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Boyka Aneva
Mihaela Kouteva-Guentcheva *Editors*

Nonlinear Mathematical Physics and Natural Hazards

Selected Papers from the International School and Workshop held in Sofia, Bulgaria, 28 November–02 December, 2013

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Foreword

Advancing hazard-resistant design demands an understanding of what happens when a disaster occurs. Documenting and sharing the key lessons learned from extreme events around the world contribute significantly to advancing research and practice in hazards engineering. Sustainable development of different scale administrative-territorial units (ATU) requires an adequate comprehensive risk assessment due to relevant natural hazards, considering the links between the risk sources and elements. Therefore, risk assessments, analysis, and forecasts for the overall impact in the realization of a national threat as natural hazards with certain characteristics on given territory have become a very actual scientific problem with the related practical, social, and economic aspects. The materials in this book concern the mathematical physics background tools for modeling and analysis of catastrophic events and natural hazards; available information sources—national and international specialized databases (data acquiring and data processing); engineering use of these data.

This book reflects our recent regional collaboration with leading European experts in: (i) better understanding and modeling the nonlinear natural hazard phenomena that might cause ecological and socioeconomical disasters and (ii) mitigating the negative risk consequences associated with the earthquake disasters.

The book is addressed to physicists, geophysicists, earthquake engineers, as well as to every other young and senior researcher interested in the problems of nonlinear mathematical physics and natural disasters and relevant multi- and interdisciplinary collaborations.

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Preface

This book is a collection of selected papers from the International School and Workshop on *Nonlinear Mathematical Physics and Natural Hazards* which was held in Sofia, in the period November 28–December 02, 2013. The scientific forum was organized with the UNESCO financial support as an activity within the Southeast European Network for Mathematical and Theoretical Physics, SEENET MTP, thus extending fundamental research to applied science. It was devoted to current advanced achievements in the field of nonlinear mathematical physics and modeling of critical phenomena that could cause catastrophic events to occur. This multidisciplinary meeting brought together scientists developing mathematical and computational methods for the study and analysis of nonlinear phenomena and working actively to apply these tools and create conditions to mitigate and reduce the negative consequence of natural and socioeconomic disaster risk. Ten plenary talks and ten shorter session talks focused on different theoretical and applied aspects of the natural hazards were given. All the sessions were followed by interesting fruitful multidisciplinary discussions. The young researchers presented high-quality research results in ten posters at the special poster session, organized for the participating young scientists and students.

An important part of the meeting was the open discussion at the **Round Table Discussion on Perspectives of Collaboration on Disaster Risk Assessment and Management in Southeast Europe and Joint EU Projects** moderated by the representative of the UNESCO Regional Bureau for Science and Culture in Europe, Venice—Mr. M. Scalet. This special session was focused on the UNESCO contribution to current and future multidisciplinary collaboration and promotion of proposals for international research and applied science projects.

The International School and Workshop on *Nonlinear Mathematical Physics and Natural Hazards* has achieved the twofold objective aimed by the organization of this scientific meeting:

(a) Presentation of current advanced research achievements on modeling and analysis of critical natural phenomena and their applications for reducing the natural hazards risk, for mitigation of the negative consequences of natural and socioeconomic disasters for the individuals and the society as a whole.
(b) Extending and strengthening the inter- and multidisciplinary collaboration at regional, the Balkans, and European level to contribute to our joint efforts on mitigation of the negative consequence of natural disasters.

An immediate step to further extending the communications and collaboration between the scientists in the Balkan region was the mobility program realized in the form of four scientific visits in the region (at: the University of Nis, IZIIS, Skopje and the Seismological Observatory, Skopje, Technical University of Istanbul and the Bogazici University, Istanbul) that came out as a follow-up activity of this meeting.

The International School and Workshop on *Nonlinear Mathematical Physics and Natural Hazards* combined the traditional school type lectures with shorter talks given by advanced researchers and informal discussions at the end of each session and of every working day. The presented latest developments on specialized topics and state-of-the-art reviews on the research in the fields of nonlinear mathematical physics in relation to natural hazards and risk mitigation met the active interest of the young auditorium. Both the high scientific and methodological quality lectures and the friendly meeting atmosphere were highly appreciated by all the participants and the sincere will and hope for future meetings and mobility of young people in the region were declared. The meeting had successful impact on the motivation of young people who decided to choose the mathematical and physical sciences application to natural hazards as their professional field.

The major topics covered by the meeting were:

– Self-organizing Systems;
– Markov Processes and Stochastic Dynamics; Chaotic Dynamics;
– Exactly Solvable and Integrable Systems;
– Soliton Physics;
– Seismic Hazard and Seismic Risk;
– Seismic Monitoring and Networking; Earthquake Engineering Monitoring;
– Early Warning Systems.

Modern quantum field theory and statistical mechanics distinguish between two types of systems: Type I is massive and its behavior follows the exponential law and Type II is critical or massless and its behavior is subject to power law. Many systems in nature and society have dynamics, whose behavior exhibits power law, such as earthquakes, snow avalanches, landslides, superconducting vortices, forest fires, rainfall, stock market indices, the extinction of species in biology, etc. These events appear in quite diverse areas from atomic to social scale. A power law probability distribution does not decay as a Poisson one and there is a finite chance for a big catastrophic event to occur.

Advanced hazard-resistant sustainable development demands an understanding of what happens when a disaster occurs. Documenting and sharing the key lessons learned from extreme events around the world contribute significantly to advancing research and practice in hazards engineering. Adequate comprehensive risk assessment, analysis, and forecasts relevant to different scale territories exposed to various natural hazards have become a very actual complex scientific problem with the explicit practical, social, and economic aspects. For this reason, the materials in this book concern the mathematical physics background tools for modeling and analysis of catastrophic events and natural hazards; available information sources—national and international specialized databases (data acquiring and data processing); engineering use of these data. Disaster Risk Mitigation concerns initiatives and measures, which might enable a society to cope with risks and hazards, minimizing potential for loss of lives and properties as a result of different hazards. Introducing education and the culture of prevention at all levels is a must, called by the occurrence of major disasters, continuously caused by different hazards. The book is a step forward to capacity building in Southeast Europe through development of skills, exchange of knowledge and training on mathematical methods for modeling nonlinear phenomena, disaster risk preparedness, and natural hazards mitigation.

The materials in this book are divided into two major parts following the scientific program of the meeting:

Part I—Nonlinear Mathematical Physics Towards Critical Phenomena;
Part II—Seismic Hazard and Risk.

Among the topics covered in the first part are predictions and correlations in self-organized criticality, space-time structure of extreme current and activity events in exclusion processes, quantum spin chains and integrability of many-body systems, applications of discriminantly separable polynomials, MKdV-type of equations, and chaotic behavior in Yang–Mills theories. The second part is devoted to probabilistic seismic hazard assessment, seismic risk mapping, seismic monitoring, networking and data processing in Europe, mainly in Southeast Europe.

This volume is addressed to physicists, geophysicists, earthquake engineers, and to every other young and senior researcher interested in the problems of nonlinear mathematical physics and natural disasters and relevant multi- and interdisciplinary collaborations.

The editors express their sincere gratitude to all the authors of this volume for their contributions. The precious UNESCO Regional Bureau for Science and Culture in Europe, Venice, support and sponsorship are highly appreciated by all the participants in this initiative. The support of the local organizations and authorities (Institute for Nuclear Research and Nuclear Energy and Bulgarian Academy of Sciences) is kindly acknowledged.

Sofia
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Committees

Organizing Committee

Boyka Aneva (Bulgaria)
Giuliano F. Panza (ICTP, Trieste, Italy)
Peter Varga (Hungary)
Mihaela Kouteva-Guentcheva (Bulgaria)
Mario Scalet (UNESCO Venice office)

Scientific Committee

Boyka Aneva (Bulgaria)
Radu Constantinescu (Romania)
Gheorghe Marmureanu (Romania)
Giuliano Panza (Italy)
Peter Varga (Hungary)

Invited Lecturers

G. Chouliaras
D. Dojcinovski
G. Marmureanu
G.F. Panza
A. Peresan
G. Pruessner
M. Radulian
G. Schuetz
A. Zabrodin

The Scientific Sessions and the Round table

The Poster Sessions

The Social Events

Program of the Meeting

(The presentations can be found at the website of the meeting http://www.inrne.bas.bg/international-school-sofia/)

Conference venue: Kedar Hotel, Dom na Uchenia
1113 Sofia, Geo Milev, 50 Shipchenski Prohod Blvd.
+359 2 8702140, +359 2 8710009
Arrival day: 28.11.2013; Departure day: 02.12.2013

Thursday, 28.11.2013	Arrival day
18:00	Registration of Participants
Friday, 29.11.2013	
9:00 am	**Opening of the meeting** *UNESCO Representative,* *Representatives of the Bulgarian Academy of Sciences and INRNE* *Representative of the Organizing Committee*
Session Seismic Hazard and Seismic Risk *Chairman: G. Chouliaras*	
9:30–10:15	***G.F. Panza, A. Peresan, A. Magrin, F. Vaccari (ICTP),*** The Hazard in Using Earthquakes Probabilities for Seismic Hazard Assessment
10:15–11:00	***G. Marmureanu, C.O. Cioflan, Al. Marmureanu, C. Ionescu (National Institute for Earth Physics (NIEP))***, Nonlinear Seismology the Actual Seismology in this Century
11:00–11:30	**Coffee break**
11:30–12:15	***D. Dojcinovski (IZIIS, Skopje)***, Seismic Monitoring of Structures—a Tool for Urban Seismic Hazard Reduction
12:15–12:45	***K. Hadjiyski, S. Simeonov*** (NIGGG-BAS) Seismic monitoring and Instrumentation for Earthquake Engineering Application in Bulgaria
13:00	**Lunch**

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Session Chaotic Dynamics *Chairman: R. Constantinescu*	
15:00–15:30	***A. Nicolaidis (Aristotle University of Thessaloniki),*** The Chaotic versus Regular Behavior in Yang–Mills Theories
15:30–16:00	***K. Kukic (University of Belgrade), V. Dragovic (Mathematical Institute, SANU),*** The Application of the Discriminantly Separable Polynomials in Dynamical Systems
16:00–16:30	**Coffee break**
Development Session *Moderator: M. Scalet*	
16:30–18:30	***Round Table Discussion*** Perspectives of collaboration on Disaster Risk Assessment and Management in Southeast Europe and joint EU projects. Moderated by UNESCO
19:00	**Welcome cocktail**
19:30	**Dinner**
Saturday, 30.11.2013	
Session Soliton Physics and Integrability *Chairman: A. Nicolaidis*	
9:15–10:00	***A. Zabrodin (ITEP, Moscow)***, Spectra of integrable quantum magnets via classical many-body systems
10:00–10:30	***R. Constantinescu (University of Craiova)***, Symmetries and Invariant Solutions for Evolutionary Equations
10:30–11:00	***V. Gerdjikov (INRNE-BAS),*** Riemann–Hilbert Problems, Families of Commuting Operators and Soliton Equations
11:00–11:30	**Coffee break**
11:30–12:00	***D. Mladenov (University of Sofia)***, Bianchi cosmological models as integrable geodesic flows
12:00–12:30	***T. Popov (INRNE-BAS)***, Parastatistics and Homotopy Algebras
12:30–13:00	***N. Nikolov (INRNE*-BAS)**, An operadic bridge between renormalization theory and vertex algebras
13:00	**Lunch**
	Session Stochastic Dynamics and Self-organizing Systems *Chairman: A. Zabrodin*
15:30–16:15	***G. Schuetz (FZ Julich),*** The Space-time Structure of Extreme Current Events in the ASEP
16:15–17:00	***G. Pruessner (Imperial College, London)***, Self-Organized Criticality: It's Past and a Recent Field Theory
17:00–17:30	**Coffee break**
17:30–19:00	**Poster Session**
19:30	**Conference Dinner**
Sunday, 01.12.2013	
	Session Nonlinear Seismology and Early Warning Systems *Chairman: A. Peresan*
9:30–10:15	***M. Radulian (NIEP)***, Nonlinear dynamics in Vrancea source: numerical simulation

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10:15–11:00	***C. Ionescu, Al. Marmureanu, G. Marmureanu (NIEP),*** Romanian-Bulgarian early warning system (EWS) developed for strong Vrancea earthquakes
11:00–11:30	**Coffee break**
	Session Seismic Monitoring and Networking *Chairman: D. Dojcinovski*
11:30–12:00	***M. Popa (NIEP)***, Romanian Network for Seismic and Crustal Movement Monitoring
12:00–12:30	***D. Cernih (Seismological Observatory, Skopje)***, Seismic Monitoring and Data Processing in Seismological Observatory in Skopje—Republic of Macedonia—basis for a complex geophysical monitoring
13:00	**Lunch**
	Session Prognostic Seismic Hazard Assessment *Chairman: G. Marmureanu*
16:15–17:00	***G. Chouliaras (Institute of Geodynamics, Athens)***, Statistical Seismology and Earthquake Prediction in Greece
17:00–17:30	**Coffee break**
17:30–18:15	***A. Peresan (ICTP), A. Nekrasova, V. Kossobokov (MITP-RAN), G.F. Panza (ICTP)***, Predicting Earthquakes and Related Ground Shaking: Testing and Validation Issues
18:30	**Closing**
19:30	**Dinner**
Monday, 02.12.2013	**Departure**

List of Poster Presentations

C. Babalic (University of Craiova)—Multipoles Soliton Solutions for Tzitzeika Type Equations

Gergana Georgieva (University of Sofia)—Upper mantle structure beneath Bulgaria

Bozhin Karaivanov (University of Sofia)—About Alcaraz method for determination of critical exponents in sandpiles

E.F. Manea, D. Toma, C.O. Cioflan, Ghe. Marmureanu, M. Radulian, S. Balan (NIEP, Bucharest)—Steps in seismic risk mapping for Romania capital city

I.E. Nastase (NIEP, Bucharest)—The NIEP network of permanent GPS stations

Emilian Panaintescu, Mihai Stoicescu, Isabela Stefarta (University of Craiova)—Nonlinear electronic circuits modeling neural flows

V.S. Gerdjikov (INRNE-BAS), D.M. Mladenov, A.A. Stefanov, S.K. Varbev (University of Sofia)—One parameter family of MKdV equations related to so(8) algebra

V.S. Gerdjikov (INRNE-BAS), D.M. Mladenov, A.A. Stefanov, S.K. Varbev (University of Sofia)—New type of equations related to sl(n) algebra

D. Arnaudov, R.C. Rashkov and T. Vetsov (University of Sofia)—On the algebraic curves for circular and folded strings in AdS5 × S5

R.C. Rashkov, H. Dimov and S. Mladenov (University of Sofia)—String approach to strong coupling phenomena: ABJM case