CIM Series in Mathematical Sciences

Volume 1

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The CIM Series in Mathematical Sciences is published on behalf of and in collaboration with the Centro Internacional de Matemática (CIM) in Coimbra, Portugal. Proceedings, lecture course material from summer schools and research monographs will be included in the new series.

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Dynamics, Games and Science

International Conference and Advanced School Planet Earth, DGS II, Portugal, August 28–September 6, 2013

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ISSN 2364-950X ISSN 2364-9518 (electronic)
CIM Series in Mathematical Sciences
ISBN 978-3-319-16117-4 ISBN 978-3-319-16118-1 (eBook)
DOI 10.1007/978-3-319-16118-1

Library of Congress Control Number: 2015945812

Mathematics Subject Classification (2010): 37-02, 37-06, 91-01, 91-02

Springer Cham Heidelberg New York Dordrecht London
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Printed on acid-free paper

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Foreword

I was very honored to be invited by Professor Alberto Adrego Pinto to the lecture at the Advanced School Planet Earth, Dynamics, Games and Science II (DGS II) from August 28 to August 30, 2013, and to speak at the associated international conference from September 2 to September 4, 2013. I have known Alberto since I was a graduate student at the CUNY Graduate Center in the 1980s. After both of us completed our Ph.D. degrees, we worked on a similar subject: smooth rigidity for one-dimensional dynamical systems and its generalization to Anosov dynamical systems of the two-torus, for many years. I was impressed by his work with his collaborators, using techniques and methods in smooth dynamical systems to develop many excellent results on smooth rigidity. Meanwhile, my collaborators and I tried to develop smooth rigidity into symmetric rigidity by applying techniques and methods in quasiconformal mappings theory and Teichmüller theory, and to build up a new Teichmüller theory for dynamical systems. So I knew that attending the DGS II would be stimulating and rewarding. Also, I knew that Alberto is an outstanding organizer and has the talent to lead a successful advanced school and conference, and indeed, his organizational skills and talents were proven again. I had a wonderful time in Lisbon, Portugal, and enjoyed many fruitful discussions with Alberto and his Portuguese colleagues. In particular, Alberto and his collaborators explained to me their work in game theory and some basic facts about its related Nash equilibrium, and we discussed some differences and similarities between the Nash equilibrium and the Gibbs equilibrium from a dynamical systems point of view. The Advanced School DGS II and the Conference DGS II were very successful. The Advanced School DGS II and the Conference DGS II in Portugal were parts of the international year of the Mathematics of Planet Earth 2013 (MPE 2013) held under the patronage of UNESCO. The activities at the Advanced School DGS II and the Conference DGS II were held in the beautiful city of Lisbon. The Advanced School DGS II was held in Escola Superior de Economia e Gestão, Universidade Técnica de Lisboa (ISEG-UTL), Lisbon, Portugal, and the Conference DGS II was held in the renowned Calouste Gulbenkian Foundation, Lisbon, Portugal. This was my third trip to the city of Lisbon. The previous two were only for one or two days, but this one was for a week. On this trip, I not only had many fruitful discussions with

other lecturers and speakers and Portuguese mathematicians, but I also visited a museum in Lisbon where I learned more about Prince Henry the Navigator and his school of navigation, where some of the leading geographers, cartographers, astronomers, and mathematicians of the fifteenth century from various parts of Europe came to work; and participants were trained in navigation, map-making, and science, including mathematics. The school of navigation started the Portuguese as well as the European exploration of new lands. So, following the scientific tradition of Portugal, this volume contains the broad mathematical themes of this conference on dynamical systems and game theory. It contains samples of the numerous talks and presentations given at the Advanced School DGS II and the Conference DGS II. The reader will find many interesting topics in dynamical systems and game theory, including many interdisciplinary contributions from economics, population dynamics, ecology, healthcare, disease epidemics, cell biology, and physics. This volume will also encourage and help the reader to explore "new lands" in various scientific areas. Finally, I would like to express my thanks to Alberto Adrego Pinto, Jean-Pierre Bourguignon, Rolf Jelstch, and Marcelo Viana for their efforts in editing and putting together this important volume.

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Foreword

I was quite pleased, and honored, to be asked by Alberto Pinto to speak at the International Conference and Advanced School Planet Earth, Dynamics, Games and Science II (DGS II) and to lecture in the advanced school that accompanied the conference from 28 August to 6 September, 2013. I had met Alberto at several conferences over the previous years and was well aware of the high-quality work that he and many of his Portuguese colleagues were doing in many branches of mathematics and science. So I knew that attending DGS II would be stimulating and rewarding. I was, however, unaware of Alberto's extraordinary organizational and leadership talents, as were displayed by these events. The extent of the diverse activities organized under Alberto's leadership as president of the international Center of Mathematics (CIM), together with Irene Fonseca (president of the CIM's scientific council) and a large number of Portuguese mathematicians, universities, institutions and organizations, is quite remarkable. These activities constitute an outstanding contribution to the international year of the Mathematics of Planet Earth 2013 (MPE 2013), held under the patronage of UNESCO, during which mathematical organizations, universities, and research centers around the world hosted conferences, workshops, schools, and long-term programs intended to showcase the ways in which the mathematical sciences can be useful in addressing our planet's many problems.

A highlight of the MPE 2013 activities centered in Portugal was the DGS II conference and the associated advanced schools, held at the facilities of the renowned Calouste Gulbenkian Foundation and the Escola Superior de Economia e Gestão, Universidade Técnica de Lisboa, respectively. These locations in the beautiful city of Lisbon are wonderful venues for scientific meetings and their hospitality was greatly enjoyed by all. The broad mathematical themes of the conference were dynamics and game theory. The chapters in this volume constitute a sampling of the numerous talks and presentations held during this event. A casual glance at the table of contents will show the reader a list of contributions to the mathematical development of game theory and dynamical systems as well as inter-disciplinary contributions from numerous scientific fields , including economics, population dynamics, ecology, healthcare, disease epidemics, cell biology, and

physics. Game theory's roots were in economics and the contributions in this volume show that its vibrant role in economics continues unabated. More recently, game theory and methodologies inspired by game theoretic ideas have made foundational contributions to other disciplines, the life sciences being a notable example. For example, extensions of game theoretic methods to dynamic settings have been and continue to be developed in order to model and understand evolutionary and adaptive processes in biology, with impacts ranging from the evolution of antibiotic resistance of pathogens to large-scale ecosystems.

This volume serves well to illustrate the many roles that mathematics can play in addressing a wide variety of scientific problems that relate to our planet earth. I am confident that the reader will be inspired by the contributions and will be stimulated to learn more about the goals of MPE 2013. I want to thank Alberto and his fellow editors, Jean-Pierre Bourguignon, Rolf Jelstch, and Marcelo Viana, for their efforts in putting this important volume together.

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Preface

As the International Center for Mathematics (CIM) celebrated its 20th anniversary on the 3rd of December 2013, it is the perfect opportunity to look back on this past year, which has undoubtedly been one of the most ambitious and eventful ones in its history. With the support of our associates from 13 leading Portuguese universities, our partners at the University of Macau, and member institutions such as the Portuguese Mathematical Society, in 2013 the CIM showed yet again the importance of a forum such as this for bringing together leading Portuguese-speaking scientists and researchers from around the world.

The hallmark project of the year was the UNESCO-backed International Program Mathematics of Planet Earth (MPE) 2013, which the CIM participated in as a partner institution. This ambitious and global program was tasked with exploring the dynamic processes underpinning our planet's climate and man-made societies, and with laying the groundwork for the kind of mathematical and interdisciplinary collaborations that will be pivotal to addressing the myriad issues and challenges facing our planet now and in the future. The CIM heeded the MPE's call to action by organizing two headline conferences in March and September of 2013: the "Mathematics of Energy and Climate Change" conference in Lisbon in the spring, and the conference "Dynamics, Games, and Science II" in the fall. Both were held at the world-renowned Calouste Gulbenkian Foundation in Lisbon, one of more than 15 respected Portuguese foundations and organizations that enthusiastically supported the CIM conferences. As well as the conferences themselves, well attended "advanced schools" were held before and after each event: at the Universidade de Lisboa in the spring, and at the Universidade Técnica de Lisboa in the fall.

These conferences succeeded in bringing together some of the most accomplished mathematical and scientific minds from across the Portuguese-speaking world and beyond, while also serving as a launch pad for one of the CIM's most exciting endeavors in years: the new CIM Series in Mathematical Sciences, which will include lecture notes and research monographs and be published by Springer-Verlag. "The collaboration with Springer will bring mathematics developed in Portugal to a global audience," CIM President Alberto Adrego Pinto said at the time

of the announcement, "and will help strengthen our contacts with the international mathematics community."

These first two volumes in the series, consisting of review articles selected from work presented at the "Mathematics of Energy and Climate Change" and "Dynamics, Games, and Science" conferences, reflect the CIM's international reach and standing. Firstly, they are characterized by an impressive roster of mathematicians and researchers from across the United States, Brazil, Portugal, and several other countries whose work will be included in the volumes.

The authors are complemented by the editorial board responsible for this first installment, a world-renowned "quartet" consisting of: president of the European Research Council Jean-Pierre Bourguignon from the École Polytechnique; former Société Mathématiques Suisse and European Mathematical Society president Rolf Jeltsch from the ETH Zurich; current Sociedade Brasileira de Matemática president Marcelo Viana from Brazil's Instituto Nacional de Matemática Pura e Aplicada; and CIM president Alberto Adrego Pinto from the Universidade do Porto.

While the MPE program was a major focus of the CIM's activities in 2013, the center also organized a number of further events aimed at fostering closer ties and collaboration between mathematicians and other scientists, mainly in Portugal and other Portuguese-speaking countries. In this context the CIM held the 92nd European Study Group with Industry meeting, part of a vital series held throughout Europe to encourage and strengthen the connections between mathematics and industry. As the MPE program made clear, humanity faces all manner of challenges, both man-made and natural, and though industry is attempting to overcome them, in many cases mathematics and science are far better suited to the task. Yet it is often industry that delivers the kinds of innovative ideas that will launch the next great scientific and technological revolutions, and which academia must adapt to. The potential for dialogue and cooperation between academia and industry is in fact so great that I have now made it one of the core initiatives in my presidency of the US-based Society for Industrial and Applied Mathematics (SIAM).

As we look back at the successful year the CIM had in 2013, we should also bear in mind the dramatic changes currently taking place in the world, changes that above all the mathematical sciences—including statistics, operational research, and computer science—will be called upon to address. Foremost among them is the rise of Big Data, especially as it relates to national security, finance, medicine, and the Internet (among other fields), which has come to dominate research in many scientific sectors and requires new analytical tools, which mathematics can provide. This new landscape will require an unparalleled level of partnership between science and industry, and is what prompted the European Commission to recently announce its Europe 2020 Growth Strategy, which calls for investment in groundbreaking research, innovation in industry, and the cultivation of a new generation of scientists. It is no coincidence that these three pillars are at the core of the CIM's own mission, and the CIM series in Mathematical Sciences will provide the ideal platform for

communicating and broadening the impact of the CIM's activities with regard to these global challenges.

President of CIM Scientific Council Irene Fonseca

Acknowledgements

We thank all the authors of the chapters and we thank all the anonymous referees. We are grateful to Irene Fonseca for contributing the preface of this book. We thank the Executive Editor for Mathematics, Computational Science and Engineering at Springer-Verlag Martin Peters for invaluable suggestions and advice throughout this project. We thank João Paulo Almeida, Ruth Allewelt, Joana Becker, João Passos Coelho, Ricardo Cruz, Helena Ferreira, Isabel Figueiredo, Alan John Guimarães, Filipe Martins, José Martins, Bruno Oliveira, Telmo Parreira, Diogo Pinheiro, and Renato Soeiro for their invaluable help in assembling this volume and for their editorial assistance.

Alberto Pinto would like to acknowledge the financial support of Centro Internacional de Matemática (CIM), Ciência Viva (CV), Calouste Gulbenkian Foundation, Fundação para a Ciência e a Tecnologia, LIAAD-INESC TEC, USP-UP project, IJUP and Mathematics Department, Faculty of Sciences, University of Porto, Portugal.

Alberto Pinto gratefully acknowledges the financial support to the conclusion of this project provided by the FCT—Fundação para a Ciência e a Tecnologia (Portuguese Foundation for Science and Technology) within project UID/EEA/50014/2013 and ERDF—European Regional Development Fund through the COMPETE Program (operational program for competitiveness) and by National Funds through the FCT—Fundação para a Ciência e a Tecnologia (Portuguese Foundation for Science and Technology) within Project "Dynamics and Applications" with reference PTDC/MAT/121107/2010.

Bures-sur-Yvette, France — Jean-Pierre Bourguignon
Zürich, Switzerland — Rolf Jeltsch
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