December 2014

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PERSONALIA

In memory of Shulim Kogan

PACS numbers: **01.60. + q**

On October 21, 2014 Shulim Kogan, a prominent scientist in the field of theoretical physics, physical kinetics and solid-state physics, passed away. He made most part of his academic career in the Kotelnikov Institute of Radioengineering and Electronics, Moscow. He died in Palo Alto, California, USA, after a long illness.

Shulim Kogan was born in 1930 in Akkerman (Bilhorod-Dnistrovskyi, Moldova, now), which then belonged to Romania. In 1940, Akkerman was ceded to the Soviet Union but was occupied by the Nazi forces in summer of 1941 during their invasion of the USSR in the course of the Second World War. As the invasion began, Kogan's family fled to Ural deep into the Soviet territory, which actually saved his life. In 1953, he graduated from Ural State University at Yekaterinburg and taught physics in a high school for several years. In 1956, he became a PhD student of V L Bonch-Bruevich at the Chair of semiconductor physics in Lomonosov State University, Moscow. After this, he got a permanent position in the Institute of Radioengineering and Electronics of Russian Academy of Sciences (Kotelnikov Institute of Radioengineering and Electronics now). While working there, he defended his Dr. Sci. thesis and headed the theoretical group whose members made noticeable contributions to various branches of solid-state physics. It is there that he became world-wide famous for his results.

Shulim Kogan dealt with different sides of semiconductor theory. From 1962 to 1968, he studied the physics of semiconductors with negative differential conductivity. In 60's, this was one of the hottest problems in the semiconductor physics. But it is precisely his papers where the theory of electric-field domains and filaments formed due to the electric instability took its ultimate shape, in which it is used by many researchers for almost fifty years in solids, plasma and recently in low-dimensional structures.

Shulim Kogan gave a big contribution to the physics of photoelectric effects in semiconductors. He introduced the notion of photoconductivity tensor and developed the theory of anisotropic photoconductivity in homogeneous conductors with isotropic dielectric constant and conductivity. He also discovered the electronic photo-thermomagnetic effect.

Much of his research was related with shallow-impurity spectroscopy in semiconductors. He developed a new method of their characterization by means of photo-thermo-ionization spectroscopy in collaboration with the experimentalists T M Lifshits and F Y Nad'. He also proposed a new method of calculation of shallow-impurity spectra, which had a much better accuracy than the traditional variational method.

Shulim Kogan
(30.01.1930 – 21.10.2014)

Shulim Kogan showed that a resonance interaction of an electron at the impurity in a semiconductor with optical phonons results in a local optical-oscillation mode and hence in an additional line in the optical-absorption spectrum. He also made a significant contribution to the theory of disordered semiconductors. In collaboration with B I Shkolovskii, he calculated the distribution of electrical field in lightly doped compensated semiconductors.

The research interests of Shulim Kogan were not restricted to semiconductors. In collaboration with V L Ginzburg he elucidated the role of lattice deformation in experiments on excitation of electric current in a metal by means of its mechanical acceleration. In early seventies, he investigated the collisionless relaxation of the energy gap in superconductors. He established that upon initial perturbations of a definite type and in the absence of inelastic scattering, the superconducting order parameter oscillates with a frequency equal to the energy gap and with an amplitude that falls down according to a power law. This behavior is similar to the Landau damping in a collisionless plasma.

Shulim Kogan dealt with many problems, but the theory of nonequilibrium fluctuations in solids became his real lifework. In 1969, he developed a theory of semiclassical fluctuations in nonequilibrium systems and proposed a method for calculating their correlation functions. In this method, the fluctuations of electron distribution function are taken into account by adding a Langevin source to the right-hand side of the Boltzmann equation. The most nontrivial point in this theory was the derivation of correlation function of Langevin sources based on the idea that that charge-carrrier scattering is a Poissonian random process. These results are cited in the Course of Theoretical Physics by L D Landau and E M Lifshitz. Initially, the theory developed by Shulim Kogan was used for calculations of hot-electron noise in homogeneous semiconductors. However it took on a new lease of life in 90's when it was successfully applied to calculations of the shot noise in nanostructures with degenerate electrons. With its help, the nonequilibrium noise was calculated in metals with high impurity content and even in hybrid superconductor – normal-metal systems. This method is often referred to as Boltzmann – Langevin method and is indispensable for calculating the noise in systems with strong inelastic (electron – electron or electron – phonon) scattering.

Another big achievement of Shulim Kogan was putting forward a new mechanism of low-frequency current noise in metals with spectrum inversely proportional to the frequency, i.e. the so-called $1/f$ noise. He attributed this noise to the thermal motion of defects in them and showed that its magnitude should be proportional to the level of internal friction in these metals. More recently, this mechanism was nicknamed 'the local interference mechanism' and its existence was experimentally confirmed. Shulim Kogan put a great deal of thought into the origin of the low-frequency noise and attempted to relate it with the most fundamental properties of disordered systems like the hierarchy of activation energies between their different states. In particular, he made the prediction that spin glasses should exhibit a low-frequency equilibrium magnetic noise with spectrum also inversely proportional to the frequency. Unfortunately, he never realized some of his ideas in this field.

Shulim Kogan considered electric noise not only as an interference for experimental measurements but also as a source of valuable information about the physical phenomena in different conductors. He laid out his vision of the nature of electric noise in his book *Electronic Noise and Fluctuations in Solids*, which was published in English in 1996. In this book, he analyzed the basic known mechanisms of noise in different systems ranging from semiconductors to superconductors and gave simple qualitative explanations of this noise along with its rigorous theory. This book became now classical and is cited in Wikipedia as the primary review on electrical noise. In 2009, it was translated into Russian and published in Russia.

Shulim Kogan brought up a whole constellation of disciples. Six persons got their PhD's under his supervision, and two of them got a Dr. Sci degree later on.

Shulim Kogan was very good at finding fundamental scientific problems and always very deeply comprehended them doing his best to get to their bottom. In his work, he used very efficiently his remarkable physical intuition in combination with scientific rigor. He had an admirable artistic temperament and was an excellent lecturer and speaker. Shulim Kogan was very much respected as a scientist by the solid-state physicists and his colleagues in the institute. He was a very communicable and cheerful man, and his colleagues often asked him for help and advise. He was devoted to science and conducted the research till his last chance. We cherish his memory.

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