# Traditions and Reforms in Bulgarian Physics Milko Borissov (1921 – 1998)

Ganka Kamisheva

*Institute of Solid State Physics, 72 Tsarigradsko chousse, 1784 Sofia, Bulgaria, gkamish@issp.bas.bg*

**Abstract.** University physics in Bulgaria is examined comparatively. Physical chairs, courses, lecturers and students, finished Sofia University successfully, are analyzed quantitatively. Traditions in Experimental physics are traced into scientific results of Professors P. Bachmetjew, A. Christow, and G. Nadjakov during the first half of XX century. Professor Milko Borissov's reformations of University physics in the second half of XX century are analysed.

**Keywords:** History, Physics, Bulgaria, Milko Borissov, Nadjakov, Bachmetjew, Sofia University, Traditions, Reforms.
**PACS:** 01.65.+g; 01.30.-y; 01.40Fk; 01.50.ff; 01.60.+q.

## INTRODUCTION

University physics have 120 years history in Bulgaria. Education and research on physics began, when Faculty of Physics and Mathematics established in the Sofia University (1889). History of physics in the Sofia University is considered in some philosophical investigations of Nikolina Sretenova. She analyzed university crisis (1907), and drama of Porphiry Bachmetjew [1]. We studied physical courses [2-3], physics as an independent subject [4], chair of theoretical physics [5-6], and first doctoral dissertations in physics [7] at the Sofia University. Historical period 1889 – 1944 is presented in the publications above. Andrey Apostolov shared memories [8], and Milko Borissov gave historical notes [9] about university physics in Bulgaria during the second half of XX century. Comparison between traditions and reforms in physics at the Sofia University are goal of this work.

## PHYSICAL SPECIALITY

Sofia University "St. Kliment Ohridski" was an only University for physicists in Bulgaria up to the end of the World War Second. First Bulgarian University started as a Normal school (1888), renamed High school (1889), and became University in 1904. Faculty of Physics and Mathematics created in the beginning (1889 – 1963) [10]. Independent Faculty of Physics separated from the oldest Faculty of Physics and Mathematics in 1963 at the time, when Milko Borissov was dean.

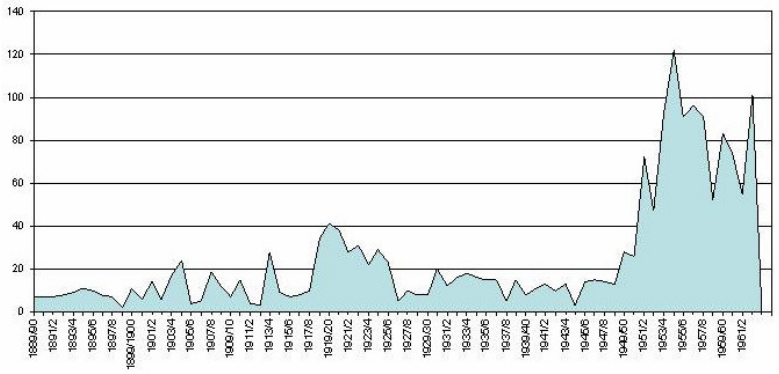


**FIGURE 1.** Students on physics finished Sofia University.

CP1203, *7th International Conference of the Balkan Physical Union,* edited by A. Angelopoulos and T. Fildisis

Faculty of Physics and Mathematics, situated on the Moskovska Street (1889 – 1960), had two Institutes of physics (from 1897). Astronomical Observatory was built in the King's garden. Physical Institute consisted of two experimental physics laboratories, dark room for spectral investigations, electrical engineering laboratories, meteorological station in the University garden, and nuclear laboratories in a house, situated on Shipka Street 14).

Physicists, received absolutorium from Sofia University, are below 20 during the first 50 years, because an only possibility for physicists in Bulgaria was to be teachers. Common mathematical and physical speciality existed in the beginning. Separate physical speciality started in 1921 [4]. In that reason, finished students had mathematical and physical subject from 1889 to 1925 and physical speciality from 1926 to 1963 (Fig. 1). Physicists took one year probation and state teacher examination. Sofia University educated PhD students in physics since 1928. First PhD candidates in physics wrote down in 1933. Four PhD students in physics finished Sofia University in the first half of XX century [7]. Number of physicist with degree from Sofia University grew up ten times, when new job for engineer-physicists appeared in the second half of XX century.

## PHYSICAL CHAIRS

Physical chairs of the Sofia University grow up twice in every 30 years. Three stages are show in Fig. 2. First stage (1889 – 1918) has two physical chairs (experimental physics and astronomy). Second stage has six chairs (1919 – 1944). Four new one are meteorology, nuclear, theoretical and technical physics. Third stage has twelve chairs in the second half of XX century. Six new one are general physics, semiconductors, optics, quantum electronics, condensed matter physics and nuclear engineering. Pedagogical department is not included there.

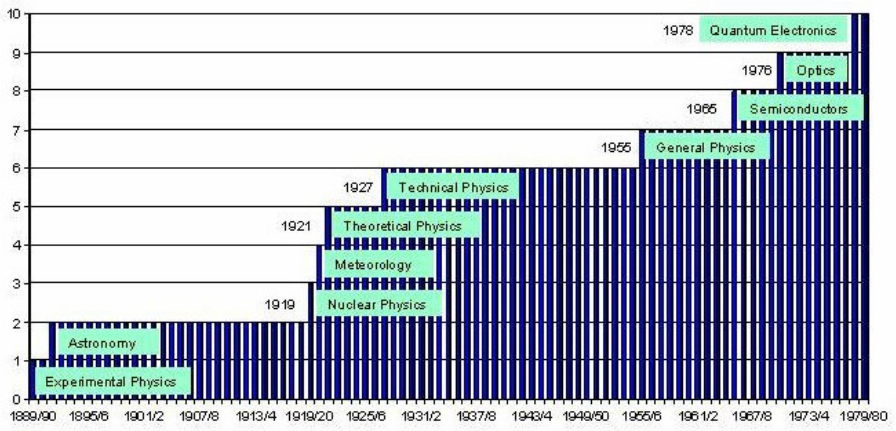


**FIGURE 2.** Physical chairs of the Sofia University.

University lecturers received academic rank in 1894 for the first time in Bulgaria. All lecturers had academic rank after that up to 1952. Number of university lecturers grew up during the second half of XX century, when Sofia University appointed many lecturers having and not having academic rank (Fig. 3).

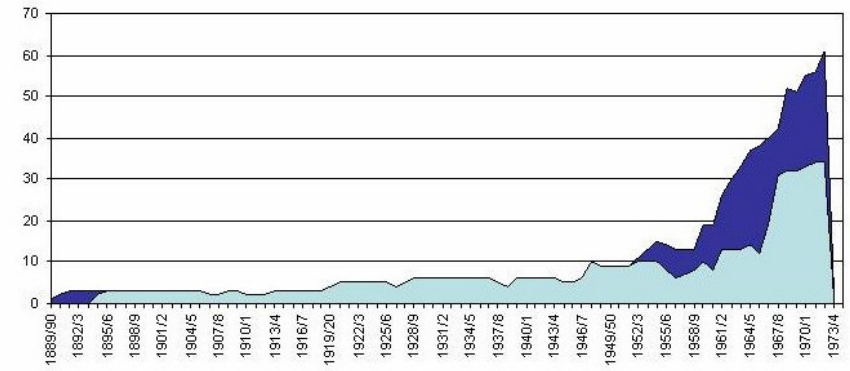


**FIGURE 3.** Physical lecturers having academic rank (light blue), not having academic rank (dark blue).

Because departments are created in different way before and after World War Second, number of physical chairs is equal to number of lecturers up to 1947 (Fig. 4).

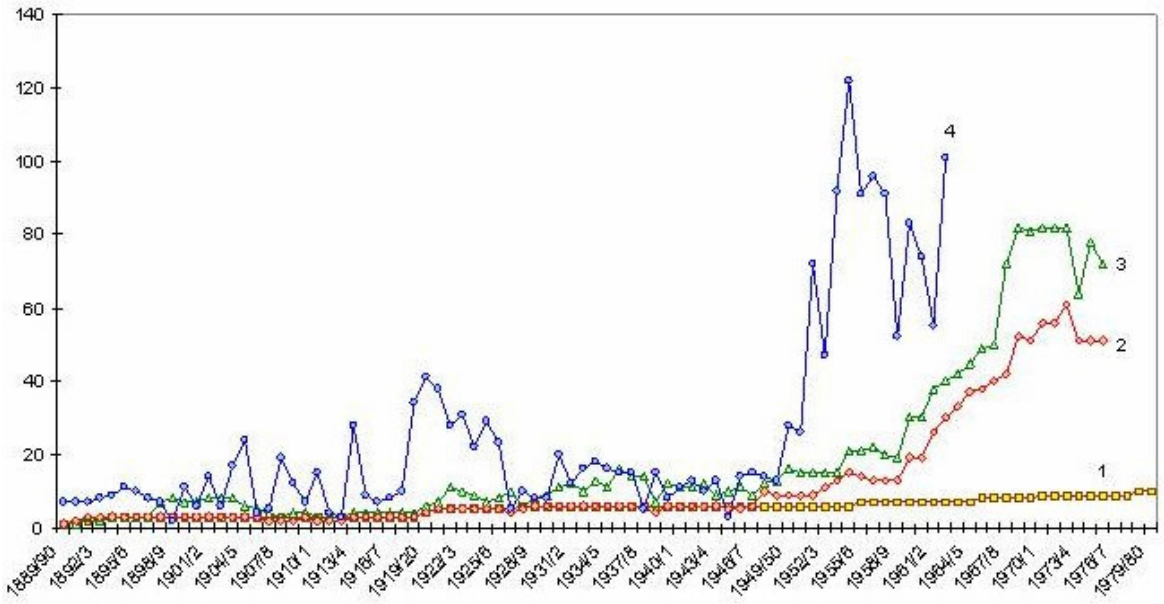


**FIGURE 4.** Chairs (1), lecturers (2), courses (3), students (4)

Professor Marin Batchevarow created chair of Astronomy (1892 – 1926) and university Astronomical Observatory. He initiated many courses: "astronomy" (1892 – 1897), "spherical astronomy" (1898 – 1904), "practical astronomy" (1898 – 1904), "celestial mechanics" (1898 – 1904), "astrophysics" (1898 – 1904), "spherical and practical astronomy" (1904 – 1926), "theoretical astronomy" (1904 – 1926), and "meteorology" (1898/9 – 1905/6). Professor Nikola Bonev (1928 – 1963) carried on astronomical courses and initiated "geodesy" from 1931 [11].

Nuclear physics chair built Extraordinary Professor Petar Penchev (1919 – 1938). He initiated courses: "physics: measurement methods and units" (1919/20 – 1937/8) and "electrical phenomena in gases and radioactivity" (1919/20 – 1937/8). Associate Professor Elzbeta Kara-Michailova (1939 – 1955) carried on tradition in "experimental atomism with radioactivity**"** and initiated new course "spectral analysis" from 1943. Next Professors in nuclear physics are Leon Mitrany (1955 – 1958), Christo Yankov Christov (1958 – 1967), Tsvetan Bonchev (1968 – 1992), Ani Minkova (1993 – 1995), and Ivan Mandjukov (1995 – 2003) [11].

First Professor in Meteorology Ruscho Raynov (1920 – 1958) initiated courses "meteorology (atmosphere dynamics, optics, acoustics and electricity)" (1920/1 – 1957/8), "meteorological and climatic conditions in Bulgaria" (1921/2 – 1945/6), "practical meteorology" (1921/2), "dynamical meteorology" (1921/2 – 1925/6), "meteorological optics" (1921/2), "meteorology and climatology" (1923 – 1924), "meteorological instruments" (1923 – 1924). He introduced course "seismic waves" (1930/1 – 1934/5), latter called "geophysics" (1935/6 – 1957/8). Next Professors in meteorology are Ljubomir Krastanov (1960 – 1974), and Stoycho Panchev (1974 – 1994) [11].

Theoretical physics chair built Professor Georgi Manev (1921/2 – 1943/4) [6]. He initiated courses: "mathematical physics" (1921/2 – 1924/5), "theoretical physics (mechanics, thermodynamics, optics, electricity and magnetism)" (1925/6 – 1943/4), "vector calculus" (1923/4 – 1934/5; 1938/9 – 1943/4), "vector and tensor calculus" (1935/6 – 1937/8), "theory of relativity" (1922 – 1923), "kinetic theory" (1929 – 1930), "quantum theory" (1931/2 – 1941/2), "statistical mechanics" (1935 – 1936), "electron theory" (1936/7 – 1942/3), "heat radiation and atomistic" (1939 – 1940), "theory of heat, kinetic theory of gases" (1939/40 – 1941/2). Professor Christo Yankov Christov initiated course "mathematical methods in physics" (1949). Next Professors in theoretical physics are Asen Dachev (1947 – 1984), Ivan Zlatev (1984 – 1991), Matey Mateev (1991 – 1993; 1995 – 2003) and Plamen Fiziev from 2003 [11].

Predecessor of Technical physics chair was Porphiry Bachmetjew's course "applications of electricity" (1902/3 – 1903/4). Georgi Nadjakov initiated course "physical basis of electrical engineering" (1935/6 – 1937/8). First Professor in technical physics became Emil Djakov (1939 – 1967) [11].

# TRADITIONS IN EXPERIMENTAL PHYSICS

Experimental physics is the oldest physical chair in the Sofia University. Mathematician Emanuil Ivanov initiated first university course on physics at the Faculty of Physics and Mathematics (1889 – 1890). The foundation of Experimental physics chair lay Professor Porphiry Bachmetjew (16 years from 1890 to 1906), Professor Alexander Christow (30 years from 1909 to 1937), and Professor Georgi Nadjakov (35 years up to 1963).

Porphiry Bachmetjew (1860 – 1913) investigated magnetism and thermoelectricity until to come in Bulgaria. In the Physical Institute at the Sofia University he experimented Earth electricity and currents, and constructed physical instruments. Measuring temperature of butterfly under 0 degree of Centigrade with sensitive nickel-manganese thermo-couple, he found out a new living state, called by him anabiosis. The temperature of living butterfly, placed in ace cooled metal tube, falling down to $-10^{o}$ C, raise jumping to $-1{,}5^{o}$ C (when liquid form passed in liquid crystalline state), and fall down again. If the cooling process stopped before temperature falling under $-10^{o}$ C, the butterfly came back to life. State when organic liquid form is in liquid crystal state Bachmetjew called anabiosis [12]. It was first Bulgarian considerable new result in physics. He wrote two volume "Experimentalle entomologische Studien" in German language (Leipzig, 1901, 1907).


**FIGURE 5.** Experimental Physics Professors on the left side, Solid State Physics Professors on the right side

Alexander Christow (1872 – 1951) was elected Professor and corresponding member of the Bulgarian Academy of Sciences in 1921 for results in surface stress, absorption, contraction, and dilation of molecular volume of dissolved solids.

Professor Georgi Nadjakov (1896 – 1981) is second Bulgarian physicist, achieved remarkable new result in physics. It is formally recognized in Bulgaria after his death. Photo-electrets state of matter was written down in Government invention register of Bulgaria in 1981. Georgi Nadjakov suggested dielectrics, polarized through photoconduction, to be called photo-electrets. He prepared stable photo-electrets state by applying electric field of 470 Volt per centimeter to a sulphur disc illuminated by 6000 lux for 12 minutes. He measured the charge of sulphur by keeping the sample in a "box" between two different electrodes. Sample was polarized by illumination through upper semitransparent electrode along direction of the electric field. After polarization illumination and electric field were switched off and the sulphur was kept in darkness for 4 minutes. One electrode was then connected to electrometer and the other was grounded. After that the sulphur was re-illuminated, after which a discharge current was observed. It was found that polarization and depolarization currents are both equal except to difference in polarity.

Electrets are an electric counterpart of magnets. Oliver Heaviside coined the term electrets in 1885. Electrets are dielectric materials. Electrets generate internal and external electric fields. Now there are two types of electrets: real-charge electrets with a surface charge or a space charge, and oriented-dipole electrets. Polarization through photoconduction was discovered as early as 1911 by Goldman and Kalandyk. They observed discharge currents in polycrystalline sulphur. Photo-electrets differ from thermo-electrets by use of light treatment instead of thermal treatment during polarization processes. Thermo-electrets have been prepared by Eguchy in 1922 for the first time. Georgi Nadjakov discovered the photo-electrets investigating photo-conducting properties of sulphur in 1937. Photo-electrets state of matter has various practical applications. Important application of photo-electrets is "xerography", which has been developing steps, starting from the principle of electro graphology, suggested by Seleneyi. Photo electrets and thermo electrets have some military applications too. Georgi Nadjakov was head of Laboratory for special investigation up to the end of his life.

# REFORMATIONS OF PROFESSOR MILKO BORISSOV

Living in exclusive and fateful historical period between nuclear energy, cosmic techniques, microelectronics, and cybernetics discovery; exponential development of industry and damage to destruction of the unique nature of the Earth [9], Milko Borissov (18.02.1921 – 05.11.1998) succeeded the experimental physics chair (1963 – 1980), changed the name "Solid State Physics" (1972), and preserved tradition in it. He mentored some generation scientists and 10 PhD students in Bulgaria.

Milko Borissov studied physics in the Sofia University (1939 – 1943), specialized crystal growth in Germany (from November 1954 until February 1955) and nuclear physics in Russia (June 1956 – July 1957). He took his university degree in 1945, got married (1948) to Nadejda Borissova Dacheva (01.07.1920 – 27.07.2007) [13], and after that, he was Professor Georgi Nadjakov's assistant (1945 – 1948), and Associate Professor (1957 – 1963) [14].

Professor Milko Borissov initiated innovative courses: "nuclear spectroscopy" (1957/8 – 1958/9), "selected subjects of solid state physics" (1959/60 – 1960/1), "introduction to solid state physics" (1961/2 – 1977/8), "physical base of acoustical-electronics and acoustical-optics" [11]. He wrote university textbooks: "Lectures on experimental physics", three volumes (1963), "Physics. Part One. Mechanics" (1965); "Introduction to solid state physics", co-authors Krasimira Germanova, and Krasimira Marinova in two volumes (1977 – 1978); "Surface acoustic waves and some their applications", co-authors Kliment Branzalov, Julian Burov, and Dimitar Stoyanov (1980); "Short introduction in solid state physics", co-author K. Kalaydjiev (1986); "Physics of linear acoustic and electromagnetic waves", co-author Veselin Strashilov (1989). Lecture hall was placed in Chemistry building against ecclesiastical school in Lozenets district, from 1960 to 1990, when new Faculty Campus of Physics was built.

Professor Milko Borissov has remarkable results as a number and variety. He investigated physical problems with one hundred co-authors and made 403 publications in 30 different areas. His research model has cyclic direction between scientific articles, patented inventions, and manufactured technologies. He investigated experimentally: "photo-dielectric effect in crystalline-phosphorus", "photo-electromotive stress in cadmium sulphide thin layers", "negative internal photoelectric effect", "electrically stimulated currents in mono-crystals of cadmium sulphide", "positron annihilation in solids", "movement of holes in crystals of cadmium sulphide", "Shark-effect of excitons and electro-optical effect", "ionic vibration and waves in gas plasma", "vibrations and waves in solid plasma", "current oscillations in cadmium sulphide by flexion", "generation and amplification of flexural vibrations and waves in cadmium sulphide", "phonon spectrums and elastic modules of semiconductors crystalline", "transversal acoustic-voltage effect", "photo-charge effect in conductive materials".

Milko Borissov calculated theoretically temperature waves and proposed model for high temperature superconductivity. He invented sensitive new methods for measuring small quantities: "measuring method for dielectric losses in crystalline-phosphorus", "method for reaction of valve-generator", "modulation methods for investigation photoelectrical and optical properties", "optical and interferential measurement methods".

Professor Milko Borissov built mono-crystal growth technology for the first time in the country. Mono-crystals, produced in Bulgaria, had considerable role for our experimental solid state physics investigation during the second half of XX century. He investigated new technologies: "growing crystals and layers of $A_2B_6$", "hydro-thermal growing of quartz crystals".

Fifteen inventions and innovations are recorded to patent office by him: 1973 – "resonance transistor with vibrator"; 1974 – "photo-resonance frequency-selective transistor"; "low frequency generator"; "oscillator for surface acoustic waves"; 1975 – "electrically controled bar for mechanical waves"; "device for control on the phase of radio-signals"; "piezoelectric delay line"; 1977 – "piezoelectric transformer"; 1978 – "laser-Dopler velocity measurement device"; 1983 – "autoclave with auto-packing blockade"; 1984 – "method for thin two-chrome three-oxide layer take on"; 1986 – "method for preparation humidity registration device"; "quartz resonator with linear temperature frequency characteristic"; 1990 – "method and mechanism for analysis of spatial allocation of the surface states in semiconductors"; 1993 – "generator with surface acoustic waves".

Professor Milko Borissov career started in Sofia University and finished in Bulgarian Academy of Sciences, but he had laboratories in two places all the time. Twice he was dean of the Faculty of Physics and Mathematics (28.12.1961 – 01.06.1964), and of the Faculty of Physics (01.06.1966 – 01.06.1968). Twice he was vice-rector of the Sofia University (01.06.1964 – 01.06.1966; 01.06.1968 – 01.06.1972). Professor Milko Borissov elected corresponding member (1967), and full member of Bulgarian Academy of Sciences (1984). Thirty eight years old he became vice-director of Physical Institute (01.09.1959 – 19.08.1961). Sections of Bulgarian Academy of Sciences, reorganizing by low in 21 April 1972, became Unified Centers. All units (University and Academic Institutes and

Laboratories) on the field of physics were joined to the Centre of Physics. Milko Borissov was director of the Centre of Physics from 1972 to 1988. He was president of Co-ordination Council on physics in Plovdiv as a unit of Bulgarian Academy of Sciences. After that all scientific Centers were closed down. Professor Milko Borissov became member of European Physical Society (1970) and president of Union of the Physicists in Bulgaria (1986 – 1989).

Professor Milko Borissov had paramount role to initiate new laboratories, institutes, and schools [15]. He was first director of Laboratory of acoustical electronic and acoustical optic (1977 – 1983), Institute of Solid State Physics (1972 – 1991), and International School on Condensed Matter Physics. Fifteen Proceedings of ISCMP, edited by Professor Milko Borissov, Associate Professor Alexander Vavrek, Professor Nikolay Kirov, Professor Joseph M. Marshall (06.09.1943 – 15.12.2008) [16], and Professor Alexander G. Petrov, are published in English up to now.

## CONCLUSION

Differentiation of physics as a subject and it separation from mathematics in the Sofia University and Bulgarian Academy of Sciences is long process. Identity of physical research community started by theoretical physics chair creation in the Sofia University during the 20s and the beginning of 30s years of XX century, and finished by closing the Centre of Physics from the Bulgarian Academy of Sciences in 1988. Physical research low budget, small quantities measuring, and physical apparatuses construct are traditions of Bulgarian experimental physics in generally and of the Faculty of Physics at the Sofia University in particular during the last 120 years. They were kept in the Physical institute and in the Centre of Physics at the Bulgaria Academy of Sciences too. Applied physics, and public finance are some of reforms in university physics during the second half of XX century. Bulgarian physicists made Nuclear research abroad (in Russia mainly), while solid-state physics have national priority and base for experimental research in the Institute of Solid State Physics at the Bulgarian Academy of Sciences.

## ACKNOWLEDGMENTS

We give up this work and film “Reminiscence” [17] to memory of Professor Milko Borissov [18].

## REFERENCES

1. N. Sretenova, *University and Physicists. Beginning*, Sofia: Xeron Press, 2000, pp. 25-30 (in Bulgarian).
2. G. Kamisheva, A. Vavrek, *Bulgarian Journal of Physics*, **27**, No 4, 55-58 (2000).
3. G. Kamisheva, A. Vavrek, *Bulgarian Journal of Physics*, **27**, No 4, 59-62 (2000).
4. G. Kamisheva, *the World of Physics*, No 2, 104-109 (1992) (in Bulgarian).
5. G. Kamisheva, “History of the Mathematical and Theoretical Physics in the Sofia University (1925-1935)”, *Proceedings of the Fifth General Conference of the Balkan Physical Union*, edited by S. Jokić, et al., Vrnjačka Banja, 2003, pp. 1999-2002.
6. G. Kamisheva, “Lectures in Mathematical and Theoretical Physics at the University of Sofia by Professor Georgi Ivanoff Maneff (1921-1944)” in *Prof. G. Manev’s Legacy*, edited by V. Gerdjikov and M. Tsvetkov, Sofia: Heron Press, 2005, pp. 45-53.
7. A. Vavrek, G. Kamisheva, *the World of Physics*, No 2, 130-134 (1999) (in Bulgarian).
8. A. Apostolov, *And Physicist on this World*, Sofia: University Press, 2008 (in Bulgarian).
9. L. Spassov, G. Kamisheva, *Milko Borissov for himself and the rest for him*, Sofia: Acad. Publ. House “Prof. M. Drinov”, 2008 (in Bulgarian).
10. D. Hristov, M. Kaneva, *Almanac Faculty of Physics and Mathematics at the Sofia University 1889-1963*, Sofia: Farago, 2008 (in Bulgarian).
11. *Curriculum of Sofia University*, Sofia; Univ. Press 1904-1980.
12. A. G. Petrov, ‘Historical Remarks” in *The Lyotropic State of Matter: Molecular Physics and Living Matter Physics*, London-New York: Gordon & Breach Science Publishers, 1999, pp. 12-17.
13. BAS, Scientific Archives, Fund 231 (M. Borissov).
14. Bulgarian State Archive, Fund 1790, List 12, Archive Unit 209, pp. 19-20.
15. N. Kirov, J. Marshall, A. Vavrek, “Academician Professor Milko Borissov”, in *Proceedings of the Tenth International School on Condensed Matter Physics*, edited by N. Kirov, et al., Singapore: World Scientific, 1998, pp. VII-VIII.
16. “Joseph M. Marshall (6.09.1943–15.12.2008) Obituary”, *Journal of Optoelectronics and Advanced Materials*, **11**, No 9 (2009) (in Press).
17. http://www.issp.bas.bg/lab/ephi/Museum/acMBorissov/MB55-page2.html
18. G. Kamisheva, “History of Physics in Milko Borissov’s Publications” in *Milko Borissov Memorial Session (17.10.2003)*, edited by A. G. Petrov, et al., Shumen: University Press, 2006, pp. 18-31 (in Bulgarian).