2017 IEEE First Ukraine Conference on Electrical and Computer Engineering (UKRCON)

Yevgeny M. Kuleshov, Human Delta-Function in Ukrainian Microwave Science and Technology

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***Abstract* — This paper presents a short review of the life and research achievements of remarkable person in the Ukrainian microwave and millimeter-wave science and technology of the XX and XXI centuries, Dr. Yevgeny Mitrofanovich Kuleshov.**

Keywords — quasioptics, hollow dielectric beamguide, sub-millimeter waves

Yevgeny Mitrofanovich Kuleshov, EuMA Member, IEEE Life Senior Member, 2000 IEEE Microwave Pioneer, and one of the founding fathers of the Ukrainian and USSR quasi-optics of short-millimeter and sub-millimeter waves, died on the 9-th of February 2016 in Kharkiv, Ukraine.

Born on February 21, 1922 in Voronezh, he entered a university in Moscow before WW-II but eventually graduated, in 1946, from the radio-engineering faculty of the Kiev Polytechnic Institute (KPI, now National Technical University of Ukraine "KPI"). In 1946-1955, he worked in the Ukrainian Institute of Physics and Technology (UIPT) in Kharkiv, where he became head of laboratory in 1953.

Kharkiv is the second-largest city of Ukraine (now 1.5 million). In 1919-1934, it was the capital of the Soviet Ukraine and housed up to 40% of Ukrainian industry by 1940. UIPT was founded there in 1929 (see [1] for that story). After WW-II (in 1946-1953), it belonged, in part, to the First Chief Directorate of the so-called Special Committee (of the USSR government) headed by almighty secret police tsar L. P. Beria, who additionally supervised all nuclear research and industry. After Stalin's death, Beria was jailed and shot, and in 1955 this directorate was renamed. It obtained amazingly Orwellian "Newspeak" name of the Ministry of Medium Machine-Building; until the end of the USSR in December of 1991 whole UIPT belonged to it. Still before 1955, two departments engaged in millimeter-wave magnetrons and ground-wave radar stayed off that ministry, instead subordinated to the National Academy of Sciences of Ukraine (NASU).

Eventually, after fierce internal fight, they branched off UIPT to create new Institute of Radio-Physics and Electronics of NASU (1955). After separation, Kuleshov's laboratory was upgraded to the department level and named the department of receiving and measuring devices, to be later renamed as quasioptics department. He stayed at that post until 1988.

Kuleshov's career and research into short-millimeter and sub-millimeter waves were highlighted in [2-5]; selected publications co-authored by him are [6-18], and [19-27] are some of the publications crediting Kuleshov's contribution to the development of quasi-optical technology and associated applications.

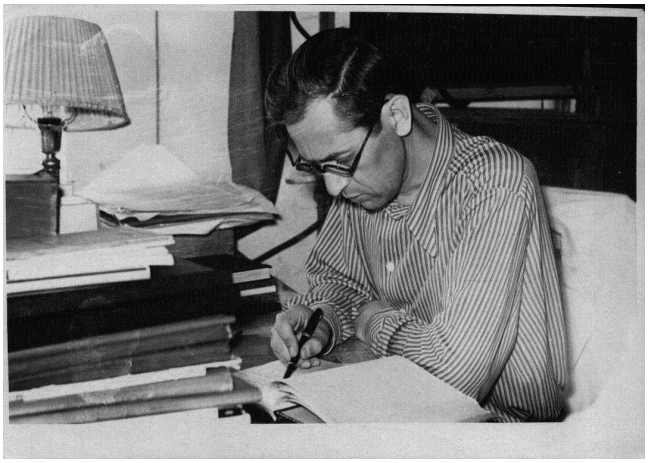

Fig. 1. At 31, Yevgeny Kuleshov became head of laboratory at UIPT in Kharkiv.

At the initial stage in the late 1950s, he was designing and developing various general-purpose devices and circuits of the millimeter-wave range (wavelength from 1 to 10 mm) on the basis of standard rectangular metal waveguides.

This became his contribution to the complex work of IRE NASU scientists on the millimeter-wave technologies, awarded with the Lenin Prize, the highest technical prize in the USSR, in 1960. Besides of military applications of these circuits in radar technologies, one more exotic area was diagnostics of hot plasma in the recently proposed Tokamak nuclear fusion machines. All Tokamaks were built in Moscow, at the Institute of Atomic Energy (IAE), which belonged to the mentioned above Ministry of Medium Machine-Building and enjoyed virtually unlimited funding until the very end of the USSR. Thanks to massive research funding of Kuleshov's department from IAE, IRE NASU was able to invest into new buildings at the Northern entrance to Kharkiv that were built in the end of the 1950s.

However the necessity of mastering even shorter, sub-millimeter wavelength range was obviously not compatible with a further use of the scaled down metal waveguides.

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Therefore as early as 1963, Kuleshov started innovative work of development of wideband quasi-optical components and circuits working in the 0.1 to 2 mm wavelength range (Fig. 2). In the beginning, this exploratory work was funded by the Ministry of Radio Industry and had no any real-life customer. However in the early 1970s, such a customer appeared, and extremely wealthy one. This was the same department of hot plasma diagnostics of the Tokamak thermonuclear fusion machines at IAE in Moscow (see [4] for details), which was then building new machines with denser and hotter plasmas and thus was interested in even shorter electromagnetic waves.

In the heart of all quasi-optical components was innovative idea of the hollow dielectric beam-waveguide (HDB) technology, first proposed in 1964 [4]. In 1972, after a long struggle with secrecy-overwhelmed USSR bureaucracy, it was patented by eight Kharkiv inventors including Kuleshov. HDB had the form of a wide (dozen of wavelengths and more) dielectric tube with the air in the inner channel, encased into a metal cover. The inner surface of the HDB dielectric lining had triangular longitudinal ribs having depth smaller than half-wavelength. In comparison to various other waveguides, the cross-sectional dimension of HDB was significantly larger as compared with the wavelength, and the dielectric lining had relatively large loss tangent (typically around 0.1) and sizable thickness. All this resulted in a specific "self-filtering effect": the higher-order modes of HDB propagate with significant losses and only the principal HE_11 mode keeps low attenuation [4,20,21]. Quite interestingly, this effect was experimentally established by Kuleshov in the mid-1960 however the full-wave modeling was done only recently in [25,26] by the international groups working with silver-coated plastic THz waveguides similar to Kuleshov's HDB.

Besides of being a team member for the Lenin Prize in 1960, Kuleshov was awarded, as team leader, the State Prize of Ukraine (1972). The latter prize was awarded entirely for the development of the pioneering HDB technology [4]. Here, its application in Tokamaks of IAE was considered as the most impressive sign of its high usefulness and practicality. Later he was awarded the titles of the USSR Honorary Inventor (1978) and Honorary Radio Engineer (1980).

In 1988, Kuleshov retired from the post of department's head however continued active and fruitful work at IRE NASU, as a senior scientist. At that time his research interests shifted to the application of HDB technology in several promising civilian and defense-oriented areas such as materials testing and RCS measurements of the downscaled models of sea-borne and air-borne targets [20] (Fig. 3). Still the sub-millimeter wave diagnostics of hot plasma inside IAE's nuclear fusion machines was the most important area of application, which culminated into the 0.195-mm wavelength 9-channel interferometer-polarimeter system installed at Tokamak-15 [8,4] (Fig. 4). When the USSR collapsed and Ukraine got independence in 1992, the smoke of secrecy around microwave research started vanishing. The Tokamak studies in Moscow not only lost their top priority but simply stopped as prohibitively expensive and actually fruitless. Such a change allowed, eventually, Kuleshov's team to start publishing their results in international technical journals and became internationally visible – see [6-27].

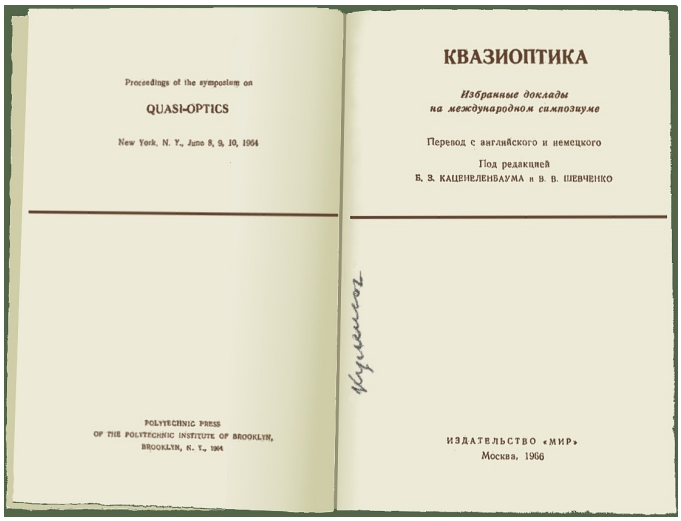
Proceedings of the symposium on
QUASI-OPTICS
New York, N. Y., June 8, 9, 10, 1964
POLYTECHNIC PRESS
OF THE POLYTECHNIC INSTITUTE OF BROOKLYN,
BROOKLYN, N. Y., 1964
КВАЗИОПТИКА
Избранные доклады
на международном симпозиуме
Перевод с английского и немецкого
Под редакцией
Б. З. КАЦЕНЕЛЕНБАУМА и В. В. ШЕВЧЕНКО
ИЗДАТЕЛЬСТВО «МИР»
Москва, 1966

Fig. 2. Copy of the book "Quasioptics" with Kuleshov's signature, translated in 1966 from the edition of the Polytechnic Institute of Brooklyn Press, 1964.

Fig. 3. Colonel Georgy Grechko (left) was a holder of D.Sc. degree in engineering sciences, rare achievement among the Soviet military cosmonauts (1985)

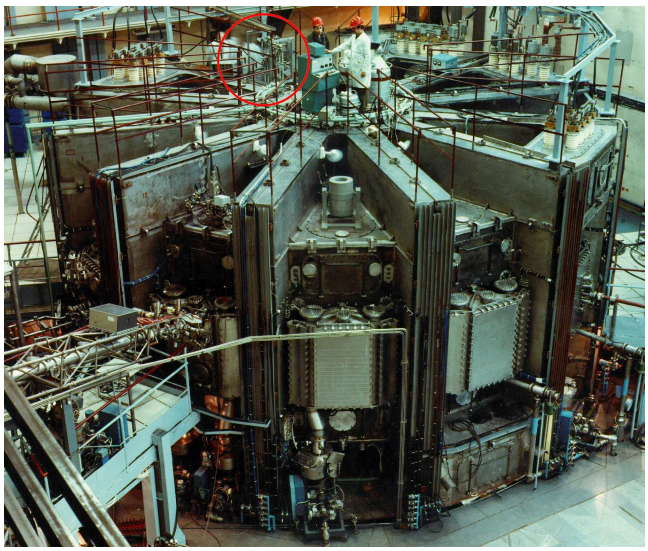

Fig. 4. Tokamak-15 nuclear-fusion machine with Kuleshov's hot plasma diagnostics sub-mm wave interferometer (red circle) , Institute of Atomic Energy, Moscow, 1990.

Thanks to that openness and international publications, in 2000 Kuleshov was awarded the IEEE Microwave Pioneer Award (Fig. 5), with citation "For development of a hollow-ribbed dielectric beamguide technology and quasi-optical measuring techniques of the short-millimeter and sub-millimeter wavelength ranges." The IEEE Microwave Pioneer Award is considered as being much higher than, for instance, the IEEE Fellow grade because every year around ten MTT Society members are elected Fellows however the Microwave Pioneer is either one or none at all.

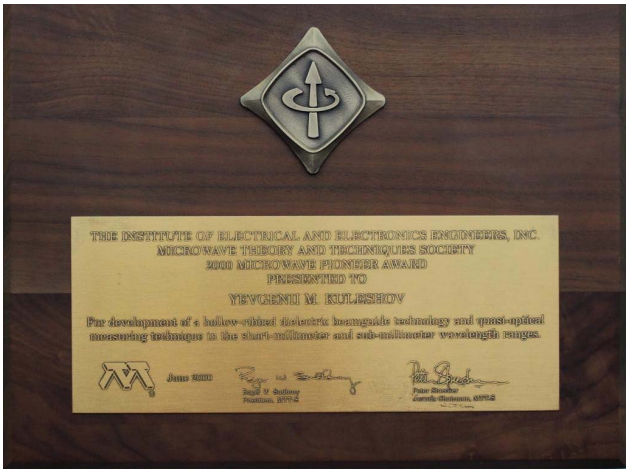

Fig. 5. Plaque of the 2000 Microwave Pioneer Award from the IEEE MTT Society

Before that, the IEEE Microwave Pioneer Award was given to the scientists from the USA and (a few times) from Japan however not to any European. Therefore Ukrainian microwave community is now proud of that achievement as a token of high recognition of its contribution to the service to humanity.

Still Kuleshov's service to the microwave community was most visible thanks to his support of all activities of the IEEE MTT Society in Kharkiv and Ukraine. He joined the Society in 1996 and was elevated to Senior Membership in 1999. In 2001 and 2002, he served as elected Chairman of the IEEE East Ukraine Joint Chapter, the largest in Ukraine (Fig. 6). This was a critical time in chapter's life because of difficult transition to annual elections of its committee by secret ballot, and Kuleshov's authority, decency, common sense, and also sense of humor helped greatly in this transition.

Fig. 6. Honorable Mention from IEEE MTTS for chairing the East Ukraine Joint Chapter in 2001-2002

In 2010, when the sum of his age and his IEEE membership reached 100 years, he was granted the honorable grade of IEEE Life Senior Member, in recognition of many years of both technical work and volunteering.

Other Kuleshov's microwave-related awards and volunteer activities were the membership in the European Microwave Association (since 2006), and IEEE Honorable Mention (2010), in recognition of the many years of loyal membership and support of the activities of the IEEE, signed by P. Ray, IEEE President.

It is worth noting that Kuleshov continued working as senior researcher at his department all the time after his retirement from the post of its head in 1988. The life happened to be more demanding than expected. In 2013, when his former student and the then head of this department died at the age of 65, Kuleshov had the courage and strength to take responsibility of an important research project of the European Union FP-7 Program. The project was dealing with HDB technology applied to the testing of Carbon-Fiber-Reinforced-Plastic materials used in the Airbus industry – see [15,17,27]. In 2015, Kuleshov received the Honorable Mention signed by the President of NASU (Fig.7), for the fruitful work and contributions to the radio physics and electronics.

Fig. 7. Honorable Mention from NASU for remarkable personal contribution to research into microwave physics and technology (2015)

It should be also emphasized that Kuleshov was never a member of the USSR Communist Party that was extremely rare exception for a head of department in the USSR Academy of Sciences. When being invited by local party bosses, he used

to decline, telling that he was "not good enough yet" and had to "work on himself." Probably it was his status of the Lenin Prize winner and also the importance of his work for IAE's Tokamaks that gave him relative immunity. Still such a decline needed great courage in those turbulent times.

Yevgeny M. Kuleshov kept working till the very last months (Fig. 8) and passed away shortly before his 94-th birthday, in clear and even humorous state of mind. His last words were "my bolt is shot." Ukrainian microwave community will keep alive the memory of this outstanding scientist and respected colleague, the founder of quasi-optics department and one of the founding fathers of IRE NASU.

Fig. 8. Dr. Y. M. Kuleshov in IRE's scientific library, which he was visiting for 56 years.

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