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NIKOLAI YEVGRAFOVICH KOCHIN (on the 100th anniversary of his birthday)†

The 19th May 2001 marks the 100th anniversary of the birth of the outstanding Russian scientist Nikolai Yevgrafovich Kochin, who made a great contribution to the development of meteorology and hydrodynamics and was one of the founders of the modern school of hydroaerodynamics in Russia.

Even in school, Kochin's teachers were impressed by his remarkable capabilities and his brightness and speed of thought. In 1918 he entered the Mathematics Section of the Physics and Mathematics Department of Petrograd University. In 1919, however, he was called up by the Red Army, within whose ranks he took part in the siege of Petrograd, and it could be said to be a miracle that he survived. In 1922 he returned to university, where, in spite of the interruption caused by the war, he graduated in 1923.

In 1922, before graduating, on the invitation of Professor A. A. Fridman, he began working in the Mathematics Department organized by Fridman at the Main Geophysics Observatory, and he worked there right up to his move to Moscow in 1935. Fridman is rightly considered to be the founder of the school of meteorology in Russia. He is also widely known as the author of the famous non-stationary solution of the equations of the General Theory of Relativity which had only recently been published; this solution is of fundamental importance to cosmology and is often referred to as the model of the expanding universe. In the same time, Fridman completed his book *Experiments in the Mechanics of a*

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Compressible Fluid, and its contents were set out in lectures which Kochin attended. After the publication of the book, Kochin studied it so thoroughly that Fridman on one occasion remarked "Kochin knows my book better than I do". In 1934, Kochin took part in the editing of the second, posthumous edition of this book and wrote extremely interesting appendices to it.

Fridman was Kochin's teacher in the area of fluid mechanics. He formulated one of the first problems whose solution brought him fame. He found a solution of the equations of the dynamics of a compressible fluid, taking into account the rotation of the Earth, that presented a model of cyclonic eddies. This model essentially generalized the most complete model of Fridman that was available at the time. The results obtained in the work, and, in particular, the trajectories of gas particles, were in good agreement with available observations.

Continuing to work at the Main Geophysics Observatory, Kochin formulated and solved the most important problems of meteorology. In a series of publications he studied the discontinuity surfaces in a compressible fluid, incidentally obtaining a solution of the problem of the decomposition of an arbitrary discontinuity in an ideal gas, that was rapidly recognized as definitive. However, the main focus of his research was the surfaces that separate flows or masses of air with different parameters in the atmosphere. These surfaces largely determine the most important atmospheric effects and represent tangential discontinuities whose behaviour is greatly influenced by the Coriolis force. These had been studied previously in work by Rayleigh, Margules, and Bjerknes on the assumption that the air moves along the constant latitude and that cyclones and anticyclones arise as a result of the development of instability of these surfaces.

Kochin set about investigating the unusually complex problem of the stability of flows of this kind. First, together with L. V. Keller, he obtained the criterion of stability of flows in relation to disturbances independent of longitude, i.e. reducing to the displacement of annular fluid tubes. He then examined the problem of the stability of discontinuity surfaces in relation to arbitrary disturbances and the problem of the waves of air flows with different parameters on a discontinuity surface. At medium and high latitudes, such a surface is inclined at a small angle to the horizontal. This fact, and also the large horizontal scale of meteorological effects compared with the thickness of the atmosphere, made it possible to introduce a substantial simplification of the problem, which subsequently almost always came to be used in meteorology. Namely, instead of the projection of the equation of motion onto the vertical axis, Kochin proposed that the equation of hydrostatics be used, as in "shallow-water" theory. However, even then the problem remained complex, and it was reduced to an eigenvalue problem for a certain ordinary second-order equation. In the plane of the parameters characterizing the problem, a curve was found that corresponds to the existence of neutral disturbances. The results laid the foundation for subsequent research using computer simulation.

In the case of stability, the waves propagating over a discontinuity surface were studied in a non-linear formulation. In some studies, he made possible conclusions concerning the motion of fronts over the Earth's surface that might be drawn on the basis of his investigation of discontinuity surfaces.

Kochin also obtained fundamental results in the theory of the general circulation of the atmosphere. He was the first to examine the influence of the friction of atmospheric air against the Earth's surface, which had previously been neglected. As was shown, this effect is important owing to the action of turbulent viscosity many orders of magnitude greater than molecular viscosity. The thickness of the boundary layer on the Earth's surface, in which an important role is played by the Coriolis force, was estimated. It turned out that this thickness is of the order of a kilometre, i.e. comparable with the thickness of the troposphere. Taking into account simplifications stemming from the relative thinness of the atmosphere, it was shown that, for a complete determination of all the elements of circulation of the atmosphere in the steady case, it is sufficient to know the temperature distribution in the air and the pressure over the Earth's surface, and appropriate computer procedures were developed. One more pioneering study is the wet cyclone model the constructed. These studies laid the foundation for subsequent research in meteorology.

After the death of Fridman in 1925, Kochin effectively became the head of the school of Russian meteorologists. In parallel with his scientific research, he taught at Leningrad University, where he carried out mathematics and mechanics exercises and gave special courses. In 1932 he also began to work at the Physics and Mathematics Institute of the USSR Academy of Sciences. After the institute was divided into the Physics Institute and the Mathematics Institute, Kochin, as Head of the Department of Mechanics of the V. A. Steklov Mathematics Institute, moved to Moscow in 1935. In 1935–1938 he worked simultaneously at the Central Aerohydrodynamics Institute (TsAGI), where at that time a group of outstanding young scientists (P. A. Val'ter, V. V. Golubev, M. V. Keldysh, M. A. Lavrent'yev, A. I.

Nekrasov, G. I. Petrov, L. I. Sedov, Ya. I. Sekerzh-Zen'kovich, L. N. Sretenskii, and S. A. Khristianovich) were working, under the supervision of S. A. Chaplygin, on problems associated with the development of aviation and the motion of ships, including submarines. Kochin was actively involved in investigating new problems which he solved using the theory of an ideal incompressible fluid. He had conducted a number of investigations on this subject before he moved to Moscow.

He carried out research on the theory of waves on water and on problem associated with the motion of bodies over the surface of a liquid. The first step in the study of wave generation by such bodies was made by Keldysh, who solved the plane problem of the motion of a vortex with a specified circulation over the surface of a heavy liquid. Subsequently, Keldysh and Lavrent'yev solved the problem of the motion of a profile of specified shape. At the same time, this and also the more complex problem of the motion of three-dimensional bodies in water, were solved by Kochin, who developed a new efficient method for problems of this kind, based on the introduction of a function later termed "generalized circulation". All the characteristics of the flow and the action of a liquid on a body were expressed in terms of this function. Kochin suggested a simple method for constructing approximate solutions. Using this method, he obtained solutions of a number of important problems, in particular the steady vibrations of bodies beneath the surface of a liquid in plane and three-dimensional formulations, and he also constructed solutions of problems of the effect of the relief of the Earth on internal waves in the atmosphere (in two- and three-dimensional formulations), on the flow of a heavy liquid through a shelf on the sea bed, and on a lattice of profiles.

In yet another series of investigations he constructed a solution of the problem of the flow around a slender wing, circular in plan, both in the stationary case and when the wing was executing periodic vibrations. The accurate solutions obtained are regarded by specialists as unsurpassed.

Besides the large number of investigations outlined above, the legacy he left includes individual studies that also contain important results. For example: a new solution of the Cauchy–Poisson problem concerning water waves, where, using dimensional methods, a fundamental solution was found that could be used to construct a general solution of the problem, an investigation of the torsional vibrations of the crankshafts of piston machines, in which he examined the stability of motion and internal resonances in a mechanical system with many degrees of freedom and variable generalized masses and an investigation of possible forms of air balloon tether under the action of a wind which varied with height.

After moving to Moscow, Kochin taught at Moscow University, where he initially gave special courses on wave theory, and from 1938 until the end of his life he headed the Department of Fluid Mechanics. In 1938–1940 he was Secretary of the Moscow Mathematics Society, and in 1939 he was elected immediately as a full member of the USSR Academy of Sciences, without first becoming a corresponding member. In the same year, the Institute of Mechanics of the USSR Academy of Sciences was founded, and Kochin went there to work as head of department. At the start of World War II, he, together with the Institute of Mechanics, moved to Kazan. Soon after his return to Moscow, he died in 1944 as a result of a serious illness at the age of 43.

Besides his individual research, Kochin wrote generalizing books which represent an epoch in meteorology and fluid mechanics. His enormous contribution to meteorology was summed up in the two-volume work *Dynamic Meteorology* (1935). He wrote the textbook *Vector Calculus and the Principles of Tensor Calculus*, many editions of which have been published, and finally, together with A. I. Kibel' and N. V. Roze, wrote the outstanding two-volume course *Theoretical Fluid Mechanics*, which has been, and continues to be, used to teach many generations of Russian mechanics.

Apart from work on creating teaching courses, with appendices added to the many new editions published during his life, Kochin carried out a large amount of work on editing and publishing 13 books, including treatises by A. M. Lyapunov, I. A. Lappo-Danilevskii, and V. I. Smirnov, and translations of books by Hurwitz and Courant. As an author, referee, and member of the editorial board, he took an active part in publication of the journal *Applied Mathematics and Mechanics* from the time of its organization.

His principal publications have been issued in the two-volume *Collected Papers* [1]. A full list of his more than 100 scientific treatises is given in his biography [2]. An analysis of the development of his ideas and methods and also very interesting recollections of scientists who worked with him or were personally acquainted with him are contained in the papers of a conference [3] held to mark the 80th anniversary of his birth.

Kochin's vast output during his short life is a source of wonder and admiration. The results he obtained and the projected trends of development determined for many years ahead, and continue to determine to this day, the face of fluid dynamics and meteorology.

REFERENCES

1. KOCHIN, N. Ye., *Collected Papers*. Izd. Akad, Nauk SSSR, Moscow–Leningrad, Vols 1 and 2, 1949.
2. KOCHINA, P. Ya., *Nikolai Yevgrafovich Kochin*. Nauka, Moscow, 1993.
3. *N. Ye. Kochin and the Development of Mechanics*. Nauka, Moscow, 1984.

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