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FOREWORD

Special issue honoring Prof. Dr. Voicu Lupei at his 70th anniversary

It is a pleasant duty for me to write again in this journal about one of the most distinguished Romanian physicists, Prof. Dr. Voicu Lupei, at his 70th anniversary.

Voicu Lupei was born in Dec 20th, 1938 in Brad, Hunedoara County, in the so-called Zarand Country from the Western Mountains of Romania, in a family of intellectuals. Due to his social origin, he was forbidden by the communist regime to follow the traditional high school after graduation of elementary school (in 1952) and was thus forced to enroll in a mining technical high school, closely related to the local gold mines, among the largest in Romania. The geology courses and the practical work in the gold mines, as well as the family tradition of natural sciences and geology, put him in contact with the world of minerals and raised questions on the nature and causes of the variety of crystals that related to the new concepts of atomic physics and structure of matter. At the same time, an enthusiastic professor of mathematics from the mining school trained a group of studies in mathematics that became very prolific at the regional and national Olympiads of Mathematics and contributed to install a spirit of scientific search and attitude. Since the mining high school did not offer him the possibility to continue his studies in other fields than mining, he had to take jobs that enabled him to follow the conventional high school by correspondence; these contributed further to his decision to direct towards profession related to the structure of matter.

The Physics Department of University of Cluj and the Solid-State Laboratory organized by Professor Ioan Ursu in 1960, after a successful post-doctoral stage at Princeton University, was an almost perfect surrounding to pursue such studies. Voicu Lupei started his work in the laboratory from very beginning and at his graduation of the Physics Dept. of the University of Cluj in 1963, he was appointed there as physicist in the group for electron paramagnetic resonance studies. Since at that time the techniques of crystal growth were very limited in Romania, large part of his work was performed on natural crystals, particularly on iron-group (3d) ions such as Mn^{2+} in carbonates and on the effects of nuclear irradiation on these crystals or on semiconductor crystals. These studies offered him the possibility to refine the theoretical formalism of the spin-Hamiltonian description of the EPR spectra of the doping ions, particularly the electron-nucleus hyperfine structure of spectra, and the published results found rapidly international recognition. His doctoral thesis (1968) was devoted to such studies. He took also active part in the colloquia of the International Society on Magnetic Resonance AMPERE.

At the beginning of 1969, Voicu Lupei was transferred at the Institute of Atomic Physics Bucharest, where he organized a more systematic electron paramagnetic resonance activity on doped and irradiated materials. He has major contribution, as Scientific Secretary, in the organization (1969) of the first International Summer School of the society AMPERE and of the largest meeting (over 700 participants) of Society AMPERE (1970), which was raised to the rank of congress. During 1071 and beginning of 1972, he obtained a grant from the Academy of Sciences of USA to work at the University of California at Los Angeles and at the Argonne National Laboratory. The work at UCLA under supervision of Professor R. Orbach was very important for him, since it determined the shift of activity towards the doped crystals of interest for solid-sate lasers. The work at Argonne offered him the possibility to start investigation the electronic structure of the high-valence Uranium ions in crystals.

Returning to Romania, Dr. Lupei initiated a systematic research program of basic and applied research on laser materials, which was subsequently extended to involve solid-state lasers and selected applications of these lasers. He organized a new research laboratory at the Institute of Atomic Physics, the laboratory of Interaction of Radiation with Matter that gradually evolved to the actual Solid-State Quantum Electronics Laboratory of The National Institute of Laser, Plasma and Radiation Physics. The basic concept of the actual laboratory is the connection between structure-properties-functionality for the active materials as an essential principle for improvement and diversification of the sources of photons with controlled and optimized properties (wavelength, temporal regime, power or energy range and so on) able to extend the applications of photonics. This laboratory was well equipped with technological and research equipment for technology of the laser and nonlinear optical materials (various methods of crystal growth, processing of laser and optical components), equipment for investigation

of structural and spectroscopic properties (magnetic resonance, optical and laser spectroscopy), equipment for passive laser components (mirrors, filters), design and construction laboratories for lasers and laser equipment for selected applications of solid-state lasers. Organizing this modern laboratory, Dr. Lupei founded a real research school in the field, in Romania. He engaged and qualified in this activity a large number of young researchers, who became prestigious scientists. He accompanied the scientific research by educational activity as scientific supervisor for doctoral theses, master courses at the University of Bucharest, invited professor at the Universities Claude Bernard Lyon 1 and University Pierre et Marie Curie Paris VI and the Interuniversity National Laboratories of Natural Sciences Okazaki-Japan. Providing to various domains of activity laser equipments, which were unavailable from abroad during the period of isolation of the country determined by the communist regime, the laboratory of Dr. Lupei contributed to introduction of modern laser techniques for material processing or for medicine in Romanian institutions and to formation of specialists in these fields.

The main achievements of this activity could be organized in two groups: basic and applied ones. In the **basic research**, I should firstly remark Lupei's contributions in ***the physics of doped laser materials***, theoretical and experimental investigations of the structural and quantum properties (energy levels, transition probabilities, static and dynamic interactions with the host crystal and with external fields) of crystals doped with elements of transition groups (3d-elements, lanthanides, actinides), more specifically:

– characterization of the crystal field effects on the energy level structure of the doping ions;

– development of the spin-Hamiltonian description of the angular dependence of the positions and intensities of the allowed and forbidden hyperfine structure lines in electron paramagnetic resonance (known as the Bir-Lupei model);

– characterization of a large variety of new Uranium centres of various valence states in crystals: symmetry and structure, charge compensation effects, crystal field and hyperfine electron-nucleus effects, relativistic effects in the hyperfine interactions, the effect of various physical (irradiation with ionising radiations, temperature) and chemical factors on the structure of the centres. This enabled a more systematic characterization of the f-electron systems at the beginning of the actinide series. The relativistic treatment of hyperfine structure in the electron paramagnetic resonance of Uranium ions enabled re-evaluation of the magnetic moment of the 235 isotope of this element;

– a generalized concept based on the statistical distribution of the doping ions at the available lattice sites and on the specific dependence on distance of the various interactions (crystal field effects, energy transfer processes), that relates the real crystalline structure of the host material, the structure of the optical spectra (positions and intensities of lines, spectral satellites) and the dynamics of emission.

This concept enables a deeper characterization of the properties of the laser crystals and provides a rigorous base of selection;

– the structural and spectroscopic characterization of emerging laser materials based on transparent polycrystalline materials produced by ceramic techniques enabled to make evident the differences and similarities between these materials and the corresponding single crystals and contributed to introduction of these materials in the laser construction practice.

His contributions in ***quantum electronics and laser physics***, the development of theory of the laser emission processes, the control of the temporal properties of emission, the atomic and bulk nonlinear processes, are equally well recognized:

– modelling of laser emission processes in relation with the spectroscopic and dynamic properties of the laser material, characteristics of optical pumping and the design of the laser resonator leading to criteria for optimisation of laser emission, enhancement of global emission efficiency, reduction of heat generation by parasitic processes in the pumped laser material and scaling to higher power;

– development of passive and combined passive-active Q-switching of solid state lasers and characterization of passive Q-switch saturable absorbers;

– laser frequency modification by nonlinear processes in nonlinear materials;

– self-frequency modification of laser emission in activated nonlinear crystals;

– modification of emission frequency (down- or up-conversion) by atomic processes: multi-step energy transfer, cooperative processes, photon avalanche;

– development of emission sensitisation theory.

In **applied and technological research,** Dr. Lupei obtained important results also. More specifically, ***in the field of laser materials***, he contributed to:

– development of crystal growth techniques for high quality laser materials, (such as high-melting materials – garnets, perowskites, sapphire and ruby and so on) or nonlinear optical crystals (niobates, tantalates, oxoborates etc) and organization of small-scale production of laser crystals;

– development of cosmic microgravity techniques for growth of profiled crystals;

– characterization of transparent polycrystalline ceramic laser materials and comparison with the single crystal materials. Some of the new laser materials evidenced by these studies are considered in literature as potential laser for more efficient lasers in the petawatt regime for nuclear physics and fusion;

In the field of quantum electronics and lasers**,** V. Lupei got remarkable results:

– modelling, design and construction of a large variety of solid state lasers based on the laser materials produced in laboratory: continuous-wave emission, long-pulse regime, giant-pulse regime, highly-repetitive short-pulse emission;

– development of a new concept for construction of highly efficient neodymium lasers, based on direct pumping into the emitting level of concentrated

laser materials, coupled with an advanced design of the laser resonator. Some of the laser based on this concept show record performances on world-wide scale, such as slope efficiencies close to the quantum limit of the emission process in case of Nd in garnet, vanadate or hexa-aluminate crystals.

In the field of laser and photonic applications**,** he developed techniques for laser processing of materials and design and construction of specialized, automated and computer-controlled laser equipment for materials processing (welding, drilling, cutting, marking, rapid prototyping) or for medical applications (surgery, coagulation). These activities had a strong impact in the development of laser application in various fields of industrial production and health care in Romania.

In the field of nuclear techniques, Dr. Lupei found out new methods for non-destructive determination for ultra-trace levels of uranium in aqueous solutions or solid samples, non-destructive methods for assessment of uranium isotopic composition and new thermo-luminescent detectors.

These result are the subject of almost 800 scientific works (240 papers in refereed scientific journals and books, 380 communications in international conferences – 35 invited lectures and about 280 published in proceedings and books, 180 in national conferences) and 17 patents (1 in USA, 3 in Japan). These works have large international circulation, manifested in a large number of citations by foreign scientists in papers, books, PhD theses and inventions.

Dr. Lupei is member of international professional societies as AAAS, IEEE, SPIE, OSA, ERES. He is holder of the 1967 Prize of the Romanian Academy for Physics "D. Hurmuzescu". He was awarded with the "Scientific Order" of the Romanian Presidency medal (1978) and Order (1983) and with the National Order "For Merit" in rank of Commander.

The journal "Romanian Reports in Physics" is indebted to Prof. Dr. Voicu Lupei for his scientific competence and for his profound reviews of many papers, which increased the scientific quality of this journal. At this anniversary, the Editorial Board of the journal and I are wishing to our senior colleague and friend, Voicu, good health for him and for his family, as well as new and fruitful ideas in his scientific and technological works, to which he has dedicated his life.

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Chief Editor of "Romanian Reports in Physics"