A Brief History of Superconductivity in Bulgaria

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Abstract. Physics of low temperature and superconductivity has more than half-century history in Bulgaria. The contribution of E. Leyarovski in this area is leading. Self made low temperature apparatuses, new methods, high-temperature superconducting materials and theoretical models are objects of this study. We examine highly effective method for separation of noble gases by the air, technologies of production and storage inert gases, high-temperature superconductor with zero resistance at 86.5^{o}K and vibronic model for high-temperature superconductivity are produced in the Bulgarian Academy of Sciences.

Keywords: History, Physics, Bulgaria, Low Temperatures, Superconductivity

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1. Introduction

Physics of low temperature has important role in the history of physics in Bulgaria at the second half of the 20 century. Professor Porphiry Bachmetjew started low temperature investigation in 1890s. First publication about Kamerling – Ones came in Bulgarian literature in 1915. N. Tonchev, B. Nikolov at al., discuss our low temperature scientific school [1]. D. Usunov [2], V. Kovachev [3] and E. Nazarova [4] give their historical remarks for superconductivity in Bulgaria. The aim of this paper is to show a brief history of the organization, scientists, and their results in the field of low temperature physics and superconductivity obtained in Bulgaria as well as some reasons for that.

2. History of Organizations

The low temperature physics and superconductivity have three stages of organization in Bulgaria. Cryogenics and magnetic research began during the first stage (1959 – 1972). Bulgarian Academy of Sciences organized Laboratory of low temperature. It was a technical unit at the Atomic research experimental reactor of the Institute of Physics in the beginning (1959). It became research group in 1961, and research laboratory in 1963. Technology for production and storage of liquid inert gases (neon and helium) was developed there. The second research center for superconductivity and related topics (low temperature techniques and magnetism) [3] was built in the Faculty of Physics of the Sofia University. Magnetic investigations started in its Department of Experimental Physics during the 60s of the 20 century. Laboratory of low temperatures (1971), and Group of magnetic and structure investigations (1975) grew up there [5]. Bulgarian partnership in the International Laboratory of High Magnetic Fields and Low Temperatures in Wroclaw had great importance for qualification of scientists, providing them modern equipment and international experience.

The scientific collaboration between laboratories of the Academy and departments of the University gave positive results in Bulgaria during the second stage (1973 – 1988). Bulgarian Academy of Sciences organised a separate scientific division on physics (United Center of physics) in 1972. It provided scientific unification between physical laboratories and departments. Sector Magnetism and low temperatures at the United Center of Physics had three laboratories:

Superconductivity and superconducting materials, *Cryogenics and cryogenic engineering*, and *Low temperatures and magnetic phenomena*. Common research programme, called "*Physical problems of magnetic and superconducting materials*" was approved and its implementation began in 1973 [6]. Continuous production of the liquid helium, neon and hydrogen by liquefaction of air, purification, collection and storage were realized after that [7]. Bulgarian Academy of Sciences hosted the Counsel for Mutual Economic Assistance 21 International Conference on "*Low temperature physics and techniques*" from 11 to 14 October 1983 in Varna. Superconducting research started during the second stage. Bulgarian scientists focussed there efforts to study conventional superconductivity. Technology of growing the superconducting ceramics was created. Various aspects (mono- and poly-crystals, thin and thick films, multi-structures, tapes and wires) of high-temperature superconducting materials were investigated [1].

The production and investigation of high-temperature superconducting materials marked third stage. The common research between Bulgarian Academy of Sciences and Sofia University finished (1988) and some Bulgarian scientists left the country after that. Superconductivity is still the topic of research for many institutes and laboratories in Bulgaria. Some of them are the Institute of electronics, Institute of general and inorganic chemistry, University of chemical technology and metallurgy, Sofia University (Faculties of chemistry and physics), and Institute of solid state physics.

3. Scientists

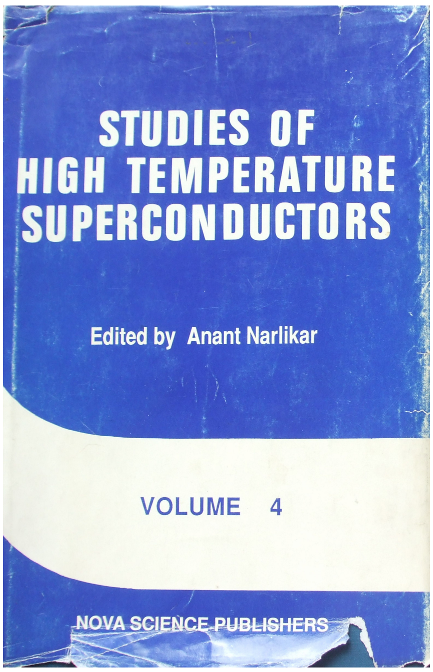
During the second half of 20 century Bulgarian low temperature physicists worked in favourable but very difficult circumstances. They were overloaded to do so many things – to be movers and managers, to do setup and build technics for it, to investigate new scientific ideas and published results. The names of six physicists are written in the history of superconductivity in Bulgaria. They are Sazdo Ivanov, Eugenie Leyarovski, Vesselin Kovachev, Borislav Nikolov, Vasil Lovchinov, and Petko Vasilev.

3.1. Sazdo Ivanov Trichkov (02.04.1899 – 30.09.1999) is a manager and creator of low temperature physics in Bulgaria. He studied physics in the Sofia University (1918 – 1924). After that he was a teacher (1924 – 1927) and Professor Georgi Nadjakov's assistant (15.05.1927 – 20.09.1945) in the Sofia University. In the Technical University in Sofia, he became associate professor (20.09.1945) and professor in physic (1946 – 1965). He was dean and rector there (1951 – 1953 and also 1953 – 1960). Sazdo Ivanov led a group realized first Bulgarian TV center (1951 – 1954) with public demonstration in 1 May 1954. Bulgarian Academy of Sciences appointed him to a deputy-director of the Institute of Physics (15.05.1962 – 15.05.1972). Sazdo Ivanov led a group of Bulgarian experts in low temperature at the Counsel for Mutual Economic Assistance from 1962 to 1968. He signed agreement for establishment the International Laboratory of High Magnetic Fields and Low Temperatures in Wroclaw, Poland in 11 May 1968. Polish Academy of Sciences awarded him with a medal (1978) as a counsellor of the Laboratory (1968 – 1973) [8].

3.2. Eugenie Iliev Leyarovski (05.07. 1933 – 23.04.1999) is a founder of the low temperature physics and techniques in Bulgaria [9, p. 207]. He was an excellent gas liquefaction engineer, physicist, and scientist of the Bulgarian Academy of Sciences with 18 inventions and 12 international recognised patents [10]. Eugenie Leyarovski was born in Sofia. He came from two or three hundred years old moulders family with Macedonian roots [6, p. 92-95]. He graduated from the Institute of chemical technology in Sofia (1953 – 1957) and studied physics as an extramural student (1961 – 1963). He became an assistant (1966), associate professor (1972), and professor (1987) of the Bulgarian Academy of Sciences.

Eugenie Leyarovski was very curious erudite knowledgeable man. As a young engineer of low temperatures, he worked in the Chemical factory of Dimitrovgrad (15.05.1957 – 27.08.1957) and in the Metallurgic factory of Pernik (15.12.1957 – 27.08.1959). Bulgarian Academy of Sciences appointed him in 27 August 1959. He headed Low temperature laboratory at the Institute of Physics (1959 – 1972), and Sector of magnetism and low temperatures in the Institute of Solid State Physics. He was scientific secretary (1969 – 1970 and 1982 – 1989), deputy director (1989 – 1991), and chief of its scientific counsel (1991 – 1994). Eugenie Leyarovski was a deputy director of the International Laboratory of High Magnetic Fields and Low Temperatures in Wroclaw (1974 – 1977). He was member of its international scientific counsel (1968 – 1990). Polish Academy of Sciences awarded him with silver medal (1978). Eugenie Leyarovski settled with his family in United State of America and came to live and work in Chicago and California up to the end of his life (April 1997 – 1999) [11, sheet 25].

3.3. Vesselin Tasev Kovachev was born in Kunino near Vratsa (16.07.1940). Engineer Kovachev studied Technical Institute in Leningrad (Saint Petersburg now) from 1960 to 1965 and defended his PhD in technical science in 1970. He became D.Sc. in 1986 and Professor in 1987 in Bulgaria. Institute of Physics, BAS, appointed him (01.02.1966) and later he worked in the Institute of Solid State Physics up to his retirement. He lectured 10 university cources for 15 years and tutored three PhD students. He headed the *Laboratory of Superconductivity and superconducting materials* 30 years (1973 – 2003) and 11 years he was deputy director of the Institute of Solid State Physics (1978 – 1988). He was a member of scientific council of the International Laboratory of High Magnetic Fields and Low Temperatures in Wroclaw (1974 – 1978; 1999 – 2004. He lectured cources *freezing technics* (1984 – 1985) and *electrical apparatuses* (1987 – 1988) in the Technical University in Sofia. He was visiting professor in United States of America (Brookheaven National Laboratory 1977 – 1979; Superconductivity Super Collider Laboratory in Dallas 1990 – 1995), England (1985), and Japan (National High Energy Laboratory, National Institute for Metals and National Institute for Fusion Science 1996 – 2000) with SSCL diplom (1992). He published 4 books and 167 articles and only 37 of them were in Bulgarian language. He had nine patents and realized in practice six of them [12].



4. Scientific Results

Some important results in the area of low temperature physics and superconductivity obtained in our country do not receive industrial application in Bulgaria.

4.1. Scientific Apparatuses: Vesselin Kovachev produced thin film Platinum resistance thermometer for measurements in high magnetic fields (1990) [13] and investigated thermocouple Chromel-Cupper properties (1989) [14]. The Laboratory built many selfmade apparatuses. Some of them were: *cryostat* for investigation of heat transport and mechanical deformations in nitrogen temperatures (1968); *electromagnets* (1968); *cryopump f*or obtaining vacuum up to 10^{-7} Torr (1969); *solenoid* with nitrogen cooling maximum field up to 25 kG (1969); *model of neon liquefier* (25 International Fair in Plovdiv, 1969); *liquid helium installation* (1972)*; liquid neon installation* (1972); *nitrogen installation* (1974); *semi-industrial installation for obtaining pure Ne and He from the air* (1975); three *cryostats* in ultra low temperature (for Bulgaria, Poland and Italy, 1980).

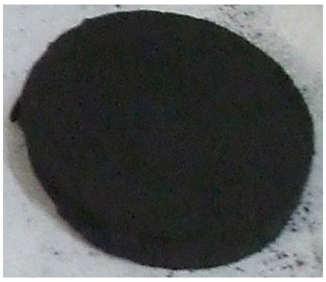
Vesselin Kovachev initiated production of liquid helium in the Institute of Solid State Physics (KGU-150/4.5). It is the first still working liquid helium station in Bulgaria. It was planned to produce up to 40 liters per hour. Now, it is in a state to produce only 20 liters per hour [15].

4.2. Methods: Eugenie Leyarovski patented new adsorption methods and apparatuses for cryogenic separation of gas mixtures from the air patented in Bulgaria (Patents No 10549 from 25 May 1964, and Patent No 5548 / 2 July 1965), USA, and al. [10]. His patents won gold medals from the World patents exhibitions in Geneva (1973) and Brussels (1975).

He developed new experimental method and techniques for measurement temperatures below 1°K and nano-Kelvin range (300°nK) [1, p. 151-152]. His Laboratory constructed original technology for semi-industrial production and storage of liquid nitrogen and helium (1980) in Bulgaria but filed to implement it.

Vesselin Kovachev published a method for preparation of high temperature superconducting thin films in 1989.

4.3. Materials: Eugenie Leyarovski found out conventional superconductivity transition in metal borides (1979) [1, p. 152].



Vesselin Kovachev synthesized new polyphase high-temperature superconducting material (oxide ceramics Y-Ba-Cu-Pt-O shown in left) in 20 of April 1987. He registered superconducting transition at temperature T_c=86.5°K [16-17] and two transitions in antiferromagnetic ordered state at temperature 17,5°K and 4,0°K.

Vesselin Kovachev investigated alternating current losses on heat-treated superconducting super collider cables, conductors, and high-energy booster dipole magnets (1991 – 1993) [18].

4.4. Models: Vesselin Kovachev created some numerical and analytical models. He formulated the 110 K phase in Bi-Sr-Ca-Cu-O and Bi-Pb-Sr-Ca-Cu-O materials in 1992 [19].

Milko Borissov and Mladen Georgiev proposed pairing off-center polarons about dipole-dipole interactions [20]. Their vibronic (bipolaron) model of high-temperature superconductors offered a possible explanation of high-temperature superconductivity in complex oxides [21].

5. Conclusion

History of low temperature physics has three stages in Bulgaria during the second half of the 20 century. They are low temperature and magnetism (1959 – 1972); conventional superconductivity (1973 – 1987); and high-temperature superconductors since 1988. Although simultaneously loaded scientific and administrative duties, the three discussed above talanted scientists achieved significant scientific results in Bulgaria. Cooperation is the next reason for our achievements. One kind of cooperation was a local teamwork of physicists, chemists and engineers in the Laboratory. The State level of cooperation was between BAS and SU at the United Center of Physics. The international level of cooperation was the International Laboratory of High Magnetic Fields and Low Temperatures in Wroclaw.

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