50th Edition of WILGA Symposium on Photonics Applications

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Abstract—The Jubilee 50th edition of WILGA Symposium on Photonics Applications crowns 25 years of diligent service by this exceptional series of scientific and technical meetings to the local and international photonics research, academic, industrial, business and societal communities. The paper reviews concisely, and only generally without details, some of the chosen topical tracks related to photonics present during the previous meetings and in particular during WILGA 2022 sessions. The paper summarizes shortly the achievements of WILGA Photonics Applications meetings of young researchers, during the quarter of a century, and gives a general sense of the unique nature of these meetings. Wider description of WILGA achievements are available in around 30 Proc. SPIE volumes published continuously under the common title Photonics Applications in Astronomy, Communications, Industry, and High-Energy Physics Experiments in the years 2002-2022.

On occasion of the 50th edition of WILGA meeting it is necessary to summarize their role and impact on the photonics community in Poland, and in this geographical region, during the last quarter of a century. WILGA Symposium [1-2] on Photonics Applications 2022 was split traditionally to two parts, held in January as the 49th winter edition, also in May/June and in September during the split 50th summer edition [3]. All sessions gathered more than 150 participants, national and international young researchers in photonics, optical engineering, electronics, mechatronics, applied physics and related areas in which photonics plays a key role. A characteristic feature of WILGA 2021 and 2022 Symposia on Photonics Applications was numerable participation of researchers, students, and presented works from Ukraine.

Post-pandemic situation forced the organizers to split and reduce considerably some of the plenary WILGA meetings, with traditional participation of several hundred young researchers, to more confined hybrid events. WILGA Symposium is a research, technical and social event organized by students for students with a leading motto: Come here to have fun, to have a lot of fun, and to learn a lot! WILGA Symposium for young researchers, in her middle age, was a research event ahead of its time in terms of organization, research program, and the way of presentations. Very current and interesting scope of topical tracks and exceptional way of conducting the research and technical session were the factors that used to attract, literally speaking, crowds of young researchers.

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This unique and incomparable research and teaching event has now reached a round number of fifty editions. During the quarter of a century WILGA gathered more than 8000 young researchers, most of them post-graduated and Ph.D. students active in photonics applications and related fields. More than 3000 indexed papers were published in WILGA proceedings and journals. WILGA proceedings have been published since 2002 (editions 9th and 10th) in the series Proc. SPIE [4-6]. Patronage over WILGA Symposium was held by the Photonics Society of Poland, IEEE Poland Section, Association of Polish Electrical Engineers, Polish Optoelectronics Committee, Committee of Electronics and Telecommunications of Polish Academy of Sciences, and Warsaw University of Technology. WILGA Symposium was generously co-sponsored by SPIE, PSP, IEEE and WUT.

Wilga sessions on material science in the field of photonics, apart from laser semiconductors and optically active dielectrics, were usually centred around glass technology for photonics, sensors, optical fibres, integrated optics, nano-photonics, etc. This year, these sessions were correlated with the International Year of Glass declared by the United Nations [7]. Wilga session on glass technology development was devoted to the dedication of the Year of Glass. Similarly to the International Year of Glass of 2022, Wilga celebrated the International Year of Light in 2015 with a number of dedicated sessions and invited tutorials by international experts in photonics. Wilga Symposium also participated in exceptional Warsaw SPIE Congress on Optics and Optoelectronics with over 1500 participants in 2005.

Glass played an essential role in the development of laser technologies. In 1961, Elias Snitzer fired the first optical fibre laser, which was 1 m long. Lasers, glass and optical fibres have changed in science and in societal applications everything. Femtosecond lasers gave birth to new tooling for femto-physics and femto-chemistry and to much more precise research of liquid-to-glass transition. Observations of glass behaviour under the interaction with femtosecond laser pulses are the key to understand the glass transition phenomenon. This research led to fs-laser glass micromachining technologies with sub-nm precision. Glass is a non-crystalline amorphous solid, formed by quenching, with internal atomic arrangement similar to liquid but more tightly packed. The glass-liquid thermal

transition region T_g is all the time subject of research, using statistical and rheological approach. Non-crystalline character of glass means that inside the material there is no long range order and material is in a complete disorder, even microscopically. Glass is in a non-equilibrium state from the point of view of thermodynamics. Chemical bonding constraints, impose that glasses possess a high degree of short-range order with respect to local atomic polyhedral. A few strong glass research centres do high quality applied science in Poland and used to participate in Wilga with their engaged young researchers.

Ergodicity of the dynamic system, like glass, shows how the properties of a small random sample of glass images average behaviour of large sample with time. This is necessary to master the material even more precisely, and safely apply glass, as a miraculous base in very promising solutions of nano-photonics. Nano-photonic circuits basing on glass enable near-field and nonclassical, sub-Poissonian light functionalities, including shaping and management of single photons, dressed photons, trapped and virtual photons, and photon based quantum emergencies like coupled photon-electrons, photon-polaritons, which are impossible, or difficult to obtain in other conditions. Other Wilga nonclassical light sessions concentrated on practical applications of squeezed light and other nonclassical light states like Bessel beams.

Nanometre size, periodic glass structures enable manufacturing of functional devices compatible with the photonic integrated circuits PIC and optical fibre technology, and resigning from volume optics using, even miniature, but classical lenses. The boundary between ergodic and nonergodic areas in glass is indicated by the value of the Deborah number, which is subject of research using physical phenomena of very different timescales like ablation, thermal diffusion, re-solidification, carrier-carrier and carrier-phonon scattering, radiative recombination, and photon absorption. These effects span from 10^{-5}s to 10^{-16}s. These effects are grouped into four basic categories, thermal and structural effects, carrier removal, thermalization and carrier excitation.

Wilga sessions on quantum information technologies QIT were in particular associated with building at WUT a two hundred qubit quantum computer and a ultraprecise quantum optical fibre link for data transfer to/from the trapped ion based NISQ (noisy intermediate-scale quantum) processor to the distant computational centre. The quantum processor is controlled, on the hardware layer, by a network of associated microwave and laser beams. Physical qubits are organized up the software stack into functional logical qubits which, even higher in the computational stack, are available by the NISQ users. Ph.D. students are engaged in the project and report some of the results in Wilga. Active work goes on cybersecurity, including provision of safe computation and transmission on the photonics layer of the QIT infrastructure. Classified algorithms are implemented for quantum error correction on physical and logical layers. Ironically, the infrastructure will be also used for works on post-quantum era cybersecurity technologies. Building of middle-size quantum computing and QIT infrastructure at WUT encouraged the group to launch a series of lectures on quantum computing, with emphasis on linear photonic solutions and on QIT for M.Sc. and Ph.D. students to attract them to these technologies.

QIT has strong impact on development of biomedical engineering. Wilga optogenetics, biophotonics and quantum biophotonics sessions were associated with the new track of research and didactic designed also for postgrad and Ph.D. students to familiarize them with new technologies and to encourage to join the quantum information technology research teams formed at WUT and other universities. Optogenetics hardware layer was constructed in cooperation between WUT, innovative spin-offs and Medical University in Warsaw. The tiny integrated electronics-photonics probe was implanted into the animals brain to test control of their behaviour induced via quantum opto-chemical reaction in their organisms. Some of these pioneering optogenetics results were published in Wilga proceedings. Other Wilga sessions on biophotonics included photoacoustic spectroscopy, photodynamic and low-level laser therapy, laser equipment for biomedicine, but primarily biofluorescence with green fluorescent protein, and bioluminescence as well as biophosphorescence. Integrated photonic equipment was constructed and tested in several laboratories for biophotonics measurements.

Wilga sessions on optical networking were, in a sense, associated with the development of wireless networking by light and photonic options for the 5G/6G. Light assisted networking includes massive data layer at TB rates, at the network core, with optical pipes, as well as the wireless Li-Fi user access layer, at MB/GB rates, at the network access peripheries. Numerable Li-Fi solutions were implemented in various, intentionally chosen, easy and very difficult infrastructural conditions to test the photonic signal integrity, availability, practically available transmission rates, multipath disturbances, environmental noise, reliability, energy efficiency, etc. Li-Fi research results presented in Wilga have shown the beauty of this technology by its availability to extended and quite advanced research for students. The number and variety of tested LED lamps and other compatible light sources applicable for the Li-Fi in various environmental conditions was amazing. Some of these solutions have found real life applications and started to be manufactured by innovative photonic spin-offs.

A very special, dedicated Wilga session was organized on attosecond and exawatt laser pulses, and laser pulse compression technologies. Exceptional occasion for this session was that the Military Academy of Technology in

Warsaw awarded professor Gerard Mourou (Nobel Prize 2018 in Physics with Donna Strickland), with the honorary doctorate for his work on chirped pulse amplification and laser pulse compression.

Ph.D. students and young researchers from WUT, UW and other universities, are engaged in several projects associated with large, scientific, discovery class infrastructures in Europe. These infrastructures contain a lot of combined and frequently well integrated electronics and photonics functional instrumentation. The functions include measurements, equipment diagnostics, realization of work tasks, routine system maintenance, control, timing and synchronization, also providing safety. The infrastructures with active engagement of students from Poland are: European X-ray Free Electron Laser in DESY, European Spallation Neutron Source in Lund, ATLAS and CMS experiments at LHC in CERN, CBM – compressed baryonic matter and other experiments at GSI/FAIR in Darmstadt, Tokamak development projects associated with the ITER infrastructure, etc.

During these 25 years WILGA organized numerable sessions on the development of research equipment for these large experiments starting many years ago with reports on the ZEUS/HERA developments and achievements in DESY Hamburg. Now, one of the leading topics is development of precise photonic and electronic equipment for the compressed baryonic matter experiment at the Facility of Antiproton and Ion Research.

Wilga groups of young researchers were involved in several astronomical and space research projects. A close cooperation in this respect was developed between WUT, UW and the Centre of Space Research CBK PAN. Pi-of-the sky project, and constructed round-the-globe optical observatory, performing continuous measurements for more than a decade culminated in a discovery and co-discovery, as the first observer, of several optical flashes accompanying large GRB effects. Young researcher groups from CBK PAN, which report their results in Wilga, specialize in construction of innovative, specialized board computers for satellites. These constructions contain highly reliable photonics components integrated into the system functionality. Wilga sessions on space and satellite engineering has always been attended by numerous young researchers from several research and technical centres and innovative firms in Poland. Wilga was lucky to carefully observe the birth of these technologies in Poland with the establishing of many dedicated spin-offs to space research.

Wilga continuous Photonics Applications sessions were devoted to the development of a multitude of components, devices, sensors and larger pieces of functional equipment containing key photonics components. It is interesting to list a few of such systems, presented in Wilga at early stage of development, which work today as standards, in some cases, worldwide. One of the birth places of optical fibre based White Rabbit system of precise time distribution was WUT, with initial ideas presented in Wilga around 20 years ago. Now the system is a widely adopted standard adding to the PTP protocol.

Wilga Symposium was correlated, inside the local, very active photonics research community, with other domestic and international photonics meetings organized in Poland. Very frequently, after gaining an initial experience in Wilga, the young researchers presented their works during the meetings co-organized by the Photonics Society of Poland, and other national photonics organizations like Symposium on Laser Technology, Optical Fibres and Their Applications, Optical and Electronic Sensors, Integrated Optics, etc. All of these meetings published, for some time, their works in Proc. SPIE.

The Wilga symposium on Photonics Applications undoubtedly left an indelible mark on the Polish photonics research community. A lot of then young researchers starting their research career with Wilga are now leaders of their own research groups in governmental laboratories academia, and in the industry. A number of them opened their own stat-ups and spin-offs and operate successfully on the quite demanding high technology market. Twenty five years ago, when we started with the first Wilga, it was a novel approach and initiative adding decisively and strongly to the education style via dynamically changed projects rather than via the permanent, not often changed, curriculum. Today, these early participants, now established experts, when looking back into past admire very frequently with awe the foundations of this initiative.

The distinguished 25th anniversary of the Wilga symposium and its 50th edition raises questions about its future. Wilga meetings are older than the Photonics Letters of Poland and contributed there numerable papers. The first one was WILGA Symposium on Photonics Applications, published as editorial in PLP 1(2) 2009. The question about Wilga future has to be answered by the new generations of young researchers in photonics and their tutors supervising the development of their scientific and technical careers, choosing and fitting the relevant methods to the changing research environment and legal academic requirements. These have recently changed a lot what requires form Wilga to find new ways of attracting interaction with young researchers.

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