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Physics at the Bulgarian Academy of Sciences (1946–1988)

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Abstract: – Bulgarian Academy of Sciences transformation into experimental research institution during the second half of 20th century has examined briefly. New scientific branches together with new members of Bulgarian Academy of Sciences have shown. Self-made scientific apparatuses and new scientific and applied results have pointed out.

***Key-Words*:** – Bulgarian Academy of Sciences, experimental physics, history

1. Introduction

Bulgarian Academy of Sciences has one century and half long history. It starts as a literary society. Physics as a science is part of this history. M. Borissov investigated history of physics in Bulgaria up to 1911 [1]. In this paper we examine physics at the Bulgarian Academy of Sciences.

1.1. Physics at the Bulgarian Literary Society (1856–1911)

Meteorology and experimental physics are areas of physics created in Bulgaria in the beginning. Many physicists took part in Bulgarian Literary Society creation. Demetrius Mutieff (04.09.1818–13.01.1864) is philosophy doctor from the University of Berlin in the

area of theoretical meteorology (1842). He has been an editor of the scientific magazine "Bulgarian Books" published by the Municipality of Bulgarian Literature in Istanbul (1857–1858). This first attempt for registration Bulgarian scientific society failed because Turkish Government did not recognize the Municipality of Bulgarian Literature officially [2]. Ivan Guzelev (24.06.1844–06.10.1916) as student on physics in the University of Odessa became foundation member of Bulgarian Literary Society, registered in Braila (1869; corresponding member 1875; and member 1884). Members of the Bulgarian Literary Society before 1911 are meteorologist Spas Vatsov (18.05.1856–02.02.1928, member 1881) and Sofia University Professor Porphiry Bachmetjew (26.02.1860–14.10.1913, corresponding member 1898; member 1900). Bachmetjew started to elaborate self-made apparatuses and new methods at the Sofia University Institute of physics. Tradition of making apparatuses is alive in Bulgaria up to now.

1.2. Physics at the Bulgarian Academy of Sciences (1911–1945)

Bulgarian Literary Society has renamed to Academy of Sciences in 1911. Alexander Vavrek (12.03.1947–07.08.2003) investigated history of physics in Bulgaria documentary from 1911 to the end of World War Second (1945) [3]. Physical chemistry and analytical mechanics are new areas of physics in Bulgarian Academy of Sciences during the period 1911–1945. Alexandar Christoff (20.03.1872–18.10.1951) was philosophy doctor on physical chemistry from the University of Leipzig (1896). He became Sofia University professor of experimental physics (1909–1937), and corresponding member of Bulgarian Academy of Sciences (1921). Ivan Tzenov (02.01.1883–19.09.1967) was Sofia University professor of analytical mechanics (1914–1958), corresponding member (1925), and member (1929) of the Bulgarian Academy of Sciences. History of physics passed through publication results only by the Bulgarian Academy of Sciences up to 1945.

Bulgarian Academy (BAS) has an important role in our physics during the second half of 20th century. The object of this documentary research is history of experimental physics at the Bulgarian Academy of Sciences. We based our inquiry on documents from the Bulgarian Academy of Sciences archive. The period of our documentary research is from 1946 to 1988. The aim of this paper is to determine characteristics of historical period (1946–1988).

2. BAS Institute of Physics (1946–1972)

Georgi Stefanov Nadjakov (26.12.1896–24.02.1981) has leading position at the Bulgarian Academy of Sciences during the second half of 20th century [4]. He was associate professor of the chair of technical physics (1927–1937), professor of experimental physics (1937–1963), Faculty of Physics and Mathematics dean (1939–1940; 1944–1947), and Sofia University rector (1947–1951). Photo electrets (a new kind of electrets, formed by light and electricity) are state of matter prepared by G. Nadjakov for the first time in 1937 [5]. Together with Razum Andrejchin (09.04.1911–26.09.1997), they found contact-potential photovoltaic effect in 1937. Political changes gave possibility G. Nadjakov to build a new experimental scientific complex on physics after that.

Bulgarian Academy of Science created scientific Institute of Physics by decision from 30 July and 17 November 1945. G. Nadjakov became member of Academy (1945) and director of the new Institute of Physics. He created first Bulgarian institute for experimental research on physics outside university (1946) [6]. G. Nadjakov was director of this BAS Institute of Physics almost all time of its existence (05.05.1946–26.12.1971) [7]. BAS Institute of Physics existed up to the end of 1972. New line for applied research introduced by him has important significance for Bulgarian industry.

As a result of providing financial support for the next year (1946), Bulgarian Academy of Sciences appointed R. Andrejchin to be Institute of Physics first assistant (1 June 1946). Regulation for BAS institutes has accepted (16 July 1946) [8, p. 51].

The academic law from 1 February 1947 and academic statute from 27–28 February 1947 determined applied scientific research to be with priority for Bulgarian physicists. Principles planning, accountability, and connection between investigations and needs of Bulgarian industry have adopted [8, p. 55]. Bulgarian Academy of Science elected G. Nadjakov to be vice-president (4 March 1947–1959) [9]. Institute of Physics has started to prepare research plans with subject, researchers and fixed time for realization since 3 January 1948.

Bulgarian physicists worked in favourable but very difficult conditions during the second half of 20th century. They have overloaded to build technique, to investigate new scientific ideas, and to publish results. We are finding small differences in their family name writing after 1945.

General physics laboratory headed by G. Nadjakov at the BAS Institute of Physics has three members (R. Andrejchin, M. Borissov, and N. Kashukeev) in the beginning [8, p. 51]. Later on, R. Andrejchin created photoelectric phenomena laboratory. M. Borissov using germanium crystals made investigations and created solid-state physics institute. N. Kashukeev worked in the area of nuclear physics.

Experimental investigations on physics have been transferred from Sofia University laboratories to BAS Institute of physics during first years. Subjects of research are photovoltaic effects and photoelectric properties of dielectrics and wideband semiconductors, physics of metal surface, contact potential difference, semiconductor properties of copper oxide (M. Moldovanova), selenium and selenium rectifiers (J. Kassabov).

Georgi Nadjakov initiated a new scientific journal "Compte rendus de l'Academie Bulgare des Sciences" since 1948. Russian, English, French and German are languages of articles in the beginning. BAS Institute of Physics published yearly "Bulletin de l'Institute de Physique et de recherches atomiques" in Bulgarian language (1950–1974). Bulletin has renamed "Bulgarian Journal of Physics" after that (1974). Four issues yearly have published in English now.

2.1. BAS Institute of Physics new laboratories (1946–1951)

Four new members of BAS created four new laboratories on physics in BAS Institute of Physics. Newly elected physicists were Rostislaw **Kaischew** (physical chemistry, corresponding member 1947, member 1961, and BAS vice-president 1962–1968); Lubomir **Krastanow** (meteorologist, corresponding member 1947, member 1961, and BAS president 1962–1968); Nikola **Bonev** (astronomer, corresponding member 1948, and member 1977); and Emil **Djakov** (technical physicist, corresponding member 1948, and member 1967). They created BAS Institute of Physics new laboratories on 1) physical chemistry (1947), 2) geophysics and meteorology, 3) astronomy, and 4) technical physics. J. Malinowski (physical chemistry), Dimitar Samardjiev (meteorology), Malina Malcheva (astronomy), and Vasiliy Kanev (technical physics) are their first assistants. Several years later, independent institutes on physical chemistry (01.04.1958), meteorology and geophysics (1958), astronomy (1958), and electronics (1962) have dissociated from the BAS Institute of Physics. Their directors became members of BAS R. Kaischew, L. Krastanow, N. Bonev, and E. Djakov.

Central Laboratory on electrochemical electricity sources and photo processes separated from Institute on Physical Chemistry (31.08.1967) headed by Ewgeny Budevsky and Jordan Malinowski (03.06.1923–12.03.1996) [8, p. 60-61].

State Institute of Hydrology and Meteorology has established (1954) and transferred to Bulgarian Academy of Sciences (1962). Independent Institute of Geophysics has established since 29 January 1960 for research on terrestrial magnetism, seismology, gravimetry, and physics of atmosphere. L. Krastanow became its director.

Astronomy at the BAS Institute of physics started as a section (1952). N. Bonev headed it up to 1973. The Institute of Physics astronomy section became BAS independent section (1958–1995). It has renamed Institute of Astronomy with seven laboratories (sun; solar system; variable stars; stellar atmospheres and stelar nebulae; chemically peculiar stars; stellar clusters; and galaxies) after that.

Bulgarian Astronautic Society exists since 7 December 1957. Cosmic research started in Bulgarian Academy of Sciences since December 1956. L. Krastanow, G. Nesterov, and N. Belopitov initiated a new center for ionosphere research. It became part of the Institute of Geophysics (1967) [8, p. 64]. L. Krastanow (as a director) and Kiril Seraphimov (as a deputy director) headed laboratory for space physics (August 1969). The laboratory evolved into independent Central Laboratory for Space Research (28.06.1974), and Space Research Institute (03.03.1987) as a unit of United Center of Physics. Bulgarian Academy of Sciences established a new laboratory for Solar-Terrestrial Influences since 1990. It became Institute in 2008. Two institutes formed a new unit in 23.03.2010 renamed Space Research and Technology Institute.

Construction of unique cosmic apparatuses started since 1969. First Bulgarian cosmic apparatus for ionosphere research flyed with Intercosmos-8 space-rocket in December 1972 (showing on the picture above). More than 150 unique cosmic apparatuses have developed and produced in Bulgarian Academy of Sciences. Part of them work on the International Space Station up to now. Newest spectrometer, created from the Institute works on an aircraft around the Earth from 29 October 2018. Another Bulgarian device for studying cosmic radiation has sent to the International Space Station on 19.02.2022. Bulgaria became third country in the world (outside America and Russia) producing space foods. BAS Space Research and Technology Institute celebrated its 50 anniversaries during 2022.

Bulgarian Academy of Sciences created Institute of Electronics with two laboratories on physical electronics and applied electronics (since 24 September 1962). They came from the Institute of Physics together with their leaders Vasiliy Kanev and Vasil Stefanov Vasilev (21.01.1930–04.06.2014). Laboratory for electronic scientific apparatuses has transferred from the Institute of Physics to the Institute of Electronics too (February 1963). Six new laboratories have created after that (physics and techniques of over super high frequencies; electro-vacuum devices; physics of gas plasma; physics of ultra-high vacuum; quantum electronics; and electronics of thin layers). New building for the Institute of Electronics has constructed from 1966 to 1969 [8, p. 61].

2.2. BAS Institute of Physics new laboratories (1951–1959)

Three new physics laboratories have established at the BAS Institute of Physics during the period 1951–1959 (optics and spectroscopy, theoretical physics, and nuclear physics). New members of BAS are A. **Datzev** (theoretical physicist, corresponding member 1952, member 1961, secretary 1962–1968), Ch. Y. **Christov** (nuclear theoretical physicist, corresponding member 1952, member 1961), and Angel **Balevsky** (metallurgist corresponding member 1952, member 1967, and BAS president 1968–1988). Bulgarian Academy of Sciences created Institute on metallography with director A. Balevsky (1960). Physics of metals became aim for research in it [8, p. 65].

2.2.1. Optics and spectroscopy laboratory at the BAS Institute of Physics has created and headed (1951–1990) by Paraskeva Dimitrova Simova (06.01.1920–2010). She was PhD student on molecular spectroscopy in Russia (1946–1951). In Bulgaria, she used spectrograph for ultraviolet spectral range (ISP22) and spectrograph for visible range (ISP51) to investigate spectrum of liquid crystal compounds, electro-optical memory and phase transitions in liquid crystals. She initiated research on nonlinear optics (lasers) [10, p. 21].

2.2.2. Electron microscopy laboratory started with two members. Nikolay Pashov (15.09.1929–2008) and Michail Michailov in 1953. N. Pashov became head of the laboratory. He specialized in Halle (Germany). He was assistant (April 1953–1971), associate professor (1971–1986) and professor (1986–1994). N. Pashov investigated structure of crystals by electron and X-ray diffraction. Electron microscopes (EM-3,5 kW) have been delivered from Russia (1953) and from Japan (1960s) [11].

2.2.3. Theoretical Physics department at the BAS Institute of physics has been created and headed by Assen Borissov Datzev (14.02.1911–12.02.1994) during the period 1952–1972. A. Datzev studied theoretical physics course of Professor Georgi Maneff at the Sofia University (1929–1933). After that, he was PhD student in Paris (1934–1938) obtaining doctor degree. He became assistant professor of physics (1939–1944), associate professor (1947–1950) and professor (1951) at the Sofia University where he took up a professorship desk (1955–1984). He was dean of the Faculty of Physics and Mathematics (1950–1955) [12].

Georgi Nadjakov (BAS Institute of Physics director) realized important role of theoretical physics for applied research projects. He found out and appointed first scientists for theoretical physics department R. Zaycoff (1953) and Nikola Kalitzin (1955).

Rashco Gavrilov Zaycoff **(**10.12.1901–25.11.1982**)** became associate professor at the BAS Institute of Physics theoretical physics department (04.12.1953–01.09.1961). As a mathematical genius, he used his talent to do theoretical and applied research on physics. Although studying one professional school and two prestigious universities abroad, R. Zaycoff graduated secondary school (1921) and university in Sofia (1928). He spoke seven languages: German and English good; French and Russian in average level; Turkish, Greek and Italian slightly. His work on theory of relativity marks beginning of this field in Bulgaria (1925–1935). Personal friendships with Einstein during the first half of 20 Century and with Nadjakov in the second half of 20th Century have very important role for his success in science. R. Zaycoff worked in Siemen's factories two times (1933–1935, and 1942–1944). H*e* worked on creation the important nuclear apparatus – betatron [accelerator] in Germany during the Second World War. In that reason, nuclear physics theory became area of his academic research after that [13].

Nikola Stiliyanov Kalitzin (01.12.1918–10.08.1970) graduated High Technical School in Berlin (1943) and mathematics at the Sofia University (1947). He was associate professor (1948–1953) and professor on theoretical mechanics (1953–1955) in Varna. G. Nadjakov appointed him associate professor (1955–1961) and professor (1961–1970) at the BAS

Institute of Physics theoretical department. Nikola Kalitzin was a PhD student at the Russian Academy of Sciences (1962) and became D.Sc. at the Moscow State University (1963). After that, he had theoretical physics specialization in Dubna (1964). His results are in theory of elementary particles, nuclear physics, and theory of space shuttles.

2.3. Nuclear laboratories at the BAS Institute of Physics

Georgi Nadjakov proposed and realized Bulgarian nuclear program. The program started with three nuclear research laboratories. They are cosmic ray station (1954, headed by Leon Mitrany), laboratory for radioactive monitoring and radiometry (1955, headed by Elisabeth Kara-Michailova), and experimental reactor (1955, headed by Simeon Ruskov).

Station for cosmic rays has built on the Musala peak. It has put into operation after equipment with Hungarian and our self-made apparatuses (14 December 1959). Bulgarian Cosmic ray station burned out and stop worked since 29.10.1983. Now, it has transformed into Basic environmental observatory.

Bulgarian government purchased reactor IRT-2000 from Russia (1955). Bulgarian Academy of Sciences constructed new institute and reactor buildings (21 February 1956–1959). BAS experimental reactor has put into operation since 18 September 1961 (20:15 P.M). After that, nuclear power station has built in Kozloduy on the end of this program (1968 – 30.06.1974) [8, p. 55].

During the period 1955–1963, Christo Yankov Christov (12.06.1915–20.03.1990), Vassil Yosifov Christow (02.10.1922–05.08.1999), and Ivan Todorov worked in the BAS Institute of Physics theoretical department. In 1958, R. Zaycoff, V. Christow, and Ivan Todorov specialized in Dubna (Russia). They worked in quantum field theory, theory of elemental particles, and nuclear theory at the Russian Joint Institute for Nuclear Research. In the next decade, Emil Nadjakov (27.11.1929 – 27.03.1996) and Ivan Zheljazkov Petkov (1932–1995) worked in theory of nuclei. Laboratory for theory of nucleus and elementary particles has created in 1972 headed by Ch. Y. Christov and Ivan Todorov.

Nikifor Kashukeev (24.10.1917–19.03.2008) specialized physics of neutrons in Russia (1955). He created and headed new laboratory of neutron physics (1956) at the BAS Institute of Physics. V. Christov specialized physics of nuclear reactors in Russia (1955). Zhelu Zhelev specialized nuclear spectroscopy in Russia (1955–1964). He created and headed laboratory for nuclear spectroscopy at the BAS Institute of Physics. New apparatuses for nuclear

research (mass-spectrometer, gamma-spectrometer, and beta-spectrometer) have delivered from Russia [8, p. 58].

On the end of 1962, BAS Institute of Physics has nine nuclear laboratories (one theoretical, four nuclear laboratories and four laboratories in reactor). 1) N. Kashukeev headed nuclear physics laboratory. 2) E. Kara-Michailova headed laboratory for radioactivity. 3) P. Markov headed laboratory for nuclear photo-emulsion and high energies. 4) Ch. J. Christov headed cosmic ray laboratory with Musala station. Reactor has four laboratories for: radiochemistry, reactor physics, dosimetry, and effect of nuclear radiation in solids [8, p. 60].

Ten years later (1972), nuclear laboratories grew up to 13 (eight research laboratories and five laboratories in reactor). These are: 1) nuclear theory (headed by Ch. J. Christov); 2) nuclear and X-ray research (E. Nadjakov); 3) neutron physics (N. Kashukeev); 4) radioactivity and nuclear spectroscopy (J. Jelev); 5) high energies (P. Markov); 6) cosmic rays (B. Betev); 7) nuclear methods for matter analysis (T. Dragnev); and 8) computing center (I. Nedjalkov). Laboratories in reactor are radiochemistry (M. Michailov); reactor physics, technics and energetics (V. Christov); dosimetry (I. Mishev); radioactive waste with nucleus standard (G. Delchev); and central measurement (I. Vankov).

2.4. Non-nuclear laboratories at the BAS Institute of Physics (1959–1972)

New members of BAS became M. **Borissov** (solid-state physicist corresponding member 1967, member 1984), Ivan **Todorov** (nuclear theoretical physicist corresponding member 1967, member 1974), and Georgi **Bliznakov** (physical chemist corresponding member 1967, member 1979, and BAS vice-president 1975–1977; 1982–1988). They build new academic institutes and laboratories in the area of physics.

Milko Borissov was deputy director of the BAS Institute of Physics (01.09.1959–15.08.1961). He investigated electrically stimulated current in mono-crystals of cadmium sulfide and used result for measuring gamma-ray dose. He invented counter for alpha and beta particles using produced in Bulgaria mono-crystals of cadmium sulfide. During the period (1962–1972), he investigated oscillations of ionic plasma in medium of rare gas and original method to determine electron structure of solids by positron annihilation [14].

Six solid-state physics laboratories have created from 1959 to 1972. New laboratories on liquid crystals (1957–1968), microelectronics (1959), low temperature physics (1959), germanium (1961), atomic spectroscopy (1962), and lasers (1964) achieved significant scientific results, new methods and self-made scientific apparatuses.

2.4.1. Liquid crystal laborator at the BAS Institute of Physics has created and headed (1968–1992) by Alexander Derzhanski (10.02.1933–06.04.2015). He became corresponding member (1995) and member of BAS (2008). His investigations started with nuclear magnetic resonance (1957). He headed laboratory for nuclear magnetic resonance (1966) and discovered gradient of flexoelectric effect in nematic liquid crystals in inhomogeneous electric fields together with A. G. Petrov (1971–1974) [10, p. 173]. His successor A. G. Petrov created new theoretical model to describe elasticity and flexoelectricity of biological membranes. He discovered flexoelectric oscillations in nematic liquid crystals (1975–1979), and inverse flexoeffect of bilayer lipid membranes (1993).

2.4.2. Microelectronics laboratory has been initiated and headed by Jordan Dimitrov Kassabov (16.08.1928–13.04.1992). Its name was Silicon at the beginning (1959–1966). J. Kassabov became doctor (1955), Sc.D. (1974), assistant (18.04.1956–01.04.1963), associate professor (01.04.1963–15.03.1967), professor (1974), and corresponding member of BAS (1976). He built technology for Silicon crystal growth (1959) and new method for silicon melting (1962). He developed new technologies for solar panels in the area of integral electronics, MOS (metal-oxide-silicon) transistors (1966), micro resistors, and integral circuit for electronic calculators (Elka 42 calculator wined a gold medal at the Osaka World Exposition in 1970). J. Kassabov and some members of Silicon laboratory created Central Institute for elements (1967). J. Kassabov became its director (15.03.1967–01.12.1973;

01.06.1974–31.12.1978). After that, he returned to BAS and headed microelectronics laboratory (01.01.1979–09.11.1989) at the Institute of solid-state physics [8, p. 201].

2.4.3. Laboratory of low temperature has been created at the BAS Institute of physics as a technical unit of atomic research experimental reactor in the beginning (27.08.1959). It became research group in 1961, and research laboratory in 1963. Many self-made apparatuses as cryostat for investigation of heat transport and mechanical deformations in nitrogen temperatures (1968); electromagnets (1968); cryopump for 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) have built. Eugenie Iliev Leyarovski (05.07.1933–23.04.1999) patented new adsorption methods and apparatuses for cryogenic separation of gas mixtures from the air in Bulgaria (Patents No 10549 from 25.05.1964, and Patent No 5548 / 02.07.1965) and USA (1969). Three research groups worked in the low temperature laboratory: cryoengineering, magnetism (1974), and superconductivity (1988). Bulgaria became member of International laboratory for strong magnetic field and low temperature in Wroclaw (Poland) since 11 June 1968. Sazdo Ivanov member from 01.05.1968 to 1973) and Eugenie Leyarovski (member from 1969, and deputy director from 1974 to 1978) took part in its scientific council [15].

2.4.4. Germanium laboratory has created and headed by Petko Rusev Kamadjiev (08.12.1918–26.12.1976). He studied physics at the Sofia University Faculty of Physics and Mathematics (1937–1942) and Ph.D. at the Russian Academy of Sciences Institute of Semiconductors (15.10.1956–15.06.1960). P. Kamadjiev spoke fluently Italian, Czech, Polish, German, French, English and Russian languages. In the BAS Institute of Physics, he headed Germanium Laboratory (01.01.1962), and Laboratory for Structural Defects in Semiconductors. He built equipment for the purification and extraction of germanium single crystals and equipment for measuring the parameters of germanium. In the BAS Institute of Solid State Physics P. Kamadjiev headed Physical Problems of Integrated and Thin Film Microelectronics laboratory. He laid foundations of epitaxial research in Bulgaria [8, p. 199-200].

2.4.5. Atomic and plasma spectroscopy laboratory has created and headed by Yordanka Christova Pacheva (05.01.1919–05.03.2003). After specialization in Leningrad (Sankt Petersburg) State University, she was atomic spectroscopy associate professor (1963–1983) and professor (1983–1988) at the BAS Institute of physics and Institute of Solid-State Physics.

She investigated hyperfine atomic structure using plasma of hollow cathode discharge and headed atomic spectroscopy laboratory (1973–1988) [8, p. 217].

2.4.6. Lasers laboratory has created and headed by V. Stefanov. He build first Bulgarian solid-state pulsed ruby laser at the BAS Institute of Electronics (01.02.1964). His Helium Neon gas laser emitted red wavelength beam 0,63 μm (22.06.1965). Carbon Dioxide laser emits in infrared wavelength 10,6 μm was the next step (23.03.1967). Bulgarian pulsed dye laser with tunable wavelength has shown at the Hanover Industrial Exhibition (1985). Laser locator is monitoring atmosphere at a distance up to 25-30 km (1975). Nikola Vasilev Sabotinov found a strong effect of hydrogen in lasers and put into operation metal vapour laser in the BAS Institute of Physics (1970). His copper bromide vapor laser generating a power of up to 18 W and a frequency of laser pulses of 15 kHz by introducing hydrogen into the gas mixture has demonstrated at the international technical fair in Hanover and awarded a gold medal at the Plovdiv Fair. Its production has organized in Plovdiv. Copper bromide vapour lasers have industrial production in Bulgaria and abroad now. N. Sabotinov became member (2003), vice-president (01.11.1996–17.03.2008), and president (2008–2012) of BAS [16].

During the period (1959–1972), BAS Institute of physics has eight non-nuclear laboratories. 1) G. Nadjakov headed laboratory for photo-electrets. 2) Stefan Kanev headed photoconductivity laboratory. 3) R. Andrejchin headed laboratory for photoelectric phenomena. 4) P. Kamadziev headed Germanium laboratory. 5) J. Kassabov headed Silicon laboratory. 6) N. Pashov headed electron microscopy laboratory. 7) Paraskeva Simova headed optical laboratory with three research groups: radio-spectroscopy (Jordanka Pacheva); molecular spectroscopy (Sava Simeonov), and nuclear magnetic resonance (A. Derzhanski). 8) Eugenie Leyarovski headed low temperature physics laboratory [8, p. 62-63].

BAS divided Institute of Physics into two institutes with government decision 362 / 16 October 1972. Ch. Y. Christov became director of the Institute for nuclear research and nuclear energy (INRNE) (1973–1988). M. Borissov became director of the Institute of Solid-State Physics (ISSP) (1973–1991).

3. BAS United Centre of Physics (1973–1988)

Government replaced sections of Academy with scientific centers unifying Academy and University by law from 21 April 1972. Bulgarian Academy of Sciences created United Center

of Physics from 27.05.1972. M. Borissov was its director (1973–1988). United Center of Physics headed scientific research and education of the Sofia University Faculty of Physics and BAS institutes on physics. The main task of United center of physics was to do scientific, applied research and education in contemporary physics according of Bulgarian needs. Physicists from Bulgarian Academy started to give lectures in the Sofia University [8, p. 43].

United Center of Physics has eleven scientific units on the end of the period (1988). Five of them are institutes: 1. Institute of Solid-State Physics, 2. Institute for Nuclear Research and Nuclear Energy, 3. Institute of Electronics, 4. Space Research Institute, and 5. Institute of Applied Physics (since 1979). Three units are central laboratories: 6. Central Laboratory for Solar Energy and New Energy Sources, 7. Central laboratory of Optical Recording and Information Processing, and 8. Central Laboratory of Automation and Scientific Instrumentation. Last three units are 9) Section of Astronomy with National Astronomical Observatory Rozhen, 10) Base for Development and Implementation (since 1974), and 11) Computing Center. Sofia University Faculty of Physics has functional connection with United Center of Physics.

Number of people in the BAS United Center of Physics has been 1584,5 on the end of 1982 with annually increase around 163 people. The state subsidy for BAS United Center of Physics has BGN 6 849 620 in 1982. Salary fund have half of them (around BGN 3 689 500). Total expence were BGN 9 155 981. Diference (BGN 2 306 000) has been covered by income contracts. There are many kinds of contracts: planned contracts, out-plane contracts, national contracts, international contracts with total earning BGN 3 284 000 during 1982. Out-plane contracts for scientific investigations were 45 in 1982 [17, sheet 2].

United Center of Physics and all its units (institutes and laboratories) have two different accounts – one for incomes and another for expenses. All unused funds have returned to the state budget on the end of every year.United Center of Physics has 11 funds. Some of them are foreign currency, for Social and cultural events, about Technical and scientific creativity of youth, and for one magazine. During 1983, there are some expences for guest welcome (BGN 1216), and patent supporting (BGN 17 648) [18, sheet 9 back].

During 1984, BAS United Center of Physics has state subsidy BGN 6 904 000 and own income BGN 849 000 or total BGN 7 753 000. Ministry of finance prohibited unification budgetary and extra-budgetary accounts by letter 1300-113/ 23.03.1984 [19, sheet 1].

All BAS physics institutes and laboratories had many out-plane contracts. During the period 1980–1985, number of United center of physics out-plane contracts is 213 with value BGN 4 588 000 and profit BGN 858 000 [20, sheet 67].

	Units	Contracts 1980–1985/1985	Value 1980–1985 / 1985	Profit 1980–1985 / 1985
1	ISSP	48 / 11	420 300 / 130 400	35 000 / 17 000
2	INRNE	72 / 15	1 832 000 / 221 000	356 000 / 69 000
3	IE	31 / 7	948 000 / 300 000	230 000 / 15 000
4	SRI	0 / 0	0 / 0	0 / 0
5	Ins.Applied Physics	7 / 0	163 000 / 0	380 000 / 0
6	CLSENES	14 / 4	102 000 / 33 000	35 000 / 8 000
7	CLORIP	20 / 6	342 000 / 25 870	25 392 / 8 644
8	CLASI	0 / 0	0 / 0	0 / 0
9	SA with NAO Rozhen	0 / 0	0 / 0	0 / 0
10	BDI	10 / 1	517 000 / 166 000	0 / 0
11	Computer Center	11 / 3	264 000 / 70 000	139 000 / 64 000
	Total	213 / 47	4 588 000/946 000	858 000 / 162 000

Implementation of physics results has some organisation peculiarity in United Center of Physics. Scientific, technical-economic, and technical counsels have taken decisions for introduction scientific results into production. United Center of Physics department “Planning, implementation and instrumentations” carried out responsibility for state program implementation. Bulgarian Academy of Sciences signed international contracts for implementation applied results. Every unit carried out responsibility for their new applied results implementation outsite BAS directly [21, sheet 34].

International collaboration has important significance for scientific research on physics in Bulgarian Academy of Sciences. Colaboration with Russia has most effective and largest scientific results during the period 1973–1988 [21, sheet 35].

	Units 1985	Articles	Reports	Books
1	ISSP	181	26	0
2	INRNE	385	83	8
3	IE	64	132	4
4	SRI	0	0	0
5	Ins.Applied Phys.Plovdiv	8	1	0
6	CLSENES	24	10	0
7	CLORIP	18	29	0

8	CLASI	60	0	0
9	SA with NAO Rozhen	120	49	1
10	BDI	0	0	0
11	Computer Center	11	10	-
	Total	871	340	13

Table 1. Scientific results for the year 1985 [20, sheet 29].

United Center of Physics scientific results (13 books, 871 articles, and 340 reports) for the year 1985 are shown above. Institute for nuclear research and nuclear energy has largest scientific results followed by Institute of solid state physics on the second position and Institute of electronics on the third position in 1985 [20, sheet 29]

3.1. Institute of Solid-State Physics created two new laboratories in the area of crystal growth, and acoustical electronics. Some results of applied research in 1985 are 3 precise programmable thermoregulators with total value BGN 30 000; cryostat, digital thermometer, temperature sensors, interferometric filters, cryostat for 3He (exported for Russia), and magnetometer (for the Institute of Low Temperatures in Wroclaw) [20, sheet 50].

Institute of Solid State physics created in the field of integrated optics via international cooperation during the year 1986 a 25-channel multiplexer operating in the range from 0.83 to 1.55 μm using a planar waveguide in glass, and standard multimode fibers [22, sheet 7].

3.1.1 Laboratory of acoustical electronics and acoustical optics has created and headed by M. Borissov (1977–1983). He was supervisor of ten Ph.D. Ph.D. students future associate professors (Kliment Branzalov, Nguyen Thanh, A. Vavrek, and Ognjan Ivanov) and professors (Milko Iliev, Julian Burov, Losan Spassov, Dimitar Stoyanov, Veselin Strashilov, Ljudmil Konstantinov) in this area. M. Borissov initiated electromagnetic waves in crystals research. Apparatus for growth of single crystal of cadmium sulfide has constructed in his laboratory at first. Experiments for generation and amplification of oscillations and bending waves began after that. Results have applied to develop interferometric method for measuring small mechanical oscillations by scanning the quartz resonator surface. M. Borissov realized his program for education and training people from industry to work with acoustoelectric materials. He organized post-graduated evening course “physics of acoustic waves” for physicists, chemists, and electrical engineering. A workshop on acoustical electronics and optics, a national school with international participation on surface acoustic waves in crystals and their applications, a school on “physical properties of synthetic quartz crystals”, and “acoustical electronics” national scientific and technical conference with international

participation have organized after that. In 1986, Institute of Solid State Physics elaborated 100 piezo-resonant thermosensitive sensors with a linear temperature-frequency characteristic in the temperature range from -60°C to +250°C and sensitivity up to 10^{-4}°C based on a new cut of quartz [22, sheet 6].

3.1.2. Laboratory of crystal growth started as a research group at the BAS Institute of Solid-State Physics acoustical-electronics and acoustical-optics laboratory. Apparatus for crystal growth bismuth-silicate (Bi12SiO20) and bismuth germanate (Bi12GeO20) by Czochralski method was installed and put into operation from old installations. An apparatus for the hydrothermal growth of piezoelectric quartz crystals under different conditions and different raw materials has made with own efforts. Machines for cutting, grinding and polishing crystal wafers have purchased and put into operation. A vacuum installation with an electron gun for vaporizing metal coatings has supplied.

Crystal growth research group became laboratory in 1981. Three different crystal growth techniques have used in it: 1) Czochralski method for growing optical and acoustical materials; 2) Bridgeman and travelling heater method for growing microelectronic compounds; and 3) method of high temperature solution for growing complex oxide materials. Laboratory of crystal growth had four research groups: crystal growth; structure and defects in crystals; electrical, optical and magnetic properties of crystals; and phase transitions in ferroelectric and ferromagnetic crystals. In 1986, an automated system has created in the crystal growth laboratory for monitoring diameter of growing bismuth germanate single crystal by controlling the weight of the melt by the Czochralski method [22, sheet 6].

Marin Mirchev Gospodinov became head of the laboratory of crystal growth (1982). He was born in Dolna Sekirna village (1944). M. Gospodinov studied physics at the Sofia University (1970). His research started in BAS Institute of Physics Germanium laboratory headed by P. Kamadziev (1970–1973). Epitaxial growth of A_2B_6 semiconductor layers was his research area in the beginning. At the Institute of Solid-State Physics Germanium laboratory, he became assistant III degree (1973–1976). He transferred to the acoustoelectric laboratory and became assistant II degree (1976) and I degree (1980). He defended his PhD thesis for "crystal growth of alpha mercury" (1981), and Sc.D. dissertation and became professor.

United Center of Physics organized National conferences "Physics and manufacture" in Kazanlak and "Physics and electronization" in Plovdiv.

3.1.3. Biennial International School of Condensed Matter Physics are organising by BAS Institute of Solid-State Physics (1980–2022). Twenty-two proceedings of ISCMP have published in English during the last 40 years. Directors of the Institute are chief editors of school proceedings traditionally. Professor Ivan Lalov is initiator and president of its first edition. Nikolay Kirov was president of the next four schools during the period 1992–1998. A. G. Petrov was president of the next eighth schools during the period 2000–2014. Prof. Hassan Chamati was president of the last three schools during the period (2016–2022).

Ivan Jotov **Lalov** was born in Lovech (04.10.1938). He graduated physics from the Sofia University (1961), PhD (1977), and ScD (1988). After that, he was assistant (1961), senior assistant (1968), assistant general (1976), associate professor (1980), and professor of physics of electromagnetic phenomena (1991) at the Sofia University Faculty of Physics. He thought courses in condensed matter physics, solid-state physics, electricity, magnetism, and optics. His theoretical results are in area of condensed matter spectroscopy. He published more then 80 scientific articles, school and university textbooks on physics. Prof. Lalov was dean of the Faculty of Physics (1991–1993) and Sofia University rector (1993–1999). He has short political career as a minister of education, science and technology from February to May 1997. Prof. Lalov was president of the Union of physicists in Bulgaria (1992–2001) and the Balkan physical union president (2003–2006).

Milko **Borissov** Ivanov (18.02.1921–05.11.1998) headed five editions of the school during the period 1982–1990. He graduated physics at the Sofia University (1943). He specialized in Russia and Germany in solid-state physics and acoustoelectric. M. Borissov investigated electronic processes in dielectrics and semiconductors, acoustoelectric interactions in crystals, their growth and application for generate, amplifying and studying waves and vibrations. He patented detector for nuclear radiation. M. Borissov became professor at the Sofia University. Bulgarian academy of sciences appointed him for director of the Institute of Solid-State Physics (1973–1991) and President of the United Center of Physics (1973–1988) [14]. M. Borissov became corresponding member (1967) and member (1984) of the Bulgarian academy of sciences [23-31].

Nikolay **Kirov** Nikolov (22.10.1943–20.03.2013) graduated chemistry at the Sofia University. At the Institute of Solid-State Physics, he became PhD (1973) and ScD (1988). He was professor in the area of molecular

spectroscopy and head of the Optics and spectroscopy laboratory (1986–2002). Nikolay Kirov was director of the Institute of Solid-State Physics (1991–1999). He thought course on "Molecular spectroscopy in condensed matter physics" in Parma, Italy (1983–1985) and course on "New sense in optical spectroscopy of condensed medium" at the Calabria University in Italy (1986–1988) [8, p. 202].

Joseph M. **Marshall** (06.09.1943–15.12.2008) was editor of nine International School of Condensed Matter Physics proceedings (1990–2008). He graduated physics from the Sheffield University (1965) and PhD degree from the University of Edinburgh (1970) United Kingdom. At the University of Abertay, Dundee, he was lecturer (1974), senior lecturer (1981) and associate professor (1984). J. Marshall was professor of electronic materials at the University of Wales Swansea (1987–2002). He published more then 180 scientific articles about: 1) photoconductive properties of crystalline, polycrystalline, amorphous and organic semiconductors; 2) numerical modelling of carrier transport of semiconducting materials and electronic devices; 3) design, fabrication and characterization of tin-film sensor devices and systems about information technology, medicine and automotive industry. He was member of the organizing committee of annual Chelsea conferences on amorphous and liquid semiconductors in London. He was financial chairman of the international conference on amorphous semiconductors in Cambridge (1993). In Bulgaria, he was co-director of NATO Institute for Advance Study "Photovoltaic and photoactive materials, properties, technology and applications" in Sozopol (2001). Bulgarian Academy of Sciences awarded him with Marin Drinov medal (1998), and Georgi Nadjakov sign of honour from the Institute of Solid-State Physics (2005) [16].

Alexander G. **Petrov** was president of the International School of Condensed Matter Physics (2000 – 2015). He was born in Stara Zagora (p. 27.05.1948). He studied nuclear physics at the Sofia University Faculty of Physics (1970). He was PhD student at the BAS Institute of Solid-State Physics (1974) and defended DSc (1987). A. G. Petrov was researcher in the laboratory of liquid crystals (1971–1974), assistant (1974–1984), associate professor (1984–1990) and professor (1990–2017). He headed biomolecular layers laboratory (1991–2008), and soft matter physics laboratory (2006–2015). He was BAS Institute of Solid-State Physics

director (1999–2015) and president of the Union of physicists in Bulgaria (2003) and president of the Balkan physical union (2015–2018).

Prof. Hassan **Chamati** is president of the International School on Condensed Matter Physics since 2016. He is BAS Institute of Solid-State Physics director since 2015 and head of the theoretical physics department. He investigated topological transitions in two-dimensional lattice models of liquid crystals, critical dynamics in closed systems, first-order phase transitions in classical lattice gas spin models, phase transitions in three-dimensional generalized x-y models, application of statistical mechanics to blackbody radiation. Institute of Solid-State Physics celebrated its 50 anniversaries (17.10.2022).

3.2. Institute for nuclear research and nuclear energy had many directors as Ch. Y. Christov (1973–1989), I. Vankov (1989–1993), Y. Stamenov (1993–2010), D. Tonev (2010 – 2022), and L. Georgiev (since 2022). Zh. Zhelev (1973–1989), and D. Damjanov (1973–1989) were its deputy directors. Many scientists hold position of scientific secretary as B. Betev (1973–1974), C. Palev (1974–1978), I. Zhelyazkov (1978–1980), D. Fakirov (1981–1984), A. Antonov (1984–1987), and N. Ahababjan (1987–1989).

Institute for nuclear research and nuclear energy has five theoretical laboratories for nuclear physics theory (R. Zaycov and N. Kalitzin), elementary particle theory (I. Todorov), atomic nucleus theory (I. Nedjalkov, P. Raychev, and M. Stoicov), mathematical modeling (D. Stoyanov), solitons (S. Manov), and nuclear reactions (E. Nadjakov). Experimental laboratories are eight: for nuclear spectroscopy (Zh. Zhelev, W. Andrejtscheff), Mössbauer spectroscopy (T. Ruskov), mass spectroscopy (B. Amov), high energy physics (P. Marcov), nuclear electronics (I. Vankov), physics of reactors (V. Christov), physics of neutrons (N. Kashukeev), and nuclear energetics.

On the end of period (1973–1988), Institute for nuclear research and nuclear energy has seven big laboratories. Theoretical physics laboratory (headed by I. Todorov) has three research groups. Nuclear physics and astrophysics laboratory (Wenzeslav Andrejtscheff) has four research groups. Neutron and reactor physics laboratory (N. Janeva) has four research groups. Nuclear energetics laboratory (P. Tsvetanov) has four research groups. Laboratory for nuclear methods (T. Ruscov) has six research groups. Laboratory for radiochemistry and radioecology (M. Michailov) has three research groups. High-energy laboratory (V. Penev) has three research groups. K. Krejov headed nuclear reactor. Bulgarian Government awarded body of

reactor with Bulgarian National Republic medal I degree by decree 3086 in 11 September 1986.

In 1982, Institute for nuclear research and nuclear energy has 437 people (188 scientists) with real maintenance BGN 8 854 965. Bulgarian nuclear scientists has 23 out-plane contracts with BGN 711 860 income. Neutron hygrometer and gamma-irradiation device have been produced for Albania in 1985. During 1986, fully equipped laser optical photographic system for a streamer camera and an advanced version of a mechanical neutron monochromator have constructed [22, sheet 5].

Many national and international scientific events as a International School of Nuclear Physics, Neutron Physics and Applications, Theory of Elementary Particles, and International Symposium on Nuclear Electronics have been organized. Although the institute and its reactor have successful theoretical, experimental, and applied results, Bulgarian experimental reactor has closed.

3.3. Institute of electronics headed by Alexander Spassov (16.05.1934–10.04.2015) created (in 1985) technology and experimental series of ionization converters for high and ultrahigh vacuum; high-purity oxygen-free copper for laser mirrors with volume 50 kg in value BGN 7 500; demonstration helium-neon laser and technology for the Optikoelectron factory in Panagyurishte; 25 hygrometers; two BINION-400 pumps for the German Institute of Semiconductor Physics, and 100 laser systems for medical terrapy.

3.4. Institute of Applied Physics has created in Plovdiv as a unit of BAS United Centre of Physics (01.04.1979) with the name Central Laboratory. It became Institute of Applied Physics from 1983. M. Borissov headed contract for research and production of photoresistors with differential output. Pilot production of sensors and sensor apparatuses started from 01.04.1984. Some new series lasers, photoresistors, microcallipers, polymer magnetic surfaces, and planar magnetotransistors have produced (1985). Institute of Applied Physics registered subsidiary small company for sensors and sensor devices by government decision 247/30.12.1985 since 01.01.1986. The company started production of magnetic sensors and contactless switch based on the magnetosensitive bipolar transistor created by the Institute of Solid State Physics [22, sheet 7].

3.5. Central laboratory of optical recording and information processing has created as a unit of BAS United centre of physics in 28.02.1975. M. Kovachev and V. Sajnov started

research in holography at the BAS Institute of Solid-State Physics in 1974. M. Kovachev became its first director.

3.6. Central Laboratory of Solar Energy and New Energy Sources became an independent unit after separation from the Institute of Solid-State Physics by government decree since 1 July 1977. Stefan Kanev (17.08.1929–26.12.2012) was its first director (1978–1994). Central Laboratory of Solar Energy and New Energy Sources has a new building since 1982 [18, sheet 12]. Some new results obtaining in 1986 are high-temperature coatings of tantalum (Ta), tantalum carbide (TaC) and tantalum nitride (TaN) on a quartz glass substrate with a reflection coefficient in the infrared region of 85% at an optimal thickness of coatings from 0.4 to 0.6 micrometers by chemical deposition from gas phase [22, sheet 7-8].

3.7. Central Laboratory of Automation and Scientific Instrumentation became unit of BAS United Centre of Physics (1974). Ljubomir Antonov was its first director. In 1985, 30 KAMAK systems with microprocessor "Electronica" have exported to Russia with price BGN 2 400 000 and 26 vending machine with floppy disk operating systems have produced with price BGN 2 200 000. Central Laboratory of Automation and Scientific Instrumentation has closed after 1988.

3.8. Section of Astronomy has Astronomical Observatory built on the Rozhen Mountain near to Smolyan with altitude 1759 m since 13 March 1981. The observatory has six telescopes: Ritchey-Chretien-Coude 2 m telescope, 60 cm Cassegrain reflector, Schmidt telescope 50-70 cm, Solar coronagraph 15 cm telescope, 30 cm MEADE, and 18 cm Meniscas Cassegrain. A method for structural analysis of images from globular clusters in the Andromeda galaxy has developed In 1986. The orientation and ellipticity of over 100 clusters were analyzed by this method. Catalogs of sunspots and starbursts in the Pleiades cluster have been created [22, sheet 6].

3.9. Computing center

In 1985, Computing Center created sorce block for input with copper bromide vapor; 100 microwave moisture-meters; vacuum chamber with vacuum system 1000 l/sec; neutron soil moisture-meters 2 pieces; and laser gas analyzer [20, sheet 53]

Bulgarian Academy of Sciences created Co-ordination council on physics in Plovdiv as a division. M. Borissov was president of the Co-ordination council on physics in Plovdiv. All BAS scientific centers have closed down in 1988.

4. Conclusion

Experimental physics at the Bulgarian Academy of Sciences has long and interesting history during the period from 1946 to 1988. We find two stages. G. Nadjakov initiates first stage (1946–1972). He organized and build a new experimental BAS Institute of Physics (1946). Applied physicd is a new element in experimental physics research in Bulgaria. M. Borissov manages second stage (1973–1988). He organised and headed all institutes and laboratories on physics into United Center of Physics (1973). He initiated a model for closed research circle in Bulgarian experimental physics starting with scientific investigation, passing through applied result and finishinhg with production with significant economical effect.

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