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History

To the centenary anniversary of birthday of Professor Mykhailo Pavlovych Lisitsa

Professor Mykhailo Pavlovych Lisitsa is one of outstanding physicists, whose works have made a considerable contribution to the fundamentals of modern optics and spectroscopy of semiconductors and dielectrics.

M.P. Lisitsa was among the first opticians in Ukraine, who in the early 60's became involved in the problems of laser physics and nonlinear optics. Later, Mykhailo Pavlovych was practically the first optician in Ukraine, who appreciated the future importance of fiber optics and wrote with his students in 1968 the world's first monograph "Fibre Optics", which was translated abroad into English in 1972.

Since 1950, at the beginning of his scientific activity Mykhailo Pavlovych obtained many interesting and important results in optics of ultrathin metal layers, spectroscopy of organic liquids, and in decision of a problem related with creation of polarizers suitable for infrared radiation. That time he taught at the university and worked on his doctoral dissertation that was defended in 1961. At the same time, he and his graduate students began researches in optics of semiconductors. Especially intensive these researches became since 1961, after his heading the Optics Department in the newly organized academic institute – Institute of Semiconductors, Academy of Sciences of Ukrainian SSR.

Organization of the Optics Department coincided in time with one of the most important events in the development of optics in the 20^{th} century, namely, the invention of lasers. M.P. Lisitsa immediately appreciated historical significance and prospects of this discovery. Therefore, the main scientific direction of the department was supplemented with researches in optical quantum electronics and nonlinear optics.

It is worth to note several main scientific areas of M.P. Lisitsa and their disciples.

1. Researches in quantum electronics and interaction of laser radiation with semiconductors: (i) the method for modulating the convergence of a laser resonator under the influence of semiconductor nonlinear optical elements. For a ruby laser, these were plates of crystals grown from A^2B^6 compounds, which were clarified at a certain intensity of laser radiation, resulting in a giant gain of its peak power at the laser output; (ii) the proposed method for using the nonlinearly absorbing and optically active semiconductor wafers to limit the power, stabilize and correct the spatio-temporal intensity distribution of laser beams, which was of great practical importance.

2. Optical and spectroscopic investigations of semiconductors and dielectrics to ascertain the features of their energy structure and different types of elementary and collective excitations. It is quite natural that the staging of these studies and their focus were tightly related with the previous experience, profound knowledge and remarkable scientific intuition of the head of department. A couple years before Mykhailo Pavlovych's transferring to the Institute of Semiconductors, his university graduate and PhD students had already begun using infrared spectroscopy in the study of semiconductors. Therefore, it is not surprising that one of the first research groups in the department was the infrared spectroscopy group. This group was the first one in our country who performed fundamental infrared studies of semiconductor crystals.

3. Another area of researches performed by M.P. Lisitsa with co-workers during the same period in the infrared spectroscopy group was related with the disordering and doping effects on the fundamental optical characteristics of semiconductors. The importance of these factors was associated with the inconsistency of many experimental data obtained studying the same semiconductors in different laboratories around the world. Particularly critical in this case was obtaining the data on edge absorption of semiconductors. The results obtained in this department for the heavily doped CdS crystals removed available contradictions between many results concerning the edge absorption of heavily doped semiconductors. It was shown that in this case the high concentration of free charge carriers requires taking into account not only the well-known Burstein–Moss optical effect, but also the theoretically considered by V.L. Bonch-Brujevich exchange interaction of carriers. Since the latter, in contrast to the Burstein–Moss effect, causes an effective decrease rather than an increase in the energies of the interband transitions, the resulting effect of the absorption edge shift can change its sign with a change in doping concentration.

4. The field of researches that were begun using IR spectroscopy continues up to this day and uses the above method along with the method of Raman scattering (RS). Both these approaches are focused on vibrational excitations in solids. It became a logical continuation of

the university activity of M.P. Lisitsa devoted to spectroscopy of vibrations of molecules and ascertaining the role of resonant interactions. After his transfer to the Institute, the emphasis was made on the study of spectroscopic manifestations of resonances in the crystalline phase of matter. In this case, the intermolecular interaction also becomes relevant in addition to the possible intramolecular anharmonic resonance of Fermi. In this case, the idea to develop this approach was to consider intramolecular vibrations as an oscillating exciton of the Frenkel type and to use the known ideas about intermolecular resonance developed by academician A.S. Davydov. The possible variety of the resulting vibrational spectra inherent to the crystal is defined by the relationship between Fermi (intra-molecular anharmonic) and Davydov (intermolecular exciton) splitting. M.P. Lisitsa and A.M. Yaremko developed a quantum-mechanical theory of the resulting resonance, which was called the combined Fermi–Davydov resonance and was generalized by them in their monograph.

5. Another area of researches related with vibrational spectroscopy was the problem of local oscillations of impurity centers in different types of dielectric and semiconductor crystals and the rearrangement of phonon and polariton spectra in mixed multicomponent semiconductors, which eventually became widespread materials in electronics and optoelectronics. The fundamental significance of manifestation of anharmonic resonances in the spectral features of vibrational spectra under varying composition and temperature of crystals was ascertained. These studies became part of a series of dissertations prepared by numerous students of Mykhailo Pavlovych (more than 20 doctors of sciences and about 50 PhDs) and defended under his scientific guidance. In principle, in semiconductor crystals, in contrast to the classical Fermi intramolecular resonance for discrete states, the band nature of the phonon spectra of crystals causes manifestation of resonant mixing in a specific form of the Fano resonance with a possible characteristic antiresonance spectral dip. It was usually observed earlier in the autoionization atomic spectra, and long before that it was theoretically substantiated by Breit and Wigner in nuclear physics.

6. Most of the above results and developed non-traditional approaches to investigations of semiconductors and interpretation of their properties were carried out due to the scope breadth inherent to Mykhailo Pavlovych when setting the tasks before co-workers, in terms of both investigated new phenomena and studied materials. The latter were not limited only to the classic for that time semiconductors silicon and germanium as well as A^2B^6 and A^3B^5 compounds typical for investigations in other departments of the Institute.

M.P. Lisitsa considered also silicon carbide as very important and promising for future electronics. He organized a special group for studying it, which performed both fundamental optical researches and technological applications for the development of very stable LEDs in the interests of several ministries. And in this direction, Mykhailo Pavlovych’s ideas were ahead of their time. Silicon carbide turned out to be a very interesting object for fundamental studies by using Raman scattering. Analysis of the phonon spectra of different SiC polytypes based on ideas about transformation of the Brillouin zone due to superperiodicity was used in the late 1960s, long before this approach became standard for considering the phonon problems of semiconductor superlattice nanostructures. That is why, it was so easy for the staff of the Optics Department, who carried out these researches, to later become involved in the study of semiconductor superlattices.

7. M.P. Lisitsa initiated a new direction in the department, namely, the study of optical and structural properties of layered materials. He believed that studying them could provide an interesting new knowledge in both fundamental and applied aspects, and even brought from the Mineralogical Museum of Kyiv University several samples of layered crystals for beginning optical researches. Over time, in several scientific institutions and universities of Ukraine, as well as abroad, evidence was obtained that these compounds are promising to be used in holographic information recording, for creation of electro-optical devices, capacitors and batteries, for intercalation processes in these materials. Based on studying the phonon spectra in these crystals performed in IFN, a general approach to the dynamics of their lattice was developed, which takes into account the significant difference between the forces of intralayer and interlayer interactions (the latter are mainly of the van der Waals type).

Mykhailo Pavlovych always supported not only the professional but also the social growth of his students. Evidence of this was his support to F.F. Sizov during the elections as the corresponding member of the National Academy of Sciences of Ukraine. On the initiative by Mykhailo Pavlovych earlier, in 1992, his disciple M.Ya. Valakh was also elected as the corresponding member of NAS of Ukraine.

The work on nanostructures in the Optics Department was initially carried out mainly in cooperation with foreign colleagues from England, the United States of America, Germany, France, and Russia, where the authority of Mykhailo Pavlovych was very high. Thanks to international cooperation, opticians at the Institute of Physics of Semiconductors were among the first in Ukraine who studied samples with semiconductor nanoislands (quantum dots) grown using the method of molecular beam epitaxy.

The last years of his life Mykhailo Pavlovych Lisitsa devoted to realization of his old dream – to write a popular scientific 5-volume edition of “Entertaining Optics”, which was published over several years and deals with atmospheric and space optics, physiological optics, animal’s sight, and bioluminescence, as well as fiber optics.

Main dates of M.P. Lisitsa's life

1921, 15 January – born in the village of Vysoke (the Zhytomyr region).
1939 – 1945 – participation in the Second World War.
1950 – completed his studies at the Kyiv State University.
1950 – PhD student of the Kyiv State University.
1953 – 1961 – associate professor of experimental physics department at the Kyiv State University.
1954 – defended PhD theses at the Kyiv State University.
1961 – was conferred with the doctor of sciences degree (Phys & Math).
1961 – joined to the Institute of Semiconductors, Academy of Sciences of UkrSSR.
1961 – Professor at the Physical Department of Kyiv State University.
1966 – Editor-in-Chief of the collection "Quantum Electronics".
1981 – State Prize of Ukrainian SSR in the field of science and technology "Comprehensive study of optical and photoelectric properties of semiconductor compounds of elements of the second and sixth groups of the Periodic Table", M.P. Lisitsa (together with G.A. Fedorus, M.K. Scheinkman, I.B. Mizets'ka, S.I. Pekar, O.V. Snitko, V.Ye. Lashkaryov, Ye.A. Sal'kov).
01.04.1982 – was elected as academician of Academy of Sciences of UkrSSR.
1984 – awarded with the Jan Marek Marci annual medal to distinguished scientists by the Slovak-Czech Spectroscopy Society.
1986 – State Prize of the Ukrainian SSR in the field of science and technology for the series of works "Physical research and metrics of semiconductor solid solutions of cadmium-mercury-tellurium and lead-tin-tellurium, aimed at the development of their industrial production for IR photoelectronics", M.P. Lisitsa (together with Ye.A. Sal'kov, F.F. Sizov, G.A. Shepel'sky).
2010 – awarded with the V. Vernads'kyi Gold medal of National Academy of Sciences of Ukraine "For distinguish achievements in optics and spectroscopy".
2012, 10 January – died in Kyiv.

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