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FOREWORD

SPECIAL ISSUE ON "CONTRIBUTIONS IN PHYSICS RESEARCH IN THE WORLD YEAR OF PHYSICS"

This special issue of *Romanian Reports in Physics* is dedicated to the 100th celebration of the extraordinary year, in which Albert Einstein, a young scientist aged 26, wrote five fundamental papers for modern physics and more generally, for modern science. This exceptional event is celebrated all over the world. The Romanian physics community, as well as our foreign friends and collaborators, join their contributions here in world "choral" to the beauty of the major physics discoveries.

Some leading physics groups from Romania and worldwide present their most up-to-date investigations in different fields of physics, as well as in their applications. Thus, the papers in this issue report new results in mathematical and general physics, nuclear and particle physics, condensed matter physics, optics and quantum electronics, plasma physics, biophysics and medical physics, physical methods and instrumentation.

The Editorial Board selected two *Review Papers* submitted by two very distinguished scientists in nuclear physics.

R.F. Casten presents how the complex nuclear systems constructed from simple ingredients, as two kinds of strongly interacting particles, can display astonishing regularities and simplicities. The recent developments in the study of the evolution of nuclear structure as a function of the number of constituent protons and neutrons are emphasized in his report.

W. Gelletly reviews the status of nuclear physics with the variety of nuclear models for understanding nuclear structure and the problem of properties of nuclei far from stability. The two experimental programmes, using methods for the creation of radioactive ion beams, are outlined in terms of how they will address the open questions.

In the section of *Mathematical and General Physics*, D. Grecu and Anca Vişinescu are reconsidering the very simple method of Akhmediev and Korneev, for obtaining the entire special class of periodic solutions of NLS equations.

B. Saha, V. Rikhvitsky and M. Visinescu are investigating a problem in the quantum field theory in curved space-time with impact on the evolution of the Universe. They use different definitions of the Bel-Robinson tensor existing in the literature (for Bianchi Type I Universe) and compare the results.

Quantum to classical transition in the Lindblad theory of open quantum systems is considered by A. Isar. In the framework of the Lindblad theory for open

quantum systems, he determines the degree of quantum decoherence and classical correlations of a harmonic oscillator interacting with a thermal bath and analyzes its transition from quantum to classical behaviour.

M. Gavaza and D. Sébilleau give a unitary view of the partition method based on scattering theory. The theory allows the decomposition (partition) of a complex problem into a certain number of independent sub-problems and reconstruct the full solution of the original problem from the knowledge of the solutions of the various sub-problems (which are much easier to be obtained, either analytically or numerically).

N. Ionescu-Pallas and V. I. Vlad calculate the discrete values of the square of momentum operator, when the wave function on the inner surface of a sphere of radius R is vanishing. Discrete values of the kinetic energy of a free particle confined inside the sphere are obtained by resorting to the momentum-energy relativistic relationship. Adopting the ortho-normalized set of asymptotic wave functions, for classifying the discrete states in terms of the two relevant quantum numbers (*N, l*), they find out a considerable number of states with negative radial quantum numbers and of asymptotic states, which are missing among the components of the multiplets (called "locked states" or antiresonances). These results are used for correct calculation of the statistical distribution of quanta or particles in the spherical cavities, in physical conditions implying a small number *N* of multiplets.

Some models of gauge theory for the gravitational interaction and a comparison with the General Relativity are presented by G. Zet. He shows that gravitation can be described by gauge potentials defined on a Minkowski (flat) space-time and so, the use of Riemann or Riemann-Cartan theories can be avoided.

S. A. Oprisan and Ana Oprisan, derive a stability criterion for the totally synchronized state of a periodic network of coupled functional units. The functional units were nonlinear discrete dynamical systems. A general approach to the study of the completely synchronized state of a population of coupled functional units based on the circulant matrices method is presented and the assumption of exponentially decaying coupling strength reduces the number of control parameters. The results could have applications in neuronal network research.

The section of *Nuclear Physics and Particle Physics* is opened by the paper on sub-quantum medium and fundamental particles by Ioan-Iovit Popescu and R.E. Nistor. Obtaining of the rest mass of leptons with electric charge –1 is pursued by considering the existence of a medium made up of sub-quantum particles having a rest energy of the order of 10^{-33} eV, *i.e.*, at the lowest limit which is possible in the Universe. This medium is assumed to have a periodic structure, with a period of the order of 10^{-15}m that generates zones of allowed and forbidden energy. The quantization of the photons in this sub-quantum lattice is achieved with the help of the operator of the square of the energy. The well-known Bloch's formula was further used to empirically fix the lattice parameters (the etheron barrier period, width and height). The rest energy of fundamental particles would correspond to

zones of allowed energy. Excellent agreement has been found with the well-known data of electronic (0.511 MeV), miuonic (105.457 MeV), and tauonic (1784.037 MeV) rest energies. The rest energies of the next heavier leptons, not yet known, are also predicted.

M. Ivascu, I. Cata-Danil, D. Bucurescu, Gh. Cata-Danil, L. Stroe, F. Soramel, C. Signorini, A. Guglielmetti and R. Bonetti show their results in a program of study of exotic decays at the proton drip-line with special attention on proton radioactivity in the light rare earth region. The theoretical calculations stress the fact that p-emitting nuclei with $54 < Z < 64$ are expected to be very deformed in their ground state and for this reason their study is an important test for the theoretical models that describe proton radioactivity. Calculations performed for a deformed proton emitter reproduce quite well the experimental results confirming that ^{117}La is strongly deformed. A search for proton radioactivity of ^{123}Pr using a ^{58}Ni beam (260-300 MeV) and ^{70}Ge target has been done. The same setup for measuring the p-decay of ^{117}La and ^{123}Pr was used to investigate a possible decay *via* proton emission of the odd-odd nucleus ^{126}Pm. They analyse the deformed proton emitter $57 \leq Z \leq 69$, by using Möller *et al.* and Relativistic Hartree-Bogoliubov models for the location of proton drip-line, the separation energies for proton separation and ground-state quadrupole deformations.

D. S. Delion and A. Sandulescu investigate the important role played by the nuclear deformations on low-lying rotational yields in cold fission. A fissioning state is considered as a resonance in the potential well between the emitted fragments. They generalize their previous approach by using a common rotational basis and considering all degrees of freedom. As fissioning states, the authors select those resonances, which are oriented close to the pole-to-pole configuration in the overlapping region. A strong dependence of decay yields upon the quadrupole and hexadecapole deformation parameters is predicted. Rotational yields for ten possible cold splittings are also given.

I. Silisteanu, W. Scheid and A.O. Silisteanu give some estimates of alpha-decay half-lives of superheavy elements. A brief outlook of the experimental results and theoretical ideas which define the clustering, tunneling and "fine structure" is presented together with quantitative estimations for resonance decay widths. They present formal considerations, derived from a shell model of the reaction theory, as well as from numerical computations based on coupled channel methods, with many-body effects included in formation and reaction amplitudes, energy shifts and total decay widths. The cluster decay properties of nuclei are considered and some spectroscopic information on the continuum states populated in the unbound intermediate systems in the decay channel is obtained.

Sub-barrier fusion reactions for synthesis of superheavy element ^{298}114 are presented by R. A. Gherghescu. Deformed two-center shell model provides the energy level schemes for shell effects. Yukawa-plus-exponential model gives the macroscopic (liquid drop) part of the total energy. Werner-Wheeler irrotational

flow hypothesis is used for obtaining the mass tensor and the minimization of the multidimensional action integral leads to the highest penetrability values. Kr-projectile reactions provide the best pairs, although the penetrabilitites are very low.

M. Rizea, S. Misicu, M. Petit, N.Carjan and G. Barreau calculate the nuclear level density relevant for Thorium-based reactors. Several performing procedures for its calculation are described: the equidistant model, empirical methods like Back Shifted Fermi Gas and Gilbert-Cameron and, with special emphasis, recent Ignatyuk-type methods. Practical recipes for the determination of the needed parameters, as: shape description, deformation energy, shell correction and collective enhancement factors (rotational and vibrational), are given. The Ignatyuk formalism is applied to study some protactinium isotopes, nuclei of practical interest which appear in the thorium fuelled nuclear reactors.

M. Popescu analyzes π^+p and π^-p experimental cross-section dependences of energy and observes that the curves exhibit striking resemblance to the scattering curves obtained by electron, neutron or X-ray scattering in liquid and amorphous materials. Then, by analogy with the case of solids and liquids and using the hypothesis that pions are scattered by unknown internal centers when they knock the proton, he develops a method to extract structural information on the proton internal structure, considered as a cluster of subparticles with specific configuration and distances between them.

In the section of *Atomic & Molecular Physics*, M. C. Stroe, A. I. Florescu, M. Fifirig, F. O. Waffeu Tamo, V. Ngassam, O. Motapon and I. F. Schneider present a theoretical description of quantum interferences of super-excited states. They outline the various aspects of this approach – representations of molecular states (many of them, electronically or ro-vibrationally super-excited), channel interactions, mechanisms and competitive processes. The multi-channel character of the collisions, implying quantum interferences between zero-order states of the molecular system, is emphasized and applications on various diatomic molecular cations with electrons of energy between 0.01 MeV and 13 eV are shown. The computed cross sections and rate coefficients provide input data for the kinetic modeling of ionized media in atmosphere physics, astrophysics, environment and energy research.

In the section of *Condensed Matter*, M. Crisan, I. Grosu and I. Tifrea are presenting a model for the Bose-Einstein condensation in a low dimensional exciton system. Using the Renormalization Group method and a Phi4 model, they calculate the temperature dependence of the correlation length, magnetic susceptibility, critical density, and the critical temperature. The model can describe the macroscopic coherence observed in GaAs/AlGaAs coupled quantum wells structure.

I. Baltog, M. Baibarac, L. Mihut, N. Preda, T. Velula and S. Lefrant do correlated studies of UV-VIS absorption spectroscopy, surface enhanced Raman scattering (SERS) and photoluminescence (PL) in order to evidentiate the

aggregation of C_{60} in binary solvent mixtures. Aggregation process was studied in o-dichlorobenzene (DCB)/acetone and DCB/N-methyl-2-pyrrolidinone solvent mixtures.

The *Optics and Quantum Electronics* section is opened by an important review paper of I. Ursu and V. Lupei on stimulated emission, solid-state quantum electronics and photonics: relation to composition, structure and size. The relation of the radiation emission properties of the doped photonic materials to the composition, structure and size of these materials is discussed. It is shown that a proper use of this relation can extend or improve the performances of the photon sources and of their applications.

V. I. Vlad, A. Petris, V. Babin, E. Fazio and M. Bertolotti present their results in polarization evolution of spatial solitons in photorefractive BSO crystals with large optical activity and absorption. They calculate the Stokes parameters of these solitons and show their polarization evolutions on the Poincaré sphere, in function of the crystal orientation, propagation distance, the soliton-background-intensity-ratio and the external electric field. The experimental polarization states correspond well to their analytical results and numerical simulations. The results are useful for the selection of optimum parameters in spatial soliton generation and applications in optical switching, routing and storage.

L.-C. Crasovan, D. Mihalache, R. Iliew, C. Etrich and F. Lederer investigate the possibility of solitary wave formation in a singly resonant synchronously pumped lithium triborate based optical parametric oscillator for both femtosecond and picosecond pump pulses and the influence of the involved parameters on the solitary wave formation. In the femtosecond regime, for a wide range of pump durations, the width of the solitary wave formed in the cavity is inverse proportional to the pump amplitude, when pumping the cavity with the same energy. Stable femtosecond pulses have been shown to be emitted by the optical parametric oscillator, even in the presence of small anomalous and normal signal dispersions. In the picosecond pumped cavity, for moderate peak power, a 5-fold compression may be achieved.

F. Iova, Ath. Trutia and V. Vasile measure and analyse optical spectra of some diffuse-reflecting pigments, in order to establish their chromaticity coordinates in the CIE^* chromaticity diagram. Color differences between nearly indiscernible colors are determined by using specific calculations. The spectra have been obtained and processed with a Cary spectrophotometer incorporating a home-made integrating sphere, an interface to PC and original software. The experimental setup, acquisition method and the calculation programs are suitable for any diffuse reflecting or transmitting materials and may be used in painting restoration, authenticity check and establishing the origin and type of the natural and the synthetic pigments.

A. Popa is studying the classical approximation of the interaction between electrons and very intense laser beams. He shows that the solution of the Klein-

Gordon equation describing the behavior of the system (electron – very intense laser beam) is at the classical limit and that this result is in agreement to Feynman's path integral approach to this interaction. The result simplifies the analysis of systems composed by atoms and very intense electromagnetic fields, when the electrostatic interactions between electrons and nuclei are neglected.

S.-L. Tsao, M. Oane, L. Li, Fl. Scarlat, F. Scarlat, C. Oproiu and I. N. Mihailescu are developing an analytical model to study temperature distributions in optical materials heated by laser pulses. A three-dimensional model of heat diffusion in solids is considered and an analytical expression of the thermal field, when three-photon absorption is derived. Specific results are presented for model application in the case of laser irradiation of Al_2O_3 samples, when three-photon absorption may produce detectable temperature change.

G. Raseev and Doina Bejan develop a model of the interaction between the laser radiation and a gas-solid interface. The model uses a local dielectric function deduced from the experiment and varying with the laser energy and provide interesting results for electromagnetic fields from electron density. It describes the bulk plasma frequency at about 15.3 eV.

D. Bäuerle, J. D. Pedarnig, I. Vrejoiu, M. Peruzzi, D. G. Matei, D. Brodoceanu and M. Dinescu give an overview on recent experimental and theoretical investigations of laser processing. Among these, are: the submicron- and nano-patterning of surfaces by means of both near-field optical techniques and microlens arrays formed by self-organization processes, the pulsed-laser deposition (PLD) of thin films including organic, inorganic and composite materials and the modification of material surfaces. Particularly, the surface modification of polytetrafluoroethylene (teflon) has various applications in biotechnology and medicine.

In the section of *Plasma Physics*, M. Voiculescu and M. Ignat review two types of instabilities acting to generate ondulatory phenomena in the midlatitudes ionospheric E region plasma: the gradient-drift and the modified two stream instabilities. The physical mechanisms, the dispersion relation and the growth rate of the two instabilities, as well as the wind role in producing meter-scale waves in the mid-latitude E region are discussed. They show that, for normal propagation, the wind shear does not modify the amplification of the wave. However, it has important effects on the growth rate, when the wave-vector deviates form the normal. These results prove that the wind reduces significantly the electric fields values required for the generation of both types of waves.

The section *Biophysics and Medical Physics* includes four papers. Ana-Nicoleta Bondar presents results in the active transport of protons across biological membranes, particularly, pathways for the transfer of retinal Schiff base proton in bacteriorhodopsin photo-cycle. Recent quantum mechanical/molecular mechanical reaction pathway calculations on the mechanism of retinal deprotonation and the compatibility of various retinal configurations with a proton-pumping photocycle are discussed. The role of specific protein groups for the stability of the ion-pair

state (*i.e.*, the state with protonated Schiff base and the proton acceptor group) is also considered.

Irinela Chilibon, Martine Wevers and J.-P. Lafaut are studying ultrasound underwater transducers for extracorporeal shock wave lithotripsy (ESWL).The transducer exhibits low resonance frequency, tunable energy, broad bandwidth and low quality factor, that means it is optimum for this application. Extracorporeal shock wave lithotriptor system generates cavitation bubbles, which have an essential role in the disintegration of renal calculi.

A. Glodeanu develops a kinetic theory for chemically interacting biomolecules with hyperlipemic diet and drug administered to living systems. Since in many cases the experimental parameters (serum concentration of different bio-molecules) are slowly varying with respect to time, a linear kinetic description of these phenomena is considered to be appropriate. The author takes into account the chemical coupling among the involved bio-molecules and their interaction with the molecules of the supplied external factors. The results are important for emphasising the major risk of the diet for many diseases.

S. Grigorescu, C. Ristoscu, G. Socol, E. Axente, F. Feugeas and I. N. Mihailescu present the behaviour of hydroxyapatite pulsed laser deposited (PLD) thin films, when submitted to biological simulated tests. Structures of hydroxyapatite (HA) thin films were deposited on commercially pure Titanium grade 4 by PLD and heat treated in water vapors. In this study, processes taking place at the hydroxyapatite/Hank's solution interface, for 21 days, at a constant temperature of 37°C, are investigated. The deposited layer was neither dissolved nor destroyed due to hydroxyapatite's good chemical stability and adherence to substrate. The results confirm the good biological simulated behaviour of hydroxyapatite films and provide very favorable premises for bio-integration and bio-activity.

S. J. Talasman gives some theoretical results the dynamics of a diffusion-reaction (D-R) system in a low amplitude radio-frequency (RF) field. He shows that, using even very low RF fields, one can control the dynamics driving the system in either a chaos state or in a coherent one. These results may have applications in a diversity of complex systems as chemical and biological ones.

The section *Physical Methods and Instrumentation* contains interesting results produced by B. Constantinescu, R. Bugoi, E. Oberländer-Târnoveanu and K. Pârvan in the application of Energy-Dispersive X-Ray Fluorescence (ED-XRF) technique for ancient silver coins characterization, using in-situ (in museums) measurements. Examples concerning originality testing, provenance (mines, workshops) identification, counterfeits selection, historical studies (manufacturing technologies, commercial, military and political relationships) are given. Other analysis methods and their use in the study of medieval coins are illustrated with the example of Particle Induced X-ray Emission (PIXE) technique.

I hope that this special issue reflects some important directions of research in modern physics and some important recent results of some very active physicists in

Romania. I express my full appreciation and gratitude to all the authors contributing to this volume. I should like to thank the distinguished members of the Editorial Board, as well as to the distinguished reviewers, for their important paper selection. Finally, the skill, dedication and energy of the technical staff of this Journal, particularly of Mrs. Marinela Dumitriu, in publishing such complex journal issue are warmly acknowledged.

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