskii makes a report at the seminar of the ICMP of the National Academy of Sciences of Ukraine on September 1, 2023

I.R. Yukhnovskii was an organizer and the first chairman of the Ukrainian Institute of National Remembrance, a newly created (in 2006) central execu-

tive body with a special status, which he headed till 2010. During his chairmanship, the Law of Ukraine "On the Holodomor of 1932–1933 in Ukraine" was adopted, the National Book of Memory of Holodomor Victims was created, the first phase of the Memorial to the Victims of Holodomors was built, and the Museum of the Ukrainian Revolution of 1917–1921 was created in the historic Teacher's House in Kyiv. Besides working in the parliament and government structures, Ihor Yukhnovskii was also actively involved in public organizations of Ukraine. For instance, he was an organizer and the first chairman of the All-Ukrainian Association of Veterans (in 1996–2009), an organizer and the president of the International Charitable Fund of National Memory of Ukraine (in 2006–2024), and a founding member of the Initiative Group "First of December" (in 2011–2024).

Ihor Yukhnovskii returned to Lviv in 2010 at the age of 85. Here, he continued his research on an interesting problem of describing, from first principles, the behavior of a system of interacting particles at the critical point and at lower temperatures. In 2017, for the cycle of scientific works "Asymptotic Methods of Nonlinear Mechanics and Statistical Physics", he was awarded (together with M.O. Perestyuk) the M.M. Bogolyubov Prize of the NAS of Ukraine, and his last article, co-authored with R.V. Romanik, was published in 2024 in the Ukrainian Journal of Physics.

I.R. Yukhnovskii's scientific output includes more than 500 scientific articles, as well as 7 monographs and textbooks. The list of his disciples includes about 40 PhD students and 20 Doctors of science. His disciples continue the work of their teacher. In 2025, the defense of a doctoral dissertation by Khrystyna Gaidukivs'ka took place, who became a Doctor of science in the fourth generation of Yukhnovskii's disciples. The school founded by him continues to develop actively, and the Institute for Condensed Systems Physics, which he created and which has recently been named after him, has become one of the leading scientific centers in Ukraine and Eastern Europe in the fields of statistical theory of condensed matter, soft matter physics, computer simulation of many-particle systems, and a new interdisciplinary direction, the theory of complex systems. Substantial is Yukhnovskii's contribution to the development of such domains as economics (in the 1990s, he initiated detailed studies of the productive forces of Ukraine), the fundamentals of constitutional law (during the preparation of the Constitution of Ukraine), the principles of strategic state planning (at the beginning of the 2000s, he created and headed the Special Commission on the Issues of the Future at the Supreme Council of Ukraine), and history (he was one of the developers of the policy of national memory, an organizer and the head of the Ukrainian Institute of National Remembrance in 2006–2010).

On September 1, 2023, on the day of his 98th birthday, Ihor Yukhnovskii spoke at a seminar of the Institute for Condensed Matter Physics of the NAS of Ukraine, which he created, with a report "A New Insight on Phase Transitions of the First Order". His speech lasted more than an hour and was then accompanied by a lengthy discussion. He was tired, but his face was full of satisfaction emotions and joy of a physicist after a well-done job.

Ihor Yukhnovskii was an Honorary Doctor of the M.M. Bogolyubov Institute for Theoretical Physics of the NAS of Ukraine, Ivan Franko National University of Lviv, Lviv Polytechnic National University, Lesya Ukrainka Volyn National University, Vasyl Stefanyk Carpathian National University, and Uzhhorod National University. He was an Honorary Citizen of the town of Lviv and the town of Kremenets. His work was honored with several high state awards, including the distinction of the President of Ukraine, the Order of Merit (I degree), the Orders of Prince Yaroslav the Wise (V, IV, and III degrees), the Order of Liberty; he is the Hero of Ukraine and the recipient of the Order of State. The person of Academician Yukhnovskii is forever engraved in the pantheon of great Ukrainians.

I.M. MRYGLOD, O.L. IVANKIV