Physics – Uspekhi **40** (2) 225 – 226 (1997)

FROM THE HISTORY OF PHYSICS PACS number: **01.60 + q**

Il'ya Mikhaiĭlovich Lifshits (on the 80th anniversary of his birth)

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His life was not sparkled with great events;
great events occurred in his mind.
L Boltzmann

The name of Il'ya Mikhailovich Lifshits is closely associated with the evolution and advancement of the condensed matter physics. He was among the founders of this field in its present-day sense, which encompasses not only the traditional physics of solids, the physics of crystals, but also the physics of disordered and amorphous bodies, quantum crystals and liquids, liquid crystals, polymers, and particularly importantly, the physics of biological systems.

Recently, the collected works of Lifshits were published. They cover disordered systems, real crystals, the electron theory of metals, quantum liquids and quantum crystals, polymers, and biopolymers.

In all of these areas, Lifshits made important contributions leaving a remarkable footprint on science. In many cases, Lifshits's research gave rise to wholly new areas in the physics of condensed matter. Especially impressive examples are the theory of quantum crystals and the theory of disordered systems.

It is notable that the quantum crystal as a special state of matter was discovered by Lifshits and Andreev in the sixties 'on the tip of a quill', as the saying goes. Following their discovery, quantum crystals became the subject of active studies for many theoreticians and experimentalists.

The theory of disordered systems and the allied theory of real crystals took a special place in Lifshits's creativity, if only because he pursued this theme throughout his life. His first paper on the topic saw the light of day in 1937, and his last was published in the issue of *Journal of Statistical Physics* dedicated to his memory (1985, vol. 38, no. 12, pp. 37-63). In the year of his death, a monograph appeared in print: I M Lifshits, S A Gredeskul, and L A Pastur, *An Introduction to the Theory of Disordered Systems* (Moscow: Nauka, 1982, 360 pp.), which summed up his activity in this area. It would be no exaggeration to say that Lifshits was among those whose labours made this field one of the major divisions of theoretical physics, within only a generation. Lifshits's works advanced many fundamental concepts of this new science and created a language now universal in the theory of disordered systems.

It will suffice to mention fundamental achievements, such as the theory of local perturbations, the origin and properties of impurity bands, studies into the behavior of the density of states near the boundaries of energy bands, and research on the role of fluctuation levels and the passage of particles through randomly inhomogeneous media.

Uspekhi Fizicheskikh Nauk **167** (2) 239 – 240 (1997)
Translated by B V Kuznetsov

Il'ya Mikhaiĭlovich Lifshits
(1917 – 1982)

In such a classical and fundamental area as the kinetics of first order phase transitions, the credit goes to Lifshits and Slezov for the theory of growth and evolution of nucleation centers, now widely quoted in diverse works covering physical metallurgy to biophysics.

In the mid-1960s Lifshits turned to polymers and biopolymers and soon became one of the world's leaders in the modern physics of these materials. He proposed an in-depth and exceptionally fruitful approach to their physics based on the view that these materials are partial equilibrium systems. Coupled with works of teams headed by P de Gennes and S Edwards, this idea made the theory of polymer and biopolymer systems into one of the most dynamic areas of physics.

It was Lifshits and his disciples who largely built the electron theory of metals as we know it today. Their research provided the basis for a new area which has come to be known as fermiology. It was born when Lifshits and Kosevich had their paper *On the Theory of the de Haas–van Alphen Effect for Particles under an Arbitrary Dispersion Law* published in the journal *Doklady Akademii Nauk SSSR* (1954, vol. 96, no. 5, pp. 963-966). An advantage of fermiology is that it integrates a geometrical language and geometrical patterns into the electron theory of metals. Anyone involved with the electron theory of metals speaks and thinks in terms of Fermi sections, diameters, and surfaces, and accepts the difference between points and lines on a Fermi surface. Lifshits predicted the existence of a kind of topological transition in normal metals, traceable to changes in the connectivity of a Fermi surface under the action of hydrostatic pressure, and later this transition was discovered.

Today, the energy structure of almost all monatomic metals and many intermetallic compounds has been fully deciphered, atlases of Fermi surfaces have been compiled, and the huge wealth of knowledge about the structure of Fermi surfaces is gradually being put to use.

Lifshits was always attracted to inverse problems. In particular, as early as 1954 Lifshits came up with, for the first time ever, a rigorous mathematical statement of the inverse problems for the recovery of both the Bose and Fermi branches of the energy spectrum of a macroscopic body.

Lifshits' ability to unravel the theoretical physical essence in an area traditionally distant from theoretical physics, to formulate the problem rigorously, and to find, or sometimes to develop, the mathematical tools necessary to solve the problem he himself had formulated — all of this drew metal scientists, biologists, chemists, and mechanicians toward him. Lifshits knew how to communicate (to understand and to be understood) both with mathematicians who highly valued his intuition in rather abstract fields of mathematics, and with engineers whom he helped to tackle applied tasks. He shared his ideas both easily and lavishly.

Except in his early studies done before 1937, Lifshits never busied himself with 'pure' mathematics. Nevertheless, mathematics figured prominently in his activities. He had a perfect command of it and had, as already noted, a remarkable intuition which helped him to develop new mathematical tools adequate to solve new theoretical-physical problems. Being nontrivial, 'Lifshits mathematics' attracted professional mathematicians and sometimes stimulated the development of new sectors of mathematics. In the Landau school, Lifshits was reputed as an expert in mathematical problems.

Those who never met Lifshits may be helped by these words. Lifshits had an immense passion for science and achieved great results in it. He sought them until the very end of his life. Although he avoided the almost ubiquitous aping of youth's fashion, he made, among scientists, the impression of a talented and inquisitive young man, but remained Teacher to most of them. Lifshits was liked very much. No less important, he knew how to stimulate in a person the traits and features that person liked in himself or herself most of all. Nobody could resist his charm, but fortunately, this need never be done. It is very difficult to write about Lifshits a standard piece 'on the occasion': simply, he was a remarkable person and an outstanding physicist.