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In memory of Dmitriĭ Vasil'evich Volkov

On January 5, 1996 the heart of a remarkable man stopped, a world-renowned theoretician of physics, an academician of the National Academy of Sciences, Dmitriĭ Vasil'evich Volkov.

D V Volkov was a pioneer in the development of new and fundamental trends in theoretical physics of elementary particles and the quantum field theory. His name will forever be associated with the discovery of supersymmetry and supergravity, which laid the basis for modern research aimed at constructing a unified field theory.

D V Volkov was born on July 3, 1925 in Leningrad. In 1943 he was drafted into the army as a private and participated in fierce battles on the Karelia and Far East fronts. He was seriously wounded and in 1946, at the end of the war against Japan, was discharged from the military due to the condition of his health. He was awarded three medals for military valour. The war did much to solidify his character and attitude towards life. In 1947 D V Volkov entered the Physics Faculty of the Leningrad State University and then in 1951, by order of the Ministry of Higher Education he was sent along with the best students to the recently founded nuclear department of the Physics and Mathematics Faculty of the Kharkov State University, which he graduated from in 1952. After completing his graduates studies in 1956 under the supervision of A I Akhiezer he was assigned to work at the Kharkov Institute of Physics and Technology, where he spent nearly 40 years of his career from junior research worker to academician.

The physics of elementary particles was materializing in the Fifties and after defending his candidate's dissertation on scalar quantum electrodynamics D V Volkov embarked upon research on the fundamental problems of the quantum field theory. He studied the linkage of spin and statistics, established a connection between the Pauli theorem and CPT-symmetry of commutation relations and in 1959 devised a new scheme for quantum fields, i.e. the so-called parastatistics or Green-Volkov statistics, which generalized the statistics of Bose-Einstein and Fermi-Dirac. Parastatistics played an important role in developing a hypothesis on the quantum structure of hadrons.

At the beginning of the Sixties Regge's theory of poles was gaining currency and D V Volkov performed in-depth research on the behaviour of poles in a relativistic region. In 1962, together with V N Gribov, he discovered a phenomenon which came to be known as 'Regge's poles conspiracy'. The theorem on the 'poles conspiracy' established links between the poles of relativistic amplitudes of scattering particles with a spin and paved the way for a large set of theoretical and experimental studies on high energy physics. In 1965 D V Volkov introduced the important concept of collinear subgroups of symmetry and became a trend-setter who provided the opportunity for effectively studying the processes of particle scattering based on the theory of high symmetry group representation.

Dmitriĭ Vasil'evich Volkov

In the mid Sixties D V Volkov was involved in developing yet another trend, i.e. the algebra of currents, spontaneously broken symmetries and completed a cycle of classical studies on the interaction of particles in systems with a degenerated vacuum. D V Volkov based these studies on the theoretical group methods of E Cartan, constructed a general theory of interacting Goldstone particles in field systems with an arbitrary and spontaneously broken group of internal symmetry. Using methods which he developed, D V Volkov solved the complex problem of spontaneous vacuum transitions in the dual models of Veneziano and Neveu–Schwarz and established an important link of dual amplitudes and the Regge trajectories with internal symmetries and current

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algebras. In statistical physics D V Volkov considered magnons as Goldstone particles and constructed a general Lagrangian of spin waves in magnetic ordered and disordered media.

D V Volkov generalized the method of phenomenological Lagrangians on groups of unbroken symmetry, which included spatial and time transformations, and in 1971 he posed the question of whether Goldstone particles can be fermions. After giving an affirmative reply to this query, in 1972 D V Volkov discovered supersymmetry independently of Yu A Golfand and E P Lichtman's paper of 1971.

Supersymmetry presented itself as an entirely different type of symmetry, whose transformations mix bosons and fermions. The introduction of supersymmetry removed some radical restrictions which had stood in the way of nontrivial unification of internal symmetry groups with the Poincare group and led to the discovery of superspace, by combining the traditional coordinates of time and space with anticommuting spin variables.

After introducing supersymmetry D V Volkov posed the issue of compatibility of its transformations with general covariant transformations in curved space-time. After examining this problem, D V Volkov zeroed in on the need to localize the transformations of supersymmetry, which in turn demanded a radical reconceptualization of Einstein's general theory of relativity. D V Volkov was the first to realize and show that localizing the super-Poincare group, i.e. generalizing supersymmetry on gravity, would require introducing a new fermionic gauge field — gravitino — which bears a spin of 3/2. At the same time he showed that the spontaneous breaking of supersymmetry in presence of graviton and gravitino fields leads to the super Higgs effect. Thus, he arrived at the theory of supergravity in 1973.

While elaborating on supergravity, D V Volkov formulated the basic concepts of differential geometry of superspace, which, together with supersymmetry, were used in constructing a theory of superstrings, which was a harbinger to the unified theory of fundamental interactions.

D V Volkov received an honourary invitation to attend the international conference for authors of original ideas and Twentieth Century discoveries in the field of particle physics which was held in Italy in 1994, where he delivered an address and expounded upon his seminal works in which supergravity was discovered†.

One of D V Volkov's most laudable skills was his ongoing aspiration to update and broaden the range of his scientific interests. He carefully monitored the appearance of new trends in the physics of elementary particles and actively took part in their development. At the beginning of the Eighties D V Volkov initiated research into the problem of spontaneous compactification of space and performed a set of unique research projects devoted to the compactification of spatial dimensions in theories of supergravity with a space-time dimension $D = 10$, 11 and studied the structure of compactified spatial dimensions in generalised Kaluza-Klein theories.

Among his other studies, the spin structure of space-time is note worthy, in the process of which he rediscovered Poisson's odd bracket (the Buttin bracket) and showed that the dynamics of a broad class of Hamiltonian systems in phase superspace allows for an alternative formulation on the basis of an odd bracket. D V Volkov found an unexpected application for the odd bracket in describing hydrodynamics as a Hamiltonian system and built an infinite number of hydrodynamic invariants. He analysed issues related to the theory of relativistic field systems with fractional statistics and spin, and made a notable contribution to framing the theory of supersymmetric particles and strings.

At the end of the Eighties, D V Volkov, advocated new ideas associated with the inclusion of twistors in the theory of superparticles and superstrings, and made new twistor-like formulations of the action functionals for these theories. Based on them, D V Volkov elucidated the geometrical meaning of the mysterious k-symmetry in the theory of superparticles and superstrings as the symmetry of superdiffeomorphisms of their world lines and surfaces. Progress in understanding the nature of k-symmetry shed new light on the problem of covariant quantization of superstrings. D V Volkov's last speech at the international conference "Supersymmetry-95" in France contained a new conception of the generalized principle of action for superstrings and supermembranes. He linked the use of this principle to the possibility of solving the problem of the covariant quantization of superstrings.

D V Volkov devoted much time and energy to the organization and promotion of both scientific and public activities, as a member of special-purpose scientific councils, editorial boards of scientific journals and collections, head of a scientific seminar on the physics of particles at the Kharkov State University. Special mention must also be made of the long years D V Volkov spent in supplying his Institute with scientific and technical information, which was a great challenge due to difficulties encountered in recent years.

D V Volkov was an Honourable Scientist of Ukraine and his devotion to science was acknowledged when he was awarded Order of the Red Banner of Labour and a number of medals. D V Volkov published more than 150 articles on theoretical physics, a number of which were co-authored with his pupils, for whom collaboration with D V Volkov was the best school. Driven by the beauty of new ideas, D V Volkov was able to inspire his fellow researchers with the strength, enthusiasm and transparency of all his fresh new scientific ideas and achievements. His authority was great and he was sought after by many. D V Volkov was always pleased to discuss any problems and his conversations were helpful since he was able to grasp the essence of a question and suggest unorthodox solutions and approaches. The school of science established by D V Volkov in Kharkov is actively engaged in researching promising areas of theoretical physics and enjoys a fine reputation throughout the world. Many well-known physicists look up to D V Volkov as their teacher. D V Volkov had a wide circle of international contacts and worked in various world centres of science. Science always occupied an exclusive place in the life of D V Volkov. He jealously guarded its purity and was adamantly opposed to any and all breaches of scientific ethics or encroachments of bureaucratic attitude in the domain of science.

In his scientific pursuits D V Volkov was driven by his sense of beauty and aspiration towards harmony. His profound intuition enabled him to grope for key ideas and constructs. His creative work was veiled in secrecy and romanticism, which attracted many colleagues from within the world scientific community.

† D V Volkov *Supergravity before 1976* Proceedings of International Conference "History of original Ideas and Basic Discoveries in Particle Physics" (Plenum Publishing Corporation, 1996) pp 663–674.

As a human being, D V Volkov was deeply democratic and possessed of high principles, combining genuine intellectual virtues with modesty. All who remember D V Volkov will recall his never-falling respectful attitude towards others, his kindness, sincere desire to be supportive and helpful in difficult matters. D V Volkov passionately loved life, his family, friends, travelling, forests, rivers and bonfires. He was highly knowledgeable of Hindu philosophy, classical literature and practised yoga. He was interested in the mysteries of the human psyche, the powers of self-suggestion and using them to heal the body.

The life of D V Volkov came to an abrupt end during one of his many upsurges in solving a complex problem. As always, he was brimming with ideas and overjoyed by his passion for science. He worked intensely up until the final day of his life.

The glowing memory of Dimitiĭ Vasil'evich Volkov — this magnanimous and noble man, disinterested toiler and cavalier of science, wise and good teacher, will forever remain dear to the hearts of his friends, colleagues and pupils.

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