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Aleksandr Fedorovich Andreev (on his 70th birthday)

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Academician Aleksandr Fedorovich Andreev, the brilliant physical theorist, a prominent man of science, and one of the top managers of the Russian Academy of Sciences, celebrated his 70th birthday on December 10, 2009.

In 1956, A F Andreev enrolled at the Moscow Institute of Physics and Technology (MFTI in *Russ. abbr.*) and, having successfully passed L D Landau's Theoretical Minimum exam, already started his career in research in 1959. L D Landau immediately spotted the remarkable gifts of his pupil; on his initiative, A F Andreev was allowed to graduate from MFTI ahead of schedule, in 1961.

His entire life in physics unfolded within the Institute for Physical Problems (IPP) of Russian Academy of Sciences. His work was very soon highly praised by the institute director, the patriarch of physics in this country, P L Kapitza. As Andreev reached maturity, he was surrounded by such outstanding theoretical physicists as E M Lifshitz, I M Khalatnikov, A A Abrikosov, L P Gor'kov, I E Dzyaloshinskii, and L P Pitaevskii, and such brilliant experimentalists as A I Shal'nikov, A S Borovik-Romanov, Yu V Sharvin, I E Alekseevskii, M S Khaikin, and many others. A F Andreev learnt much from his older colleagues, first of all the gut feeling of the priority of fundamental science, the serious and honest attitude vis-à-vis scientific creativity.

The most valuable element of his research work lies in the seminal fundamental ideas which informed the subsequent evolution of a number of fields in physics. This is true, first and foremost, of his work in such areas of condensed matter physics as superconductivity, quantum liquids and quantum crystals, magnetism, the physics of surfaces, and mesoscopic phenomena. He obtained fundamental results in hydrodynamics, the theory of elasticity, optics, and the theory of gravitation.

Already in one of his first publications, he suggested an idea of a new type of reflection of a very unusual nature — that of conduction electrons from the interface between a normal metal and a superconductor. This phenomenon became widely known as 'Andreev reflection' and quite some time ago entered the textbooks on solid-state physics. The heart of the matter is that an electron impinging on the interface from the side of a normal metal generates a Cooper pair in the superconductor, while the current continuity at the interface is provided by the transformation of the electron into a hole moving along a time-reversed electron trajectory. This idea allowed him to explain a number of anomalous properties of the intermediate state of superconductors. Subsequent research demonstrated that Andreev reflection (and its analogs) is the norm in low-temperature physics, rather than an exception; it is inherent not only in electron excitation but also in other quasiparticles in widely varying physical systems. This result of 'pure science' finds practical implementations: the phenomenon of Andreev reflection is used in so-called Andreev interferometers and in designing modern high-sensitivity radiation detectors; it may be widely applied in future electronic devices.

Aleksandr Fedorovich Andreev

Andreev's classical paper, written in collaboration with I M Lifshits, formulated the fundamental idea of quantum crystals as a new class of solids in which the amplitude of zero-point oscillations is so anomalously high that it produces qualitatively new effects. Point defects, such as vacancies and impurities, are delocalized and behave in quantum crystals as quasiparticles with a very special energy spectrum; as a result, crystals acquire very unusual properties. The most representative example is so-called 'quantum diffusion'. Together with A Ya Parshin, he suggested the idea of the dissipationless nature of growth and melting of quantum crystals and predicted a new type of oscillations of crystal surfaces — crystallization waves. This and a number of A F Andreev's subsequent publications on quantum crystals were conclusively confirmed by experiments in many laboratories around

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the world and stimulated the birth of a new, actively developing field — the physics of quantum crystals.

A F Andreev made a fundamental contribution to the theory of magnetism. He proposed (in collaboration with V I Marchenko) a classification of symmetry and the dynamic properties of magnets, which consistently accounted for the exchange interaction and weaker relativistic interactions, and gave an elegant physical description of a new class of ordered materials — magnetic analogs of liquid crystals. The existence of magnetic polarons formed by quantum vacancies in solid helium-3 is another of A F Andreev's beautiful results obtained long before a similar phenomenon gained popularity in connection with the work on the mechanisms of high-temperature superconductivity.

A number of A F Andreev's ground-breaking publications deal with the physics of surfaces. They cover the theory of surface states of helium-3 in helium-4 (known as 'Andreev states'), the principally important aspects of the theory of emergence of crystal faceting, his work on the theory of the Kapitza jump, and surface phenomena in metals and antiferromagnets.

The framework of this *Personalia* does not allow us even to list all the problems whose solutions received essential contributions from A F Andreev. We will only mention the results that he obtained recently in the physics of mesoscopic systems, such as ultracold gases in magnetic traps and metallic nanoparticles (mesoscopic quantum dots). He was able to clarify the exotic nature of superfluidity, superconductivity, and magnetism in mesoscopic systems. It turned out that an adequate description of mesoscopic superconductivity can be obtained on the basis of the concept of superspace that found use in modern supersymmetric field theories. An experimental verification of the description of the superconducting and magnetic properties of nanoparticles, thus formulated, will make it possible to arrive, at the current level of technology, at a direct confirmation of the concept of superspace.

L D Landau had always been and always will be the ultimate judge and authority for Aleksandr Fedorovich the scientist. He organically grew into the style of work of his teacher. For Andreev, the predominant characteristics are a profound understanding of theoretical physics as a unified science, the striving to bring out the true simplicity and coherent unity of physical laws, the ability to produce an impeccable formulation of a problem at a phenomenological level, and an undisguised dislike of various sorts of models and of cumbersome numerical calculations. When he advances a new idea, even a very radical one, he invariably aims at achieving complete conceptual clarity and transparency of the theoretical approach. Every one of his papers, even those in which he resolves a theoretical matter of principle, is a challenge to experimentalists and stimulates further research.

A F Andreev's work is widely recognized. He was elected Corresponding Member of the USSR Academy of Sciences in 1981, and then Full Member in 1987; he is a foreign member of many academies of sciences abroad, and is honorary professor at a number of foreign universities. He was awarded the Lomonosov Prize (1984), the Lenin Prize (1986), the Carus Medal and the Prize of the Deutsche Akademie der Naturforscher Leopoldina (1987), the F Simon Memorial Award (1995), the P L Kapitza Gold Medal (1999), the Russian Triumph Prize (2003), the International I Ya Pomeranchuk Prize (2004), the International John Bardeen Award (2006), and a number of Russia State distinctions, including the Order of Services to the Fatherland of Third Class, and the Commendation of the President, Russian Federation. A F Andreev also received Poland's Commander's Cross of the Order of Merit.

A F Andreev has a very high standing at the state administration level, being a member of the Presidium of the Commission on State Prizes and Awards with the office of the RF President.

In 1984, A F Andreev became deputy director, and in 1990 the director of IPP, RAS. In 1991, he was elected Vice President of the RAS. He is a member of the Bureau of the RAS Physical Sciences Division and Chairman of the RAS Council on the Low-Temperature Physics. A F Andreev as scientific leader and administrator is known to be attentive and kind to colleagues, which does not affect his unbiased and rigorous evaluation of their creative output. His moral support to those scientists who left IPP and work abroad help them feel that they are still at home at IPP.

A F Andreev chairs the Learned Council of the International Laboratory of Strong Magnetic Fields and Low Temperatures in Wroclaw (Poland), maintains direct personal contacts with leading foreign scientists, and helps improve international links with Russian scientists.

Despite his huge administrative load, the occupation of principal importance for Aleksandr Fedorovich is his research. He frequently presents talks at seminars, attempting each time to describe his work in a manner that makes it understandable to an audience that is as large as possible. He constantly discusses with colleagues both his own and their work, always being accessible to people wishing to discuss some aspect of physics. His opinion is always precisely and clearly argued and is highly valued both at IPP and far beyond its confines.

Aleksandr Fedorovich devotes much of his time and energy to training new generations of scientists. He holds the position of Professor at MFTI and M V Lomonosov Moscow State University, is Chair of Low-Temperature Physics at the MFTI, and is Head of the MFTI Coordination Council. Following P L Kapitza's tradition, he personally interviews each candidates for IPP postgraduate courses, follows attentively and understandingly their maturation as researchers, and tries to support every young talent. He is keen on working individually with his immediate students; many of them have already grown into well-known scientists. His publication activities can be regarded as a continuation of his teaching work. Since 1993, he has been Editor-in-Chief of the magazine *Priroda* (Nature), and in 1997 he became Editor-in-Chief of one of the most authoritative Russian physics journals — the *Journal of Experimental and Theoretical Physics* (*JETP*).

A F Andreev steps into this jubilee with a great deal of vigor, energy, and plans for new research. We wish him from the bottom of our hearts much success in his studies and in science management.

A A Abrikosov, Zh I Alferov, S T Belyaev,
A A Boyarchuk, Yu M Kagan, L V Keldysh,
V V Lebedev, V A Matveev, G A Mesyats,
A Ya Parshin, L A Prozorova, I M Khalatnikov