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ACADEMICIAN LEV DAVIDOVICH LANDAU

(On the fiftieth anniversary of his birth)

LEV Davidovich Landau, one of our greatest theoretical physicists, completed his fiftieth year of life on January 22.

L. D. Landau was born in 1908 in the city of Baku. His mathematical talents began to appear at a very early age. He can scarcely remember not being able to differentiate and integrate. At the age of fourteen he was admitted as a student in the Physics Faculty of the University of Leningrad, where he completed his studies in 1927. This time marks the beginning of Lev Davidovich's intense scientific activity.

Lev Davidovich began his scientific work in the Leningrad Physico-technical Institute; two years later, in 1929, he received the opportunity to spend considerable time in study abroad. For a year and a half he worked at the Institute for Theoretical Physics in Copenhagen, and also in Germany, England, and Switzerland. Discussions and collaboration with the leading theoretical physicists of that time aided in the development of the wide scope of his interests as a physicist; this is particularly true of his association with Niels Bohr, and Lev Davidovich regards himself as a pupil of Bohr.

After his return from abroad he did not remain long in Leningrad, and moved to Khar'kov, to the Ukrainian Physico-technical Institute, where he was the head of the theoretical section for five years. This same place saw the beginning of his pedagogical activity, in the Physico-mechanical Faculty of the Khar'kov Institute of Machine Construction and at the University of Khar'kov. Lev Davidovich's talent as a teacher was apparent from his early years, and pupils began to gather around him. Thus his time in Kharkov already saw the beginning of the broad scientific school of Lev Davidovich Landau.

Lev Davidovich's main pedagogical principle is his conviction that independent creative work in any field of theoretical physics must begin with a sufficiently deep mastery of all its branches. For this purpose he developed a special program which has become widely known among young physicists under the name of the "theoretical minimum".

In 1937 Lev Davidovich moved to Moscow, where he is the head of the theoretical section of the then newly organized Institute for Physical Problems of the Academy of Sciences of the U.S.S.R. He is continuing his pedagogical activity at the University of Moscow; for a number of years he was a professor in the Physico-technical Faculty, and is at present a professor in the Physics Faculty.

The important scientific and scientific-social services of L. D. Landau have found their due recognition in the Soviet Union: in 1946 he was elected an active member of the Academy of Sciences of the U.S.S.R., and he has been awarded the Stalin Prize three times and has been honored with Soviet decorations. Outside his own country Lev Davidovich has been elected to membership in the Danish and Dutch academies of science.

The scientific activity of L. D. Landau amazes one by its extraordinary versatility. In our age of specialization, when there remain almost no physicists of universal interests, he not only feels at home in all the main fields of theoretical physics, but also has to his credit a number of important contributions in hydrodynamics and aerodynamics. His approach to the study of theoretical physics is characterized by the fact that he does not separate the theory from natural reality, nor from experiment, so that he remains close to experimental physics, on which he has a great influence. It is not without significance that at the weekly seminar which Lev Davidovich conducts at the Institute for Physical Problems reports are presented not only on theoretical researches but also on the results of experimental work on the most varied problems in physics. Participants in the seminar are repeatedly amazed to see Lev Davidovich show equal enthusiasm and thorough knowledge in discussing, for example, the energy spectrum of the electrons in silicon, directly after dealing with the properties of the so-called "strange" particles.

The scientific works of L. D. Landau are so numerous and of such varied natures that it is impossible to give in a few pages any sort of complete survey and characterization of all his contributions, which have been of great importance in all fields of theoretical physics, beginning with hydrodynamics and ending with quantum field theory. We shall confine ourselves to mentioning only the most significant of his publications.

In 1927, in connection with the problem of radiative damping in quantum mechanics, Lev Davidovich was the first to introduce the concept of the density matrix (in the energy representation).[1]

In 1930 he published his classic work on the diamagnetism of electrons in a metal (Landau diamagnetism),[2,3] which later led to the explanation of the variations of the magnetic susceptibilities of metals at low temperatures in strong magnetic fields (de Haas-van Alphen effect). Another important contribution to the development of present ideas about the magnetic properties of matter is contained in a paper published in 1935 (together with E. M. Lifshitz),[4] in which the thermodynamic theory of domains in ferromagnetic substances and the foundations of the theory of ferromagnetic resonance were given for the first time. Credit is also due to Lev Davidovich for first introducing into physics the idea of the antiferromagnetic ordering of magnetic moments, as a special phase of a substance, which exists at low temperatures and goes over into the paramagnetic condition at a point of phase transition.[5]

During this same time Lev Davidovich put forward the important idea of the autolocalization of electrons in a crystalline lattice,[6] which subsequently influenced S. I. Pekar's development of his polaron theory.

In addition to papers containing new theoretical ideas, Lev Davidovich's creative activity in science is also characterized by papers devoted to the solution of difficult theoretical problems by brilliant mathematical flank attacks. An example is his general method for solving quasi-classical collision problems, published in 1932.[7]

Lev Davidov made a fundamental contribution to thermodynamics by developing his theory of phase transitions of the second kind, which reveals their deep connection with the symmetry properties of a substance.[8] The methods he developed were first applied to transitions of a structural character, and later were applied with success to the study of piezoelectricity, ferroelectricity, antiferromagnetism, and so on.

The name of L. D. Landau is associated with the creation of a theory of the superfluidity of liquid helium,[9] which he developed with a completeness that makes possible an exhaustive explanation of the numerous phenomena in liquid helium, and which has now won its way to general acceptance. For this work and for his work on the theory of phase transitions Lev Davidovich was awarded the Stalin prize in 1941.

Landau's contribution to another problem of low-temperature physics — superconductivity — is primarily comprised in his theory of the laminar structure of the intermediate state.[10]

Quite recently Lev Davidovich has developed a new general theory of the quantum Fermi liquid, which has predicted a number of interesting phenomena in liquid He^3 (Ref. 11) which still await experimental confirmation.

Turning to the field of nuclear physics, we must note first of all a paper by Lev Davidovich in 1937[12] in which, starting from an idea of N. Bohr, he laid the first foundations of the quantitative statistical theory of the nucleus, and in particular obtained a connection between the neutron width and the separation of the levels. In 1938 Landau (together with

G. Rumer) gave an elegant mathematical theory of the production of electron-photon showers;[13] the procedure developed in this paper subsequently became the basic method in the study of cascade processes. In 1953, starting from an idea of Fermi, he constructed a consistent hydrodynamical theory of multiple production of particles in collisions of fast particles.[14]

In the last few years Lev Davidovich has published a series of papers on quantum electrodynamics (together with A. A. Abrikosov and M. I. Khalatnikov), in which the asymptotic forms of the propagation functions at high energies are determined.[15] Starting from these results,[16] I. Ia. Pomeranchuk subsequently arrived at a most important conclusion, that it is impossible to construct a relativistic theory of the strong interactions as point interactions.

Only a year ago, in connection with the exciting question of the nonconservation of parity, Lev Davidovich proposed the ingenious hypothesis of the conservation of the combined parity,[17] which at present is still awaiting experimental confirmation.

In concluding this brief survey, in order to show the breadth of L. D. Landau's scientific interests, we shall mention a few more papers that stand a bit aside from the others: the throry of the fine structure of the Rayleigh scattering (together with G. Placzek);[18] the now widely used kinetic equation for the case of Coulomb interaction between the particles;[19] the theory of the structure of shock waves at great distances from their place of origin.[20]

The breadth of Lev Davidovich's grasp of contemporary physics is even more convincingly shown by the course of theoretical physics which he has written together with E. M. Lifshitz.[21] Taken together, these books are a fundamental treatise on theoretical physics. In originality of exposition and broad grasp of the material they are unprecedented in the whole world-wide literature of physics, and so have attained wide popularity not only in our country but also abroad.

The contribution for which theoretical physics is indebted to Lev Davidovich is not exhausted by his own scientific writings. We have already spoken of another side of his activity — his founding of a broad school of Soviet theorists.

His inextinguishable enthusiasm for science, his acute criticism, his talent and clarity of thought attract many young people to Lev Davidovich. The number of those, both young and mature scientists, who turn to Dau (as his pupils and associates have come to call him) is very large. Lev Davidovich's criticism is hot and merciless, but behind this outer sharpness is hidden devotion to high scientific principles and a great human heart and human kindness. Equally sincere is his wish to aid the success of others with his criticism, and equally warm is his expression of approval.

Together with all the physicists of our country, the editors of the JETP place a high value on the great contribution which Lev Davidovich has made to the development of our science, and we send to him sincere wishes for many years of health, happiness, and creative success in the service of Soviet science.

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[1] The Problem of Damping in Wave Mechanics. Z. Physik **45**, 430 (1927).

[2] The Diamagnetism of Metals. Z. Physik **64**, 629 (1930).

[3] Appendix to paper by D. Shoenberg, Proc. Roy. Soc. **A170**, 341 (1939).

[4] On the Theory of Dispersion of Magnetic Permeability in Ferromagnetic Bodies. Phys. Z. Sowjet. **8**, 153 (1935).

[5] A Possible Explanation of the Field Dependence of the Susceptibility at Low Temperatures. Phys. Z. Sowjet. **4**, 675 (1933).

[6] On the Motion of Electrons in a Crystal Lattice. Phys. Z. Sowjet. **3**, 664 (1933).

[7] On the Theory of Energy Transfer in Collisions. Phys. Z. Sowjet. **1**, 88 (1932); **2**, 46 (1932).

[8] On the Theory of Phase Transitions. J. Exptl. Theoret. Phys. (U.S.S.R.) **7**, 19 (1937); Phys. Z. Sowjet. **11**, 26, 545 (1937).

[9] The Theory of Superfluidity of Helium II. J. Exptl. Theoret. Phys. (U.S.S.R.) **11**, 592 (1941); J. Phys. U.S.S.R. **5**, 71 (1941);

[10] On the Theory of Superconductivity. J. Exptl. Theoret. Phys. (U.S.S.R.) **7**, 371 (1937); Phys. Z. Sowjet. **11**, 129 (1937). On the Theory of the Intermediate State of Superconductors. J. Exptl. Theoret. Phys. (U.S.S.R.) **13**, 337 (1943); J. Phys. U.S.S.R. **7**, 99 (1943).

[11] Theory of the Fermi-liquid. J. Exptl. Theoret. Phys. (U.S.S.R.) **30**, 1058 (1956). Oscillations of the Fermi-liquid. J. Exptl. Theoret. Phys. (U.S. S.R.) 32, 59 (1957), Soviet Phys. JETP **5**, 101 (1957).

[12] On the Statistical Theory of Nuclei. J. Exptl. Theoret. Phys. (U.S.S.R.) **7**, 819 (1937); Phys. Z. Sowjet. **11**, 556 (1937).

[13] The Cascade Theory of Electronic Showers. Proc. Roy. Soc. **A166**, 213 (1938).

[14] On the Multiple Production of Particles in Collisions of Fast Particles. Izv. Akad. Nauk SSSR, Ser. Fiz. **17**, 51 (1953).

[15] On the Elimination of Infinities in Quantum Electrodynamics. Dokl. Akad. Nauk SSSR **95**, 497 (1954). Asymptotic Expression for the Green's Function of the Electron in Quantum Electrodynamics. Dokl. Akad. Nauk SSSR **95**, 773 (1954). Asymptotic Expression for the Green's function of the Photon in Quantum Electrodynamics. Dokl. Akad. Nauk SSSR **95**, 1177 (1954). The Mass of the Electron In Quantum Electrodynamics. Dokl. Akad. Nauk SSSR **96**, 261 (1954).

[16] On the Point Interaction in Quantum Electrodynamics. Dokl. Akad. Nauk SSSR **102**, 489 (1955).

[17] On the Conservation Laws for Weak Interactions. J. Exptl. Theoret. Phys. (U.S.S.R.) **32**, 405 (1957), Soviet Phys. JETP **5**, 336 (1957); Nucl. Phys. **3**, 127 (1957).

[18] The Structure of the Undisplaced Scattered Line. Phys. Z. Sowjet. **5**, 172 (1934).

[19] The Kinetic Equation for the Case of Coulomb Interaction. J. Exptl. Theoret. Phys. (U.S.S.R.) **7**, 203 (1937); Phys. Z. Sowjet. **10**, 154 (1936).

[20] On Shock Waves at Large Distances from the Place of their Origin. Prikl. Mat. i Mekh. **9**, 286 (1945); J. Phys. U.S.S.R. **9**, 496 (1945).

[21] Статистическая физика (Statistical Physics), 1st ed. 1938; 2nd ed. 1940; 3rd ed. 1951. Механика (Mechanics), 1941. (Theory of Fields), 1st ed. 1941 (English Transl. by M. Hamermesh, Addison Wesley Press, Cambridge, 1951; 2nd ed. 1948. Механика сплошных сред (Mechanics of Continuous Media), 1st ed. 1944; 2nd ed. 1953. Квантовая механика (Quantum Mechanics) 1948. Электродинамика сплошных сред (Electrodynamics of Continuous Media) 1957.

Translated by W. H. Furry
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REFLECTION OF SLOW ELECTRONS FROM THE SURFACE OF PURE TUNGSTEN AND FROM TUNGSTEN COVERED WITH THIN FILMS. II

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Studies have been made of the reflection of slow electrons from monocrystalline tungsten and from tungsten crystals on which a layer of tungsten has been deposited by evaporation, under conditions of ultra-high vacuum ($p < 10^{-9}$ mm Hg) to ensure a clean surface. Anomalous changes occur in the reflection coefficients when thin layers of Ba, BaO, and Ba-O are applied to a tungsten single crystal; a possible explanation is discussed. The experimental results are compared with calculations for the case of slow electrons reflected from a potential barrier possessing a maximum. The diffraction of slow electrons from monocrystalline tungsten has been studied, and also the effect of depositing thin films of barium.

A previously published paper[1] contained a report of the results of studies on the reflection of slow electrons from the surface of a polycrystalline tungsten ribbon, and from thin films of barium and oxygen upon the tungsten. The experiments were carried out in sealed-off tubes at total pressures of the order of 10^{-9} mm Hg, and with equivalent pressures of 10^{-10} to 10^{-11} mm Hg in the adsorption regions, thus preventing any distortion of the results by the adsorption of residual gas. The reflection coefficient R for slow electrons from the surface of the tungsten target showed an unusual type of dependence on the energy of the incident primary electrons, V_p; as the energy increased, so did the reflectivity. Meyer[2] has obtained similar results with tungsten. This behavior of the reflection coefficient cannot be explained as an interaction of the electrons with the potential barrier at the metal-vacuum boundary, for any reasonable barrier shape must give a decrease in reflectivity