Journal of Statistical Physics, Vol. 38, Nos. 1/2, 1985

Ilya Mikhailovich Lifshitz

Ilya Mikhailovich Lifshitz, one of the world's foremost theoretical physicists, who made a decisive contribution to modern quantum physics of the condensed state, died on 23 October 1982 at the age of 65. Although his death was the aftermath of a grave heart condition, he worked till his last day. The memorial issue of the journal devoted to him opens with a paper written between attacks of disease. In the hospital and at home a few days before his death he rewrote certain chapters of his *Introduction to the Theory of Disordered Systems* for an English-language edition of the monograph.

Lifshitz devoted all his life to theoretical physics. Displaying a gift for mathematics and theoretical physics even at school, he made an early start in creative activities: his first independent works date back to his student years. A 1935 issue of the Kharhov Institute of Mechanical Engineering

(Photograph taken by Dr. Joaquim M. Luttinger on May 24, 1961, while attending a meeting in Odessa, U.S.S.R.)

0022-4715/85/0100-0003$04.50/0

Journal carried his first paper, "On Determining a Minimal Surface by a Given Spherical Image of its Plane Contour." In those years he was more interested in pure mathematics. In 1936 and 1937 two more mathematical works appeared in the same journal, and in 1937 he published his first paper on theoretical physics, "On the Kinetic Theory of Phase Transitions." In 1939 Lifshitz defended his candidate dissertation, "On the Theory of Solid Solutions," followed two years later by his doctoral dissertation, "The Theory of Optical Behavior of Non-Ideal Crystal Lattices in the IR Region." Forever after, Lifshitz preserved this interest in phase transitions and disordered systems, which are among the most challenging objects for scientific research.

The modern dynamic theory of solids is the theory of real crystals, which contain impurities, dislocations, and other imperfections. Lifshitz's research has done much to promote the development of this currently interesting field of physics. He was the first to analyze the photon and electron spectra of crystals with defects, discovering, among other things, the local levels. The approach to the problem that he developed and his mathematical formalism still constitute the basis for all research in this area.

One of the fundamental problems in solid state physics is that of determining the energy spctra of solids. Lifshitz originated the idea of reconstructing the energy spectrum from experimental data and laid the foundation for a possible solution of this problem based on the idea of quasiparticles—bosons and fermions—that are the elementary motions of atomic and subatomic particles in the solid. He showed that it is possible, in principle, to reconstruct the Bose branches from the temperature dependence of the thermodynamic characteristics. Reconstruction of the Fermi branches of the spectra of metals (the dispersion law of conduction electrons) proved to be a much more difficult problem and required the development of a research program on subtle effects in magnetic fields. The work of Lifshitz and his pupils on the electron theory of metals completely revolutionized this vigorously developing field of solid state physics. The most visible recognition of a scientist's work is practical assimilation and development of his achievements and discoveries. The geometric language used to formulate the results—the language in which everyone concerned with the physics of metals thinks—was developed in its entirety by Lifshitz and his pupils. A kind of spectroscopy of metals that uses the properties of metals in a strong magnetic field has emerged and is being developed actively. Today, we are as familiar with the electron energy spectra of metals as we are with the spectra of atoms and molecules.

The great interest shown in the study of quantum crystals of solid helium has arisen largely out of the fundamental results obtained by Lifshitz. He demonstrated that two types of motion, characteristic of solids and

liquids, are possible in quantum crystals, so that one can speak about a unique state of matter intermediate between liquid and solid. According to Lifshitz, defects and impurities in quantum crystal behave as free quasiparticles, thereby producing the quantum diffusion phenomena. Quantum diffusion has now been observed experimentally.

As we have already said, Lifshitz was always deeply interested in the theory of phase transitions. He predicted the peculiar phase transitions known as transitions of "order two and a half," which are related to the rearrangement of the Fermi surface of a metal. He also explained the highly specific kinetics of second-order phase transitions and the kinetics of transitions of metals from the superconducting to the normal state in a magnetic field. Lifshitz developed a theory of first-order quantum transitions at low temperatures when quantum tunneling processes, rather than the usual thermal-activation mechanism, play the principal role in the nucleation of a new phase.

His interest in the theory of phase transitions naturally led him to phase transitions in polymers. As usual, in this area, too, Lifshitz developed a fundamentally new approach based on the profound physical idea of regarding a polymer chain as a partial equilibrium statistical system with bulk interaction and linear memory. His works on the subject oriented to the physics of biopolymers are the focus of keen attention of specialists in polymer physics and in biophysics.

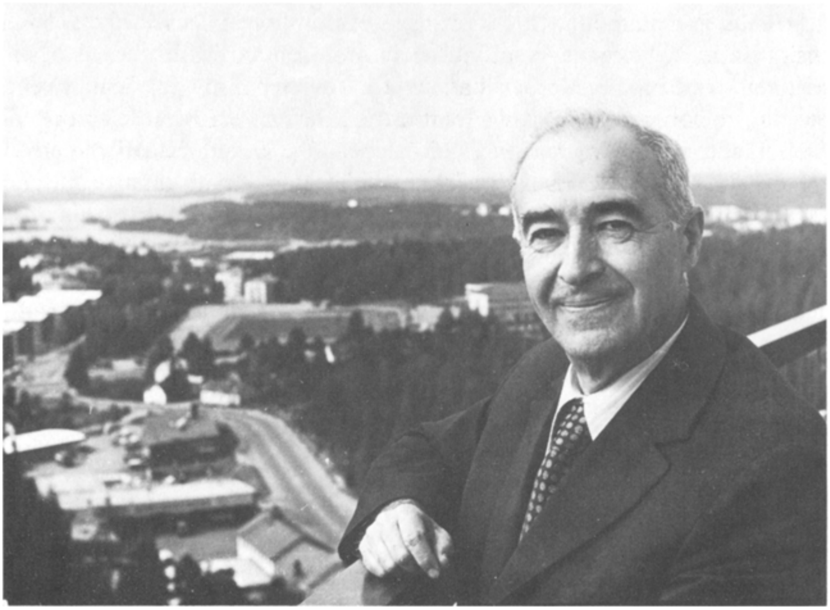
This brief record of achievements is by no means a sum total of Lifshitz's life work. The rapid progress in solid state physics is closely associated with his name. The scientist and his school always remained in very close contact with experimentalists. It is no exaggeration to say that his work reshaped the quantum theory of solids, stimulated new experiments, and breathed new life into traditional ones.

Looking back, we can now understand how bold Lifshitz was to undertake research which brought him world renown: pioneering work on quantum mechanics of disordered systems, at a time when theoreticians were afraid to touch upon this topic; the theory of galvanomagnetic effects of real anisotropic metals, at a time when the experimental data available were seen as "boring zoology"; and, finally, the physics of polymers and biopolymers, at a time when biophysicists failed to discern their unique physical properties but were interested only in the particular mechanisms of functioning of individual biopolymers.

Lifshitz had a splendid mastery of subtle mathematical methods. Never returning to mathematics for its own sake after his student years, he nevertheless always found an adequate mathematical apparatus for solving truly difficult problems posed by theoretical physics. These findings, in turn, enriched the corresponding branches of mathematics. Having an amazing intuition, he easily grasped the latest tools of theoretical physics and was at home with them. Everyone who came in contact with him was astonished at his unbounded range of grasp in physics.

Lifshitz never confined himself to narrow bounds of computational theoretical physics in tackling practical problems involved in the development of a new technology, such as zone melting of metals, or of a new device, such as the diffusion pump. All his life he was attracted to fundamental problems, the last few years being marked by a special interest in the functioning of living organisms, biological evolution, and related problems. Although Lifshitz had no publications on these topics, he repeatedly discussed them with biophysicists, who were fascinated by this insights into problems on the borderline of physics and biology.

Lifshitz had an amazing gift for revealing theoretical depths in narrow, seemingly dull, problems, such as the diffuse-viscous flow of solids. True, there are other physicists who easily reduce the practical problem at hand to



manageable proportions and apply the rule of thumb to explain or predict results, but frequently such quick-fix techniques simply do not work. Lifshitz could elevate a problem to the theoretical level and find a solution which often called for a tailor-made mathematical formalism. The abundance of results, as a rule unexpected ones, always justified the efforts. A striking example of this approach is the theory of coalescence.

Lifshitz always regarded himself as a member of the Landau school, to whom he was linked by many years of scientific and personal friendship. Lifshitz had many pupils. He was not only a brilliant scientist but also a wonderful teacher. His keen mind and deep insights enabled him to give a useful advice on the diverse research conducted by his pupils. Never the one to assert his personality, Lifshitz enjoyed authority because his guidance was always sound and to the point: he set tasks, pointed out nontrivial solutions, and showed the best way of overcoming a difficulty. His critical remarks, no matter how severe, never gave offence. He had the knack of criticizing without reflecting on the worth of the object of criticism. One could frequently see how, after a "consultation" which had shot the topic full of holes, the author left Lifshitz in excellent spirits, full of hope and plans. Although Lifshitz headed a large research staff, he never put subordinates on the carpet for poor performance. He felt that since capacity for creative work is, to a large extent, an inborn quality, criticizing a person for lack of scientific results is tantamount to criticizing a person for physical defects. By the same token, an elegant result, especially if obtain with the help of a nontrivial mathematical procedure, was a source of joy for him. Even in everyday routine work he could frequently find that "extra little something" which made it more interesting and appealing. Unquestionably, personal contact with Lifshitz stimulated his pupils to maximal performance, although it would be difficult to explain how exactly he succeeded in it: this is one of the secrets of this personality.

Lifshitz spent several decades of creative and teaching activities at Kharkov. It is therefore natural that most of his pupils, whose scientific activity has not abated since he moved to Moscow in 1969, should be concentrated there. It is Lifshitz's pupils who are responsible for the high level of solid state theory at Kharkov and who make Kharkov one of the centers of theoretical physics.

Since 1969 Lifshitz headed the theoretical division of the Insitute for Physical Problems of the USSR Academy of Sciences and taught at the Moscow State University Physics Depatment, where he organized the Solid-State Physics speciality and guided it to maturity.

Lifshitz's breadth, his kindness and benevolence, uncompromizing rigor yet unoffending uprightness, and his easy accessibility attracted many to him. In his office one could meet all kinds of people: a metallurgical engineer, a biologist, a mathematician, and, of course, a theoretical physicist. When one listened to him speak with passion and complete immersion in the subject, it was difficult to believe that what was discussed was somebody else's problem. He never refused advice even to persons who hardly knew him and came to him for the first time.

The scientific community recognized Lifshitz's achievements: in 1948 he was elected corresponding member, and in 1967 a full member of the Ukrainian Academy of Sciences. In 1960 he was elected corresponding member and in 1970 full member of the USSR Academy of Sciences. In 1952 he was awarded the Mandelshtam Prize of the USSR Academy of Sciences, in 1962 the Simon Prize of the British Physical Society, and in 1967 the USSR Lenin Prize. In 1982 the U.S. National Academy elected Lifshitz its Foreign Associate.

Complacency and self-importance were alien to him, and his spirit was always in turmoil, keenly interested in the world, in its cares and burdens.

Those who knew him were used to his compassion: his first response to someone else's trouble was to ease, to help in all possible ways. And he did ease and help, though at the expense of his health and time. Many people remained grateful to fate for bringing them together with Lifshitz.

In a short article it is difficult to draw a portrait of a man true to the original. Mere enumeration of features produces a portrait of a standard scientist, rather than of a charming person with a sparkle to his eye, with a keen sense of humor, and capable of seriously discussing the latest movie.

Lifshitz was also one of the major philatelists of the world. He achieved in stamp collecting the same high degree of professionalism as in science. When friends appreciated his collection, this was a source of special pleasure for him.

Important people have been known to feign democracy. Lifshitz's democratism was natural and sincere; it was a continuation of his intellectualism. He was equally polite with an interlocutor of any rank. On the other hand, he respected others' success, for in his view success added to one's personality. This, however, did not prevent him from accurately assessing a persons's real worth.

Lifshitz was a very kind person. Although his kindness was immutable, it never degenerated into weakness of character or unprincipledness. His sympathies and antipathies were always clear-cut and unambiguous. His pronouncements on research works were espcially straightforward: he defended works which he considered to be sound, and criticized those which he held to be wrong. What he said was far from pleasing everyone at all times, but he could not stay silent when he thought that going on record was called for.

There was much of a child in him. His friends and relatives used to call him Lyola, an affectionate dimunitive form of his first name. Vulnerable like a child, he carried scars of rudeness and injustice on his overworked heart. We often forgot about this and did not protect him.

Lifshitz enjoyed the well-deserved love of all.

* * *

More than one year has passed after Lifshitz's death. Those who knew him well still feel the emptiness left by his departure, time has not yet healed the wound left by this loss. This issue of the *Journal of Statistical Physics* is meant as a tribute to Lifshitz, who did so much to develop this science.

M. I. Kaganov