

The Discovery of Magnetic Resonance in the Context of 20th Century Science: Biographies and Bibliography. Preface

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In 2019, 75 years had passed since Evgeny K. Zavoisky discovered the first of magnetic resonance phenomena in condensed matter – electron paramagnetic resonance (EPR) or, as it is also referred to, electron spin resonance (ESR). This discovery opened up opportunities unseen before for investigating composition of the matter, physics of interactions, mechanism of chemical reactions, mysteries of geological processes, nature of biological processes, and many other areas of interest in modern science. Early in 2021, it had been 75 years since Edward M. Purcell and Felix Bloch, the Nobel Prize winners “for their development of new methods for nuclear magnetic precision measurements and discoveries in connection therewith”¹, discovered nuclear magnetic resonance.

Anniversaries of this significance call for thorough retrospective analysis – at the very least, of the first steps toward the breakthrough and of some major milestones further along the way, as it would be an impossible undertaking to contextualize the whole journey within a single book. Having neither resources nor ambition to give a full picture of the evolution of physics prior to the World War II that led to the discovery of magnetic resonance, we (A. V. Kessenikh and V. V. Ptushenko) focused upon its three pioneers: Evgeny Konstantinovich Zavoisky, Edward Mills Purcell, and Felix Bloch. Birth of a new field of physics cannot by any means be narrowed down to the three scientists alone, even though they were acknowledged discoverers of this new field. And yet, their scientific

journey, the logic behind and context of their investigations seem to accurately reflect triumphs and failures, advancements and limitations that shaped the history of magnetic resonance.

In this monograph, we were keen to explore personal motivations that drove the pioneers of magnetic resonance, as well as historical context and socio-economic circumstances their discoveries were made in, apart from the logic of scientific knowledge.

Sadly, utter disregard for the life and talent of an outstanding physicist cast its shadow over the Zavoisky's breakthrough². His nuclear magnetic resonance (NMR) experiments were cut short on the verge of discovery. His experimental genius that could have been of great benefit for the Soviet army was entirely neglected during the war. Even after he had succeeded in observing EPR – for the first time in the history of science and despite his straitened circumstances – Zavoisky was not given resources needed to launch the full-fledged scientific research. From this standpoint, it was a blessing for both Soviet science and for Zavoisky himself, that, in 1947, Igor V. Kurchatov took him under his wing and provided him with support more adequate for his talent as a physicist, an experimenter, and an inventor. Over the course of time, Semen A. Altshuler and Boris M. Kozyrev, Zavoisky's collaborators in Kazan in his search for NMR, established their schools that later on contributed greatly to investigation of the magnetic resonance phenomena.

¹ Nobel Prize Winners: an H.W. Wilson biographical dictionary (The H. W. Wilson Company), 1987.

² For the full story, see V. D. Novikov, N. E. Zavoiskaya (contributing editors): *Magician of Experiment: Reminiscences about Academician E. K. Zavoisky* (Nauka, Moscow), 1993.

Bloch and Purcell, who performed their NMR experiments at Stanford and Harvard Universities, respectively, both seem to have been exceptionally equipped, in every sense. Even better were they positioned to study NMR applications and NMR-related phenomena. Purcell reached the zenith of his career by the time of his NMR studies and was equally successful in investigating other fields, such as radio astronomy and radio wave propagation. In his experimental work, he used the newest methods in radiophysics available at the time. Bloch, in his research, was supported by Varian Associates, a manufacturer of scientific instruments, and therefore, one can say, he laid foundations of the NMR instrumentation industry. Bloch succeeded to go through with his original plans to determine magnetic moment of the neutron and of the simplest nuclei (of hydrogen isotopes), as he succeeded to suggest one of the possible approaches to the quantum statistical theory of behavior of nuclear moments in a sample.

Recognizing the inventors, we felt compelled to mention other brilliant scientists who shaped the history of magnetic resonance. To that end, we included a brief historical overview of the first decade of magnetic resonance development in the Soviet Union, integral to the advancement of magnetic resonance studies and instrumentation in the rest of the world.

Finally, the book contains an extensive standalone bibliography and, to some extent, historiography of magnetic resonance, providing a reference list of more than 1000 original publications and reviews on the theory, breakthroughs, research, and major applications of magnetic resonance, as well as biographical memoirs and personal reminiscences. The list is supplied with detailed description, general and footnote commentary, and is arranged in a thematic and chronological order – original work, reviews and monographs, works on the history of magnetic resonance, and links to Internet resources, all listed independently. Within each such group links are sorted by years. In more detail, the structure is explained in the commentary section of Chapter IV. Every chapter includes its own reference list, each arranged by citation order. For instance, majority of the works by Russian authors are listed in Chapter III, and thus are not duplicated in Chapter IV. Only some of the sources cited in the first three chapters are included in the historiographical reference list in Chapter IV. No matter how comprehensive a bibliography is, it can by no means be complete. Nonetheless, the reference list provided in this book covers major milestones of magnetic resonance research in both theory and numerous applications. We did our best to keep it objective, yet this bibliog-

raphy may still have been influenced by our personal biases, for which we offer our apology to the reader.

The authors are grateful to Vl. P. Vizgin for arranging a discussion of some of the materials comprising this book at the Moscow Seminar on the History of Physics and Mechanics. We would like to acknowledge N. E. Zavoiskaya, K. A. Tomilin, and V. M. Berezanskaya who have assisted with writing this monograph, and Y. I. Talanov – for the material he has provided. Research on one of the stories recounted in this book, the one about the purchase of the Bloch–Hansen patent by Varian Associates, was inspired by a brief conversation one of the authors once had with Loren Graham, a renowned American historian of science (see also his interview to the *Independent Newspaper*³).

Research material collected by N. E. Zavoiskaya was widely used to narrate the lives and work of the three magnetic resonance inventors, in particular that of Zavoisky⁴.

Sadly, my coauthor, Alexander V. Kessenikh, who put his heart and soul as well as many years of his life into the backbone of this book – a comprehensive review of the literature, did not live to see the English translation to be prepared and published. I thank my lucky stars that I was blessed to work (although only for a few years) with A. V. Kessenikh, whose aptitude to hard work until his last days I have always admired. I am grateful to the Editorial board of *Biochemistry (Moscow)* for the decision to publish this book in English. Personally, I would like to thank Anna E. Evstigneeva for organizing all the difficult and diverse work on this English edition of our book. My special thanks to Alena V. Silina for her excellent translation of the text as well as for correcting mistakes made by the authors in the original (Russian) version of the text and inaccuracies in the references. Her meticulous work has made our text even much better than it was originally in Russian. I am grateful to Prof. Deborah Charlesworth for her help in finding an adequate title for the book in English. I am grateful to everyone who contributed to the appearance of this publication. I know, it would have brought a great joy to my coauthor to see our work translated for the English-speaking audience. The thought of this gives me inspiration to go on working both on this publication and on other scientific projects in our difficult times.

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³ A. Vaganov (2011) *Technologies in the Trap of Ideology. Interview with Loren Graham, Professor Emeritus*, *Independent Newspaper*, Moscow, 17, 221.

⁴ N. E. Zavoiskaya (2007) *The History of One Discovery*, Group ITD Ltd., Moscow, p. 208.