

Progress Report May 2011 – April 2014

of the activities of the UNESCO Chair on Sustainable Development through Research and Education in Modern Physics

The Chair has been established by an agreement between UNESCO and Horia Hulubei Foundation (HHF), Bucharest-Magurele, Romania, signed on March 23, 2010.

The activity of our Chair has been oriented according to the Medium-Term Strategy for 2008 to 2013. In the field of the sciences, the overarching objective was mobilizing scientific knowledge and policy for sustainable development. Our Chair followed the following two, out of the three strategic programme objectives:

- Leveraging scientific knowledge for the benefit of the environment and the management of natural resources;
- Fostering policies and capacity-building in science, technology and innovation.

The activity of the Chair has been developed on several levels: **(1) scientific research, (2) scientific exchanges, (3) workshops and conferences, (4) dissemination.**

1. Scientific research

The Chair is involved in two research projects, a Romanian one: ***1.1. Development of models and methods for computation of the nuclear matrix elements involved in the study of double-beta decay - and a European one: *1.2. Horizons in Physics Education (HOPE).**

1.1. Development of models and methods for computation of the nuclear matrix elements involved in the study of double-beta decay - and a European one: *1.2. Horizons in Physics Education (HOPE).

Project beneficiary: ANCS (National Authority for Scientific Research)

Project cod: PN-II-ID-PCE-2011-3-0318

The project intends to develop new nuclear structure models and high performance computing codes based on the Shell Model to provide a reliable description of the nuclear matrix elements (NMEs) involved in the double-beta ($\beta\beta$) decays. The NMEs are essential to improve the knowledge of the absolute neutrino masses, and to investigate the possibility of determining the leading mechanisms for the neutrinoless double beta ($0\nu\beta\beta$) decay mode. The specific objectives of this project include: i) establish reliable effective shell model NN interactions that can adequately reproduce the spectroscopic properties of the nuclei in the mass-regions of the main $\beta\beta$ decay emitters; ii) develop an efficient code to calculate the two-body matrix elements of the $0\nu\beta\beta$ -decay operator, including high orders effects in the nucleon currents, short-range correlations and other nucleon-dressing

effects; iii) estimate the effects of enlarging the size of the shell model spaces that may break general symmetries; iv) predict new limits and uncertainties for the effective $0\nu\beta\beta$ neutrino mass assuming a standard $0\nu\beta\beta$ decay half-life of 1026 years; v) derive explicit expressions for the transition amplitudes of other possible $0\nu\beta\beta$ decay mechanisms and investigate strength of their contributions; vi) disseminate the results to the experimentalists, which are using theoretical NMEs in the planning their $\beta\beta$ decay experiments.

1.2. Horizons in Physics Education (HOPE)

The academic network HOPE – Horizons in Physics Education – has been launched for three years, starting from October 2013, with the support of the HOPE's goal is to enhance the impact of physics on the European economy and its visibility and consequence in society in general. Since the project is promoted by academic institutions, there are four interlinked aims which form the basis of the work programme, and which are effectively developed by four working groups (WGs). Our UNESCO Chair is involved in two of them:

WG1. Inspiring Young People to Study Physics

WG4. Improvements in the Training and Supply of Physics School Teachers

The activity of WG1 already started; in this framework, our Chair is in charge of monitoring the science journalism, the adult science education, the science publishing houses, etc.

1.3. Scientific (research) publications

a) Articles in astroparticle domain, published in ISI indexed journals

- Study of nuclear effects in the computation of the $0\nu\beta\beta$ decay matrix elements, A. Neacsu and S. Stoica, accepted in J. Phys. G: Nucl. Part. Phys. 41 (2014).
- New Calculations for Phase Space Factors Involved in Double Beta Decay, S. Stoica and M. Mirea, Phys. Rev. C 88, 037303, (2013).
- Fast, efficient calculations of the two-body matrix elements of the transition operators for neutrinoless double- β decay, A. Neacsu, S. Stoica and M. Horoi, Phys.Rev. C 86, 067304 (2012).
- Neutrino properties probed by lepton number violating processes at low and high energies, S. Stoica, Rom. J. Phys., 58, nos. 5-6, (2013).
- Shell model calculations for neutrinoless DBD through exchange of heavy neutrinos, A. Neacsu and S. Stoica, accepted in Rom. Rep. Phys. Vol 59, no. 2 (2014).

- Phase space calculations for β - β - decays to final excited 2+1 states, T. Pahomi, A. Neacsu, M. Mirea, S. Stoica, accepted in Rom. Rep. Phys., vol. 59, no.2 (2014).
- First forbidden β -decay rates for neutron-rich nickel isotopes in stellar matter, J. Un-Nabi and S. Stoica, arXiv:1211.6968 [nucl-th] and Astrophys. & Space Science, ISSN: 0004-640X (2013)
- Efficient double beta decay nuclear matrix elements computations, A. Neacsu, Proceedings of CSSP12, AIP Conf. Proceedings Vol.1498, 354 (2012).
- Neutrino properties deduced from the study of LNV processes at low and high energies, S. Stoica, Proceedings of CSSP12, AIP Conf. Proceedings Vol. 1498, 246 (2012).
- Neutrino properties probed by lepton number violating processes, Stoica Sabin, Open Journal of Microphysics, ISSN 2162-2450, DOI:10.4236/ojm2013, 3-4, (2013).
- PHASE CHANGE MATERIALS: CHEMICAL BONDING AND STRUCTURAL PROPERTIES , AlinVELEA a,b, Mihai POPESCU, *PROCEEDINGS OF THE ROMANIAN ACADEMY, Series A, OF THE ROMANIAN ACADEMY Volume 10, Number 3/200.*
- A POSSIBLE BOOLCHAND INTERMEDIATE PHASE IN WATER
M. POPESCU, F. SAVA, A. VELEA, - Journal of Non - Oxide Glasses **Vol. 4**, No. 1, 2012, p. 5 – 11.
- Tellurium based phase change materials, A. VELEA,
JOURNAL OF OPTOELECTRONICS AND ADVANCED MATERIALS, **Vol. 11**, p. 1983 – 1987.
- COMMUTON – A NEW CONCEPT IN SWITCHING MATERIALS
M. Popescua, A. Velea, A.Lőrinczi, F. Sava, Journal of Ovonic Research **Vol. 5**, No. 2, April 2009, p. 27-34.
- QUANTITATIVE STRUCTURE – ACTIVITY RELATIONSHIP IN ANTIDIABETIC DRUGS BY USING TOPOLOGICAL DESCRIPTORS,
M. POPESCU, A. VELEA, C. MIHAI, S. TIVADAR, Digest Journal of Nanomaterials and Biostructures **Vol. 5**, No 3, July-September 2010, p. 629– 633.
- Photoexpansion and nano-lenslet formation in amorphous As₂S₃ thin films by 800nm femtosecond laser irradiation, A. Velea, M. Popescu, F. Sava, A. Lőrinczi, I. D. Simandan et al., J. Appl. Phys. **112**, 033105 (2012).
- Boolchand intermediate phases: Glass formation ability and average electronegativity
M. Popescua,b, A. Velea, Chapter 16, INOE Publishing House Series: Optoelectronic Materials and Devices, ISSN 1584-5508 **Volume 6**, 2009, Rigidity and Boolchand intermediate phases in nanomaterials, ISBN 13/978-973-88109-4-5.

- Optics of microlenses created by irradiation of As₂S₃ amorphous chalcogenide films with femtosecond laser pulses, M. Popescu , A. Velea , S. Miclos & D. Savastru (2013): *Philosophical Magazine Letters*, DOI:10.1080/09500839.2012.760058.

b) Publications in educational physics, history of science

- Goethe's theory of colors between the Ancient philosophy, Middle Age occultism and modern sciences, V. Barsan, A. Merticariu: to appear in *Interdisciplinary Science Reviews* (accepted)

- Understanding quantum phenomena without Schroedinger equation, submitted to *Physics Education*, V. Barsan

c) Participations and presentations at Conferences:

- Theoretical aspects of Double Beta Decay (invited lecture), Sabin Stoica, NEMO & SuperNEMO collaboration meeting, March 18-21, Prague, (2013).

-Motivation for the search of LNV processes at high energy(invited seminar), Sabin Stoica, CERN Meeting - January (2013).

- Efficient double beta decay nuclear matrix elements computations, A. Neacsu, Carpathian Summer School of Physics, Sinaia 2012 (CSSP12), 24 June – 4 July, oral presentation, (2012).

- Neutrino properties deduced from the study of LNV processes at low and high energies (invited lecture), S. Stoica, CSSP12, Sinaia, 24 June – 4 July, invited lecture, (2012).

- The double beta decay: theoretical challenges, M. Horoi (invited lecture), CSSP12, Sinaia, 24 June – 4 July, invited lecture, (2012).

- LNV processes at low and high energies (invited lecture), S. Stoica, workshop on "Towards a resolution of the double-beta decay problem", ECT*-Trento, 3-7 September, invited lecture, (2012).

- Fast, Efficient Calculations of the Two-Body Matrix Elements of the Transition Operators for Neutrinoless Double Beta Decay (oral presentation), A. Neacsu, Workshop " Towards a resolution of the DBD problem", ECT*, Trento, 3-7 September, (www.ectstar.eu), (2012).

- Neutrino properties probed by lepton number violating processes at low and high energies (invited lecture), S. Stoica, SEE-UNESCO conference on QFTHS, 19-22 September 2012, Craiova, Romania (invited lecture).

- New results in the theory of double-beta decay (invited lecture), S. Stoica, SNEMO meeting, Prague, 15-18 March, 2013 (invited lecture).

- New calculations of the phase spaces and nuclear matrix elements for double-beta decay, S. Stoica (invited lecture), MEDEX2013, 11-15 June, Prague, 2013.

- Neutrino properties probed by lepton number violating processes (oral presentation), S. Stoica, Conference: Molecular, Atomic, Nuclear and Particle Physics, 14-16 August, 2013, Beijing, China, Open Journal of Microphysics, 2013. ISSN 2162-2450, doi: 10.4236/ojm2013, in press (www.scirp.org/journal/ojm/) (2013).

2. Scientific exchanges

A project financed by the Central European Initiative (CEI) – according to CEI terminology, a ‘cooperation activity’ – has been run in 2013, and provided the framework for several scientific exchanges. It will be described in the next paragraph.

2.1. CEI Cooperation Activity “Fostering scientific cooperation in CEI countries through research and training in renewable energies and nanophysics” (2013): this activity comprised several working stages and a workshop.

The working stages took place in the laboratories of the Faculty of Physics of the University of Bucharest and of the National Institute for Material Physics. The Faculty hosted two Serbian PhD students, Sanja Milenovic and Goran Cvetkovic, who studied about two weeks (10 – 24 September 2013) specific aspects of photoconversion. The ATM (atomic force microscope) team of the Institute provided a short training for two Croatian scientists (Branko Pivac and Pavlo Dubcek, 24 – 28 September 2013).

2.2. Visits of two outstanding researchers at Horia Hulubei Foundation:

2.1.1. Prof. Jameel Un-Nabi, from GIK Institute of Engineering Sciences and Technology, Pakistan, visited HHF and our UNESCO Chair for a scientific collaboration on first forbidden beta decays from stellar medium. This visit can be considered within the Chair strategy of North-South relationships. We published a joint paper, in *Astrophys. & Space Science* journal (see the above list).

2.1.2. Dr. Javier Menendez, from the Institute for Nuclear Physics, Darmstadt, Germany. During his visit we started a collaboration on the study of double beta decay process. A paper on this subject is in progress.

3. Workshops

3.1. Advanced workshop on solar energy conversion, 21-24 May 2012, Bucharest

3.2. Advanced workshop on new trends in nanophysics and solar energy conversion, 23-25 September 2013, Bucharest

These workshops cover some of the most important themes of condensed matter physics, which overlap in several areas – nanophysics and solar energy conversion. Both theoretical and experimental results have been reported and discussed. The workshops

contributed to the strengthening of scientific cooperation between scientists from the Central and South-Eastern Europe, with the perspective of setting up a more systematic regional and international cooperation, in the fields of nanophysics and renewable energies.

Both workshops took advantage of the scientific support of ICTP (partner in the establishment of our UNESCO Chair), from the theoretical side, and of LIOS (Linz Institute for Organic Solar Cells), from the experimental side. It is important to note that, among the invited lecturers, were present Prof. Serdar Sariciftci, the initiator of organic solar cells, the director of the LIOS, and Stefano Fabris and Nicola Seriani, co-authors of one of the most powerful soft for computational physics with applications in photovoltaics, Quantum Espresso, from ICTP.

A satellite event of the 3.1 workshop was the award of the honorific title of Doctor Honoris Causa of the University of Bucharest to Prof. Sariciftci. This event was organized in close cooperation by the UNESCO Chair at HHF and the Faculty of Physics of the University of Bucharest.

The workshops included in their programme not only scientific lectures, but also round tables on subjects like regional cooperation and practical aspects of solar energy conversion.

A more detailed description of the workshops can be found at <http://unescochair.mdeo.eu>

4. Dissemination

The dissemination activity has three aspects:

4.1. The publication of the proceedings of a workshop on educational physics, organized by our Chair in July 2010; the proceedings was issued in *Journal of Optoelectronics and Advanced Materials – Symposia*, vol. 3, no. 1, 2011.

4.2. The publication of a book of educational physics, “Hands-on science, innovative teaching, gates to research” by V. Barsan (Editor), at Stiinta Publishing House, Chisinau, ISBN 978-9975-67-873-5. We mention that “Stiinta” is the publishing house of the Academy of Sciences of the Republic of Moldova.

4.3. Papers published in the HHF journal, *Curierul de Fizica*; for instance, in December 2013, an interview with the scientific editor of Humanitas Publishing House, presented by Victor Barsan, with special focus on two recent publications (books about Feynman and Bohr), translated by members of our UNESCO Chair.