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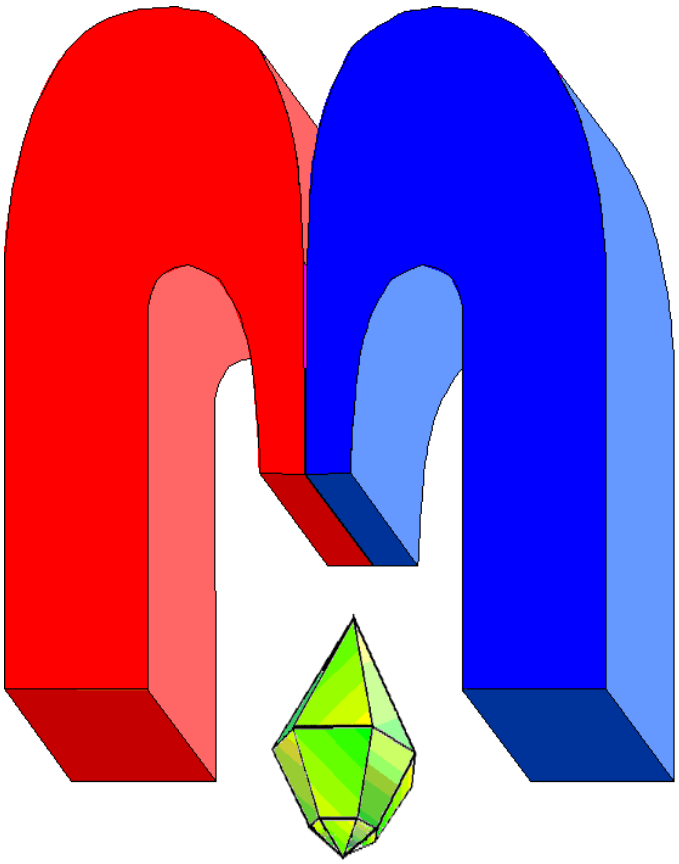

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* In Kazan University the Electron Paramagnetic Resonance (EPR) was discovered by Zavoisky E.K. in 1944.

Magnetic resonance: from investigation of the aging processes in human brain to the study of the structure of heavy oil fractions†

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A review of the twenty-year history of the activities of the International School of Young Scientists "Actual problems of magnetic resonance and its applications" in Kazan, Russia, is presented.

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Such was the range of topics of lectures made by well-known scientists and reports presented by young researchers at meetings of the International Youth School "Actual Problems of Magnetic Resonance and its Applications". This year, 2018, marks the twentieth anniversary since the School started. Anniversary is always a reason to look back at the path traveled, to evaluate what has been done, to understand the mistakes and, hopefully, to get positive emotions.

The science of magnetic resonance, beginning with the discovery by Evgeny Konstantinovich Zavoisky at Kazan University of the phenomenon of Electronic Paramagnetic Resonance (EPR), has a very strong tradition in the USSR and then in Russia. Seminars and conferences on various aspects of magnetic resonance attracted the most famous physicists, chemists, biologists of our country. In 1968, Georgy Viktorovich Skrotsky organized the “School on Magnetic Resonance”, the purpose of which was to rally the country's magnetic resonance community and to enable young scientists to receive the latest “news” of resonance science. The School took place in various cities of the USSR, which were interesting both due to their scientific level and beauty of landscape of their neighborhood and that is why the School enjoyed immense popularity. Soon it turned into a busy conference with an extremely packed program. The viability of such “volunteer” events like the School is one hundred percent dependent on the activity and selflessness of its organizer, and therefore, when Georgy Viktorovich’s age prevented him from giving a lot of energy to the School, it gradually ended, transferring topics, in parts, to various seminars and conferences

In 1997, under the initiative of academician A.S. Borovik-Romanov, professor A.V. Aganov, Dean of the Faculty of Physics, Kazan University – the Russian “homeland” of magnetic resonance, as well as the director of the Kazan Physical-Technical Institute of the Academy of Sciences of the USSR, professor K.M. Salikhov, there was established the organizing committee of the School of Young Scientists "Actual Problems of Magnetic Resonance and its Applications". The organizers of the School, professors M.S. Tagirov (Kazan University, KSU) and V.A. Zhikharev (Kazan Physical-Technical Institute, KTPI), were motivated by the desire to continue the glorious traditions of the School of G.V. Skrotsky. The principles that they used as the basis for the School’s work were as follows: ensuring a high level of lectures, only oral presentations by “pupils”, a competition for the best scientific work among “pupils” and for the best presentation at the School session, master-classes on performing of real work on modern spectrometers for "pupils"-experimenters, cultural program for participants that promoted establishment of closer contacts among young researchers from various

† This material is prefaced a publication of papers selected at XX International Youth Scientific School "Actual problems of magnetic resonance and its application", Kazan, 24–29 September 2018. The MRSej Editors, Prof. M.S. Tagirov and Prof. V.A. Zhikharev, are responsible for the publication.

research centers. To solve these problems, the Program Committee of the School was created, headed by professor Vadim Alexandrovich Atsarkin (IRE, Moscow) – the most famous expert in the field of magnetic resonance in Russia and one of the most active participants in the G.V. Skrotsky's School.

Well-known scientists in the field of magnetic resonance joined and still actively participating in the Program Committee of the School. Among them: professors A.V. Aganov. (KSU, Kazan), B.I. Kochelaev (KSU, Kazan), I.V. Ovchinnikov (KPTI, Kazan), K.M. Salihov (KPTI, Kazan), I.A. Garifullin (KPTI, Kazan), L.R. Tagirov (KSU, Kazan). The scientific part of School's operation was organized by the Rectorate of the School (Rector prof. Tagirov M.S. (now Kazan Federal University, KFU, Kazan) and Vice-Rector prof. Zhikharev V.A. (now Kazan National Research Technological University, KNITU, Kazan)). Local organizing committee, consisting of I.G. Motygullin, I.P. Volodina, A.V. Klochkov, E.M. Alakshin, T.R. Safin, E.I. Kondratieva, A.V. Bogaychuk (all KFU), played very important role in solving organizational everyday issues. The work of this team at all schools deserved the highest praise.

The School at different times was financially supported by the Russian Foundation for Basic Research, the Russian Academy of Sciences, the Academy of Sciences of the Republic of Tatarstan, the international company Brooker, the Dynasty Foundation, and the Institute of Applied Research of the Academy of Sciences of the Republic of Tatarstan.

Figure 1. The first meeting of the School "Actual problems of magnetic resonance and its applications", Kazan, 1997.

Figure 2. Meeting of the School-2002. In auditorium of Butlerov Chemical Institute of Kazan University. Kazan, 2002.

During the 20-year history of the School, more than 150 well-known scientists acted as its lecturers. Sometimes the School coincided in time with international scientific conferences held in Kazan. Then the participants of these conferences gladly spoke to the "pupils" as a lecturer, and the "pupils", in turn, delighted in the atmosphere of the conferences discussing the latest achievements in the physics of magnetic phenomena. We give the names of only a few foreign scientists – lecturers of our School: Nobel laureate, professor K.A. Müller (Switzerland), professors K. Kono, H. Suzuki, K. Kumagai, D. Constantinov (Japan), U. Eichhoff, K. Babershke, A. Bussmann-Holder (Germany), Yu. Bunkov, Z.-P. Nocher, A. Godfrin (France), A. Shengelaya, T. Sanadze (Georgia), B. Tsukerblatt (Israel), I. Jeru (Moldova), S. Ryabchenko, A. Roitsin, S. Lukin (Ukraine), B. Rameev (Turkey), S. Vasilyev (Finland). A huge role in raising the level of the young generation of scientists in the field of magnetic resonance in Russia was played by lectures of Russian scientists. Here are a few names: A.I. Smirnov, A.V. Kessenikh, V.V. Dmitriev, T.A. Babushkina (Moscow), A.S. Moskvin, S.V. Verkhovsky (Yekaterinburg), V.V. Fedorov, V.A. Chizhik (St. Petersburg), I.I. Proskuryakov (Pushchino). Of particular note is the contribution to the successful work of the School of three Moscow professors V.A. Atsarkin, F.S. Dzheparov and E.B. Feldman – regular participants of the

Figure 3. Professor K. Kono (Japan) gives a lecture at the School-2009, dedicated to the memory of professor M.A. Teplov, Kazan, 2009.

Figure 4. Academician V.V. Dmitriev (Institute for Physical Problems of the RAN, Moscow) gives a lecture on "Zavoysky readings", Kazan, 2018.

School, wonderful lecturers and interlocutors for young scientists, permanent members of the jury for the best work at our School. And, of course, a large number of Kazan scientists participated in the School as lecturers: academician K.M. Salikhov, professors B.I. Kochelaev, M.M. Zaripov, G.B. Teitelbaum, L.R. Tagirov, B.Z. Malkin, I.A. Garifullin, L.K. Aminov, M.V. Eremin, V.D. Skirda, Yu.I. Talanov, N.F. Fatkullin, V.V. Klochkov, S.B. Orlinsky, M.R. Gafurov, D.A. Tayursky and many others. At several last Schools, some former "pupils" acted as lecturers: I. Mukhamedshin, R. Eremina, R. Yusupov, E. Vavilova, I. Romanova, A. Klochkov, E. Alakshin, V. Kuzmin, K. Safiullin…

The total number of young scientists, undergraduate and graduate students who have passed through the School's audiences is almost 1,000. The vast geography of "pupils" deserves a special mention: Irkutsk and Kaliningrad, St. Petersburg and Rostov-on-Don, Ivanovo and Syktyvkar, Moscow and Nizhny Novgorod, Kharkov, Ufa, Yekaterinburg, Novosibirsk, Yoshkar-Ola… Young scientists from Germany, Poland, Turkey and India also presented their reports at the School. In many scientific centers and universities of Russia you can find on the walls of laboratories diplomas awarded at the School for winning competition for the best scientific work. Young experimenters from different cities of Russia expressed their gratitude to the scientists of the Kazan University, associate professors S.B. Orlinsky and V.V. Klochkov for extremely interesting and useful master-classes in performing research work using most advanced NMR and EPR spectrometers of the Brooker company.

At about the same time as the School's inception, another good tradition of supporting young physicists appeared in Kazan. At the initiative of the dean of the Physics Department prof. A.V. Aganov and Mayor of Kazan K.Sh. Ishakov (a graduate of the Faculty of Physics of KSU), the annual "E.K. Zavoisky Youth Scientific Award" was established. Naturally, the School and the Prize "found each other" and all subsequent years the awarding ceremony took place during special session of our School.

The School is usually accompanied by several evenings of networking among young people, concerts and trips to interesting places in the vicinity of Kazan. Such trips were: visiting of the Raifa Monastery, famous Kazan Astronomical A.E. Engelhardt Observatory, several interesting museums of the Kazan University, the modern planetarium, the E.K. Zavoisky Memorial Museum and much more.

The twentieth School-2018 (September 24-29, 2018) was attended by young scientists from research centers in Moscow, Kazan, Yekaterinburg, Chernogolovka (Moscow region), and also Donetsk (Ukraine). They presented 27 oral reports. 18 lectures were given by leading scientists in the field of magnetic resonance from Russia (Moscow, Kazan, Chernogolovka), France (Grenoble), Germany (Karlsruhe), Finland (Turku), Turkey (Gebze).

Figure 5. Granddaughter of E.K. Zavoisky at the ceremony of presenting "E.K. Zavoisky Youth Scientific Award", Kazan, 2018.

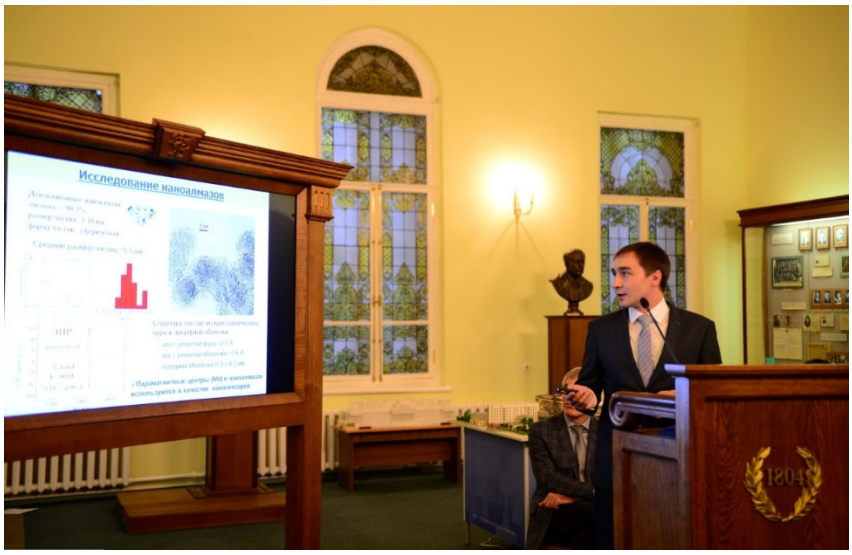

Figure 6. Winner of "E.K. Zavoisky Youth Scientific Award" for 2018 Kuzmin V.V. (S.A. Altshuler's Laboratory, KFU).

School 2018 was opened with a lecture by Uwe Eichhoff (Karlsruhe, Germany) "The human brain: development and aging explored by MRI", which described advanced research in magnetic resonance imaging of the human brain. In other lectures of our foreign guests (S.A. Vasilyev – Turku, Finland; B.Z. Ramyev – Gebze, Turkey) and leading Russian scientists (F.S. Dzheparov, V.V. Dmitriev – Moscow; E.B. Feldman – Chernogolovka; Yu.M. Bunkov, B.I. Khairutdinov, M.R. Gafurov, R.M. Eremina, S.B. Orlinsky – Kazan) a wide range of applications of magnetic resonance in various fields of science and technology was discussed. Among them: modern developments of devices for magnetic resonance investigations, subterahertz EPR spectroscopy, application of magnetic resonance to the study of oils, macro-, micro- and nanodiamonds, investigation of low-dimensional systems, the study of spin dynamics and its application in quantum computer science, magnetic properties of high-temperature superconductors, as well as theoretical aspects of the magnetic resonance.

Very wide range of scientific studies using the technique and methods of magnetic resonance was reflected in the reports of the young participants of the School-2018. Their scientific level, as well as the ability of young scientists to report on their scientific results, to bring them to the audience, the ability to lead a scientific discussion was evaluated by a jury composed of professors F.S. Dzheparov, E.B. Feldman, M.S. Tagirov and V.A. Zhikharev. The jury determined three winners of the competition of reports of young participants of the School-2018, which were awarded diplomas and valuable prizes. They are:

1. Georgy Bochkin (Chernogolovka) for the report "Decay of multiple quantum NMR coherences in calcium fluorapatite", which deals with a multiquantum NMR experiment on fluorine nuclei in calcium fluorophosphate. A theoretical description of the experiment with second-order coherences, which is in satisfactory agreement with the experimental data was presented.

2. Sofya Gotovko (Moscow) for the report "Multiferroicity of $CuCrO_2$ tested by ESR", in which an extensive study of the magnetic properties of $CuCrO_2$ was carried out both theoretically and by various EPR techniques.

3. Alexander Germov (Ekaterinburg) for the report "NMR study of electron-doped cubic manganites $Sr_{1-x}La_xMnO_3$", which presented a detailed study of the temperature dependences of the NMR signals in $Sr_{1-x}La_xMnO_3$ manganites for various values of x.

Also, the jury especially noted the high scientific level of the following reports by "pupils": Gleb Dolgorukov (Kazan) "Atomic-scale probing centers for nanodiamonds by ^{3}He NMR", Kirill Vasin (Kazan) "Elastic interactions of anusotropic cubic media", Albert Farhutdinov (Kazan)

Figure 7. Participants of twentieth School-2018, Kazan, 2018.

"Conventional magnon BEC in YIG films", Margarita Goldberg (Moscow) "Synthesis of hydroxyapatite doped with aluminum", Dmitry Ivanov (Kazan) "Resinous-asphaltene aggregate by NMR analysis", Rodion Likerov (Kazan) "Investigation of YVO_4 monocrystals doped by $^{143}Nd^{3+}$ and $^{145}Nd^{3+}$ rare earth ions by EPR and crystal field parameters calculations", Elena Razina (Kazan) "EPR of calixarenes dopped by rare-earth metals ions".

If you compare the following two photos – the first School of 1997 and the twentieth, of 2018, you will easily notice that the School organizers became considerably older! But "pupils" are as young as twenty-one years ago. And this is good, because it is evidence that the International Youth School "Actual Problems of Magnetic Resonance and its Applications" is alive and will live for many years.