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Abram Slutskin and Radiophysics in Ukraine of the First Half of the 20th Century: World Dimension

Abstract

The article discusses the scientific and pedagogical activity of the outstanding Ukrainian radiophysicist Abram Slutskin in the context of the development of world radiophysical research. It is substantiated that the theoretical works of the scientist defined a new direction of research in Ukraine, namely the radar, and were important for the development of ultrahigh frequency physics.

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Innovative research initiated by Abram Slutskin found application in new defense technologies, military equipment, and special devices for medicine, biology, navigation, communications, household television and the radio industry. The article proves that Abram Slutskin had priority in launching research in the field of biophysics in Ukraine. The research on the use of ultrahigh frequencies for treatment of oncological patients carried out by scientists were unique for that time. Abram Slutskin's graduate students became well-known specialists, who further developed the scientist's ideas by initiating innovative areas of research and creating new institutions. We have grounds to consider Abram Slutskin as one of the founders of the Ukrainian scientific radio-physical school.

Keywords: *radiophysics, magnetron, radar, Slutskin, Ukrainian scientists*

Abram Slutskin i radiofizyka na Ukrainie w pierwszej połowie XX wieku: światowy wymiar

Abstrakt

Tekst przedstawia działalność naukową i pedagogiczną wybitnego ukraińskiego radiofizyka Abrama Słutckina w kontekście rozwoju światowych badań radiofizycznych. Udowodniono, że prace teoretyczne naukowca wyznaczyły nowy kierunek badań na Ukrainie – technikę radarową i miały znaczenie dla rozwoju fizyki ultrawysokich częstotliwości. Innowacyjne badania zainicjowane przez Abrama Slutskina znalazły zastosowanie w tworzeniu nowych technologii obronnych, sprzętu wojskowego, urządzeń specjalnych dla medycyny, biologii, nawigacji, łączności, telewizji domowej i przemysłu radiowego. Udowodniono, że Abram Slutskin był prekursorem badań w dziedzinie biofizyki na Ukrainie. Wyjątkowe jak na tamte czasy były prowadzone przez naukowców badania nad wykorzystaniem ultrawysokich częstotliwości w leczeniu chorych na raka. Doktoranci Abrama Slutskina stali się znanymi specjalistami, którzy rozwinęli idee naukowca w zakresie wytyczania innowacyjnych obszarów badań i tworzenia nowych instytucji. Daje to podstawy do uznania Abrama Słuckina za jednego z założycieli ukraińskiej naukowej szkoły radiofizycznej.

Słowa kluczowe: *radiofizyka*, *magnetron*, *radar*, *Abram Słuckin*, *ukraińscy naukowcy*

1. Introduction

The scientific research in radiophysics in Ukraine began in the early 20th century. The development of the field was linked with an activity of outstanding Ukrainian scientists, whose achievements received recognition worldwide. Among them, special place belongs to an academician of the USSR Academy of Sciences, doctor of physical and mathematical sciences, Professor Abram Slutskin. The 130th anniversary of his birthday was in 2021.

Abram Slutskin, a talented representative of a radiophysical scientific school formed in Kharkiv in the first half of the 20th century, was professor Dmytro Rozhanskyi's student. Thanks to Slutskin's persistent and fruitful work the world's radiophysical research has been significantly expanded in promising areas. He was the inventor of unique devices, the author of theoretical foundations of ultra-high frequency technology, the initiator of a number of innovative technical projects, and the leader of the scientific school. He also contributed to training in radiophysics for scientific and engineering personnel. His students, like Semen Braude, Oleksandr Usikov, and others, founded new scientific areas and institutions.

The study of the history of Ukrainian radiophysics requires comprehensive approach, i.e. identification of key events, in-depth study of scientific schools and biographies of renowned radiophysicists. In the present paper, its authors have used the following methods: content analysis, historiographic analysis, chronology, historical and comparative analysis, biographical methods, and critical analysis based on historism and objectivity. Abram Slutskin's scientific and educational activity formed a very important page in the history of world radiophysics and needs to be studied in detail. Besides, Abram Slutskin's personality was not studied yet. A brief information was presented in numerous studies on the evolution of radar technology in Ukraine by Kostenko and Nosich.[17] However, these works were not free of certain incorrectness, in particular, presented photos did not correctly identify persons in the pictures. What concerns other works on this topic, some parts of Abram Slutskin's scientific activity are covered in publications on the history of the National Science Center "Kharkiv Institute

[17] Kostenko, Nosich and Tishchenko 2001; Nosich 2017; Kostenko, Nosich and Raniuk 2005; Kostenko, Nosich and Yakovenko 2005; Nosich, Kostenko 2010.

of Physics and Technology" (NSC "KhIPT")[18] – and in the anniversary publications on the history of Kharkiv University.[19] The fragmentary scientific achievements of the scientist were already presented,[20] but no comprehensive study of the life and influence of this prominent Ukrainian radiophysicist has been carried out yet.

The materials of the State Archives of Kharkiv region, the archives of the Institute of Archival Studies of NASU of the National Library of Ukraine, the archive of the Presidium of the NAS of Ukraine, and the archive of the National Scientific Center "Kharkiv Institute of Physics and Technology" were the sources of this study.

This article presents a brief biography of Academician Abram Slutskin. His contribution to the development of radio engineering research in Ukraine and abroad is also assessed.

2. Biographical information

Abram Slutskin (Fig. 1) was born on July 5 (July 17), 1891, in the city of Borisoglebsk, Tambov Province, into a burgher family. He graduated from Borisoglebsk Gymnasium in 1909 and in the same year entered Kharkiv University. After graduating from the University in 1916 with a degree in physics, he stayed there to continue his studies. In 1919, he began teaching at the Department of Physics, which was a part of the Higher Courses for Women (later the Institute for Public Education). In 1922–1925, he studied at the Postgraduate School at the Research Department of Physics under the guidance of Dmytro Rozhanskyi.

In 1924–1925, he developed, together with Dmytro Steinberg, a new method of generating high-frequency oscillations (waves of 7–50 cm) and created the world's first magnetron (wavelength of 7.3 cm). From 1926, he was an assistant at the Department of Physics at Kharkiv University, and headed the section of electromagnetic oscillations at the Department of Physics in the Institute for Public Education. In February 1929, he began working at the UIPT[21], where he was the Head of the Department of Electromagnetic Oscillations.

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[18] Founded as the Ukrainian Institute of Physics and Technology (UIPT).

[19] Tanshyna 2014; Ulianov 2003; Kohan, Sofronyi 2009.

[20] Palii 2013; Semynozhenko (eds.) et al. 2012; Sukhyna 1998.

[21] Since 1939, the Kharkiv Institute of Physics and Technology of the Academy of Sciences of the USSR – KhIPT.

Fig. 1 Abram Slutskin. Archive of the Presidium of the NAS of Ukraine, f. 251, desc. 1, case 256, p. 5.

In 1933, he headed the Department of Electromagnetic Oscillations at Kharkiv University (since 1939 it was called the Department of Technical Physics) and worked as a professor at Kharkiv Electrotechnical Institute. In 1937, he received the degree of Doctor of Physical and Mathematical Sciences without defending a dissertation. During next two years he supervised the building of a three-unit radar in the range of decimeter waves, as well as the first radar equipment in the USSR. In 1939, he was elected a corresponding member of the USSR Academy of Sciences. In 1948, he became an academician of the USSR Academy of Sciences. He died on July 13, 1950, in Kharkiv.[22]

3. Initiation of radiophysical research in Ukraine

The University in Kharkiv was a center of scientific research in the field of physics in the early 20th century. Thanks to the efforts of Andriy Shymkov, Oleksandr Gruzyntsev, Mykola Pylchykov, and others, conditions

[22] Archives of the Presidium of the NAS of Ukraine, f. 251, desc. 1, case 256, pp. 2–4.

for research and training were created at the Department of Physics there. Moreover, a physics laboratory installed with modern equipment was established by Mykola Pylchykov at the Kharkiv Institute of Technology (KhIT). These circumstances contributed to launching of a new promising area of research – radiophysics in Kharkiv.[23]

A characteristic feature of the scientific school of radiophysics was the succession of generations. The experience of Slutkin's teacher, Dmytro Rozhanskyi, during his scientific and pedagogical activity at the Department of Physics of the St. Petersburg Electrotechnical Institute under the leadership of Oleksander Popov contributed to the formation of his scientific worldview, in his becoming a scientist and a founder of the scientific school of radiophysics. This influence was then visible in the next generation of researchers, in particular Abram Slutskin. Working as the head of the Department of Physics at the Kharkiv University, Dmytro Rozhanskyi involved students in his research in the field of radiophysics. The physics seminar held in the Faculty of Physics and Mathematics of the University was of great importance for the development of radiophysical research and training in this specialization.[24] The seminar was, and remains, an important factor for the formation of the scientific school, because it has allowed for implementing a number of important discoveries. In particular, there was an exchange of experience and relevant scientific information; reports, speeches, discussion of results, and critical remarks. There, the researchers, postgraduate students, and students were involved in promising work. The issues discussed at the meetings were relevant and new to the city's scientific community. The scientists of the Departments of Physics at the Kharkiv University, Institute of Technology, and Veterinary Institute took part in the seminars.[25]

In 1911, at the physics seminar, Abram Slutskin, who was still a student at that time, made his first report, "Cathode rays". This period coincides with a fruitful period of Dmytro Rozhanskyi's scientific work. (At the time, he developed theoretical questions into oscillations in related circuits, properties of an electric arc, and an effect of a spark on the period of electrical oscillations. He also studied

[23] Tolok 2004, p. 229.
[24] Kudriavtsev 2016.
[25] Rozhanskyi et al. 2003, pp. 21–29.

discharges in rarefied gases; absorption of cathode rays by substances; measurement of radioactivity of some drugs, as well as some questions into spectroscopy.)[26]

After obtaining a first degree diploma, Abram Slutskin stayed at the Department of Physics to continue his studies. He worked in the laboratory, supervised by Dmytro Rozhanskyi, and studied design of spark radios, in particular the influence of a spark on oscillations of a capacitor discharge. His first scientific paper, reflecting his supervisor's work interests, was published in 1918.

These studies by Slutskin helped him to learn how material and size of a spark gap influence the period of the oscillating discharge of a capacitor. Later, the work of Abram Slutskin became the basis for more accurate calculations of wavelengths for spark radio stations.[27]

In 1921, Dmytro Rozhanskyi moved to Nizhny Novgorod, where in a radio laboratory he dealt with issues of short waves, transmission of telegraphy and telephony in waves of several tens of meters; and theoretical problems of stabilization of tube generators. He took part in computational works, when the antenna of the first radio receiver was built in the USSR. The Nizhny Novgorod Radio Laboratory, the first center for research in radio engineering in the USSR, became the center for practical experience. In 1923, Dmytro Rozhanskyi accepted an invitation from Abram Joffe and continued his scientific activity in Petrograd (St. Petersburg). Meanwhile, Rozhanskyi continued the radiophysical research at Kharkiv University, supported cooperation with former colleagues, provided advice and assistance to his students.[28] Under his guidance, the first teacher of radio engineering in KhIT, Oleksii Khinkulov, studied methods of radio measurements, and became acquainted with the radar equipment in the laboratory.[29] On the initiative of Dmytro Rozhanskyi, a research department of electromagnetic oscillations, physical properties of substances, and physics of gas discharge was established in Kharkiv in 1921.[30]

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[26] Tkach 1953, p. 17.
[27] SAKhR, f. R-2792, desc. 20, case 130. pp. 4–5.
[28] Kuzmenko 2013, p. 194.
[29] Tverytnykova, Gutnyk, Salata 2020, p. 383.
[30] Ulianov 2003, p. 7.

4. Research on magnetrons

Meanwhile, Dmytro Rozhanskyi continued the study of ultrahigh frequencies and constantly emphasized the importance of the ultra-high frequencies for further development of radio engineering and radiophysics. At his suggestion, the Department of Physics at the Kharkiv University organized a research unit and began studies on generation and application of decimeter and centimeter waves. The study was led by Rozhanskyi's students, – Abram Slutskin and Dmytro Steinberg[31] (fig. 2).

Fig. 2 Dmytro Steinberg and Abram Slutskin, 1926.
Source: Kostenko et al. 2005, p. 131.

In 1926, a Research Department of Physics (headed by Dmytro Rozhanskyi) with a section of electromagnetic oscillations (headed by Abram Slutskin) was established at the Kharkiv University. Later, in 1933, the first in Ukraine Department of Electromagnetic Oscillations was opened there, and training in the field of radio physics began.[32]

Abram Slutskin's scientific interests at that time concerned problems of generating decimeter waves using magnetic field. The need for

[31] IASNLU, f. 220, desc. 1, case 1. p. 2.
[32] SAKhR, f. R-2792, desc. 20, case 130. p. 3.

industrial application of decimeter waves became obvious. Regardless of foreign researchers, Slutskin hypothesized that a solid-anode magnetron could be a source of ultrahigh-frequency oscillations. He studied processes occurring in electronic lamps under influence of an external magnetic field in order to obtain electromagnetic oscillations in a magnetron-type generator. Thusly, in 1924 Abram Slutskin together with Dmytro Steinberg developed a new method of generating high-frequency oscillations in magnetrons with a wavelength of 7 to 50 cm. In 1925, the researchers proposed a working model of a magnetron radio wave generator (wavelength 7.3 cm).[33] Their goal was to create the world's first magnetron that generated microwaves in the ultrahigh frequency range.[34] The new magnetron methods of generating radio waves became a theoretical basis for creating ultra-high frequency technology.[35] In Kharkiv, these studies became the basis for the development of radar equipment, in particular for building a shortwave radio transmitter in 1926.[36] It was one of the first such transmitters in the world.

It should be noted that similar studies on the creation of various magnetron designs were carried out in many countries by: American radio technician Albert W. Hull, Czechoslovak physicist Augustin Zhachek, German researcher Erich Habann, Italian Ivo Ranci, and Japanese scientists Hidetsugu Yagi and Kinjiro Okabe. Despite the fact that microwave oscillations (wavelength 66 cm) were first recorded by Heinrich Hertz in 1888, further research led to experimenting with incoherent oscillations of low intensity.[37]

Only in 1919, German physicists Heinrich Georg Barkhausen and Karl Kurz obtained coherent excitations in a vacuum triode of low-frequency range. In 1921, Albert Hull published his papers "The Effect of a Uniform Magnetic Field on the Motion of Electrons between Coaxial Cylinders" and "The Magnetron", in which he substantiated the principle of controlling the motion of electrons between coaxial cylinders by means of a direct magnetic current and proposed the term

[33] Kostenko 2010, p. 63.
[34] Korsun 2020, p. 87.
[35] Slutskyn, Shteinberh 1926.
[36] Archives of the NSC "KIPT", f. 1, desc 1, case 517, p. 32.
[37] Archives of the Presidium of the National Academy of Sciences of Ukraine, f. 251, desc.1, case 256, p. 21.

"magnetron". Also, he showed subcritical, critical and supercritical modes of operation of the cylindrical diode.[38]

In 1921, at All-Russian Electrotechnical Congress, a Ukrainian scientist, Professor of the Kharkiv University, Oleksandr Danilevskyi, reported the results of his own research, regarding in particular the waves of the length of 20 cm.[39] Independently of each other, Augustin Zhachek and Erich Habann discovered the property of the decimeter wave generation magnetron (100 MHz – 1 GHz). In particular, Augustin Zhachek, based on the design of the magnetron proposed by Albert Hull, received the first microwave oscillations in 1924.[40]

Also, studies of a cylindrical split magnetron were conducted by Hidetsugu Yagi and his postgraduate student, Kinjiro Okabe, during 1927–1929. In 1929, Ivo Ranci published his work "Negative Resistance in a Diode Subject to a Magnetic Field".[41]

In France, the leadership in the field of microwave technology and the creation of resonant magnetrons belonged to an inventor Maurice Ponte, who in 1932 improved the design of the magnetron by Kinjiro Okabe and began research on a multi-segment resonating anode. The work of a French researcher Henri Gutton in 1934–1938 allowed for creation of a decimeter radar. He tested a large number of anode designs and proposed the design of an 8-segment anode. His research was industrially implemented and the first decimeter radar was built in 1935 (Fig. 3).[42]

In 1935, Scottish scientist Robert Watson-Watt proposed one of the first radars, designed for detecting airborne objects. The wavelength range, in which this radar operated, was different from the working ranges of devices developed in other countries. Later on, this invention, under the code name Chain Home, played an essential role in the development of radar target detection methods. It was one of the first, and helped to protect Great Britain from Nazi air raids.[43]

An important milestone for the development of microwave technology and the creation of radars was the invention of a klystron by two

[38] Trubetskov 2007, p. 109.
[39] Hlebova 2016, p. 78.
[40] Andreev et al. 2019
[41] Fisk et al 1946, pp. 168–170.
[42] Blanchard 2010.
[43] Hanbury Brown 1994, pp. 31–40.

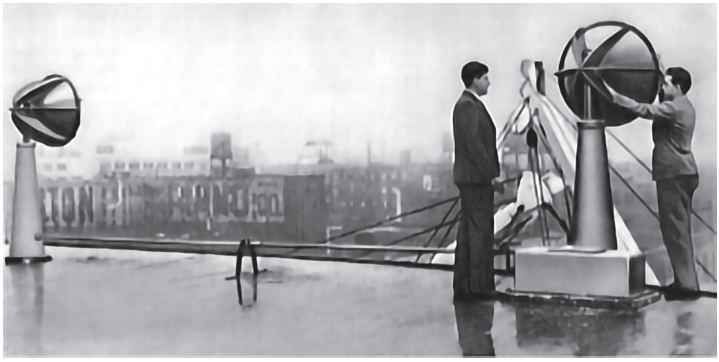

Fig. 3. Tests of the decimeter radar on the board of the "Normandy" liner, New York, 1935. Source: Blanchard 2010, p. 4.

American brothers, Russell and Sigurd Varian. In 1937, they built the klystron device for generating the electromagnetic oscillations.[44]

As far as Abram Slutskin is concerned, he took an active part in establishing of the All-Ukrainian Association of Physics. This organization was necessary for coordinating work in the field of physical research. The lack of connections between scientists of the various scientific centers in the early 1920s, poor material and technical resources, and lack of access to international scientific publications hampered the development of physics in Ukraine.

The All-Ukrainian Association of Physics included such leading physicists as Dmytro Rozhanskyi, Mykhailo Sakharov, Andrii Malinovskyi, Georgy De-Metz, and others. The Association was headed by Andrii Zhelekhovskyi. Abram Slutskin was the secretary of the association's board. As early as in 1928, the Association held the first congress of the Ukrainian Association of Physicists and started to publish a journal "Ukrainian Physical Notes".[45]

As demonstrated, a significant contribution to the development of the short wave magnetrons was made by representatives of many countries, namely the first inventor of the magnetron, Albert Hull, and Japanese researchers Hidetsugu Yagi and Kinjiro Okabe. Undoubtedly, the priority in the experimental establishment of high-frequency oscillations belonged to Augustin Zhachek, and the theoretical substantiation was

[44] Blanchard, Gaspare, Genderen 2013, pp. 245–248.

[45] Scientific institutions and organizations of the USSR 1930, p. 14.

obtained by the Ukrainian radiophysicists, Abram Slutskin and Dmytro Steinberg.

In 1928, Abram Slutskin went on a business trip to Germany, where he spent two months as an intern in the famous Barkhausen laboratory at Dresden Technical University.[46]

5. Research in the field of radiolocation

In 1929, Abram Slutskin was invited to the Ukrainian Institute of Physics and Technology (UIPT), where he continued to study a new method of generating powerful oscillations with short waves and initiated a laboratory (department) of electromagnetic oscillations (LEMO). He became the scientific director of the laboratory and worked there for 20 years. His further research has proven that the powerful oscillations method is useful in many industries, including medicine.[47] According to the memoirs of other famous theoretical physicist, academician Oleksander Akhiezer, the defense-related project was started in the UIPT with a promising research by Abram Slutskin in the field of radiolocation.[48]

Some interesting facts can be found in Leonid Piatyhorskyi's memoirs. He was a student of the outstanding physicist-theorist Lev Landau, and described a very difficult and tragic period in the development of the UIPT in the first half of the 1930s. It turned out that despite important research on the radar equipment under the leadership of Abram Slutskin, it was believed that these studies prevented the UIPT and Ukraine from developing theoretical physics. Moreover, there were attacks on Slutskin and his team, and proposals were made to exclude the laboratory of electromagnetic oscillations from the UIPT.[49] Subsequent events, like arrest of leading scientists of the UIPT, including Lev Landau, reduced interest in this subject, and Abram Slutskin's laboratory continued to operate.[50]

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[46] Archives of the NSC "KhIPT", f. 1, desc. 1, case 517. p. 5.

[47] SAKhR, f. R-2792, desc. 20, case 130. p. 7.

[48] Interview with Academician of the National Academy of Sciences of Ukraine O.I. Akhiezer 2016.

[49] Raniuk 1999, p. 84.

[50] Nosich, Kostenko, Tishchenko 2005, pp. 125–126.

Unique for that time were Slutskin's studies on the use of ultrahigh frequencies for treatment of cancer patients in the Department of Biophysics of the Ukrainian Institute of Experimental Medicine. The department itself was established in 1933 by Slutskin due to his colleague's, Vasyl Danilevskyi's, suggestion (he was the head of the Department of Physiology of the Kharkiv University).[51] Abram Slutskin's initiative was to create the first Ukrainian ultra-high frequency medical equipment for the treatment of various pathological processes. In 1935, the scientist headed the All-Union Conference on the use of ultrashort radio waves in medicine and biology. Among many issues addressed during the conference, there was a question of determining the possibility of negative effects of high-frequency and ultra-high-frequency radiation on the human body. These studies of Abram Slutskin were continued in subsequent years. Then, a new field of research was launched at the Kharkiv University – radiospectroscopy and electrophysics of biological media; a specialty of biophysics was opened, and a corresponding department was established.[52]

Slutskin's extraordinary insight led him to focus on development of sources of powerful microwave oscillations. He was aware that they might be important for the further development of science and technology. Here, Abram Slutskin's experiments focused on creation of powerful magnetrons with a split anode, as well as on research on continuous and pulsed modes. A thorough study on the properties of magnetrons, sources of microwave oscillations, led Abram Slutskin to formulate a theory of the magnetron generator.

His further research was aimed at developing a method for generation of microwaves using contour oscillations in a magnetron. In 1937, the decimeter wave reached a power of about 20 kW – in the mode of continuous radiation (developed by Abram Slutskin, Semen Braude, Ivan Truten), and about 100 kW – in the pulse mode (Oleksander Usikov, Yosyf Vygdorchik, Peter Lelyakov, and others). Until 1948, their results remained unsurpassed either in the USSR, or abroad.[53]

A new idea of magnetrons with a multi-segment anode, two-anodes, etc., was developed in the UIPT laboratory. In 1937, the design

[51] Danilevskyi 1900.

[52] Tverytnykova et al. 2021, p. 164.

[53] Archive of the Presidium of the NAS of Ukraine, f. 251, desc. 1, case 256. p. 42.

of a multi-segment magnetron with three-dimensional contours preceded the research of foreign radiophysicists in the field of radar technology. The results of English scientists appeared only in 1940.

In general, the results of this period were:

- the study of physical processes occurring in magnetron,
- identifying the mechanism of different types of oscillations,
- developing methods of generator control and design, in order to obtain large power in the range of decimeter and centimeter waves,
- and substantiating the importance of magnetrons in solving various technical problems.[54]

Concerning the results of theoretical and experimental work of 1931–1938, conducted by Abram Slutskin's research group, seventeen scientific articles were published, including nine publications in a scientific journal "Physikalische Zeitschrift der Sowjetunion" in German, which testified to the high level of the research and value of the results. This journal was published in Kharkiv between 1932 and 1938, and it was the first Soviet scientific publication with articles in English, German and French that were subject to mandatory review. This contributed to the dissemination of the results in the world of science.[55]

Abram Slutskin's works enabled him to lead a set of research projects on pulse detection systems, which were innovative and the first in the USSR. The creation of the decimeter-range radars started in 1937. As a result, as the first in the USSR, a model of pulsed three-coordinate radar in the range of decimeter waves, using a magnetron as a generator of powerful high-frequency pulses, was designed.[56] The "Zenith" decimeter radiolocation equipment was successfully tested in 1938, and determined the distance, azimuth and altitude of an aircraft with high accuracy. It was the world's first radar to detect three characteristics of an aircraft in the air.[57] Further research focused on building a new station, called "Rubin" (Fig. 4). This station had improved technical characteristics. Abram Slutskin was the leader of these important works (valuable also to the military) and continued them while evacuated

[54] Archive of the Presidium of the NAS of Ukraine, f. 251, desc. 1, case 256. p. 39.
[55] IASNLU, f. 220, desc. 1, case 1. p. 2.
[56] Nosich 2017, pp. 11–12.
[57] Archives of the NSC "KhIPT", f. 1, desc 1, case 13. p. 38.

during the World War II. Also, Semen Braude and Oleksander Ahiezer were part of this activity.[58] The unique three-coordinate radar "Rubin" was created in the USSR, in Bukhara city (Fig. 5).[59] These studies were promising, exclusive in their design and scale, and the complexity of provided solutions. They corresponded to, and outpaced in some respect, the world results in the development of radiophysics.

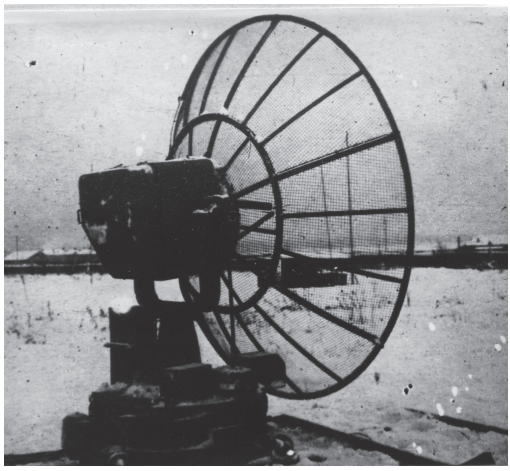

Fig. 4 The antenna unit of the single-antenna radar "Rubin".
Source: Kohan, Sofronyi 2009, p. 415

Upon returning from Central Asia in 1944, Abram Slutskin took part in the restoration of the ChIPT' laboratory base. His scientific work at that time was a thorough study of distribution and absorption of microwaves in different environments and improvement of multi-resonant shortwave magnetrons. The obtained results had both theoretical and practical significance, e.g. Usikov's device for the determination of the location of power lines damagesand multi-anode magnetrons were introduced into industry.[60]

Abram Slutskin' scientific heritage consists of more than 50 works that can be divided into the following collections: 1) study of influence of a spark on the period of capacitor's oscillation; 2) research on the

[58] Archives of the NSC "KhIPT", f. 1, desc 2, case 16. pp. 41–50; Erickson 1972, pp. 242–244.

[59] Kostenko et al. 2005, p. 10.

[60] Archives of the NSC "KhIPT", f. 1, desc. 1, case 3a, pp. 39–41.

Fig. 5 Employees of the radiolocation department of the Research Institute and KIPT while working at the station "Rubin", Bukhara, February 23, 1942. Source: Kostenko et al. 2005, p. 10.

generation of decimeter waves using a magnetic field; 3) in-depth study of the properties of field generators as sources of ultrahigh frequency oscillations; 4) methods for obtaining decimeter waves of significant power; 5) study of the properties of gas ions under the influence of magnetic field (a method for obtaining large ion currents in high vacuum was developed, and the properties of electron-ion beams in a magnetic field were studied); 6) works on oscillations obtained in plasma; 7) theory of multi-segment magnetrons.[61]

6. Pedagogical and organizational activity

As academician, Abram Slutskin made a significant contribution to the system of training experts in the field of radiophysics and biophysics. He taught for over 35 years. As a young scientist, he began to work as an assistant at the Department of Physics of Higher Courses for Women, then taught physics at Kharkiv Institute of Engineering and Economics at the Communist University, where he taught physics and high frequency oscillations. For a long time A. Slutskin worked at the Kharkiv University, headed the Department of Electromagnetic Oscillations (later – Technical Physics). His students noted his brilliant

[61] Archive of the Presidium of the NAS of Ukraine, f. 251, desc. 1, case. 256, pp. 57–58.

lecturing abilities.[62] At the suggestion of Abram Slutskin, an experiment of introducing a model of dual learning was conducted, i.e. students of the Department were obliged to have an internship in the Laboratory of Electromagnetic oscillations of KhIPT.[63]

In addition, he took part in organizing the Radio Engineering Faculty and the beginning of radiophysical research at Kharkiv Electrotechnical Institute (KhETI), which in 1950 became a part of Kharkiv Polytechnic Institute. In 1946, on the basis of the radio engineering specialty of KhETI, the Radio Engineering Faculty was organized with the Dean Oleksandr Mits. Later, Kharkiv University of Radio Electronics was established on the basis of this faculty. The new faculty included the following departments: Department of Theoretical Radio Engineering – Head Abram Slutskin, Department of Radio Receiving and Transmitting Devices – Head Semen Braude, Department of Radars – Head Yefim Kopylovych.[64]

The research work of the Faculty of Radio Engineering was focused on the methods of generation and frequency modulation of centimeter waves, generators, and measuring equipment for radar stations of the centimeter range, and others. In general, it was related to the work of the Department of Electromagnetic Oscillations. The scientists worked there on improvements to the methods of generating centimeter waves, they studied the laws of their distribution, and used them in radars, in automation and tele-mechanization of power systems.[65]

A scientific group of Abram Slutskin, Oleksandr Usykov and Ivan Truten (Fig. 6) studied the distribution of centimeter waves in waveguides, methods of generation and frequency modulation of centimeter waves, and also developed generators and measuring equipment for radar stations in the centimeter range.[66]

Oleksandr Mits, under the direction of Abram Slutskin, developed a rectangular waveguide as a wavemeter with an ability to measure the wavelength with an accuracy of 1 micron. Ivan Truten designed new constructions of centimeter wave radar generators. Oleksander Usikov

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[62] Trubetskov 2007 p. 122.
[63] Archives of the NSC "KhIPT", f. 1, desc. 1, case 43. pp. 11–16
[64] SAKhR, f. Z-5404, desc. 2, case 110, p. 2.
[65] SAKhR, f. Z-5404, desc. 2, case 87. p. 130.
[66] Yanovsky 2016, pp. 35–36.

Fig. 6 Abram Slutskin and researcher Ivan Truten are measuring the wavelength of their generator. Kharkiv, February 9, 1945. Source: Funds of the Historical Museum of NTU "KhPI"

studied the use of the pulse method for power transmission. The question of distribution of radio waves in mines, in order to establish radio communication there, was studied by Semen Braude.[67]

Abram Slutskin worked a lot on training of scientific personnel, and acted as a leader and colleague for his postgraduate students. His first postgraduate student at KhETI – Borys Koshcheev (who later founded Kharkiv Scientific School of Meteor Radiolocation and Radio Communications) conducted innovative research on magnetrons operating in a pulsed mode. During 1947–1950, Yevhen Kulieshov, a well-known radiophysicist, and a specialist in the field of microwave technology[68], studied at the KhETI postgraduate school under Abram Slutskin's supervision. Also, Ivan Turgenev made an experimental part of his dissertation at LEMO, while he was a post-graduate student at the Department of Radio Receiving and Transmitting Devices. Later on,

[67] SAKhR, f. Z-5404, desc. 2, case 66, p. 29.

[68] He was also Honored Inventor of Ukraine, and a laureate of the Lenin Prize, of the State Prize of the Ukrainian SSR, and the awards of the International Society of Electrical and Electronics Engineers.

he became a doctor of technical sciences, well-known specialist in the field of radio wave distribution, radar and radio navigation, and the founder of radiooceanography.[69]

Abram Slutskin's students were among others:

- academician Oleksandr Usykov – founder and first director of the Institute of Radiophysics and Electronics of the National Academy of Sciences of Ukraine;
- academician Semen Braude – founder of the Radio Astronomical Institute of the National Academy of Sciences of Ukraine;
- Ivan Truten – inventor of a number of unique devices, leader of a new scientific field of ultra-high frequency gas discharge, head of the Laboratory of Pulse Generation of the NSC "KhIPT";
- Yefym Kopylovych – member of a team who created radar equipment;
- Abram Chernets, specialist in the field of ultrahigh frequency physics, head of the Laboratory of Continuous Generation of the NSC "KhIPT";
- Yosyf Vyhdorchyk – a specialist in the field of radio astronomical equipment and pulse generation, author of 11 inventions;
- Volodymyr Tkach – Head of the Department of Technical Physics of the Kharkiv University;
- Oleksii Tereshchenko – Dean of the Radiophysics Faculty of Kharkiv University.[70]

It should be added here that the scientific traditions of Abram Slutskin were continued by his son, Oleksander Slutskin, Doctor of Physical and Mathematical Sciences, Senior Research Fellow of the Institute of Physics and Technology of Low Temperatures of the National Academy of Sciences of Ukraine. In 1964, he defended his dissertation on "Some questions of dynamics and kinetics of conduction electrons with a complex dispersion law" (supervised by Doctor of Physical and Mathematical Sciences, Academician Ilya Lifshitz).[71] In 1980, he defended a doctoral dissertation on "Dynamics of conduction electrons and kinetic

[69] SAKhR, f. 1, desc. 1, case 164, p. 3 and case 399, p. 4.
[70] Kohan, Sofronyi, 2009, pp. 384–385.
[71] Archives of the NSC "KhIPT", f. 1, desc. 1, case 517, pp. 40–41.

phenomena in metals under conditions of magnetic breakdown". He is also the author of a number of thorough works in the field of electronic theory of metals, as well as inventions, and patents.

7. Conclusions

In the present publication, the scientific, organizational, and educational activity of the Ukrainian radiophysicist Abram Slutskin has been analized. It has been proven that his theoretical works defined a new direction of research in Ukraine, namely, the radar device, and were important for development of the world radiophysical research. He created a complete theory of multi-segment generators with a thin anode, which became the basis for technical calculations of ultra-high frequency generators and had a significant impact on the development of ultra-high frequency physics. The innovative scientific research, initiated by Abram Slutskin within the NSC "KhIPT", Kharkiv Electrotechnical Institute and Kharkiv National University, was implemented in new defense technologies, military equipment, special devices for medicine, as well as in biology, navigation, communications, television, and radio industry.

An important result of Abram Slutskin's activity was his continued scientific school in the field of radiophysics, initiated by Dmytro Rozhanskyi at the Kharkiv University. The development of science in the first half of the 20th century can be described as a gradual transition from activities of individual scientists to a collective cooperation in its most effective form: a scientific school. So, the scientific team headed by Abram Slutskin had all the main features that characterized a scientific school. In particular, these were: theoretical and practical results that had gained world recognition; implementation of the results into the industry; presence of a leader and a system of training scientific and engineering personnel; succession of generations; development of a scientific school that resulted in creation of new scientific centers.

Upon studying the archival files of funding the NSC "KhIPT", the authors noted that Abram Slutskin was engaged in secret topics in the postwar years, and data on these studies are not presented among others. This gives reason to believe that these materials are still classified and the last page of the scientific story of Abram Slutskin is yet to be written.

Bibliography

ARCHIVAL SOURCES

Archive of the Presidium of the National Academy of Sciences of Ukraine (Archive of the Presidium of the NAS of Ukraine), f. 251, desc. 1, case 256: Personal file of Slutskin Abram Oleksandrovich (October 11, 1937 – July 13, 1950 pp.), 68 p.

Archive of the National Scientific Institute "Kharkiv Institute of Physics and Technology" (Archives of the NSC "KhIPT"), f. 1, desc. 1, case 517: Personal file of Slutskin A.O. (1942–July 22, 1950), 41 арк.

Institute of Archival Studies of the National Library of Ukraine named after V.I. Vernadsky (IASNLU), f. 220, desc. 1, case 1: Personal fund of Academician of the USSR Academy of Sciences Abram Oleksandrovych Slutskin.

Archives of the NSC "KhIPT", f. 1, desc. 2, case 16: Scientific report on the implementation of research work on the topic "Antenna and receiving device for continuous direction finding to Rubin station", 1943, 62 p.

Archives of the NSC "KhIPT", f. 1, desc. 2, case 13: Scientific report on the implementation of the research work on the topic "Radar for the determining of the aircraft location in the air", 1938, 53 p.

Archive of the NSC "KhIPT", f. 1, desc. 1, case 3a: Scientific report on the implementation of research work on the topic "Mechanism of excitation of oscillations in a multi-segment magnetron"1945, 53 p.

State Archives of Kharkiv region (SAKhR), f. R-2792, desc. 20, case 130: Personal file of Academician of the Academy of Sciences of the USSR Slutskin A.O., 32 p.

SAKhR, f. 1, desc. 1, case 164: Department of "Radio equipment". Report on the work of the Department for 1950–1951 academic year, 4 p.

SAKhR, f. 1, desc. 1, case 399: Department of "Radio devices". Report on the work of the Department for 1951–1952 academic year, 16 p.

SAKhR, f. Z-5404, desc. 2, case 110: Department of "Fundamentals of Radio Engineering". Report on the work of the Department for 1948–1949 academic year, p. 2.

SAKhR, f. Z-5404, desc. 2, case 87: Protocols of meetings of the Academic Council of the Kharkiv Electrotechnical Institute, p. 265.

SAKhR, f. Z-5404, desc. 2, case 66: Research department. Materials on research work conducting in the Institute for 1946 (reports, data, cards), 186 p.

STUDIES AND PUBLISHED SOURCES

Akhiezer, A. I. 2016: The interview with the Academician of the National Academy of Sciences of Ukraine A. I. Akhiezer (to the 20th anniversary of the establishment of the A. I. Akhiezer Institute for Theoretical Physics). *Science and Science of Science* 4, pp. 88–97.

Andreev, D.; Kuskov, A.; Schamiloglu, E. 2019: Review of the relativistic magnetron. *Matter and Radiation at Extremes* 4(067201). DOI: 10.1063/1.5100028.

Andreev, F.M., 2015. Abram Oleksandrovich Slutskin [In:] Karazintsy are the ancestors of pulsed radar equipment. Kharkiv, pp. 77–90.

Blanchard, Yves 2010: Maurice Ponte and Henri Gutton, pioneers of early French studies on resonant magnetron (1932–1940). [In:] *International Conference on the Origins and Evolution of the Cavity Magnetron Origins and Evolution*. Bournemouth, pp. 1–6. DOI: 10.1109/CAVMAG.2010.5565573.

Blanchard, Yves; Galati, Gaspare; Piet van Genderen 2013: The Cavity Magnetron: Not Just a British Invention. *IEEE Antennas and Propagation Magazine* 55(5), pp. 244–254. DOI: 10.1109/MAP.2013.6735528

Danilevskyi, V. Ya. 1900. Research on the physiological effects of electricity at a distance. Monograph. Kharkiv: Zilberberg, 159 pp.

Erickson, E. 1972: Radio-location and the air defence problem: The design and development of Soviet radar 1934–40. *Science Studies* 2, pp. 241–268. DOI: 10.1177/030631277200200302.

Fisk, J. B.; Hagstrum H. D.; Hartman P. L. 1946: The Magnetron as a Generator of Centimeter Waves. *The Bell System Technical Journal* 2, pp. 167–189.

Gutnyk, M.V.; Tverytnykova, E.E. 2021: The professor G. De-Metz's contribution to the development of physical science in Ukraine. *Ukrainian Journal of Physics* 66(9), pp. 819–829. DOI: 10.15407/ujpe66.9.819

Hanbury Brown, R. 1994: Robert Alexander Watson-Watt, the Father of Radar. *Engineering Science and Education Journal* 3(1), (February 1994), pp. 31–40.

Hlebova A. N. 2016: On the priority of creating a magnetron generator of high-frequency oscillations. *Science and Science of Science* 4 (94), pp. 78–87.

Kohan, V. S. Sofronyi, V. V., 2009: *UIFT employees are participants in the Great Patriotic War. Ed. 2, add.* Kharkiv, 432 pp.

Korsun, I. V. 2020. The contribution of Ukrainian scientists to the development of electrodynamics. *Ukrainian Journal of Physics* 65 (1), pp. 80–89.

Kostenko, A. A. 2010: D. S. Steinberg. Creative portrait. *Наука та Наукознавство* (*Science and Science of Science)* 1, pp. 64–83.

Kostenko, A. A.; Nosich, A. I; Yakovenko V. M. 2004: Radiophysical research in Ukraine. *Radiophysics and Radio Astronomy* 9(1), pp. 81–106.

Kostenko, A. A.; Nosich, A. I; Tishchenko, I. A. 2001: Development of the first Soviet 3-coordinate L-band pulsed radar Kharkov before WWII. *IEEE Antennas and Propagation Magazine* 44 (3), pp. 28–49.

Kostenko, A.; Nosich, A.; Raniuk Yu. 2005: Prehistory of the IRE NAS of Ukraine. *Наука та Наукознавство* (*Science and Science of Science)* 4, pp. 102–135.

Kostenko, A.; Nosich, A.; Raniuk, Yu. et al 2005: *Institute of Radiophysics and Electronics named after A.Ya. Usikov NAS of Ukraine. 50 years: monograph. Kharkiv.*

Kudriavtsev, V. V. 2016: Scientific schools in the field of radio engineering and radio electronics. *History of Science and Technology* 1, pp. 24–45.

Kuzmenko, N. O., 2013: Representatives of the Kharkiv School of Radiophysics of the second half of the 20th century. *Almanac of Ukrainian Studies* 14, pp. 193–196.

Nosich, A. 2017: Dramatic History and Impact of Decimeter-Wave Radar "Zenit" Developed in Kharkiv in the 1930. [In:] *XXIInd International Seminar/Workshop on Direct and Inverse Problems of Electromagnetic and Acoustic Wave Theory (DIPED)*, pp. 11–14.

Nosich, A. I.; Kostenko, A. A.; Tishchenko, I. A. 2005: Microwave and Radar Drama in Kharkov, Ukraine in 1920–30's. [In:] *100 Years of Radar (Special issue).* H. Rohling and A. Dunstheimer (Ed.). Bonn: German Institute of Navigation, pp. 123–132.

NN 1930: *Naukovi ustanovy' ta organizaciyi USSR* [Scientific institutions and organizations of the USSR]. Kharkiv.

Palii, V.M., Khramov, Yu. O. 2013: Slutskin Abram Oleksandrovych. [In:] *National Academy of Sciences of Ukraine 1918–2013: staff.* Kyiv, p. 129.

Raniuk, Yu. N. 1999: L. D. Landau and L. M. Pyatigorsky. *Questions of the history of natural science and technology* 4, pp. 79–91.

Rozhansky, I. D.; Rozhanskaya, M. M.; Filonovich, S. R. 2003: Dmitry Apollinarievich Rozhansky. Moscow: Science, 159 pp.

Seminozhenko, V.P. (ed.) 2021: Radiophysical School of A. O. Slutskin [In:] *Scientists of Ukraine are the elite of the State.* Kyiv, p. 60.

Slutskin, A.A., Steinberg, D.S. 1926: Generation of oscillations in cathode lamps using a magnetic field. *Journal of the Russian Physico-Chemical Society, physical series* 58 (2), pp. 595–602.

Sukhina, V. F. 1998: Slutskin Abram Oleksandrovich [In:]. *Outstanding teachers of the higher school in Kharkiv: biographical dictionary.* Kharkiv, pp. 556–558.

Tanshina, A. V. 2014: The UIFT Phenomenon. Historical and documentary sketch. *Bulletin of the National Academy of Sciences of Ukraine* 3, pp. 94–99.

Tkach, V. K. 1953: Abram Oleksandrovich Slutskin (on the third anniversary of his death). *Scientific notes. Proceedings of the Physical Department of the Physics and Mathematics Faculty of Kharkiv University*, 49, pp. 17–22.

Tolok, V. T. 2004: Physics and Kharkiv. *Физическая инженерия поверхности (Physical Surface Enginering)* 2 (4), pp. 229–243.

Trubetskov, D.I. 2007: Year two thousand and sixth in the dates of nonlinear dynamics. *News of higher educational institutions. Applied Nonlinear Dynamics* 15 (3), pp. 107–135.

Tverytnykova, E.; Gutnyk, M.; Salata, H.; Bachynska, N. 2021: Scientific Research on Biomedical Engineering in Ukraine: Origins of Development. [In:] *IEEE 2nd KhPI Week on Advanced Technology*, pp. 163–167. DOI: 10.1109/KhPIWeek53812.2021.9570029.

Tverytnykova, E., Gutnyk, M., Salata, H. 2020: Professors of the Kharkiv technological institute: Unknown pages of biography. *History of Science and Technology* 10(2), pp. 383–399. DOI: 10.32703/2415-7422-2020-10-2-383-399.

Tverytnykova, E., Gutnyk, M., Salata, H., Bachynska, N. 2021: Scientific Research on Biomedical Engineering in Ukraine: Origins of Development. [In:] *IEEE 2nd KhPI Week on Advanced Technology*, pp. 163–167. doi: 10.1109/KhPIWeek53812.2021.9570029.

Ulianov, V. V. 2003: To the history of the Faculty of Physics and the Department of Theoretical Physics. Part II. Kharkiv, 20 p.

Yanovsky, F. J. 2016: Glimpses of Early Radar Developments in Ukraine and the Former Soviet. *Union Radio Science Bulletin* 358, pp. 35–68.