

PERSONALIA

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Yurii Moiseevich Kagan (on his 90th birthday)

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July 6, 2018 will be the 90th birthday of one of the outstanding theoretical physicists of the Soviet postwar generation, Academician of the Russian Academy of Sciences, Yurii Moiseevich Kagan.

Yu M Kagan was born in Moscow in 1928. His father, Moisey Aleksandrovich, was a lawyer. He graduated from St. Petersburg University before the revolution. His mother, Rahil Solomonovna, was a physician.

Yu M Kagan's early youth passed during the hard war years. In 1943, he began working in a war plant and attended a young workers' evening school. In autumn 1944, as a 16-year old boy, he entered the Moscow Aviation Institute. In February 1946, he was transferred to the second course of the Engineering Physics Faculty of the Moscow Mechanical Institute, which was founded for training specialists for the Atomic Project. He graduated from there in 1950 with honors. At the same time, he forwarded all the exams of the famous Theorminimum to L D Landau, who invited him to his postgraduate course.

However, on graduating from the institute, he was sent to work on the USSR Atomic Project at the Ural Electrochemical Plant near Sverdlovsk. The plant was targeted at industrial production of uranium isotopes separated by the gas-diffusion method.

When Yu M Kagan was working at the Central Laboratory of the plant, he developed the general theory of the separation of isotopic gas mixtures in porous media for the whole range of pressures from the Knudsen regime to the hydrodynamic one. Decisive here was his original idea of replacing a porous medium by a heavy 'wall' gas with certain scattering characteristics. The problem of separating the n-component mixture on porous media was, in fact, reduced to the general diffusion problem for an $(n+1)$-component mixture in free space. (Notably, several years later a similar idea was published by American physicists, but this time the heavy gas was referred to as 'dustlike'.)

In 1954, Yu M Kagan defended his Candidate of Sciences thesis. The same year, he was invited to deliver lectures at the specialized faculty of the Ural Polytechnical Institute. For three years he would go once a week to Sverdlovsk to give a classified course of lectures.

In 1956, Yu M Kagan was invited to Moscow to the Institute of Atomic Energy (now the Russian Research Center 'Kurchatov Institute'). Since that time to the present day, his scientific activity has been connected with this Institute. In 1959, he defended his thesis for the degree of Doctor of Phys.-Math. Sciences.

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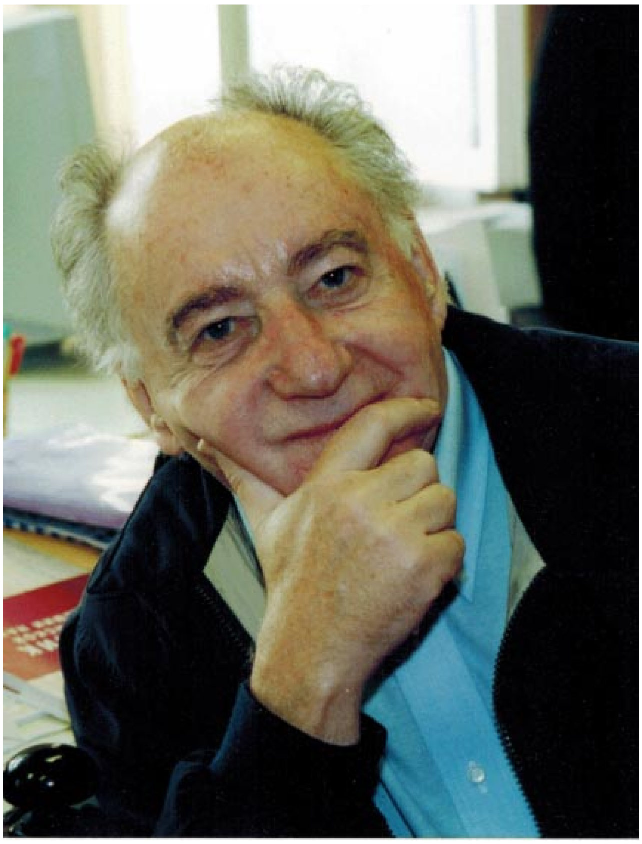

Yurii Moiseevich Kagan

Continuing to be engaged in the physics of molecular gases, Yu M Kagan formulated the kinetic theory of gases with rotational degrees of freedom. The introduction of the rotational moment vector to the theory, along with the velocity vector, radically changed the entire structure of the classical kinetic theory of gases. Together with L A Maksimov, he formulated the general theory of transport phenomena in molecular gases in external fields, which suggested, in particular, an explanation for the Senftleben effect (a change in the kinetic coefficients of a neutral molecular gas in a magnetic field), known since the 1930s.

The theory initiated a wide scope of research in this country and abroad. Its results — which, in fact, became classical — were included in monographs and textbooks. The vector composed of the velocity vector and the rotational moment pseudovector, which is playing an essential role in the theory, is referred to as the 'Kagan vector'. It is of interest that the alignment of rotational moments of molecules in a gas flow, referred to as 'Kagan polarization', was directly measured experimentally in the Leiden laboratory 25 years after its theoretical prediction.

Close to this area of research is the fundamental prediction by Yu M Kagan that in the analysis of transport phenomena in weakly nonequilibrium systems, together with ordinary thermodynamic forces, the generalized forces of the same tensor dimension, which are the derivatives of the fluxes, must be taken into account. This was demonstrated for the first time in a consideration of diffusion process in a gas with allowance for viscosity, which required an inclusion of a dissipative momentum flux. In particular, the thermodynamic coefficient of the pressure diffusion became a kinetic quantity with a substantial dependence on the viscosity coefficient. The role of this prediction is demonstrated in many monographs and textbooks.

In the 1960s, Yu M Kagan began an intense study in the field of solid state physics. He developed a consistent microscopic theory of nontransition metals showing up the decisive role of electron liquid in the formation of the static and dynamic properties of metal, especially of its phonon spectrum. The theory allowed an explanation of the origin of the unpaired internal forces and predicting the occurrence of a new type of singularities of a many-particle nature in the phonon spectrum of metal, in particular, the known logarithmic singularity in a quasi-one-dimensional metal. An important result of the theory was the removal of the constraints on the value of the electron–phonon interaction constant. The results of the theory were confirmed in numerous experiments.

For the series of studies in this field, Yu M Kagan, along with his pupil and co-author E G Brovman, were awarded the M V Lomonosov Prize of the USSR Academy of Sciences (1975).

This series was continued by Yu M Kagan's well-known work on metallic hydrogen. The existence of the metastable phase of the metallic state was proved, and its crystal structure and the vibrational spectrum were thoroughly analyzed. The pressure-dependent change in the structure and in all the parameters of the metastable phase was simultaneously examined. The equation of state was found and used to estimate the molecular-to-metal phase transition pressure. The fact that only the sharply anisotropic structures are quasistable and that with increasing pressure a clearly pronounced tendency appears to form a phase of liquid metal proved to be nontrivial. These results were used to obtain an estimate of the superconducting transition temperature for the metastable phase of metallic hydrogen at high pressure.

The study of collective coherent phenomena in resonance interaction of nuclear radiation with crystals, which was started at about the same time, takes a special place in the scientific activity of Yu M Kagan. In the series of studies done by Yu M Kagan together with A M Afanasyev, the notion of crystal-delocalized collective nuclear excitation (the nuclear exciton) appeared for the first time, and the variation in the lifetime of the excited state was predicted. One of the central results of this studies was the prediction of the suppression of inelastic channels of nuclear reaction, when a crystal strongly absorbing resonance radiation (gamma-quanta, neutrons) becomes almost transparent under certain conditions (the Kagan–Afanasyev effect). All the results of the theory were confirmed experimentally and were further thoroughly studied in our country and abroad.

The prediction and the experimental confirmation of the suppression effect for inelastic channels of nuclear reactions were honored with the State Prize of the USSR (1976).

It should be noted that this field is close to Yu M Kagan's series of studies on the theory of the basic solid-state aspects of the Mössbauer effect, which contributed substantially to the development in our country of research based on this effect.

For many years, one of the main avenues of Yu M Kagan's research was the study of low-temperature quantum kinetic phenomena in condensed media. This avenue was opened with the classical paper by Yu M Kagan and I M Livshits, where the kinetics of extremely low-temperature phase transitions was first predicted to be realized through the subbarrier tunneling of the growing new phase nuclei. The lifetime of the metastable phase at $T = 0$ will then remain finite.

A large series of studies in this field was devoted to the theory of quantum diffusion of atomic particles in a solid medium. The consideration of the diffusion of interacting particles in an ideal crystal led to the prediction of an unexpected self-localization effect for a rather low particle concentration. Simultaneously, another prediction appeared — already at a very low temperatures, the interaction with phonons leads to the occurrence of coherent quantum diffusion (without excitation of the phonon system) which removes localization. It is noteworthy that coherent quantum diffusion also removes quasilocalization that occurs upon a dynamic destruction of the band particle motion owing to the phonon field fluctuations.

These predictions were fully confirmed experimentally in the analysis of the ^{3}He atom diffusion in the ^{4}He crystal matrix and then in the numerous papers investigating quantum diffusion in other systems. Yu M Kagan was awarded the Lenin Prize (1986) for this series of works. He also participated actively in further investigations of the quantum diffusion of particles, this time in metals and superconductors.

The range of Yu M Kagan's scientific interests always involved the study of the properties of imperfect crystals. His prediction of the emergence of quasilocal levels in the phonon spectrum of the defect crystals and the related sharp anomalies in the thermodynamic and kinetic properties accumulated the occurrence of an extensive range of experimental studies. One of the central series of his studies is devoted to the theory of the amorphous state. Most attention is paid to the low-temperature properties of the amorphous state, where two-level tunneling states are decisive. Taking the interaction between the tunneling centers into consideration led to a nontrivial prediction of the universality of dynamic and static properties of ultralow-temperature amorphous bodies.

In recent years, the main scientific interests of Yu M Kagan have largely focused on the problem of Bose condensation and superfluidity in macroscopic quantum systems formed by ultracold gases. Yu M Kagan and his colleagues made an important contribution to the development of this thriving area of research. A great number of widely acknowledged pioneering results were obtained. Thus, the problem of the kinetics of formation of Bose condensate and of a long-range order from an originally purely classical gas was solved. Of particular importance is the solution of the kinetic problem for low-dimensional systems with a demonstration of the formation of a quasicondensate in the absence of long-range order (but with local correlation properties of a true condensate).

Among the papers in this series, particularly noteworthy is the prediction of the suppression effect of inelastic processes in the course of Bose-condensate formation. Interestingly, the observation of this effect in an alkali metal gas at JILA (USA) was used as a proof of Bose-condensate formation. In recent years, of great interest are the results of studies in this field devoted to the analysis of the superfluid state of atomic Fermi gas with attraction.

Close to this series of papers is Yu M Kagan's work with an unexpected prediction of the possibility of observing Bose condensation of excitations in stationary thermodynamically nonequilibrium systems.

Working all this time at the Kurchatov Institute, Yu M Kagan at the same time taught for over 40 years at the Moscow Engineering Physics Institute (MEPhI). When lecturing as a Professor at the Theoretical Nuclear Physics Chair, he delivered a remarkable course of lectures titled *Modern Solid-State Theory*, which played an important role in the choice of specialization for many generations of students. Notice that he was frequently invited to give original courses of lectures in many famous universities and research centers around the world.

Yu M Kagan trained a large group of pupils — Candidates and Doctors of Sciences and Corresponding Members of the USSR Academy of Sciences (now the Russian Academy of Sciences).

In summarizing, we should emphasize that Yu M Kagan received a huge number of results in many areas of physics that gained him wide recognition and initiated original large-scale experimental studies.

In 1970, Yu M Kagan was elected as a Corresponding Member, and in 1984 as a Full Member of the USSR Academy of Sciences. He was given the title of Honorary Doctor of the Technical University of Münich (Germany, 1990), Uppsala University (Sweden, 1996), and van der Waals Honorary Professor of the University of Amsterdam (The Netherlands, 1990). He was elected as a member of the European Academy of Science (1995) and an honorary member of the Academy of Sciences of Hungary (1998). He is a member of the American Physical Society (1994). Yu M Kagan was twice invited by Harvard University to give the famous Morris Lab Lectures (1988, 1996). He was awarded the Lenin (1986) and State (1976) Prizes, the Karpinsky Prize (Germany, 1994), the Humboldt Prize (Germany, 1994), the Triumf Prize (2006), the Demidov Prize (2009), and the I Ya Pomeranchuk Prize (2017). He was awarded the Order of the 3rd degree "For Merits before the Fatherland", two orders of the Red Banner of Labor, and the orders of Friendship and Honor.

We wish to Prof. Yu M Kagan many years of good health, creative activity, and prosperity. We hope that each day presented to Yurii by his Fate will be full of joy and satisfaction.

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M V Koval'chuk, V Ya Panchenko, L P Pitaevskii,
A Yu Rumyantsev, M V Sadovskii, A M Sergeev,
V B Timofeev, I A Shcherbakov, G M Eliashberg