

# Petr Leonidovich Kapitza

E M Lifshitz

The ninetieth anniversary of the birth of Petr Leonidovich Kapitza and the fiftieth anniversary of the Institute of Physical Problems that he founded are events which are unique to our physics, as are unique the personality of Kapitza himself and his achievements.† The main facts from the biography and activities of Petr Leonidovich Kapitza are well known in the physics world: books and articles have been written about Kapitza (which he admitted he never read); for the same reasons articles have appeared about Petr Leonidovich in *Uspekhi Fizicheskikh Nauk*. It is therefore more appropriate not to repeat these facts, but to attempt to stress those characteristics which make Kapitza's position and role exceptional in the development of Soviet and world physics.

Undoubtedly, the most outstanding feature of Kapitza's character and personality are the will and steadfastness in the realisation of his principles and convictions. In relation to organisation of scientific research, training of scientists, and the relationship between 'pure' science and its applications, these principles were laid out by Petr Leonidovich himself in his well-known book *Experiment: Theory: Practice*. However, in the adherence to once-and-for-all established principles, Kapitza does not imply dogmatism. As years and decades pass, the face of science unavoidably changes and there are consequent changes in the actual applications of Kapitza's principles. Although in 1943 he wrote that "good work cannot be done using somebody else's hands", in the sixties and seventies he stressed also the role of a scientific leader and organiser as a consequence of the increase in complexity of experiments.

In his own scientific work Kapitza obeyed these principles fully throughout his life. The majority of his scientific papers have only himself as the author. Among others, one of his coauthors of a theoretical paper was Dirac (1933): the subject was reflection of electrons from a standing optical wave! Kapitza's main scientific discoveries were almost literally the work of his own hands. Moreover, he never carried out experiments based on somebody else's ideas. For example, if an experiment close to his work was proposed by a theoretician, its performance was entrusted to one of Kapitza's collaborators. This may not be so much the consequence of the general principles, as of Kapitza's

own character. This feature of his style of work is probably the reason why he published relatively few (according to current ideas!) scientific papers: they number 78, which excludes journalistic and popular articles. However, each of them does indeed put forward something new.

The constancy of Petr Leonidovich applies to not only his beliefs and principles, but also to aspects of his character. His character is best described by the Russian word *krutoi*, which means stern. Kapitza has not softened with time or at least he did not in the last 50 years. However, this sternness should in no way be regarded as self-importance: in the usual sense of the word, there is no self-importance at all in Kapitza's character. He is approachable: in fact, Petr Leonidovich is possibly one of the most approachable to his staff among all the directors of research institutes. True, it is not always easy to talk to the Director: Petr Leonidovich always knows exactly what he wants and what he does not want. In the latter case he will say "no" without any beating about the bush; however, if he says "yes", one can be sure that he will keep his promise.

Kapitza probably has no direct disciples (in the literal sense of the word) and this is another aspect of the style of his own scientific work. However, this does not minimise the colossal contribution which he has made to the training of new generations of physicists. With this in mind, he has paid attention right from the beginning to the subject of the personnel policy in the Institute which he founded: a considerable proportion of the scientific staff should be temporary; students, trainees, postgraduates, and scientists from other institutes on temporary assignment should pass through the Institute. In this way the training role of the Institute of Physical Problems has spread far outside its walls. The whole scientific atmosphere established at his Institute by Petr Leonidovich is of pedagogical significance: in this sense all his collaborators are his pupils. Throughout the time that Kapitza has led the Institute, not one paper (at least not a single experimental paper) has been published without a discussion involving Kapitza himself. For many years this was done at the weekly seminar in the Director's study. With time, the natural (although continuously hindered) growth of the Institute made it necessary to transfer such discussions to a larger forum of the Scientific Council.

The pedagogical activities of Kapitza have extended also to university teaching: he was one of the main initiators and inspirers of the Technical Physics Department of the Moscow State University, which he established in 1946 and which soon became the Moscow Physicotechnical Institute. Over time, he presented a general course of physics in this Department together with L D Landau:

†This article was written by E M Lifshitz (1915–1985) on the ninetieth anniversary of P L Kapitza's birth. However, it was not published because of the death of Petr Leonidovich. (Note by P E Rubinin.)



Meeting of the Editorial Board of *Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*. From left to right: Z. P. Bunakova, E. M. Lifshitz, A. M. Prokhorov, M. A. Leontovich, P. L. Kapitza, E. L. Andronikashvili. Sitting with his back to the camera: V. P. Dzhelepov. End of the 1970s (photograph by Yu. G. Zaenichik).

Kapitza's lectures dealt with selected topics and outstanding experiments, whereas Landau presented a systematic course. Unfortunately, Kapitza's lectures were not recorded at the time.<sup>†</sup> There is however a remarkable collection of problems which over many years Kapitza thought up for postgraduate examinations, which he always conducted personally.

Here is the list of the most important of the scientific achievements of Kapitza:

- a new method for the generation of very high magnetic fields (1924);
- the discovery of the linear dependence of the electric resistance on the magnetic field (1928–1929);
- a new productive method for the liquefaction of helium (1934);
- the discovery of superfluidity of liquid helium (1938);
- the discovery of two forms of motion in liquid helium (1941);
- the discovery of a temperature jump between liquid helium and a solid wall (1941);
- the development of an expansion turbine method for the liquefaction of air and new methods for industrial separation of oxygen (1936–1946);

<sup>†</sup>P. L. Kapitza's archive includes shorthand reports of almost all the lectures presented by Petr Leonidovich at the Technical Physics Department of the Moscow State University in 1947–1949. These lectures are currently being prepared for publication by the Moscow Physico-technical Institute. (Note by P. E. Rubinin.)

- new types of high-power microwave oscillators (1950, 1962);
- generation of a very powerful hf filamentary discharge (1969).

The list does not need any special comments: the meaning of these discoveries and inventions is well known to physicists. However, this list reveals one other unique feature of Kapitza as a scientist: he is one of the very few (if not the only one) who is both an outstanding experimental physicist and a talented engineer. He has frequently called himself an engineer and has written about his engineering passion. It was this passion that ensured that Petr Leonidovich did not stop at the introduction (or as he preferred, the mastering) of his own method for the production of liquid oxygen, following the usual administrative channels, but himself continued further development of this method on an industrial scale.

The greatest scientific achievement of Kapitza, which is of permanent importance, is undoubtedly the discovery of the superfluidity of liquid helium and a detailed study of its properties. His investigations, carried out in an unusually comprehensive manner, have provided the basis for the development of a theory of superfluidity by Lev Davidovich Landau. Two papers of Kapitza presenting his experimental results and a theoretical paper of Landau were published in the same (eleventh) volume of *Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki* in 1941. Without question, they must be regarded as classical papers in physics. They announced the birth of a new branch of

physical sciences, which is the physics of quantum liquids. The history of these discoveries is an example of what success can come from the combination of a great experimentalist with a great theoretician.

Petr Leonidovich was awarded the Nobel Prize for ‘fundamental inventions and discoveries in the physics of low temperatures’, but it took the Nobel Prize Committee 40 years to recognise Kapitza’s work. This was accompanied by a unique event in the history of the Nobel Prizes: the laureate presented his traditional lecture not about the subject for which the Prize was given. Kapitza began his lecture by stating that the work for which he was honoured with the Prize had been done a very long time ago, that he has managed to forget his work completely, and that he would therefore speak about the subjects that he was working on currently. He then read a lecture on his research on plasma physics.

I have already mentioned the cooperation between Kapitza and Landau. I must stress also that physics owes to Petr Leonidovich the fact that Landau could fully develop his talents at Kapitza’s Institute and that the Institute became Landau’s home. There were difficult times in Landau’s life and he was helped at those times by the courage of Petr Leonidovich. Landau never forgot this.

There were also difficult years in Petr Leonidovich’s life and in those years the strength of his will and character were perhaps displayed most strongly. Prevented from continuing his work on low-temperature physics, he found the strength, the resolution, and the skill to create out of almost nothing a small laboratory in which he studied the hydrodynamics of thin liquid layers and then high-power electronics. A short paper of Kapitza belongs to this time (1951): I want to mention it, not so much because of its importance, but as a demonstration of Kapitza’s interests and capabilities. This paper is purely mathematical and he was able to find (in the course of his calculations related to electronics) something new in a subject that would seem to be thoroughly investigated in every way: the theory of Bessel functions!

From the end of 1955, Petr Leonidovich has been, without interruption, the Editor of *Zhurnal Eksperimental’noi i Teoreticheskoi Fiziki (ZhETF)*. Faithful to his own nature, he began with the development of the main principles which the editorial team should follow as a general policy and in their daily work. These principles were formulated in the specially composed *Rules for ZhETF*. They have remained basically unchanged, but have not become a dogma. The *Rules* have been subsequently modified and supplemented by numerous resolutions of the Secretariat of the Editorial Board, and carefully noted in the minutes of its meetings. Over many years Petr Leonidovich has himself chaired (every two weeks) the meetings of the Secretariat and only after some time he found it possible to move away somewhat from the current editorial work.

Naturally, physics and his own work in physics represent the mainstream of the life of Petr Leonidovich Kapitza. However, it has not been his only activity. He has become interested, to an increasing extent with the passing years, in the problems of mankind, such as the future of science in general, conservation of the environment and natural resources, the energy crisis, and even the problem of organisation of leisure time. Foremost among these inter-

ests are naturally the maintenance of peace on earth and the avoidance of the nuclear catastrophe. It is particularly important to mention the suggestions and activities of Petr Leonidovich in these fields, since they are founded on the authority and legend surrounding his name.

Aleksandr Iosifovich Shal’nikov has worked at the Institute of Physical Problems since its inception. Let us conclude with Shal’nikov’s words:

“Some time ago Petr Leonidovich, while still young, called his favourite teacher Rutherford ‘the crocodile’ for his stubbornness in moving only forward. Petr Leonidovich himself should be compared, because of his stubbornness and strength, only with a bulldog—known to pay, under appropriate conditions, no attention to any obstacles and to maintain his grip.

“Petr Leonidovich does not ask anybody for advice, listens to nobody, always does as he wants and as he has decided. He can see only the target he has set himself and attains it, while everybody around him says that the target is impossible to reach. Such is Petr Leonidovich and his bulldog grip.

“Kapitza is the Director of a tiny Institute of Physical Problems, which he has established and in which all the experimentalists and theoreticians of the Soviet Union would like to work and nobody wants to leave it.”