Efim Samoĭlovich Fradkin (on his sixtieth birthday)

V. O. Ginzburg, Ya. B. Zel'dovich, L. V. Keldysh, D. A. Kirzhnits, M. A. Markov, V. I. Ritus, V. Ya. Faĭnberg, and E. L. Feĭnberg

Usp. Fiz. Nauk **142**, 533–534 (March 1984)

February 24, 1984 was the sixtieth birthday of the prominent Soviet theoretical physicist, corresponding member of the Academy of Sciences of the USSR Efim Samoĭlovich Fradkin.

E. S. Fradkin was born in Byelorussia in the small town of Shadrin. From 1942 to 1946 he served in the ranks of the Red Army, was seriously wounded at the front near Stalingrad. From 1945 Fradkin was an external student of L'vov University and became a regular student there in 1947 after demobilization. Having graduated in 1948 Fradkin began graduate work in the theoretical division of the Physics Institute of the Academy of Sciences with which the rest of his subsequent activity was indissolubly connected. Here in 1951 he defended his candidate's thesis which was carried out under the supervision of V. L. Ginzburg, and in 1960 he defended his doctoral thesis. Starting with 1964 Fradkin became the head of the quantum field theory section in the theoretical division.

From the very beginning of his independent scientific activity Fradkin gravitated to the development of the most urgent and fundamental problems of the theory of elementary particles and quantum statistics.

During the 1950's Fradkin carried out a series of brilliant investigations on th functional formulation of quantum field theory and quantum statistics. The pioneering results of E. S. Frankin in this field have now become widely known.

On the basis of these results Fradkin developed computational methods which made it possible to go significantly beyond the framework of the traditional perturbation theory. Among these methods is the superpropagator method known as the Fradkin-Efimov theory which makes it possible to work with essentially nonpolynomial interactions and which in the 1970's gave rise to an entire scientific direction of practical calculations in the nonlinear chiral dynamics of π mesons. In relativistic quantum statistics Fradkin for the first time obtained a system of functional equations for the generating functional and Green's functions and developed a diagram technique.[1)] He showed, independently of Schwinger, in 1959 that in the limit of zero temperature and chemical potentials a Euclidean formulation of quantum field theory follows from these equations. He obtained for the first time a completely renormalized system of equations for the Green's functions. An investigation of the high energy regime of this system led him to the discovery of a conformal solution. The series of Fradkin's papers on conformal quantum theory made an important contribution to the establishment of this direction. In particular, he obtained a conformal formulation of gauge theory and obtained the critical indices of phase transitions.

In 1955 Fradkin (simultaneously with L. D. Landau and I. Ya Pomeranchuk) pointed out an internal contradiction of quantum electrodynamics—the difficulty of the "zero charge." The fundamental significance of this difficulty was deeply realized in connection with the discovery of the so-called asymptotic freedom in the quantum theory of nonabelian gauge fields—a most important property of interactions between quarks at small distances confirmed by experiments on deep-inelastic processes. Fradkin formulated the requirement of asymptotic freedom, realized in the case of special solutions of the equations of the renormalization group, as a guiding principle for the construction of grand unification models. On this basis he constructed SU(5) and E(6) asymptotically free unifications of strong, weak and electromagnetic interactions.

An important achievement of E. S. Fradkin was the derivation in quantum electrodynamics of the so-called Ward-Fradkin-Takahashi identities. On being generalized to nonabelian gauge theories these relations now are a universally utilized most important instrument for the investigation of the properties of gauge theories. These identities were also obtained by Fradkin in quantum gravitation.

Widely acclaimed also is the contribution of E. S. Fradkin to the creation of the quantum theory of a gauge field. He

Efim Samoĭlovich Fradkin

[1)] A similar technique in the nonrelativistic case was developed independently by A. A. Abrikosov, L. P. Gor'kov and I. E. Dzyaloshinskiĭ.

 0038-5670/84/030233-02$01.80

carried out a canonical quantization and obtained an expression for the S-matrix of the partition function in the Yang-Mills theory, proved the gauge independence of physical quantities, the renormalizability of a massive vector field in the gauge theory of weak interactions with spontaneous symmetry breaking. E. S. Fradkin was the first to obtain the correct expressions for the S-matrix in gravitation in an arbitrary gauge.

In recent years the work of E. S. Fradkin has been directed to the solution of fundamental problems in field theory and elementary particle physics on the basis of the study of supergauge theories. Here he has solved the problem of constructing the S-matrix for relativistic systems with couplings of the most general type, which radically broadens the existing possibilities of quantization as applied to supergauge theories. He obtained the first model of extended supergravitation unifying gravitational and electromagnetic interaction with the gravitino field, and obtained an expression for the S-matrix in supergravitation; he solved the problem of closing the algebra in the $N = 1$ and $N = 2$ theories of supergravitation.

One of the fundamental problems of quantum gravitation is the explanation of the smallness of the cosmological term. Of particular interest in this connection are Fradkin's papers in which he developed the method of calculating the effective potential (energy of the vacuum) in $N = 4$ supergravitation, and showed that local supersymmetry can be spontaneously violated already in perturbation theory and determined the conditions determining the experimental smallness of the effective cosmological term (taking quantum corrections into account).

Fradkin carried out a quantization of the locally superconformal unified theories which might lay claim to describe all interactions, including the gravitational interaction and in this connection, as a condition for avoiding a contradiction, he put forward the principle of cancellation of conformal anomalies which is equivalent to the requirement that the theory be finite. He showed that a candidate for being such a theory is the theory based on the $N = 4$ conformal supergravitation.

E. S. Fradkin has published a total of more than 180 papers. We have mentioned the most significant, from our point of view, results which provide although a not all-encompassing, but a sufficiently complete impression of the big contribution to the development of theoretical physics made by E. S. Fradkin. It is also necessary to note the important practical developments in which Fradkin participated. This work of his was rewarded in 1953 by the State Prize of the USSR. His achievements were repeatedly recognized by government awards: he is the recipient of the Orders of the Red Banner of Labor, the Red Star, the "Badge of Honor" and various medals. In 1980 for the series of papers on functional methods in quantum field theory and statistics he was awarded the I. E. Tamm Prize of the Academy of Sciences of the USSR. In 1970 E. S. Fradkin was elected a corresponding member of the Academy of Sciencs of the USSR and in 1983 a member of the Pantaniano Academy of Sciences (Italy).

Efim Samoĭlovich has educated a whole galaxy of talented theoretical physicists, and therefore one can without exageration speak of the scientific school of E. S. Fradkin. In his high human qualities he is a deserving representative of the school of I. E. Tamm. A characteristic trait of Frankin's scientific (and any other) activity is his selfless, forward-looking commitment of his abilities and energy to the solution of problems confronting him. One can only marvel at his capacity for work and at the breadth of his interests. He is held in high regard both by Soviet and foreign physicists. He is always ready to discuss and (and not only a scientific) serious problem and yet manages to find time for social and scientific organizational work. At the age of sixty Fradkin is at the peak of his creative energy and talent, he is full of new projects and ideas. His friends, colleagues, and pupils extend to him their warmest congratulations and wish him health, creative longevity, and further successes in his fruitful work for the benefit of Soviet science.

Translated by G. M. Volkoff