

*PETR NIKOLAEVICH LEBEDEV AND THE TRAINING OF RESEARCH SCIENTISTS**

N. A. KAPTSOV

Usp. Fiz. Nauk **77**, 583-588 (August, 1962)

PETR Nikolaevich Lebedev's tremendous achievements in the field of scientific research are generally known. That he was one of the outstanding physicists of his time is not subject to question. But there was yet another aspect to this remarkable man's activities which was extremely important but which is often forgotten or underestimated. In addition to being a highly gifted scientist, who combined profound insight with extraordinary experimental skill, Lebedev also organized large-scale collective research in physics. He was one of those scientists who not only advanced science by their own efforts but who induced the younger generation to take part in that work. It was his dearest dream to hand down to his students his method of scientific and creative thinking, and to make of them scientists who would be able to meet the country's practical requirements. He embraced this task with the same enthusiasm and love as he did his own scientific investigations. Lebedev's many-sided activities were cut short by his untimely death. Nevertheless, what he was able to do for the training of qualified research physicists in our then backward country is of tremendous importance in our own time, when, owing to the unremitting care of the Government and the Communist Party, all the necessary conditions have been created for the development and advancement of science in the Soviet Union and when progress in all branches of physics is closely related to that rapid growth of technology which is an essential prerequisite for the advent of the communist society.

Having received the degree of doctor of philosophy from Strasbourg University in the summer of 1891, Lebedev returned to Moscow and was there given an opportunity to work on a series of experimental projects of his own at the physics laboratory established by A. G. Stoletov in Moscow University for student practice. We are all aware of the difficulties Lebedev encountered in organizing a research team in this laboratory and setting up an apparatus-building shop. We all know, too, of the fame Lebedev earned when he completed the basic stage of his project series and reported at the World Congress of Physicists in Paris in 1900 that he had confirmed by experiment the pressure of light on solids. Even at that early period of his research activity, Lebedev began to recruit disciples from among the senior students. In 1896 P. B. Leïberg published a report on research into the attenu-

ation of acoustic resonators, which he had carried out on Lebedev's instructions, in connection with Lebedev's own study of the ponderomotive effect of acoustic modes on resonators. In 1896 Torichan Pavlovich Kravets, later corresponding member of the Academy of Sciences of the U.S.S.R. also began to work in Lebedev's laboratory, while Andreï Robertovich Kolli, later professor at Warsaw University, joined the group in 1899. Lebedev asked Kolli to investigate the behavior of the dielectric constant in high-frequency fields by studying the propagation of short electromagnetic waves in Lecher wires immersed in a liquid. This was the first time Lebedev set his students a problem connected with electromagnetic waves and the behavior of matter incident to their passage. This project and other projects in the same field, which Lebedev's students carried out later, were closely related to his study, "Double refraction of electric force beams" (1895), in which he investigated the behavior of 6 mm Hertzian waves and succeeded in obtaining electromagnetic oscillations with a wavelength of 3 mm. Lebedev's discovery of the pressure of light on solids was also reflected in the research projects in which beginning physicists engaged in those years under his direction. Inspired by his general broad knowledge of physics, Lebedev came to the conclusion, later substantiated mathematically by Rayleigh, that waves of every kind must exert a pressure on any body blocking their propagation. Accordingly, in 1901 he suggested that V. Ya. Al'tberg measure the pressure of acoustic waves. Al'tberg carried out the investigation successfully, while V. D. Zernov, under Lebedev's guidance, made use of acoustic pressure in building an instrument for determining the strength of sound in absolute units. In 1902 the present writer was told by Lebedev to detect and measure experimentally the pressure of waves moving on the surface of water. All those projects were carried out in the old Stoletov student laboratory. The equipment was disposed on the same tables on which the regular student lab equipment had been installed, and research work could be done only after 3 o'clock, when the students were out of the way.

In those years, Lebedev recruited his assistants from among the regular lab course students. He watched those who he knew intended to specialize in physics. When he happened to drop in during their lab hours, he would engage such students in conversation, in order to determine how intelligently they were carrying out the experiments required of them, what their general level of culture was, and what understanding they had of physics problems. When-

*Report presented at the Physics Institute of the U.S.S.R. Academy of Sciences at its meeting of March 12, 1962, commemorating the 50th anniversary of Lebedev's death.

ever he happened on a young man with the proper qualifications, Lebedev would invite him to carry out a "special project" under Lebedev's direction. He thus exercised the same kind of selection which now takes place before a student is allowed to work for the degree of candidate of science. His general courses, which in those years he taught with great enthusiasm ("Problems of contemporary physics", "Passage of the electric current through gases", etc.) were designed to arouse on the part of his students a desire to engage in scientific research and to give them an idea of the problems encountered and the methods used. In those courses, and in his conversations in the laboratory, Lebedev repeatedly warned the students not to take on faith everything they found in their fat textbooks. He felt that textbook writers tended to present their material too glibly, glossing over contradictions and obscurities, and therefore failed to stimulate independent scientific thought and research. He often said: "When starting on a research project, don't take as your point in departure what you find in some thick textbook; start from the original studies on the question you intend to investigate."

A new building for the Physics Institute was erected in 1904 in the courtyard of the old university building (Mokhovaya, No. 11). Lebedev was given a private laboratory in this building, consisting of two large rooms on the second floor and a semi-basement area for work carried out under his direction. This became the well-known "Lebedev basement." Lebedev chose the basement premises deliberately, feeling that it was better protected from oscillations than any other part of the building. Although at first the equipment was very scant, while packing boxes frequently made do for tables, this was a real research laboratory, entirely separate from the student lab. Researchers could work there at any time of day or night, without interfering with others. The largest room was equipped as a shop, with a lathe, a big vise and an assortment of tools. According to Lebedev's idea, his students had to build their own equipment in this shop. He considered it essential for every experimental physicist to acquire mechanical skills. Only in the case of some particularly complicated equipment were the services of the mechanic who worked in Lebedev's own laboratory enlisted. There was no glass blower either. Every researcher had to learn to prepare and assemble his own glass equipment.

From now on, Lebedev arrived at the university daily at 11 in the morning, went down into the basement and made a round of the different rooms, speaking with each of the research workers in turn, often at length. In these talks he made no distinction between some student who was beginning his first investigation and a man who had worked in research for several years.

He expected each one of his students to be able to report intelligently on what he had done so far. He would censure them, sometimes harshly, for any short-

comings or failures to think through the different stages of the investigation. But since his only reason for doing so was his desire to improve the students' work, it was impossible to take offense at his vehemence.

Lebedev insisted, above all, on the rigorous planning of every scientific investigation. At the same time, the plan must not be rigid and set, but alive and flexible. Whenever new data were discovered in the course of research, Lebedev would stop to think for a little while and then, his interest reviving, propose a new, not previously planned on, line of research. He would shoot off ideas like sparks; carried away by them, he would paint broad new perspectives before the young scientist and infect him with his own enthusiasm. It was perhaps at such moments, more than at any other time, that he was able to transmit to his students a little of his own ability to "think physically," to use Kundt's expression, and to teach them to work creatively.

From the research rooms, Lebedev would pass on to the shop; he was always interested in seeing how well his students had learned to work with their hands. Here the talk would be more general. All those present eagerly listened to what he had to say about the newest scientific and technical achievements, which he learned of from primary sources, and to his comments on current developments in university life. These comments showed him to be a consistent opponent of routine reactions and official, bureaucratic attitudes to scientific investigation. He scorned and made fun of narrow-minded functionaries who refused to understand that genuine science cannot exist without constantly moving forward, and physics in particular without intense experimental research.

Once a week the experimental scientists who worked under Lebedev's direction and a few of the older workers of the Physics Institute gathered at one of his regular seminars. These seminars had begun in the Stolevov physics laboratory, at a round table in the library. Lebedev's student recruits, the senior workers of the "Lebedev basement" and Lebedev himself participated in these seminars on an equal footing. All of them were expected to present reports on the current literature. Since this literature for the major part was in German and English, in order to participate in the seminar it was necessary to acquire a thorough reading knowledge of these languages. Lebedev enlivened the discussion by the questions he put to the speaker and by his interesting and pithy comments, and made all those present take an active part in the debate. It was a red-letter day for every physicist who worked under Lebedev when, after long and persistent research, he was permitted to report at the seminar on the results of his own investigation. Lebedev was very demanding in this regard. He would not allow his men either to make a report or to have the study published if he found it incomplete or poorly presented. He always tried to teach his students to write lucidly and

briefly. Under his guidance, the text of an article would be rewritten several times. "This is very good", he would say, after looking over the third or fourth version of an article. "You have carried out my instructions. But everything you've written in this particular section is of use only to you; to the reader it is of no significance. Cut out that section and in general shorten the article. No one reads long articles nowadays."

Lebedev was particularly exacting as regards drawings and figures. However, his criticisms and comments were never abstract. When he explained how the article should be written, he would himself draw up an outline, write introductory sentences to the different sections and sketch in the drawings. After he finally approved the latest version, Lebedev usually translated the article into German himself. Then, simultaneously with its publication in a Russian review, he would send the article to the *Annalen der Physik* with a covering letter asking that the proofs be sent to him personally.

In his conversations with the young physicists who worked under him, Lebedev did not confine himself to the work in progress. He would also talk about the newest findings in physics, of which he had learned through his wide correspondence with outstanding physicists, and expatiate on the goal for which he trained his students. He would say: "Continue to work as you have been doing. Don't be deterred by the fact that the results don't seem to be of great significance. If you persist in your efforts, you will one day do something big ("catch the elephant" as he used to say). Remember that the day is coming when Russia will need physicists." For Lebedev, scientific work meant more than the unconscious craving to satisfy one's thirst for knowledge; he realized more clearly than most of his contemporaries that technology cannot advance without science, or science without technology. He endeavored to interest his students in the latest technological developments. While persuading them to go in for scientific research, he also took them to see the first large power plant in Moscow (the MOGÉS of today) and took a genuine interest in its installation and principles of operation. He wrote in his article "The Russian society and Russian national laboratories": "Large physical laboratories used solely for scientific research have long existed in the West. Experience has shown that by a persistent study of scientific problems they have been making an unexpectedly great contribution to technology."

One more feature of Lebedev's pedagogical activity deserves mention. Lebedev's interest was not confined to his own students. He implanted in them the idea that they must continue to recruit younger men for scientific work in his favorite field. Those were his instructions when Kolli left to teach in Warsaw University and Zernov in Saratov University. When, around the year 1910, the number of researchers in

the "Lebedev basement" reached 35, he asked Petr Petrovich Lazarev to take over the direct supervision of some of them. Thus a new school was created within Lebedev's own.

Lebedev taught his young physicists to work "physically," helped them to acquire the niceties of the experimental art, taught them to think through seriously a physical problem, to use the literature, to express their thoughts in writing, and to plan their work, and implanted in them the belief that a scientist must engage in research. With his remarkable gifts and great personal charm, he served for many as an inspiration which lasted throughout their lives, directing their work into a particular field of physics. Lebedev's students not only continued their research, but went on with Lebedev's work in training research scientists in various branches of physics. This activity was also continued by those younger physicists who had not had much direct association with Lebedev, but had joined his school shortly before his death (S. I. Vavilov, S. N. Rzhavkin, B. V. Il'in, N. E. Uspenskii et al), so that Lebedev's scientific views and methods were passed on to them by their older comrades. The students of his students also carried on Lebedev's work. Within this Institute there is no need to speak of the contributions of P. P. Lazarev, S. I. Vavilov and others; those present know them better than I do. In Moscow University, under the Soviet regime, the work of Lebedev's school in the field of magnetic phenomena and short electromagnetic waves was continued by V. K. Arkad'ev, a corresponding member of the Academy of Sciences of the U.S.S.R. Arkad'ev's own school included such men as Academician B. A. Vvedenskiĭ, an outstanding radio physicist, and N. S. Akulov, member of the Academy of Sciences of the Belorussian S.S.R., who has started a number of new lines of research in the field of ferromagnetic phenomena. Other students of Lebedev, also in Moscow University, have carried out a whole cycle of investigations in electronics and gas discharges. The need for research in this field had been repeatedly stressed by Lebedev in his conversations and lectures. Lebedev's school has had offshoots elsewhere as well.

We were of course unable, in this brief survey, to name all of Lebedev's students and his students' students who have been doing fruitful work both in scientific research and in offering guidance to beginning physicists.

The physicists who long ago began their scientific career under Lebedev's direction or in close association with persons belonging to Lebedev's immediate school have met with varying success in scientific research; some were able to achieve more, others less. Taken jointly, Lebedev's students and his students' students have been carrying on his tradition of recruiting younger men for physical research and have trained a substantial part of the researchers who are working today in our scientific and technological institutes. The

only difference is that today they no longer need to convince their students that "Russia will need physicists" and do not have to prove that physics and technology are indissolubly linked. Life itself and the tremendous growth of the national economy have done this for them.

The scientific seminar has become traditional in the laboratories and departments headed by Lebedev's students and his students' students. Each of these seminars is confined to a given branch of physics. Not only current literature, but all important questions relating to that branch are discussed at them. They have played an important role both in the development of scientific research and in the training of dedicated and qualified young scientists. The seminars conducted in many of the departments of the Physics School of Moscow University may serve as an example.

Lebedev created a genuine school of physicists

which is alive and growing today. This school has been active in developing those branches of physics which Lebedev urged his earliest disciples to study back in the Stoletov laboratory and in the "Lebedev basement."

Lebedev's school also makes its influence felt even today by drawing annually hundreds of gifted young people of the great Soviet land into physics research. Lebedev's students and his students' students are continuing to prepare new physicists who meet Lebedev's specifications and the requirements of our country's economy today. The part Petr Nikolaevich Lebedev has played in making possible the training of these new scientists is truly great.

Translated by Mrs. Valentine S. Rosen