

## In memory of Lev Vladimirovich Al'tshuler

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Lev Vladimirovich Al'tshuler, Chief Research Scientist of the Institute for High Energy Densities, Joint Institute for High Temperatures of the Russian Academy of Sciences, Professor, DSc in Physics and Mathematics, died on December 23, 2003. He was one of the founders and continuous leaders in the field of physics of high energy densities: the science of the physical properties of matter at extremely high densities and temperatures.

L V Al'tshuler was born on November 9, 1913 in Moscow, into the family of a lawyer who was an active revolutionary, a social democrat of the first (Plekhanov's) wave. L V Al'tshuler's scientific career started in 1932 in the X-ray Laboratory of the Moscow Evening Institute of Mechanical Engineering. This was later reorganized into a laboratory of the Institute of Mechanical Engineering of the Academy of Sciences of the USSR, to which he was invited by V A Tsukerman and where for some time V L Ginzburg was his colleague. The science supervisor of the laboratory was E F Bakhmetev, an outstanding expert in X-ray analysis, who was arrested in 1935 during Stalin's purges; his role in the maturation of Al'tshuler the scientist was very important. In 1940–1942, Al'tshuler served in the Air Force and was called to active service when the war started. In 1943, Al'tshuler submitted and defended his PhD thesis. In 1946, Al'tshuler and V A Tsukerman won the USSR State Prize for the development of pulsed X-ray structural analysis which, among other things, allowed them to solve the mystery of the German Panzerfaust antitank weapon; at this time Yu B Khariton invited them both to take part in the atomic project.

From 1946 to 1969, Al'tshuler worked at VNIIEF — the USSR Research Institute of Experimental Physics (in Sarov) where he headed one of the core departments and took part in the principal fields of research required for the development of Soviet atomic weapons. Upon returning to Moscow, he became head of a laboratory at the USSR Research Institute of Physical Optics Measurements, and from 1989 on worked at the Institute for High Temperatures of the USSR Academy of Sciences (now the Institute for High Energy Densities, Joint Institute for High Temperatures of the Russian Academy of Sciences).

In order to solve a number of major problems of the atomic project, L V Al'tshuler had in fact created a novel scientific field: dynamic high pressure physics that deals with the behavior of matter in high-power shock waves at super-high pressures. It was necessary to develop special techniques, non-existent at the time, for studying thermodynamic and other physical characteristics of shock wave compressed materials — uranium, plutonium, construction materials, and products for the detonation of explosives — in the megabar pressure range. Al'tshuler and his team developed efficient generators of explosion shock waves and elegant



Lev Vladimirovich Al'tshuler  
(9.11.1913 – 23.12.2003)

techniques for measuring the parameters of shock compression. The research conducted by L V Al'tshuler and his colleagues covered most of the metals at pressures on the order of 10 Mbar — this was a record at the time. This work was a daring jump up the pressure scale and went far beyond the ceiling reached in the West at the time. When these data were published at the end of the 1950s and in 1960s, foreign colleagues expressed admiration and shock. Some of them even decided that such high parameters were obtained not by using chemical explosives but in collisions of ballistic rockets or satellites. The results of this research became classic and formed the basis of the DSc thesis that Lev Vladimirovich presented and defended in 1954; in 1956 the degree of Professor was conferred on him.

In 1958, Al'tshuler, together with Ya B Zel'dovich, suggested a novel method of determining the compressibilities of fissionable materials under multi-megabar pressures — the method of 'non-explosive chain reactions'. Another pioneering effort was his unique measurements, conducted in the 1960s, of the equation of state of metals at superhigh pressures (up to 50 Mbar) in the immediate neighborhood of an underground nuclear explosion.

Other important fields of L V Al'tshuler's research concerned the study of electronic and polymorphous transitions in metals, group IV elements, ionic compounds, minerals and rock, and measurements of phase diagram parameters for metals at high pressures and temperatures. He also conducted pioneering research into establishing the limits of applicability of the quasiclassical approximation (the Thomas–Fermi–Kirzhnits theory) at ultra-megabar pressures. He was the first to measure the sound velocity and shear strength of metals at high pressures achieved by shock wave compression. The diversified research of Lev Vladimirovich and his team covered practically all aspects of the physics of shock wave compression in condensed matter. The results of this research are fundamental for today's understanding of the physics of extreme states of matter, as well as for the design of nuclear weapons and devices for inertial fusion. The data he obtained were used in the development of the first Soviet atomic bomb tested in 1949.

L V Al'tshuler and his colleagues came up with one of the fundamental ideas for the creation of nuclear weapons that is incorporated now in the most advanced designs. Later, he was an active participant in developing advanced designs of atomic charges that were successfully tested in the 1950s and 1960s. His outstanding role in the nuclear program was emphasized even by his scientific opponents. Edward Teller wrote that when American scientists were developing nuclear weapons, they lacked experts of the class of such people as Al'tshuler and Zel'dovich.

The leading nuclear scientists always regarded their participation in the atomic project as dictated by the need to maintain nuclear parity. At the same time, they recognized their responsibility, believing that this terrible bomb should never be used. This non-trivial thinking was typical of Lev Vladimirovich, who also chose to hold independent standpoints on many aspects of social life. This was not only the root for his harsh conflicts with authorities and party bosses but also brought him to the ranks of defenders of the White House in August of 1991.

As Chief Research Scientist of the Institute for High Energy Densities, Joint Institute for High Temperatures of the Russian Academy of Sciences, L V Al'tshuler took part in projects aimed at obtaining equations of state of materials in a broad range of variables; he initiated the creation, and became Editor-in-Chief, of the collective monograph *Shock Waves and Extreme States of Matter* published in 2000. He published four review papers in Russian journal *Uspekhi Fizicheskikh Nauk* (*Physics Uspekhi*), all widely known and frequently cited. In recent years Lev Vladimirovich devoted much of his time to teaching and to writing the history of the Soviet atomic project. He especially emphasized the role played by Academician Yu B Khariton in organizing and conducting research at VNIIEF.

The many years of his creative career and of his life in general were inseparable from the scientific cooperation and personal friendship of such outstanding scientists as Ya B Zel'dovich, D A Kirzhnits, S B Kormer, A D Sakharov, D A Frank-Kamenetsky, Yu B Khariton, and V A Tsukerman.

L V Al'tshuler's scientific achievement in the dynamic physics of high pressures was rewarded with the Lenin Prize (1962), two State Prizes (1949 and 1953), the Prize of the Government of the Russian Federation (1999), and three Orders of Lenin. In 1991, L V Al'tshuler received the Shock

Compression Science Award of the American Physical Society.

As the founder of the Russian school of dynamic research, Lev Vladimirovich contributed greatly to training new specialists. His devotion to science, his ability to combine intense personal research with guiding his research team created an atmosphere of absolute priority of science, utmost integrity, and openness among his students and colleagues. He was exceptional in the sense of responsibility for the progress in his research field and in his readiness and desire to help all his followers. Until his last hour Lev Vladimirovich retained the ability and eagerness for active work. He was a brilliant man of impeccable integrity and firm principles, and a very welcoming human being a constant center of attraction for numerous and ever grateful students of the first, second, and third generations.

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