LANDAU The Physicist and the Man

LANDAU The Physicist and the Man

Recollections of L. D. Landau

Edited by

I. M. KHALATNIKOV

USSR Academy of Sciences
L. D. Landau Institute of Theoretical Physics
Moscow, USSR

Translated from the Russian by

J. B. SYKES Oxford, UK



PERGAMON PRESS

OXFORD NEW YORK - BEIJING - FRANKFURT SÃO PAULO - SYDNEY - TOKYO - TORONTO U.K.

Pergamon Press plc, Headington Hill Hall,

Oxford OX3 0BW, England

U.S.A.

Pergamon Press, Inc., Maxwell House, Fairview Park,

Elmsford, New York 10523, U.S.A.

PEOPLE'S REPUBLC

OF CHINA

Pergamon Press, Room 4037, Qianmen Hotel, Beijing,

People's Republic of China

FEDERAL REPUBLIC OF GERMANY

BRAZIL

Pergamon Press GmbH, Hammerweg 6,

D-6242 Kronberg, Federal Republic of Germany Pergamon Editora Ltda, Rua Eca de Queiros, 346,

CEP 04011, Paraiso, São Paulo, Brazil

AUSTRALIA

Pergamon Press Australia Pty Ltd., P.O. Box 544,

Potts Point, N.S.W. 2011, Australia

JAPAN

Pergamon Press, 5th Floor, Matsuoka Central Building, 1-7-1 Nishishinjuku, Shinjuku-ku, Tokyo 160, Japan

CANADA

Pergamon Press Canada Ltd, Suite No. 271, 253 College Street, Toronto, Ontario, Canada M5T 1R5

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First edition 1989

Library of Congress Cataloging-in-Publication Data

Landau, the physicist and the man: recollections of L. D. Landau/edited by I. M. Khalatnikov; translated from the Russian by J. B. Sykes.—1st ed.

p. cm.

Includes index.

Landau, L. D. (Lev Davidovich), 1908–1968.
 Physicists—Soviet Union—Biography.
 Khalatnikov, I. M. (Isaak Markovich)

QC16,L25L36 1988 530',092'4-dc19 88-37153

British Library Cataloguing in Publication Data

Landau: The Physicist and the Man

1. Physics, Landau, L. D. (Lev Davidovich), 1908–1968

I. Khalatnikov, I. M. 530'.092'4

ISBN 0-08-036383-0



LEV DAVIDO "H I ANDAU (F ... ait)

From the Editors

In this book we have included various recollections of Lev Davidovich Landau by his friends and pupils. The name of Landau is widely known as that of an outstanding scientist, one of the greatest of twentieth-century physicists. The combination of a mighty intellect and a vivid personality brought him almost legendary fame. These reminiscences are not the work of authors by profession, but they have the great merit of being authentic.

L. D. Landau was a magnificent teacher for the pupils he carefully chose. Teaching was his vocation. In science he maintained the highest moral standards. Being a person of wide interests, he often expressed opinions on a variety of topics having no direct relation to his professional work. These recollections will tell the reader about Landau's views on science and on various aspects of culture and life. Not all readers will agree with some of his statements, especially as these were at times excessively categorical. Some of them we ourselves would not seek to defend, although Landau, who was a brilliant controversialist, would probably have had immediate rejoinders ready in their support.

We have deliberately not revised any of the contributions. This would have been entirely inappropriate, just as there is a basic right to make statements in evidence without their being reworded. The reader is to see Lev Davidovich Landau through the eyes of his friends, and complete as he wishes the portrait of that remarkable man.

From the Translator

I have been given the task and the privilege of conveying in English the tributes paid in this volume to one of the world's greatest physicists, and I am happy to offer in this way my own tribute to one whose books have been the keystone of my career as a translator. I am conscious that one person could hardly hope to do justice to the rich variety of expression and feeling in the many contributions included here, but I hope that, even so, the translated book too is a worthy memorial to Lev Davidovich Landau.

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I. M. KHALATNIKOV

The pride of Soviet science On the eightieth birthday of Academician L. D. Landau

The history of science in our country shows many distinguished names, and among these the name of Academician Lev Davidovich Landau has its own special place. He gained fame by his work in the field of theoretical physics, and though this was in an area of fundamental science accessible only to professionals, he became a legend in his own lifetime.

L. D. Landau was born at Baku on 22 January 1908. He spent his childhood there, and from an early age he showed an interest in mathematics. At the age of twelve he understood the elements of higher mathematics, and at fourteen he became a student of physics and mathematics at Baku University. He was not a prodigy, and he always regarded prodigies with a certain scepticism. The years of his youth were years of revolution, and the whole of human history shows that such years foster the rapid development of talent. Unlike prodigies with their generally narrow range of interests, Landau concerned himself not only with physics and mathematics but also with a deep study of history, literature, and art. This wide learning of which the foundations were laid in his youth goes far to explain why he became not only an outstanding scientist but also a personality who had an exceptional influence on all around him.

After two years' study at Baku University, he moved to Leningrad University, graduating in 1927. During these years there was a constellation of outstanding physicists working at Leningrad under A. F. Ioffe, the father of Soviet physics. Here was formed a group of young theoretical physicists which included not only Landau but also Fok, Gamow, and Bronstein. There had just been a revolution in theoretical physics also, with the creation of quantum mechanics to explain atomic and molecular properties. The group of young theoreticians soon joined in work on this new topic. As early as 1926, Landau published his first paper, on the spectra of diatomic molecules.

In 1929 Landau was sent to work abroad by the Commissariat for Education. He visited Germany, Denmark, Switzerland, and England, meeting the forerunners and founders of quantum mechanics, Rutherford, Bohr,

Heisenberg, and Pauli. In Switzerland, there were difficulties in obtaining a residence permit. At first, despite the active support of physicists, the authorities gave him permission for only a very short time. Landau joked that Lenin had lived in Switzerland for several years without causing a revolution there, but the authorities now seemed to be afraid that he would cause one inside a week. It has to be said that when Landau was abroad he saw at once the faults of bourgeois society and openly branded them as such. It is not surprising that Casimir, the famous Dutch physicist, who met him at this time, says Landau gave the impression of being a revolutionary in the best sense of the word.

At Cambridge, there was working at that time with Rutherford in the Cavendish Laboratory another Soviet physicist, Pyotr Kapitza, whose achievements were already celebrated. He and Landau first met there. In seeking to explain Kapitza's results concerning the dependence of the electrical conductivity of metals on an external magnetic field, Landau solved by the methods of quantum mechanics the problem of the motion of electrons in a magnetic field. The paper on diamagnetism of metals which gave this solution attracted the attention of every theoretical physicist, and is still the basis of research in solid-state physics. Thus began the joint work of these two eminent physicists which was so significant in the subsequent development of Soviet physics, and ultimately gained two Nobel prizes.

Landau went abroad twice more, in 1933 and 1934, and established particularly close collaboration with Niels Bohr, the great Danish physicist, whom he regarded as his teacher.

In 1932, at the initiative of A. F. Ioffe, director of the Leningrad Physicotechnical Institute, three similar institutes were set up in Kharkov, Sverdlovsk, and Dnepropetrovsk, the prototypes of the centres now being set up by the Academy of Sciences. Landau moved to Kharkov, and a group of talented young people began to gather about him there. He gave much attention to their training, and it was in Kharkov that he began, together with E. M. Lifshitz, to write the textbooks of theoretical physics which afterwards became the classic work, Course of Theoretical Physics. More than one generation of physicists, both in the Soviet Union and throughout the world, have been taught by these books. In Kharkov, too, arose the school of Landau, formed by his pupils working, like himself, in almost every field of theoretical physics. Landau was a universalist, who did research in nuclear theory, solid-state physics, quantum field theory, and astrophysics; in this respect he has no equal in the history of physics over the last few decades.

In 1937 there was a worsening of conditions at Kharkov University, where Landau was teaching. He was dismissed for no good reason. At that time, Kapitza in Moscow was looking for someone to be head of the theoretical department at the Institute of Physical Problems which he set

up in 1935 after returning from England. His choice fell on Landau, who accepted the invitatior in view of the intolerable situation in Kharkov. Though he had escap d from the dark clouds gathering over him there, he did not manage to avoid trouble in Moscow. In 1938 he was arrested on a false accusation. On the day of the arrest, Kapitza wrote a letter to Stalin in which he drew attention to the fact that the loss of Landau to Soviet and world science could not be made good. There was no answer. In 1938, Kapitza discovered the phenomenon now known as the superfluidity of liquid helium. A year after Landau's arrest, Kapitza wrote to Molotov. It is instructive to quote a part of that letter (see p. 317):

Recently, during work on liquid helium, at temperatures near absolute zero, I have been able to discover a number of new phenomena which may clear up one of the most puzzling areas in modern physics. I propose to publish some of this work during the next few months. But to do so I need the aid of a theoretician. We had in the Soviet Union one who thoroughly understood the area of theory that I need, namely Landau, but he has been under arrest for a year now. I had very much hoped he would be released, especially as I must say frankly that I cannot believe he is a traitor.'

Later he continues:

'Of course, by saying all this, I am interfering in what is not my business, since this matter falls within the province of the Commissariat for Internal Affairs. Nevertheless, I feel I should point out the following abnormalities.

1. Landau has been in prison for a year and no result has yet been reached, which is an abnormally long time for the investigation to continue.

2. I am the director of the institution where he works, but I do not know at all what he is accused of.

3. Most important, Landau's mind has been denied for a year now, for some unknown reason, to both Soviet and world science.

4. He is in poor health, and if he should perish to no purpose, it will be a most shameful thing for us, the Soviet nation.

I therefore ask the Commissariat for Internal Affairs to pay special attention to speeding up the progress of Landau's case.'

Writing this letter, which was in essence a formal complaint against the Commissariat for Internal Affairs, called for a great deal of moral courage. On this occasion his reasoned approach made an impression, and Landau was released under Kapitza's personal guarantee.

In 1941 Landau published a theory of the superfluidity effect discovered by Kapitza. This was the fruit of their scientific collaboration begun in Cambridge. Superfluidity, discovered in liquid helium near absolute zero, was found to be a fundamental phenomenon in relation to the whole of modern physics. It occurs in nuclear physics in the properties of nuclei, and in astrophysics in neutron stars. For this theory, Landau was awarded the Nobel Prize in physics for 1962, and Kapitza had the same distinction in 1978 for his work on low-temperature physics. After the war, Landau took an active part in developing nuclear power in the USSR. Here he made a significant contribution to computation. He and others were the first to solve the problem of the stability of numerical methods for integration of the differential equations of hydrodynamics and heat conduc-

tion. For this work he was awarded the title of Hero of Socialist Labour. His research in quantum electrodynamics at high energies, the theory of phase transitions, and the theory of superconductivity have a permanent place in pl ysics.

Scientific activity was always vigorous around him. Every Thursday, theoretical physicists attended his famous seminars. There they would discuss the latest news in science; young physicists (and older ones too) would bring their latest work for his verdict. Anything which had passed the test of his critical mind had a mark of quality. Landau paid much attention to the young, and was always ready to discuss with them physical problems that interested them. His sharp and critical mind helped many young theoreticians to stand on their own feet. It was not by chance that everyone called him the Teacher. For teaching was his vocation. He taught a great deal at the Moscow Physicotechnical Institute and Moscow State University. He was much liked by the students, and lecture theatres were overflowing with those who wished to hear him.

At the height of his powers, Landau met with a tragic accident on the road. He lived for another six years, but was never able to return to scientific work. The way in which Landau's pupils and friends joined in the efforts that saved his life after the crash will always stand as a model of comradeship and noble endeavour.

Landau's contribution to modern theoretical physics was a great one. According to the annual listings published by one journal, he remains year after year the most quoted author in physics.

The school of Landau, represented not only by his pupils but also by a fresh generation of *their* pupils, has an important role in the development of theoretical physics. The Landau Institute of Theoretical Physics, an acknowledged centre for the subject, plays a significant part in continuing the traditions of the school of Landau.

Soviet theoretical physics is a leader in this area of world science, and to a large extent it owes that position to the fundamental contribution of Lev Davidovich Landau.

The Contributors

EVGENII M. LIFSHITZ (1915-85), theoretical physicist; Academician: close friend and pupil of Landau; joint author of the Landau-Lifshitz Course of Theoretical Physics

ALEKSEI A. ABRIKOSOV, theoretical physicist; Corresponding Member of the Academy of Sciences; department head at the Landau Institute of Theoretical Physics

ALEKSANDR I. AKHIEZER, theoretical physicist; member of the Ukrainian Academy of Sciences; department head at the Ukrainian Physicotechnical Institute

NIKOLAI E. ALEKSEEVSKII, experimental physicist; Corresponding Member of the Academy of Sciences; laboratory head at the Institute of Physical Problems

ÉLEVTER L. ANDRONIKASHVILI, experimental physicist; member of the Georgian Academy of Sciences; director of the Georgian Institute of Physics

VLADIMIR B. BERESTETSKII (1913–77), theoretical physicist; doctor of physical and mathematical sciences; professor; laboratory head at the Institute of Theoretical and Experimental Physics

HENDRIK CASIMIR, Dutch theoretical physicist; member of the Royal Netherlands Academy of Arts and Sciences; President of the European Physical Society 1972-5

DANIIL S. DANIN, writer

IGOR E. DZYALOSHINSKII, theoretical physicist; Corresponding Member of the Academy of Sciences; department head at the Landau Institute of Theoretical Physics

IMMANUIL L. FABELINSKII, experimental physicist; Corresponding Member of the Academy of Sciences; at the Lebedev Physics Institute

EVGENII L. FEINBERG, theoretical physicist; Corresponding Member of the Academy of Sciences; at the Lebedev Physics Institute

VITALII L. GINZBURG, theoretical physicist; Academician; department head at the Lebedev Physics Institute

VITALII I. GOL'DANSKII, physical chemist; Academician; department head at the Institute of Chemical Physics

LEV P. GOR'KOV, theoretical physicist; Corresponding Member of the Academy of Sciences; department head at the Landau Institute of Theoretical Physics

ZINAIDA I. GOROBETS, wife of E. M. Lifshitz

Boris L. Ioffe, theoretical physicist; doctor of physical and mathematical sciences; professor; section head at the Institute of Theoretical and Experimental Physics

Moisel I. Kaganov, theoretical physicist; doctor of physical and math-

ematical sciences; professor; at the Institute of Physical Problems

ISAAK M. KHALATNIKOV, theoretical physicist; Academician; director of the Landau Institute of Theoretical Physics

ABRAM K. KIKOIN, experimental physicist; doctor of physical and mathematical sciences; professor

ISAAK K. KIKOIN (1908-84), experimental physicist; Academician; deputy director of the Institute of Atomic Energy

ALEKSANDR S. KOMPANEETS (1914–74), theoretical physicist; doctor of physical and mathematical sciences; professor; department head at the Institute of Chemical Physics

Boris G. Lazarev, experimental physicist; member of the Ukrainian Academy of Sciences; department head at the Ukrainian Physicotechnical Institute

OLGA I. MARTYNOVA, professor at the Moscow Power Institute; wife of M. A. Styrikovich

RUDOLF E. PEIERLS, British theoretical physicist; emeritus professor of physics at the University of Oxford

JOHN R. PELLAM, American experimental physicist; professor of physics at the California Institute of Technology

VALERII L. POKROVSKII, theoretical physicist; doctor of physical and mathematical sciences; professor; department head at the Landau Institute of Theoretical Physics

YURII B. RUMER (1901–85), theoretical physicist; director of the Novosibirsk Institute of Radiophysics and Electronics

SERGEI M. RYTOV, theoretical physicist; Corresponding Member of the Academy of Sciences; department head at the Radio Engineering Institute IOSIP S. SHAPIRO, theoretical physicist; at the Lebedev Physics Institute

DAVID SHOENBERG, British experimental physicist; emeritus professor of physics at the University of Cambridge

YAKOV A. SMORODINSKII, theoretical physicist; doctor of physical and mathematical sciences; professor; laboratory head at the Institute of Atomic Energy

MIKHAIL A. STYRIKOVICH, power engineer; Academician; member of the Presidium, USSR Academy of Sciences

KAREN A. TER-MARTIROSYAN, theoretical physicist; doctor of physical and mathematical sciences; professor; section head at the Institute of Theoretical and Experimental Physics

YAKOV B. ZEL'DOVICH (1914-87), theoretical physicist; Academician; head of the theoretical physics department at the Institute of Physical Problems following the death of I. M. Lifshitz

E. M. LIFSHITZ

Lev Davidovich Landau (1908–68)*

Very little time has passed since the death of Lev Davidovich Landau of 1 April 1968, but fate wills that even now we view him at a distance, as at were. From that distance we perceive more clearly not only his greatness as a scientist, the significance of whose work becomes increasingly obvious with time, but also that he was a great-hearted human being. He was uncommonly just and benevolent. There is no doubt that therein lie the roots of his popularity as a scientist and teacher, the roots of that genuine love and esteem which his direct and indirect pupils felt for him and which were manifested with such exceptional strength during the days of the struggle to save his life following the terrible accident.

To him fell the tragic fate of dying twice. The first time it happened was six years earlier on 7 January 1962 when on the icy road, en route from Moscow to Dubna, his car skidded and collided with a lorry coming from the opposite direction. The epic story of the subsequent struggle to save his life is primarily a story of the selfless labour and skill of numerous physicians and nurses. But it is also a story of a remarkable feat of solidarity. The calamitous accident agitated the entire community of physicists, arousing a spontaneous and instant response. The hospital in which Landau lay unconscious became a centre to all those—his students and colleagues—who strove to make whatever contributions they could to help the physicians in their desperate struggle to save Landau's life.

'Their feat of comradeship commenced on the very first day. Illustrious scientists who, however, had no idea of medicine, academicians, corresponding members of the scientific academies, doctors, candidates, men of the same generation as the 54-year-old Landau as well as his pupils and their still more youthful pupils—all volunteered to act as messengers, chauffeurs, intermediaries, suppliers, secretaries, members of the watch and, lastly, porters and labourers. Their spontaneously established headquarters was located in the office of the Physician-in-Chief of Hospital No. 50 and it became a round-the-clock organizational centre

^{*} Written for the Russian edition of Landau's Collected Papers, and first published in Russian in Uspekhi fizicheskikh nauk 97, 169–183, 1969. This translation is by E. Bergman (first published in Soviet Physics Uspekhi 12, 135–143, 1969 and afterwards, with minor modifications, in L. D. Landau and E. M. Lifshitz, Mechanics, 3rd ed., Pergamon Press, Oxford, 1976), and is reprinted by kind permission of the American Institute of Physics. The reference numbers correspond to the list at the end of the article.

for an unconditional and immediate implementation of any instruction of the attending

physicians.

Eighty-seven theoreticians and experimenters took part in this voluntary rescue team. An alphabetical list of the telephone numbers and addresses of any one and any institution with which contact might be needed at any instant was compiled, and it contained 223 telephone numbers! It included other hospitals, motor transport bases, airports, customs offices, pharmacies, ministries, and the places at which consulting physicians could most likely be reached.

'During the most tragic days when it seemed that "Dau is dying"—and there were at least four such days—8-10 cars could be found waiting at any time in front of the seven-storey

hospital building. . .

'When everything depended on the artificial respiration machine, on 12 January, a theoretician suggested that it should be immediately constructed in the workshops of the Institute of Physical Problems. This was unnecessary and naive, but how amazingle spontaneous! The physicists obtained the machine from the Institute for the Study of Poliomyelitis and carried it in their own hands to the ward where Landau was gasping for breath. They saved their colleague, teacher, and friend.

'The story could be continued without limit. This was a real fraternity of physicists...'* And so, Landau's life was saved. But when after three months he regained consciousness, it was no longer the same man whom we had known. He was not able to recover from all the consequences of his accident and never again completely regained his abilities. The story of the six years that followed is only a story of prolonged suffering a 1 pain.

* * *

Lev Davidovich Landau was born on 22 January 1908 in Baku, in the family of a petroleum engineer who worked on the Baku oil-fields. His mother was a physician and at one time had engaged in scientific work on physiology.

He completed his school course at the age of 13. Even then he already was attracted by the exact sciences, and his mathematical ability manifested itself very early. He studied mathematical analysis on his own and later he used to say that he hardly remembered a time when he did not know differentiation and integration.

His parents considered him too young to enter a university and for a year he attended the Baku Economic Technicum. In 1922 he enrolled at Baku University where he studied simultaneously in two departments: Physico-mathematical and Chemical. Subsequently he did not continue his chemical education but he remained interested in chemistry throughout his life.

In 1924 Landau transferred to the Physics Department of Leningrad University. In Leningrad, the main centre of Soviet physics at that time, he first made the acquaintance of genuine theoretical physics, which was then going through a turbulent period. He devoted himself to its study with all his youthful zeal and enthusiasm and worked so strenuously that often he became so exhausted that at night he could not sleep, still turning over formulae in his mind.

^{*} From D. Danin, Literaturnaya Gaseta, 21 July 1962, reprinted in this volume (p.84).

Later he used to describe how at that time he was amazed by the incredible beauty of the general theory of relativity (sometimes he even would declare that such a rapture on first making one's acquaintance with this theory should be a characteristic of any born theoretical physicist). He also described the state of ecstasy to which he was brought on reading the articles by Heisenberg and Schrödinger signalling the birth of the new quantum mechanics. He said that he derived from them not only delight in the true glamour of science but also an acute realization of the power of the human genius, whose greatest triumph is that man is capable of apprehending things beyond the pale of his imagination. And of course, the curvature of space—time and the uncertainty principle are precisely of this kind.

In 1927 Landau graduated from the university and enrolled for postgraduate study at the Leningrad Physicotechnical Institute where even earlier, in 1926, he had been a part-time research student. These years brought his first scientific publications. In 1926 he published a theory of intensities in the spectra of diatomic molecules,* and as early as 1927, a study of the problem of damping in quantum mechanics, which first introduced a description of the state of a system with the aid of the density matrix.

His fascination with physics and his first achievements as a scientist were, however, at the time beclouded by a painful diffidence in his relations with others. This trait caused him a great deal of suffering and at times—as he himself confessed in later years—led him to despair. The changes which occurred in him with the years and transformed him into a buoyant and gregarious individual were largely a result of his characteristic self-discipline and feeling of duty toward himself. These qualities, together with his sober and self-critical mind, enabled him to train himself and to evolve into a person with a rare ability—the ability to be happy. The same sobriety of mind enabled him always to distinguish between what is of real value in life and what is unimportant triviality, and thus also to retain his mental equilibrium during the difficult moments which occurred in his life too.

In 1929, on an assignment from the People's Commissariat of Education, Landau travelled abroad and for one and a half years worked in Denmark, Great Britain and Switzerland. To him the most important part of his trip was his stay in Copenhagen where, at the Institute of Theoretical Physics, theoretical physicists from all Europe gathered round the great Niels Bohr and, during the famous seminars headed by Bohr, discussed all the basic problems of the theoretical physics of the time. This scientific atmosphere, enhanced by the charm of the personality of Bohr himself, decisively influenced Landau in forming his own outlook on physics and

^{*} He did not know, however, at the time that these results had been already published a year earlier by Hönl and London.