2015

Professor Vadim A. Atsarkin

Russia

Your scientific activity was devoted entirely to magnetic resonance, correct?
What is, in your opinion, the most attractive feature of this field of science?

Sometimes I was engaged in fields not related directly to magnetic resonance, such as quantum electronics and high-temperature superconductivity, as well as some medical applications of magnetic nanoparticles. But magnetic resonance is, surely, my main topic. I think the unique attractiveness, as well as apparent inexhaustibility of magnetic resonance, is related to the specific beauty of this physical phenomenon which is often (and fairly) called "spin ballet". Sophisticated manipulations of spin systems performed by modern researchers have no precedent in other fields of science. That is why magnetic resonance becomes an area of testing and implementation of the most daring ideas, both in pure physics and technology, such as time reversal, quantum computing, magnetic resonance imaging (MRI), and many others. As for me, I am interested primarily in pure physics, and magnetic resonance meets my needs perfectly.

What is, in your opinion, the significance of pure science, apart from practical applications?

First of all, the basic science is in fact a practical thing, since it satisfies directly one of the most important, rather biological human needs: curiosity, the desire for learning and the demand for knowledge about the world where we are living. This distinguishes humans from animals. And secondly, a high level of pure science is related to the existence of a special social layer, which is rather thin, but consists of high educated, creative people. Without such a layer, the successful education and development of modern society is impossible. Unfortunately, this is often not understood by the authorities and common people.

What are your hobbies in addition to science?

In my youth, I liked to travel with my friends by kayaks along Russian rivers. We did it every summer, and sometimes went as far as Northern Karelia and Arctic Ural, even beyond the polar circle. Stormy rapids, beautiful lakes, sunny nights, fantastic fishing… And every winter I went alpine skiing in the Caucasus. But later on and with aging, rather spiritual demands were highlighted, such as belles-lettres. I like to read fiction, both classic and contemporary authors, Russian and foreign. Additionally I write verses sometimes. Two thin books of my poetry, mostly lyrical, are published.

Atsarkin's theorems for life

Theorem 1
Criticism is always helpful, even an unkind one. The best way to have revenge upon unkind critic is to derive profit from his criticism.

Theorem 2
Any contents can be set in any space, from a few lines in encyclopedia to a thick monograph. The same applies to talks.

Theorem 3
Once written, a dissertation will be defended. The same applies to article publications.

Theorem 4
The deeper and the more original the work is, the harder it is to have it published and the less it is cited.

Awards and Honors:

1992-2015
Grants from Russian and International Foundations

1996
International George Soros Foundation Award

2003
Dozor Fellowship, Israel

DISTINGUISHED FOR HIS CONTRIBUTION TO THE DEVELOPMENT OF SPIN THERMODYNAMICS AND TO STUDYING THE DYNAMIC NUCLEAR POLARIZATION PHENOMENON

Half a century with magnetic resonance

It was 56 years ago in the spring of 1959, when I entered for the first time into the laboratory of quantum electronics which was headed by M.E. Zhabotinsky in the Institute of Radio Engineering and Electronics RAS. Previously I studied at the Lomonosov Moscow State University where I specialized in semiconductors, having no idea about quantum electronics, not to mention magnetic resonance. At that time, however, this was the only way for me to be engaged in science, and science was my only goal.

So I began working, and the research we performed appeared to be extremely intense and absorbing. All my new colleagues were young, including the most talented, really magic experimentalist Andrey Frantsesson who became my tutor and friend. We worked enthusiastically, staying in the lab till 10-11 p.m. At that time our main purpose was to create masers, the microwave quantum devices. Maser was the first invention in the era of quantum electronics opened shortly before by C.H. Townes, N.G. Basov and A.M. Prokhorov, future Nobel Prize winners. As maser materials, single crystals doped with paramagnetic ions were employed; that is why the EPR spectroscopy became the main method in maser research. So EPR entered my life, and as it turned out, it was never to leave. The first original task set to me was to design and build an EPR spectrometer. At that time, we knew nothing about Bruker. All equipment was made with our own hands.

Our masers operated in the so-called three-level mode, when the population inversion (negative spin temperature) needed for the stimulated emission at the active transition (1-2 for example) is caused by powerful microwave pumping at a higher frequency (1-3). Now this method is widely used in laser techniques, being familiar to every student. But at that time this was a revolutionary idea, and its implementation put created questions concerned with thermodynamics. Particularly, it was realized that different spin temperatures, including the negative ones, can coexist in a multi-level spin system. This concept, as well as the method of selective resonance pumping with subsequent monitoring at other frequencies, impressed me deeply. In fact, this idea determined my following work for decades; it became the main methodical trick and specific brand of our team.

As Maurice Goldman said many years later, "at that time spin temperature was the hot matter". In 1961, Boris Provotorov, a young scientist working in the Institute of Chemical Physics, Moscow, advanced a new theory of magnetic resonance based on spin thermodynamics. He suggested the fundamental concept of a two-temperature quasi-equilibrium in a spin system subjected to resonance pumping. The situation under study was really very close to that described above for masers, but the role of the active transition was now played by the dipole-dipole interactions between spin magnetic moments. According to the Provotorov Equations, this "dipolar reservoir" forms a quasi-continuous energy band characterized by its own "dipolar" spin temperature which could be strongly lowered (cooled) in magnitude, being either positive or negative. My elder colleague Maya Isaakovna Rodak predicted theoretically, based on the Provotorov Equations, some effects arising in the resonance line shape under pumping. Strictly speaking, this theory was elaborated more for NMR than for EPR, but I was sufficiently young and ignorant to neglect the difference. In 1967 my student Sergey Morshnev and I managed to discover this "Rodak effect" using EPR saturation at helium temperatures. This was the first experimental verification of the Provotorov's theory, and we were really happy.

Since this point, the direction has been chosen and events ran faster. Soon we learned to measure the dipolar temperature as well as to transfer it from impurity electrons to nuclear spins of the host lattice. Thus, the thermal mixing mechanism of dynamic nuclear polarization was ascertained; it remains urgent up to date. Subsequent findings and achievements of our group were the enhanced longitudinal susceptibility effect (ELSE), direct detection of NMR in the rotating reference frame, method of measuring fast electron spin relaxation, as well as applications of these methods in studying spin dynamics in dilute paramagnets, high-temperature superconductors, strongly correlated systems, fullerides, magnetic nanoparticles, contrast MRI agents, 2D surface objects, etc. And finally, a number of spin-charge phenomena in ferromagnetic metals and layer structures are studied at present. All these results were obtained by the use of resonant microwave pumping with low-frequency (or dc) detection. I hope this particular line of inquiry is proved to be valuable and will be followed.

I would like to say a few words about my colleagues who contributed so much to the results obtained. My best students graduated in former times from the Moscow Physical-Technical Institute and have now become distinguished scientists. Sergey Morshnev, Oleg Ryabushkin, Vladimir Skidanov, Natalia Noginova, and especially Viktor Demidov who works with me now, are my close friends and by right should share the honor of the Zavoisky Award. The same is related to my colleagues M. I. Rodak, A. E. Mefed, and G.A. Vasneva. Without their inestimable assistance my work could not be successful. Finally, a great positive influence should be acknowledged of the Moscow Seminar "The problems of magnetic resonance", where I have the honor to be a chair since 1981. The high scientific level and free spirit of the Seminar, the brilliant reports and hot discussions provide hope for future.