In memory of Sergey A. Gredeskul
(1942–2023)

Professor Sergey Gredeskul, our long-time colleague and friend, passed away on October 7, 2023, at the age of 81 (together with his wife, Dr. Victoria Gredeskul), who had also been a long-time member of B. Verkin Institute for Low Temperature Physics and Engineering of the NAS of Ukraine. The simultaneous death of this peaceful elderly couple was caused by a brutal terrorist attack by Hamas terrorists in the early morning of October 7, 2023.

Sergey Gredeskul was a renowned theoretical physicist, an expert in the theoretical physics of disordered condensed media, including the spectrum of elementary excitations and the propagation of waves and particles in such media, resonance and optical properties of magnetic media, and optical solitons to name a few. He is the author of more than a hundred scientific publications, including the monograph "Introduction to the Theory of Disordered Systems" (State Prize of Ukraine, 1985). For many years, Sergey has been actively involved in the work of our Journal.

Sergey was, apart from being an outstanding scholar and enthusiastic teacher, a very nice person. His honesty, kindness, and warmth were greatly valued by his family, friends, and colleagues. He will be dearly missed by all of us. The flow of admiration, sadness, and appreciation has been overwhelming, and a small sample is provided below.

Valentin Freilikher
Bar Ilan University, Israel

Sergey Gredeskul, my dear friend and colleague, tragically passed away on October 7, 2023. It was not a result of an accident or of an incurable disease, he was killed by blind hatred turned into inhuman atrocities. It is impossible to grasp, it must not ever be forgotten, never forgiven.

We first met 75 years ago, at the age of six. We lived in the same neighborhood, attended the same public school, then studied at the Department of the Theoretical Physics Kharkiv State University. In 1991, we immigrated to Israel together. We remained close friends until our very last day.

After graduation, we joined different Institutes and engaged in research projects that had little overlap in scope. More specifically, Sergey was focused on the theory of disordered electronic systems, while I got involved in studying microwave propagation in natural environments. At first glance, it looked like these problems had nothing in common, however, we soon realized that we were talking about similar problems, but in different physical terms. Once the language barrier was overcome, we got the impression that many interesting and practically important problems of the wave propagation theory have already been addressed in the context of quantum particle transport. It seemed that by rewriting known "electronic" formulas in appropriate notations, some optical and microwave phenomena could be explained, and perhaps new phenomena predicted. However, everything turned out to be much more complicated and challenging.

By that time, the problem of the atmospheric microwave propagation, although already had a longstanding history, remained little studied. In the early 1940s, it was discovered that under certain conditions, cm-range microwaves propagated along the sea surface for many hundreds of kilometers with anomalously low attenuation. This mysterious phenomenon intrigued the Soviet military navy commanders so much that the Academy of Sciences was immediately instructed to "urgently investigate and report back". Tasked with this was V. Fock who copped the problem brilliantly and very quickly. He showed that far-beyond-the-horizon propagation occurred due to the existence of an effective waveguide, with its lower boundary being the sea surface, and regular refraction (bending of the ray's trajectory) playing the role of the upper boundary. For this work, V. Fock was awarded the First-Degree Stalin Prize, with the rather vague (perhaps for the sake of the top secrecy) formulation "For scientific research on the theory of radio wave propagation". However, the signal levels observed in real conditions used to be much higher than those predicted by Fock's mechanism. For many years, numerous attempts to explain this discrepancy remained unsuccessful, mainly because the reliable information about the electromagnetic properties of the atmosphere was unavailable. It was only in the mid-1980s that classified data were published in open press, and we found out that the spatial structure of the refractive index of the upper troposphere above the sea surface had a well-pronounced randomly stratified character. Under anticyclone conditions, the layers are sufficiently stable over time and extended horizontally for tens, sometimes hundreds of kilometers. For us, it was good news because we understood that the problem of propagation in a randomly layered atmosphere could be reduced to a one-dimensional, in which localization effects played a significant role. In particular, since in accordance with localization theory, the reflection from a 1D disordered system is exponentially close to unity, it was natural to assume that the atmosphere can act as an upper wall of a waveguide channeling radiation along the surface, even in the absence of the regular refraction.

I was thrilled by this idea and suggested publishing immediately something entitled "Localization Mechanism of Long-Distance Tropospheric Propagation". However, Sergey did not share my enthusiasm. The thing was, that being a brilliant physicist, he considered mathematical rigor as the main principle in theoretical studies. For example, he viewed with caution the results obtained by the method of Feynman diagrams, where statistical momenta were derived by truncating the kernel of an integral equation, which corresponded to discarding infinite sequences of terms in the solution. My proposal he called a dangerous escapade, in which he would not participate, despite any physical arguments, no matter how convincing they might seem.

In order to properly verify the correctness of the idea, it was decided to calculate the energy flows generated by a point source in a randomly stratified medium. Cylindrical divergence of the flow along the layers and the exponential (as a function of the number of layers) smallness in the perpendicular direction would have been clear evidence of the existence of the waveguide-type propagation. The averaged values of these flaxes were calculated in the approximation of a delta-correlated random process. The result was catastrophic: the total upward (perpendicular to the layers) energy flow turned out to be exactly the same as in free space. This meant that, contrary to intuition, scattering on fluctuations did not affect energy flows and therefore did not contribute to horizontal propagation. Thus, to our great disappointment, the attempt to apply the quantum theory of electron localization to a classical wave problem ended in complete failure.

Just out of pure curiosity, we kept on trying to explain the meaning of the obtained analytical solution and the fallacy of the obvious physical reasoning. Although these questions seemed purely academic, the answers surpassed all expectations. After pages of calculations and hours of discussions, it became clear that the calculated spherical divergence of the *ensemble-averaged flow*, characteristic of free space, by no means ruled out the existence of a waveguide in *individual realizations*. Indeed, the averaged values take into account the contributions of all random samples, among which there are well-transparent resonant ones. Although the probability density of those samples is exponentially small, their contribution to the mean flux is exponentially large. Obviously, the result of the averaging depends on the ratio of these exponents. Analytical calculations showed that in our particular case, the average value of the energy flow radiated in the direction perpendicular to the layers was formed due to low-probable transparent samples. However, in experiments, most of the measurements deal with the so-called typical (exponentially high-probable) realizations. In such realizations, a randomly layered troposphere is a good reflector (due to Anderson localization), and the waveguide does exist. For its quantitative description, the semi-empirical model of an effective reflecting plane is a reasonably good approximation. Within this model, the field is represented as a sum of quasi-normal waveguide modes, whose decay rates (and therefore the ranges of horizontal propagation) are determined by the corresponding "one-dimensional" reflection coefficients. Numerical estimates with real parameters of the atmosphere showed that propagation in such a waveguide (we called it "fluctuational") could be an effective mechanism of long-range tropospheric propagation. Although simultaneous microwave and meteorological measurements targeted to detect fluctuational waveguides have not been carried out, a number of indirect data indicated their existence. For example, the experimentally observed correlation of the signal level far beyond the horizon with the dispersion of refractive index fluctuations was consistent with the predictions of the localization theory.

This collaboration went on for a few years; several papers have been published (see [1, 2] below and references therein). In our common opinion, not less important unpublished outcome was that Sergey eventually acknowledged the legitimacy of a moderate dose of reasonable adventurism in any theoretical research, and I realized how dangerous it was to trust intuitive reasoning (no matter how convincing it may seem) without careful mathematical verification. We often enjoyed recollecting numerous episodes of this exciting scientific adventure and even planned to resume it in light of the latest advances in the quantum mechanics of non-Hermitian systems. At our last conversation Sergey said: “We do not have too much time left. I have a suggestion what to start with. Let us discuss”…

1. S. A. Gredeskul and V. D. Freĭlikher, *Usp. Fiz. Nauk* **120**, 239 (1990) [*Sov. Phys. Usp.* **33**, 134 (1990)].
2. V. D. Freylikher and S. A. Gredeskul, *Progress in Optics* **30**, 137 (1992).

Victor Kagalovsky
Shamoon College of Engineering, Beer-Sheva, Israel

Prof. Gredeskul was always interested in new topics in condensed matter physics. Shortly after he arrived in Israel, he, together with A. Aronov and Y. Avishai won the Israel Academy of Science grant for “Disorder Effects on Pinning Vortices in Superconductors”. This topic was a new subject for Sergey. Unfortunately, Arkady Aronov, a great expert in the field, died a few months after the grant was awarded. With his PhD student G. Braverman, Sergey started to study the problem from the basics. The result was a series of brilliant papers on conventional and high-T_c superconductors with columnar defects. One of the main achievements was a prediction of a spectacular reentrant effect. Near the upper critical field in conventional type-II superconductors, a single defect causes a strong local deformation of the vortex lattice, having C_3 or C_6 point symmetry. Increasing the applied magnetic field results in reentrant transitions between symmetry configurations. These transitions manifest themselves as jumps of magnetization.

Sergey devoted his research activities to the most advanced problems of modern physics and the history of physics in his native Kharkiv, especially in his favorite FTINT. He coauthored books and articles about the exciting adventures of Kharkiv physics. He was also a brilliant lecturer on the subject. One of us (VK) hosted at least a half dozen of these fantastic presentations at the Shamoon College of Engineering (SCE) in Beer-Sheva. Sergey talked about L. V. Shubnikov, I. M. Lifshitz, B. I. Verkin, and many other outstanding Kharkiv physicists, their research, and their lives. His last lecture at SCE, “B. I. Verkin and Low Temperature Physics in Kharkiv, “occurred in 2021 during COVID-19. That outstanding Zoom presentation continued for two hours, and among many interested listeners were Ukrainian researchers from the Bogolyubov Institute for Theoretical Physics. The recording of this lecture was then distributed among Ukrainian physicists.

In addition to being an outstanding physicist, Sergey was also a great pianist. A legend tells us that when graduating from high school, he had to toss a coin to decide where he would go to study physics at the university or music at the conservatory. Lucky for a physics community, he chose physics but kept his love of music for the rest of his life.

Yuri Kivshar
The Australian National University

I met Sergey Gredeskul first in 1976 when I was a student at a secondary school in Kharkiv. I attended a series of preparatory lectures for those who planned to enter the University in the Kharkiv City Lecture Hall (“lectorii”), and Sergey was given lectures in mathematics. I asked him some tough questions, and he suggested to meet after the lecture in “predbannik” where he confirmed that one of the tasks in the textbook of Skanavi had a misprint.

Later, we overlapped with Sergey at the Institute of Low Temperature Physics and Engineering and even collaborated on a few projects starting from a paper in Physical Review Letters in 1989 where Sergey helped me to explain generic features observed in the generation of dark solitons.

Because a part of his family moved to Australia, Sergey visited Australia many times. Several times he stayed in Canberra as a visiting professor collaborating with us and also colleagues from Sydney including Ara Asatryan and Ross McPhedran. In the paper published in 2007 in Physical Review Letters, we studied the wave propagation in metamaterial structures composed of disordered alternating layers of right- and left-handed materials and revealed that the introduction of metamaterials substantially suppresses Anderson localization. Sergey was very excited about those results, especially when we found numerically that the localization length in mixed stacks is orders of magnitude larger than for normal structures, proportional to the sixth power of the wavelength, in sharp contrast to the usual quadratic wavelength dependence of normal systems. Overall, in the period 1989–2012 we published 19 papers together, and later with the members of our Nonlinear Physics Center of the Australian National University and other colleagues from Australia and Israel.

Sergey was not only an outstanding physicist but also had a remarkable personality with a fantastic range of interests and knowledge. In life and science, Sergey was an unattainable model to imitate, a remarkable mentor, and a great friend not only for me but also for many other colleagues.

Leonid Pastur
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Biographical Notes. Sergey Gredeskul was born on March 12, 1942, in Sverdlovsk (now and until 1924 Yekaterinburg, Ural region of Russia). His parents were evacuated to this city from our city of Kharkiv due to its occupation by the Nazi army during the war between the USSR and Germany in 1941–1945. After the war, the family returned to Kharkiv. Sergey graduated with a degree in theoretical physics in 1964 and received his PhD in Physics under the supervision of Professor Ilya Lifshitz in 1968 at Kharkiv University. He entered the Kharkiv Institute of Physics and

Technology (1968–1971) and then moved to the Institute of Low Temperature Physics and Engineering (1971–1991).

In 1991, Sergey's family emigrated to Israel. They settled in Ofakim, a small town in the Southern District of Israel, 20 kilometers west of Beersheba. Their home was just one block from the Negev Desert (and 18 km from the Gaza Strip). In 1992, Sergei joined the Department of Physics at Ben-Gurion University as an immigrant scientist with the rank of professor, supported by KAMEA's highly competitive program for the integration of former Soviet scientists. His wife, Dr. Victoria Gredeskul, taught mathematics at the same university.

Two points need to be made here. The first concerns Sergei's family. It is of Moldavian–Romanian origin and can be traced back to the Moldavian boyars, the country's nobles. The family fled the Turkish invasion in the early 1700s and moved to the Kharkiv region.

Sergei's great-uncle Nikolai Gredeskul was a professor at Kharkiv University and dean of the law faculty. He was a well-known public figure of the Russian Empire, vice-speaker of the First Russian Duma (parliament, 1906), and an active member of the team of technocrats and reformers led by Count Sergei Witte. Sergei's father, Andrei Gredeskul, was an engineer, professor, and head of the department at the Kharkiv National Automobile and Highway University. Sergei's mother, Bella Pesis, was a teacher.

The second point concerns Sergey's high school. It was the Kharkiv Specialized Music Gymnasium, the purpose of which was to prepare gifted children for admission to the conservatory. The school's program combined musical and general education subjects. Such specialized schools were only in large cities and cultural centers of the USSR (Moscow, Leningrad, Odesa, etc.). They replaced the standard procedure for admission to the conservatory, which involved a seven-year music school and a music college. Among Sergey's classmates at this school was Vladimir Krainev, who became a world-famous piano player. Sergey maintained close friendly relations with Krainev over many years and often met when visiting Moscow. Studying at this school left an imprint on Sergei's entire life. He played the piano beautifully, was a fine connoisseur of classical music, especially the Romantics, and had a wonderful collection of records and discs.

My work and friendship with Sergey. I have known Sergei since 1968. At that time, he was just finishing up his postgraduate studies, the topic of which was fluctuation effects in the spectra of elementary excitations of disordered systems, specifically the properties of fluctuons proposed in his thesis. I was just beginning to take a serious interest in theoretical physics and the spectral theory of disordered systems, and this and subsequent meetings with Sergei were very important to me. The meetings soon developed into joint work, which became very intensive after Ilya Lifshitz suggested that we write a joint monograph. The result of this collaboration was 12 joint works, including the monograph "Introduction to the Theory of Disordered Systems", published in the USSR in 1982 and in the US in 1988 in a significantly expanded and revised form. All these results would have been impossible without Sergei's active and decisive participation, without his ideas, enthusiasm, and efficiency.

The process of writing the book included regular trips to Moscow, where I. Lifshitz was already working at the time. This allowed me to get to know Sergei closely not only as a remarkable scientist but also as a very positive and friendly person, his, so to speak, "human dimension".

After moving to Israel, Sergey significantly expanded his scientific interests. He successfully continued his work in the theory of disordered systems and its applications (Anderson localization in optics, radiophysics, metamaterials, and magnetic systems) and published important and well-cited papers on nonlinear optics, solitons, and superconductivity. After his retirement, Sergey continued to work, attend seminars, and discuss with colleagues various topics of mutual interest.

I have outlined above briefly our joint scientific work with Sergey. In addition to this work, we have been active in the history of physics since the 1980s. The result of this collaboration was a book on Lev Shubnikov, a brilliant physicist who worked in Kharkiv from 1930 to 1937, obtained a number of remarkable and widely known results, including several Nobel-level, results, and was a victim of Stalin's repressions in 1937. We also wrote several articles on the Kharkiv school of condensed matter and low-temperature physics (one of the three leading schools of the USSR, along with Moscow and Leningrad) and its outstanding representatives (M. Azbel, B. Verkin, I. Lifshits, L. Shubnikov). It is important to note that this non-simple work, including cumbersome archival searches, meetings with participants of the events, and, often, quite nontrivial psychological moments, we did together with our colleague and friend Yuri Freiman. After Sergei's tragic death, Freiman and I planned to organize and write this text. But trouble does not come alone. Yuri, who had already had health problems for several years, took this fact very personally. His health began to deteriorate quite rapidly, and he passed away two months later.