

Exploratory Workshop
Current directions and perspectives in Mathematical research
September 17, 18, 2008, Buharesti, Romania

SCIENTIFIC REPORT

The purpose of this workshop was to use the value and the experience of the Romanian scientific diaspora to intensify large scale international collaborations in Mathematics and to increase the visibility and international impact of the results obtained by Romanian mathematicians. The directions that this workshop focused on were the following: nonlinear stochastic and parabolic equations; the mathematical modeling of some phenomenon that appear in Biology, Chemistry, Physics, Fluid Mechanics, and Mechanical Engineering; the geometry and topology of manifolds, operator algebras and applications.

The exploratory and innovative character of the theme emerges from the novelty of the proposed topics, and from the recent results obtained by the scientists that participated. The scientific quality is proved among others by the scientific positions of the participants, in top universities worldwide, members of some established scientific institutes: Cornell University, Ohio State University, University of California (USA), Universite Paris VI, Universite Paris Dauphine, Universite de Lyon, [Université Henri Poincaré Nancy 1](#) (France), Univ. Roma 2 (Italy).

Research topics discussed at the workshop

Differential equations and modelisation

- Abstract results on nonlinear equations occurring in modelling
- Mathematical problems in continuous media modelling (porous media, plasticity, phase transition, shape memory, multi-scale structures)
- Mathematical problems in quantum phenomena modelling (transport, supraconductibility, magnetic field)

Noncommutative systems of operators and applications

- Noncommutative stochastic calculus and free probabilities
- von Neumann algebras and group actions
- Riemannian structure of the noncommutative topological spaces
- C*-algebras and applications

Stochastic analysis and mathematical statistics

- Probabilistic methods in the study of the partial differential equations
- Dynamical systems with state restrictions
- Stochastic methods in finance

Geometry

- Holomorphic vector bundles on manifolds of small dimension; moduli spaces
- Geometry and topology of complex symplectic manifolds
- Geometry of harmonic mappings
- Geometry of special projective manifolds

Subjects:

Critical problems in nonlinear dispersive equations. Nonlinear dispersive equations model wave-like phenomena where nonlinear interactions occur. In a broad sense, critical means that the effect of the nonlinear interactions is comparable to the effect of the linear evolution. The aim was to introduce some of the more interesting problems in this direction, and to describe recent results and open problems concerning global regularity vs. blow-up phenomena

Quantum chemistry and control: theoretical, experimental and numerical challenges. There were presented several chemical phenomena as the basis of many industrial (e.g. combustion), biological (e.g. photosynthesis) and life sciences (e.g. biophysics) applications. The focus was on the optical manipulation of quantum phenomena. As an illustration of the interactions between mathematicians, chemists and physicists, it was addressed the present state of the art in quantum control (both at the theoretical and numerical level) and explained how this impacts the experimental research.

Intrinsic and extrinsic geometry for algebraic manifolds. Algebraic manifolds embedded in some projective space have a very rich interaction between their intrinsic and extrinsic geometry, much of it is related to LINES in the ambient projective space (e.g. tangents, secants). It was surveyed recent progress on this classical theme of projective geometry, mostly centering around the concept of "defectiv manifold".

Locally conformally Kaehler geometry. There were discussed recent results on the geometry and topology of locally conformally Kaehler manifolds, stressing the common points and the dichotomy with Kaehler geometry. The focus was on embedding properties and on the existence of global potential functions.

Stabilization for parabolic equations. Results related to the nonnegative stabilizability in terms of the sign of the principal eigenvalue of a certain elliptic operator have been presented. This principal eigenvalue is related to the rate of the convergence of the solution. Evaluations of this principal eigenvalue with respect to the geometry of the domain and of the support of the control have been given. A stabilization result for an age-dependent population dynamics with diffusion has been also established.

Research trends in solid mechanics: tradition and novelty. The continuum mechanics, physical and experimental approaches together with computational mechanics are required to advance the knowledge in material science and to contribute to solve complex problems occurring in real industrial practice. The plasticity has been developed initially within the classical theory of plasticity (small deformation rate-independent or rigid/viscoplastic models). It was referred here at the present large deformation formalism within a macroscopic approach to elasto-plasticity, developed in order to describe the irreversible behaviour of materials.

Phenomenological modelling of solid deforming bodies. There were used rate-type constitutive equations. Romanian school of mechanics has promoted and studied intensively starting with the '60 such theories. It was a significant effort to include time effects in constitutive equations in order to describe new interesting phenomena. Thus, elastic-viscoplastic models have been applied to various materials such as metals, soils, rocks and polymers for both quasi-static and dynamic problems. We illustrated how the "spontaneous" nucleation and phase Transformation of narrow zones along a tensile specimen is accompanied by a local self heating.. By using Hadamard's theory of wave propagation one has obtained important insight into the wave structure. Mathematical aspects related with the non-uniqueness of the solutions for Riemann and Goursat problems were discussed. The predictions of the rate-type model were analyzed and illustrated by numerical results.

Sobolev spaces of manifold valued maps. Such spaces appear naturally in geometry or PDEs inspired by physics (liquid crystals, superconductivity, micromagnetism). The addressed problems go beyond the special cases of interest to applications.

Applications of operator algebra in number theory. The analysis of discrete group actions as initiated by A Connes in the noncommutative geometry framework was applied to the study of the spectral gap for Hecke operators acting on Maass waveforms.

Scientific collaborations.

The workshop was an opportunity for Romanian mathematicians to initiate new international programs of scientific collaboration, and for young mathematicians to get a wide overview upon nowadays mathematical problems. We mention that the talks of Daniel Tataru (SUA) and Gabriel Turinici (Franta), were based on collaborations with scientists from “Octav Mayer” Institute of Mathematics of the Romanian Academy in Iasi . Notice also that the talk of Liviu Ornea (Romania) was based on collaborations with mathematicians from Romanian diaspora (from France and Italy).

The workshop *Current directions and perspectives in Mathematical research*, was part of the conference [Diaspora in Cercetarea Stiintifica Romaneasca](#), and took place on September 17th and 18th, 2008, at the Institute of Mathematics “Simion Stoilow” of the Romanian Academy (IMAR) in Bucharest. The organizing institution was IMAR, with the following organizing committee (Chair/Co-chair): Viorel Barbu (Romanian Academy, Iasi), Lucian Beznea (IMAR, Bucharest) and Dan Burghilea (Ohio State Univ., USA).

The scientific activity of the workshop was based the existing international collaborations with similar research centers from European and American universities. Eight scientists from the Romanian diaspora participated: three from USA, four from France and one from Italy.

List of invited talks

Daniel Tataru (Berkeley Univ. USA) : *Critical problems in nonlinear dispersive equations*

Doina Cioranescu (Univ. Paris VI, France): *Multi-scale structures and homogenization*

Liviu Ornea (Bucharest Univ. and IMAR, Romania): *Locally conformally Kaeler geometry*

Aurel Rascanu (Univ. Al. I. Cuza Iasi, Romania): *Backward stochastic differential equations and financial models*

Petru Mironescu (Univ. Lyon, France): *Sobolev spaces of manifold valued maps*

Cristian Faciu (IMAR, Romania), **Sanda Cleja-Tigoiu** (Bucharest Univ., Romania): *Research trends in solid mechanics: tradition and novelty*

Gabriel Turinici (Univ. Paris Dauphine, France): *Quantum chemistry and control: theoretical, experimental and numerical challenges*

Sebastian Anita (Univ. Al. I. Cuza Iasi, Romania): *Internal nonnegative stabilization for some parabolic equations*

Camil Muscalu (Cornell Univ. USA): *On a new multi-parameter structure in harmonic analysis and its connections to the theory of differential equations*

Paltin Ionescu (Bucharest Univ. and IMAR, Romania): *On manifolds covered by lines*

Florin Radulescu (Univ. Roma 2, Italy): *Applications of Operator Algebra in Number Theory*

Marius Tucsnak (Univ. Nancy 1, France): *Ingham-Beurling inequalities, number theory and control of PDE's*

Short presentation of the invited speakers

Sebastian Anita

Professor at Al. I. Cuza University, Iasi, well known international specialist in the field of nonlinear equations with applications in biomathematics.

Dan Burghelea

Professor at Ohio State University, important personality of the Romanian mathematical diaspora, specialist in algebraic and geometric topology and geometric analysis.

Doina Cioranescu

Elite researcher with numerous publications in the fields of: partial differential equations, asymptotic analysis, homogenization and composite materials, mathematical models of non-newtonian fluids. Doctor Honoris Causa of University of Bucharest (1995), University of Pitesti (2001), North University from Baia Mare (2002). Bordin Prize of the Academy of Sciences Paris (1996). Author of the monographs: *Homogenization of reticulated structures*, NY (1999, in colab.), *An introduction to homogenization*, Oxford (1999, in colab.). Invited Professor at the universities: Edinburgh, Lisabona, Madrid, Moscova, Bangalore, Roma, Providence, Carolina, Pisa, Santander.

Sanda Cleja-Tigoiu

Professor at the Department of Mathematics, University of Bucharest, specialist in elasto-plasticity problems.

Paltin Ionescu

Professor in the Department of Mathematics, University of Bucharest, specialist in algebraic geometry.

Cristian Faciu

SR I at the Institute of Mathematics "Simion Stoilow" of the Romanian Academy, specialist in elasto-vascoplasticity, constitutive equations, modeling and numerical solutions.

Petru Mironescu

Professor at Université Claude Bernard Lyon 1, well-known specialist in partial differential equations and theory of functions.

Camil Muscalu

Professor at Cornell University (USA), well known specialist in harmonic analysis and partial differential equations.

Liviu Ornea

Professor at the Department of Mathematics, University of Bucharest, specialist in differential geometry, the geometry and the topology of locally conformal Kahler manifolds. "Gheorghe Titeica" prize of the Romanian Academy in 1998 for the monograph *Locally conformal Kähler geometry* (Progress in Math. **155**), Birkhäuser, 1998 (with Sorin Dragomir).

Florin Radulescu

Professor at Univ. Roma 2, specialist in operator algebras, ergodic theory and group representations.

Aurel Rascanu

Professor at Al. I. Cuza University, Iasi, specialist in differential stochastic equations.

Daniel Tataru

Professor at Berkeley University of California (SUA), one of the best specialists worldwide in partial differential equations, with fundamental contributions to the study of the nonlinear wave equation. *Bôcher Prize* of the American Mathematical Society in 2001.

Marius Tucsnak

Professor at [Université Henri Poincaré Nancy 1](#), Franta, specialist in [control of systems governed by PDE's](#) and [fluid-structure interactions](#).

Gabriel Turinici

Professor at the Paris Dauphine University and researcher at INRIA, France.. Domains of research: algorithms for the experimental quantum control, mathematical models for epidemiological simulation, controllability in bilinear quantum chemical models, methods for "base reduction", algorithms for the optimal quantum control. More than 26 scientific papers in prestigious journals (*SIAM J. Numer. Anal.*, *Numer. Math.*, *J. Phys. A*). Invited speaker at many international conferences.

WORKSHOP PROGRAM

Wednesday, September 17th, 2008

- 09:00 - 09:30 **Dan Burghilea**, *Ceremonia de deschidere*
09:30 - 10:20 **Daniel Tataru**: *Critical problems in nonlinear dispersive equations*
Coffee
10:40 - 11:30 **Doina Cioranescu**: *Multi-scale structures and homogenization*
11:40 - 12:30 **Liviu Ornea**: *Locally conformally Kähler geometry*
Lunch
15:00 - 15:50 **Aurel Rascanu**: *Backward stochastic differential equations and financial models*
Coffee
16:10 - 17:00 **Petru Mironescu**: *Sobolev spaces of manifold valued maps*
17:10 - 18:00 **Cristian Faciu, Sanda Cleja-Tigoiu**: *Research trends in solid mechanics: tradition and novelty*

Thursday, September 18th, 2008

- 09:30 - 10:20 **Gabriel Turinici**: *Quantum chemistry and control: theoretical, experimental and numerical challenges*
Coffee
10:40 - 11:30 **Sebastian Anita**: *Internal nonnegative stabilization for some parabolic equations*
11:40 - 12:30 **Camil Muscalu**: *On a new multi-parameter structure in harmonic analysis and its connections to the theory of differential equations*
Lunch
15:00 - 15:50 **Paltin Ionescu**: *On manifolds covered by lines*
Coffee
16:10 - 17:00 **Florin Radulescu**: *Applications of operator algebra in number theory*
17:10 - 18:00 **Marius Tucsnak**: *Ingham-Beurling inequalities, number theory and control of PDE's*

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