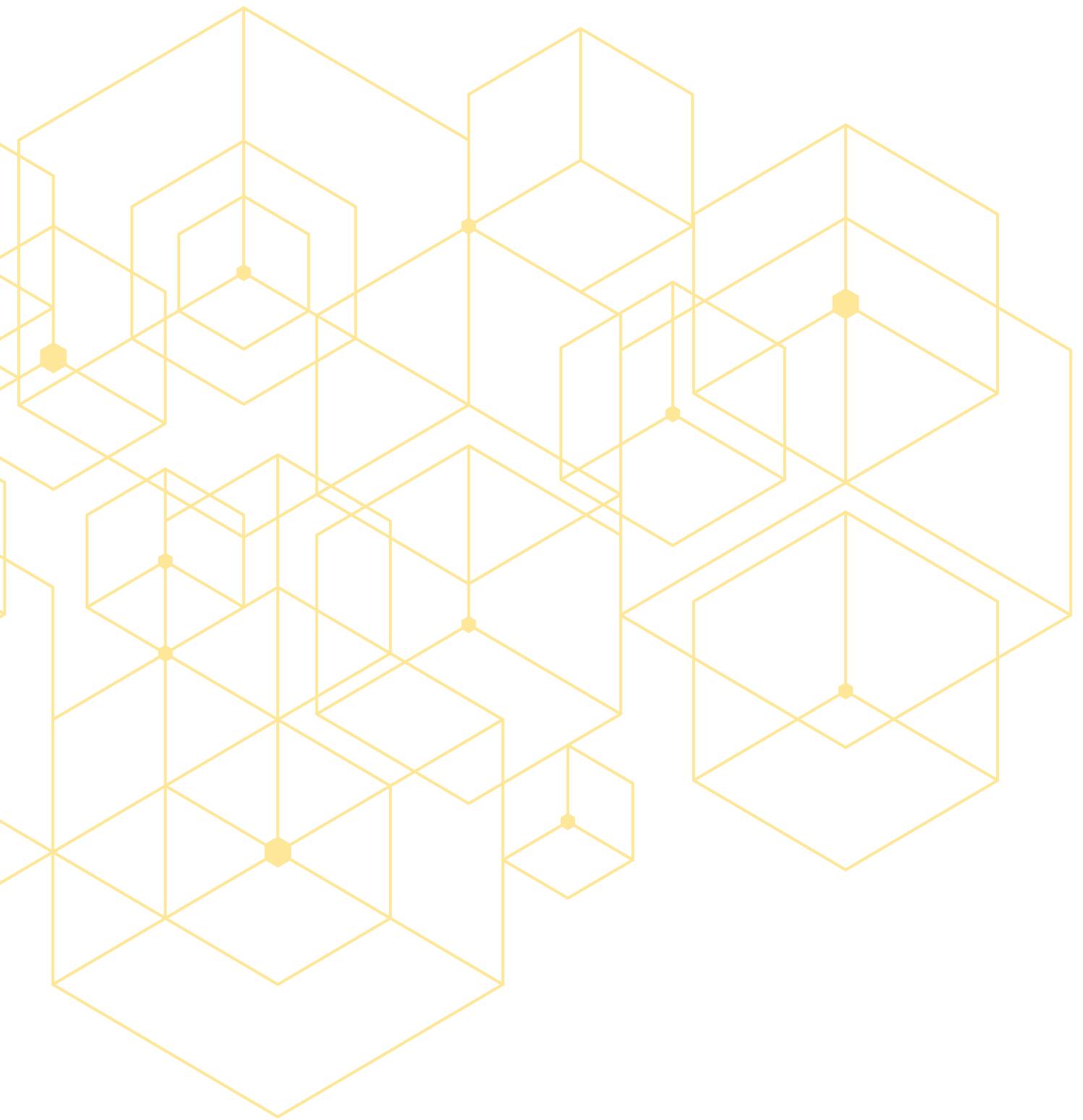# EMS Press
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The Ari Laptev Anniversary Volume

EMS Series of Congress Reports Vol. 18

Edited by:
Pavel Exner (Czech Technical University, Prague and Czech Academy of Sciences, Řež, Czech Republic)
Rupert L. Frank (California Institute of Technology, Pasadena, USA & Ludwig-Maximilians-Universität München, Germany)
Fritz Gesztesy (Baylor University, Waco, USA)
Helge Holden (Norwegian University of Science and Technology, Trondheim, Norway)
Timo Weidl (Universität Stuttgart, Germany)

This volume is dedicated to Ari Laptev on the occasion of his 70th birthday. It collects contributions by his numerous colleagues sharing with him research interests in analysis and spectral theory.

In brief, the topics covered include Friedrichs, Hardy, and Lieb–Thirring inequalities, eigenvalue bounds and

asymptotics, Feshbach–Schur maps and perturbation theory, scattering theory and orthogonal polynomials, stability of matter, electron density estimates, Bose–Einstein condensation, Wehrl-type entropy inequalities, Bogoliubov theory, wave packet evolution, heat kernel estimates, homogenization, d-bar problems, Brezis–Nirenberg problems, the nonlinear Schrödinger equation in magnetic fields, classical discriminants, and the two-dimensional Euler–Bardina equations. In addition, Ari's multifaceted service to the mathematical community is also touched upon.

Altogether the volume presents a collection of research articles which will be of interest to any active scientist working in one of the above mentioned fields.

Handbook of Automata Theory

Vol I. Theoretical Foundations
Vol. II. Automata in Mathematics and Selected Applications

Edited by Jean-Éric Pin (University Paris-Diderot & CNRS)

Automata theory is a subject of study at the crossroads of mathematics, theoretical computer science and applications. In its core it deals with abstract models of systems whose behaviour is based on transitions between states, and it develops methods for the description, classification, analysis, and design of such systems.

The Handbook of Automata Theory gives a comprehensive overview of current research in automata theory, and is aimed at a broad readership of researchers and graduate students in mathematics and computer science.

Volume I is divided into three parts. The first part presents various types of automata: automata on words, on infinite words, on finite and infinite trees, weighted and max-plus automata, transducers, and two-dimensional models. Complexity aspects are discussed in the second part. Algebraic and topological aspects of automata theory are covered in the third part.

Volume II consists of two parts. The first is dedicated to applications of automata in mathematics: group theory, number theory, symbolic dynamics, logic, and real functions. The second one presents a series of further applications of automata theory such as message-passing systems, symbolic methods, synthesis, timed automata, verification of higher-order programs, analysis of probabilistic processes, natural language processing, formal verification of programs and quantum computing.

The two volumes comprise a total of thirty-nine chapters, with extensive references and individual tables of contents for each one, as well as a detailed subject index.

Title due 2021

Topology and Geometry:
A Collection of Essays Dedicated to Vladimir G. Turaev

IRMA Lectures in Mathematics and Theoretical Physics

Edited by Athanase Papadopoulos (Université de Strasbourg & CNRS)

The present volume consists of a collection of essays dedicated to Vladimir Turaev. The essays cover the large spectrum of topics in which Turaev has been interested, including knot and link invariants, quantum representations, TQFTs, state sum constructions, geometric structures on knot complements, Kleinian groups, geometric group theory and its relationship with 3-manifolds, mapping class groups, operads, mathematical physics, Grothendieck's program, the philosophy of mathematics, and several other topics.

At the same time, this volume will give an overview of topics that are at the forefront of current research in topology and geometry. Some of the essays are research articles and contain new results, sometimes answering questions that were raised by Turaev. The rest of the essays are surveys that will introduce the reader to some key ideas in the field.

Title due 2021

Probabilistic Structures in Evolution

EMS Series of Congress Reports

Edited by Ellen Baake (Universität Bielefeld) and Anton Wakolbinger (Goethe-Universität Frankfurt)

ISBN print 978-3-98547-005-1 | ISBN online 978-3-98547-505-6 | DOI 10.4171/ECR/17 | May 2021 | 502 pages
hardcover | 16.5 x 23.5 cm | **€89**

The present volume collects twenty-one survey articles about probabilistic aspects of biological evolution, covering a variety of topics that grew out of the work done within the German Priority Programme SPP 1590.

Evolution is a complex phenomenon driven by various processes, such as mutation and recombination of genetic material, reproduction of individuals, and selection of favourable types. These processes all have intrinsically random elements, which give rise to a wealth of phenomena that cannot be explained by deterministic models. Examples of such effects are the loss of genetic variability due to random reproduction and the emergence of random genealogies.

The collection is centred around the stochastic processes in population genetics and population dynamics. On the one hand, these are individual-based models of predator-prey and of coevolution type, of adaptive dynamics, or of experimental evolution, considered in the usual forward direction of time. They lead to processes describing the evolution of type frequencies, which may then be analysed via suit- able limit theorems. On the other hand, one traces the ancestral lines of individuals back into the past; this leads to random genealogies. Beyond the classical concept of Kingman's coalescent, emphasis is on genealogies with multiple mergers and on ancestral structures that take into account selection, recombination, or migration.

The contributions in this volume will be valuable to researchers interested in stochastic processes and their biological applications, or in mathematical population biology.

Title due 2021

Lectures on Selected Topics in von Neumann Algebras

EMS Series of Lectures in Mathematics

Fumio Hiai (Tohoku University)

ISBN print 978-3-98547-004-4 | ISBN online 978-3-98547-504-9 | DOI 10.4171/ELM/32 | April 2021 | 250 pages
17x24 cm | softcover | **€39**

The theory of von Neumann algebras, originating with the work of F. J. Murray and J. von Neumann in the late 1930s, has grown into a rich discipline with connections to different branches of mathematics and physics. Following the breakthrough of Tomita–Takesaki theory, many great advances were made throughout the 1970s by H. Araki, A. Connes, U. Haagerup, M. Takesaki and others.

These lecture notes aim to present a fast-track study of some important topics in classical parts of von Neumann algebra theory that were developed in the 1970s. Starting with Tomita–Takesaki theory, this book covers topics such as the standard form, Connes' cocycle derivatives, operator-valued weights, type III structure theory and non-commutative integration theory.

The self-contained presentation of the material makes this book useful not only to graduate students and researchers who want to know the fundamentals of von Neumann algebras, but also to interested undergraduates who have a basic knowledge of functional analysis and measure theory.

Geometry and Topology of Surfaces

Zurich Lectures in Advanced Mathematics

Sebastian Baader (Universität Bern)

These lecture notes cover the classification of hyperbolic structures and measured foliations on surfaces in a minimalist way. While the inspiration is obviously taken from the excellent books Primer on mapping class groups and Travaux de Thurston sur les surfaces, the author aimed at including a little bit more of hyperbolic trigonometry, including a proof of Basmajian's identity on the orthogeodesic spectrum, while keeping the rest short.

Quasi-Periodic Solutions of Nonlinear Wave Equations on the d-Dimensional Torus

EMS Monographs in Mathematics

Massimiliano Berti (SISSA, Trieste, Italy)
Philippe Bolle (Avignon Université, France)

Many partial differential equations (PDEs) arising in physics, such as the nonlinear wave equation and the Schrödinger equation, can be viewed as infinite-dimensional Hamiltonian systems. In the last thirty years, several existence results of time quasi-periodic solutions have been proved adopting a "dynamical systems" point of view. Most of them deal with equations in one space dimension, whereas for multidimensional PDEs a satisfactory picture is still under construction.

An updated introduction to the now rich subject of KAM theory for PDEs is provided in the first part of this research monograph. We then focus on the nonlinear wave equation, endowed with periodic boundary conditions. The main result of the monograph proves the bifurcation of small amplitude finite-dimensional invariant tori for this equation, in any space dimension. This is a difficult small divisor problem due to complex resonance phenomena between the normal mode frequencies of oscillations. The proof requires various mathematical methods, ranging from Nash–Moser and KAM theory to reduction techniques in Hamiltonian dynamics and multiscale analysis for quasi-periodic linear operators, which are presented in a systematic and self-contained way. Some of the techniques introduced in this monograph have deep connections with those used in Anderson localization theory.

This book will be useful to researchers who are interested in small divisor problems, particularly in the setting of Hamiltonian PDEs, and who wish to get acquainted with recent developments in the field.

Accuracy of Mathematical Models
Dimension Reduction, Homogenization, and Simplification

EMS Tracts in Mathematics Vol. 33

Sergey I. Repin (Russian Academy of Sciences, St. Petersburg, Russian Federation)
Stefan A. Sauter (Universität Zürich, Switzerland)

ISBN print 978-3-03719-206-1 | ISBN online 978-3-03719-706-6 | DOI 10.4171/206 | August 2020 | 333 pages
hardcover | 17 x 24 cm | **€59**

The expansion of scientific knowledge and the development of technology are strongly connected with quantitative analysis of mathematical models. Accuracy and reliability are the key properties we wish to understand and control.

This book presents a unified approach to the analysis of accuracy of deterministic mathematical models described by variational problems and partial differential equations of elliptic type. It is based on new mathematical methods developed to estimate the distance between a solution of a boundary value problem and any function in the admissible functional class associated with the problem in question. The theory is presented for a wide class of elliptic variational problems. It is applied to the investigation of modelling errors arising in dimension reduction, homogenization, simplification, and various conversion methods (penalization, linearization, regularization, etc.). A collection of examples illustrates the performance of error estimates.

Mackey 2-Functors and Mackey 2-Motives

EMS Monographs in Mathematics

Paul Balmer (University of California, Los Angeles, USA)
Ivo Dell'Ambrogio (Université de Lille, France)

ISBN print 978-3-03719-209-2 | ISBN online 978-3-03719-709-7 | DOI 10.4171/209 | August 2020 | 235 pages
hardcover | 16.5 x 23.5 cm | **€59**

This book is dedicated to equivariant mathematics, specifically the study of additive categories of objects with actions of finite groups. The framework of Mackey 2-functors axiomatizes the variance of such categories as a function of the group. In other words, it provides a categorification of the widely used notion of Mackey functor, familiar to representation theorists and topologists.

The book contains an extended catalogue of examples of such Mackey 2-functors that are already in use in many mathematical fields from algebra to topology, from geometry to KK-theory. Among the first results of the theory, the ambidexterity theorem gives a way to construct further examples and the separable monadicity theorem explains how the value of a Mackey 2-functor at a subgroup can be carved out of the value at a larger group, by a construction that generalizes ordinary localization in the same way that the étale topology generalizes the Zariski topology. The second part of the book provides a motivic approach to Mackey 2-functors, 2-categorifying the well-known span construction of Dress and Lindner. This motivic theory culminates with the following application: The idempotents of Yoshida's crossed Burnside ring are the universal source of block decompositions.

The book is self-contained, with appendices providing extensive background and terminology. It is written for graduate students and more advanced researchers interested in category theory, representation theory and topology.

Classification of Complex Algebraic Surfaces

EMS Series of Lectures in Mathematics

Ciro Ciliberto (Università di Roma Tor Vergata, Italy)

ISBN print 978-3-03719-210-8 | ISBN online 978-3-03719-710-3 | DOI 10.4171/210 | June 2020 | 143 pages | softcover | 17 x 24 cm | **€36**

The classification of complex algebraic surfaces is a very classical subject which goes back to the old Italian school of algebraic geometry with Enriques and Castelnuovo. However, the exposition in the present book is modern and follows Mori's approach to the classification of algebraic varieties. The text includes the P12 theorem, the Sarkisov programme in the surface case and the Noether–Castelnuovo theorem in its classical version.

This book serves as a relatively quick and handy introduction to the theory of algebraic surfaces and is intended for readers with a good knowledge of basic algebraic geometry. Although an acquaintance with the basic parts of books like Principles of Algebraic Geometry by Griffiths and Harris or Algebraic Geometry by Hartshorne should be sufficient, the author strove to make the text as self-contained as possible and, for this reason, a first chapter is devoted to a quick exposition of some preliminaries.

Decision Support Systems for Water Supply Systems
Smart Water System to Improve the Operation of Water Supply Systems by Using Applied Mathematics

EMS Series in Industrial and Applied Mathematics Vol. 2

Edited by:
Andreas Pirsing (Siemens AG, Berlin, Germany)
Antonio Morsi (Universität Erlangen-Nürnberg, Germany)

ISBN print 978-3-03719-207-8 | ISBN online 978-3-03719-707-3 | DOI 10.4171/207 | June 2020 | 243 pages hardcover | 17 x 24 cm | **€69**

Operating water supply systems is complex. Engineers must ensure that consumers are reliably supplied with a sufficient quantity and quality of water, as well as a sufficient water pressure at all times – all while maintaining reasonable prices. This book summarizes the results of the German BMBF (Federal Ministry of Education and Research) funded joint research project, EWave (Project ID: 02WER1323F), that was initiated to develop an innovative Decision Support System (DSS) for water supply companies. For decision making and operational support, the EWave system uses newly developed integrated optimization modules. As a result, the user receives operating schedules on a 15 minute scale. To achieve this, mixed-integer linear and nonlinear mathematical optimization methods are combined. First, a mixed-integer optimization model is solved in order to derive all discrete decisions (primarily pump schedules). The aim is to approximate the

physics by piecewise linear relaxations sufficiently to optimize decisions. EWave then uses nonlinear optimization and simulation methods to verify the physics. The process is iterated as necessary. This approach enables globally optimal solutions within an a priori given quality tolerance.

Optimization results obtained in real time yield a potential of energy savings of up to 4–6% daily for the waterworks in the pilot area.

This book was written for automation experts in water supply companies as well as mathematicians who work for infrastructure companies.

t-Motives: Hodge Structures, Transcendence and Other Motivic Aspects

EMS Series of Congress Reports

Edited by:
Gebhard Böckle (Universität Heidelberg, Germany)
David Goss
Urs Hartl (Universität Münster, Germany)
Matthew A. Papanikolas (Texas A&M University, College Station, USA)

ISBN print 978-3-03719-198-9 | ISBN online 978-3-03719-698-4 | DOI 10.4171/198 | May 2020 | 473 pages | hardcover 17 x 24 cm | **€89**

This volume contains research and survey articles on Drinfeld modules, Anderson *t*-modules and *t*-motives. Much material that had not been easily accessible in the literature is presented here, for example the cohomology theories and Pink's theory of Hodge structures attached to Drinfeld modules and *t*-motives. Also included are survey articles on the function field analogue of Fontaine's theory of *p*-adic crystalline Galois representations and on transcendence methods over function fields, encompassing the theories of Frobenius difference equations, automata theory, and Mahler's method. In addition, this volume contains a small number of research articles on function field Iwasawa theory, 1-*t*-motifs, and multizeta values.

This book is a useful source for learning important techniques and an effective reference for all researchers working in or interested in the area of function field arithmetic, from graduate students to established experts.

K3 Surfaces

EMS Tracts in Mathematics Vol. 32

Shigeyuki Kondō (Nagoya University, Japan)

ISBN print 978-3-03719-208-5 | ISBN online 978-3-03719-708-0 | DOI 10.4171/208 | March 2020 | 250 pages hardcover | 17 x 24 cm | **€78**

K3 surfaces are a key piece in the classification of complex analytic or algebraic surfaces. The term was coined by A. Weil in 1958 – a result of the initials Kummer, Kähler, Kodaira, and the mountain K2 found in Karakoram. The most famous example is the Kummer surface discovered in the 19th century.

K3 surfaces can be considered as a 2-dimensional analogue of an elliptic curve, and the theory of periods – called the Torelli-type theorem for K3 surfaces – was established around 1970. Since then, several pieces of research on K3 surfaces have been undertaken and more recently K3 surfaces have even become of interest in theoretical physics.

The main purpose of this book is an introduction to the Torelli-type theorem for complex analytic K3 surfaces, and its applications. The theory of lattices and their reflection groups is necessary to study K3 surfaces, and this book introduces these notions. The book contains, as well as lattices and reflection groups, the classification of complex analytic surfaces, the Torelli-type theorem, the subjectivity of the period map, Enriques surfaces, an application to the moduli space of plane quartics, finite automorphisms of K3 surfaces, Niemeier lattices and the Mathieu group, the automorphism group of Kummer surfaces and the Leech lattice.

The author seeks to demonstrate the interplay between several sorts of mathematics and hopes the book will prove helpful to researchers in algebraic geometry and related areas, and to graduate students with a basic grounding in algebraic geometry.

Algebraic Combinatorics, Resurgence, Moulds and Applications (CARMA)
Volume 1

Edited by:
Frédéric Chapoton (Université de Strasbourg, France)
Frédéric Fauvet (Université de Strasbourg, France)
Claudia Malvenuto (Università di Roma La Sapienza, Italy)
Jean-Yves Thibon (Université Paris-Est Marne-la-Vallée, France)

This is volume 1 of a 2-volume work comprising a total of 14 refereed research articles which stem from the CARMA Conference (Algebraic Combinatorics, Resurgence, Moulds and Applications), held at the Centre International de Rencontres Mathématiques in Luminy, France, from June 26 to 30, 2017.

The conference did notably emphasise the role of Hopf algebraic techniques and related concepts (e.g. Rota–Baxter algebras, operads, Ecalle's mould calculus) which have lately proved pervasive in combinatorics, but also in many other fields, from multiple zeta values to the algebraic study of control systems and the theory of rough paths.

The volumes should be useful to researchers or graduate students in mathematics working in these domains and to theoretical physicists involved with resurgent functions and alien calculus.

Algebraic Combinatorics, Resurgence, Moulds and Applications (CARMA)
Volume 2

Edited by:
Frédéric Chapoton (Université de Strasbourg, France)
Frédéric Fauvet (Université de Strasbourg, France)
Claudia Malvenuto (Università di Roma La Sapienza, Italy)
Jean-Yves Thibon (Université Paris-Est Marne-la-Vallée, France)

This is volume 2 of a 2-volume work comprising a total of 14 refereed research articles which stem from the CARMA Conference (Algebraic Combinatorics, Resurgence, Moulds and Applications), held at the Centre International de Rencontres Mathématiques in Luminy, France, from June 26 to 30, 2017.

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Handbook of Teichmüller Theory, Volume VII

IRMA Lectures in Mathematics and Theoretical Physics Vol. 30

Edited by Athanase Papadopoulos (Université de Strasbourg, France)

The present volume of the Handbook of Teichmüller theory is divided into three parts.

The first part contains surveys on various topics in Teichmüller theory, including the complex structure of Teichmüller space, the Deligne–Mumford compactification of the moduli space, holomorphic quadratic differentials, Kleinian groups, hyperbolic 3-manifolds and the ending lamination theorem, the universal Teichmüller space, barycentric extensions of maps of the circle, and the theory of Higgs bundles. The second part consists of three historico-geometrical articles on Tissot (a precursor of the theory of quasiconfomal mappings), Grötzsch and Lavrentieff, the two main founders of the modern theory of quasiconformal mappings.

The third part comprises English translations of five papers by Grötzsch, a paper by Lavrentieff, and three papers by Teichmüller. These nine papers are foundational essays on the theories of conformal invariants and quasiconformal mappings, with applications to conformal geometry, to the type problem and to Nevanlinna's theory. The papers are followed by commentaries that highlight the relations between them and between later works on the subject. These papers are not only historical documents; they constitute an invaluable source of ideas for current research in Teichmüller theory.

Hyperbolic Flows

Zurich Lectures in Advanced Mathematics

Todd Fisher (Brigham Young University, Provo, USA)
Boris Hasselblatt (Tufts University, Medford, USA)

The origins of dynamical systems trace back to flows and differential equations, and this is a modern text and reference on dynamical systems in which continuous-time dynamics is primary. It addresses needs unmet by modern books on dynamical systems, which largely focus on discrete time. Students have lacked a useful introduction to flows, and researchers have difficulty finding references to cite for core results in the theory of flows. Even when these are known substantial diligence and consultation with experts is often needed to find them.

This book presents the theory of flows from the topological, smooth, and measurable points of view. The first part introduces the general topological and ergodic theory of flows, and the second part presents the core theory of hyperbolic flows as well as a range of recent developments. Therefore, the book can be used both as a textbook – for either courses or self-study – and as a reference for students and researchers.

There are a number of new results in the book, and many more are hard to locate elsewhere, often having appeared only in the original research literature. This book makes them all easily accessible and does so in the context of a comprehensive and coherent presentation of the theory of hyperbolic flows.

Microlocal Analysis of Quantum Fields on Curved Spacetimes

ESI Lectures in Mathematics and Physics

Christian Gérard (Université de Paris 11, Orsay, France)

We focus on free fields and the corresponding quasi-free states and more precisely on Klein–Gordon fields and Dirac fields. The first chapters are devoted to preliminary material on CCR*-algebras, quasi-free states, wave equations on Lorentzian manifolds, microlocal analysis and to the important Hadamard condition, characterizing physically acceptable quantum states on curved spacetimes. In the later chapters more advanced tools of microlocal analysis, like the global pseudo-differential calculus on non-compact manifolds, are used to construct and study Hadamard states for Klein–Gordon fields by various methods, in particular by scattering theory and by Wick rotation arguments. In the last chapter the fermionic theory of free Dirac quantum fields on Lorentzian manifolds is described in some detail.

This monograph is addressed to both mathematicians and mathematical physicists. The first will be able to use it as a rigorous exposition of free quantum fields on curved spacetimes and as an introduction to some interesting and physically important problems arising in this domain. The second may find this text a useful introduction and motivation to the use of more advanced tools of microlocal analysis in this area of research.

Gösta Mittag-Leffler and Vito Volterra. 40 Years of Correspondence

Heritage of European Mathematics

Edited by:
Frédéric Jaëck (Ecole Normale Supérieure, Paris, France)
Laurent Mazliak (Université Pierre et Marie Curie, Paris, France)
Emma Sallent Del Colombo (Universitat de Barcelona, Spain)
Rossana Tazzioli (Université Lille 1, Villeneuve-d'Ascq, France)

The present book contains the voluminous correspondence exchanged between the Swedish mathematician Gösta Mittag-Leffler and his younger Italian colleague Vito Volterra spanning a period of almost forty years at the end of the 19th and beginning of the 20th centuries. The relationship between the two men is remarkable for both personal and scientific reasons. Mittag-Leffler met Volterra for the first time as a brilliant young student of Ulisse Dini in Pisa. He was soon captivated by the creativity and the skills of the young man, and eventually became his mentor. Being himself at the center of a major scientific network, Mittag-Leffler introduced Volterra to the major mathematicians of the time, especially the Germans (Weierstrass, Klein, Cantor…) and French (Darboux, Jordan…). In a few years, Volterra became the most prominent Italian mathematician and forged his own network of scientists all over Europe, and even in the United States which he was one of the first major European mathematicians to visit. Despite their difference in age, both men developed a deep and faithful friendship and their letters reflect the variety of themes of their exchanges. Of course, mathematics was the most prominent, and both men often used the letters as a first draft of their ideas and the addressee as a first judge of their soundness. Besides mathematics, they also touched upon many aspects of both private and public life: matrimony, children, holidays, politics and so on. This vast set of letters affords the reader a general overview of mathematical life at the turn of the 19th century and an appreciation of the European intellectual spirit which came to an end, or at least suffered a drastic turn, when the Great War broke out. Volterra and Mittag-Leffler's exchanges illustrate how general analysis, especially functional analysis, gained a dramatic momentum during those years, and how Volterra became one of the major leaders of the topic, opening the path for several fundamental developments over the following decades. Through the letters one can follow the institutional career and scientific activity of both Volterra and Mittag-Leffler who shared many details about their situation.

The four editors are all specialists in the history of mathematics of the considered period. An extensive general introduction to the correspondence explains the context and the conditions in which it was developed. Moreover, the original letters are annotated with a large number of footnotes, which provide a broader cultural picture from these captivating documents.

Spectral Structures and Topological Methods in Mathematics

EMS Series of Congress Reports

Edited by
Michael Baake (Universität Bielefeld, Germany)
Friedrich Götze (Universität Bielefeld, Germany)
Werner Hoffmann (Universität Bielefeld, Germany)

This book is a collection of survey articles about spectral structures and the application of topological methods bridging different mathematical disciplines, from pure to applied. The topics are based on work done in the Collaborative Research Centre (SFB) 701.

Notable examples are non-crossing partitions, which connect representation theory, braid groups, non-commutative probability as well as spectral distributions of random matrices. The local distributions of such spectra are universal, also representing the local distribution of zeros of L-functions in number theory.

An overarching method is the use of zeta functions in the asymptotic counting of sublattices, group representations etc. Further examples connecting probability, analysis, dynamical systems and geometry are generating operators of deterministic or stochastic processes, stochastic differential equations, and fractals, relating them to the local geometry of such spaces and the convergence to stable and semi-stable states.

From the Vlasov–Maxwell–Boltzmann System to Incompressible Viscous Electro-magneto-hydrodynamics
Volume 1

Diogo Arsénio (Université Paris Diderot, France)
Laure Saint-Raymond (École Normale Supérieure, Lyon, France)

The Vlasov–Maxwell–Boltzmann system is a microscopic model to describe the dynamics of charged particles subject to self-induced electromagnetic forces. At the macroscopic scale, in the incompressible viscous fluid limit the evolution of the plasma is governed by equations of Navier–Stokes–Fourier type, with some electromagnetic forcing that may take on various forms depending on the number of species and on the strength of the interactions.

From the mathematical point of view, these models have very different behaviors. Their analysis therefore requires various mathematical methods which this book aims to present in a systematic, painstaking, and exhaustive way.

The first part of this work is devoted to the systematic formal analysis of viscous hydrodynamic limits of the Vlasov–Maxwell–Boltzmann system, leading to a precise classification of physically relevant models for viscous incompressible plasmas, some of which have not previously been described in the literature.

In the second part, the convergence results are made precise and rigorous, assuming the existence of renormalized solutions for the Vlasov–Maxwell–Boltzmann system. The analysis is based essentially on the scaled entropy inequality. Important mathematical tools are introduced, with new developments used to prove these convergence results (Chapman–Enskog-type decomposition and regularity in the v variable, hypoelliptic transfer of compactness, analysis of high frequency time oscillations, and more).

The third and fourth parts (which will be published in a second volume) show how to adapt the arguments presented in the conditional case to deal with a weaker notion of solutions to the Vlasov–Maxwell–Boltzmann system, the existence of which is known.

Eighteen Essays in Non-Euclidean Geometry

Edited by:
Vincent Alberge (Fordham University, Bronx, USA)
Athanase Papadopoulos (Université de Strasbourg, France)

This book consists of a series of self-contained essays in non-Euclidean geometry in a broad sense, including the classical geometries of constant curvature (spherical and hyperbolic), de Sitter, anti-de Sitter, co-Euclidean, co-Minkowski, Hermitian geometries, and some axiomatically defined geometries. Some of these essays deal with very classical questions and others address problems that are at the heart of present day research, but all of them are concerned with fundamental topics.

All the essays are self-contained and most of them can be understood by the general educated mathematician. They should be useful to researchers and to students of non-Euclidean geometry, and they are intended to be references for the various topics they present.

Estimates for Differential Operators in Half-space
Translated from the German by Darya Apushkinskaya

EMS Tracts in Mathematics Vol. 31

Igor W. Gel'man
Vladimir G. Maz'ya (Linköping University, Sweden, and University of Liverpool, UK)

ISBN print 978-3-03719-191-0 | ISBN online 978-3-03719-691-5 | DOI 10.4171/191 | January 2019 | 264 pages
hardcover | 17 x 24 cm | **€48**

Inequalities for differential operators play a fundamental role in the modern theory of partial differential equations. Among the numerous applications of such inequalities are existence and uniqueness theorems, error estimates for numerical approximations of solutions and for residual terms in asymptotic formulas, as well as results on the structure of the spectrum. The inequalities cover a wide range of differential operators, boundary conditions and norms of the corresponding function spaces.

The book focuses on estimates up to the boundary of a domain. It contains a great variety of inequalities for differential and pseudodifferential operators with constant coefficients. Results of final character are obtained, without any restrictions on the type of differential operators. Algebraic necessary and sufficient conditions for the validity of the corresponding a priori estimates are presented. General criteria are systematically applied to particular types of operators found in classical equations and systems of mathematical physics (such as Lame's system of static elasticity theory or the linearized Navier–Stokes system), Cauchy–Riemann's operators, Schrödinger operators, among others. The well-known results of Aronszajn, Agmon–Douglis–Nirenberg and Schechter fall into the general scheme, and sometimes are strengthened.

The book will be interesting and useful to a wide audience, including graduate students and specialists in the theory of differential equations.

Function Spaces with Dominating Mixed Smoothness

EMS Series of Lectures in Mathematics

Hans Triebel (Friedrich-Schiller Universität Jena, Germany)

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The first part of this book is devoted to function spaces in Euclidean n-space with dominating mixed smoothness. Some new properties are derived and applied in the second part where weighted spaces with dominating mixed smoothness in arbitrary bounded domains in Euclidean n-space are introduced and studied. This includes wavelet frames, numerical integration and discrepancy, measuring the deviation of sets of points from uniformity.

These notes are addressed to graduate students and mathematicians having a working knowledge of basic elements of the theory of function spaces, especially of Besov–Sobolev type. In particular, it will be of interest for researchers dealing with approximation theory, numerical integration and discrepancy.

The Shock Development Problem

EMS Monographs in Mathematics

Demetrios Christodoulou (ETH Zürich, Switzerland)

This monograph addresses the problem of the development of shocks in the context of the Eulerian equations of the mechanics of compressible fluids. The mathematical problem is that of an initial-boundary value problem for a nonlinear hyperbolic system of partial differential equations with a free boundary and singular initial conditions.

The free boundary is the shock hypersurface and the boundary conditions are jump conditions relative to a prior solution, conditions following from the integral form of the mass, momentum and energy conservation laws. The prior solution is provided by the author's previous work which studies the maximal classical development of smooth initial data. New geometric and analytic methods are introduced to solve the problem. Geometry enters as the acoustical structure, a Lorentzian metric structure defined on the spacetime manifold by the fluid. This acoustical structure interacts with the background spacetime structure. Reformulating the equations as two coupled first order systems, the characteristic system, which is fully nonlinear, and the wave system, which is quasilinear, a complete regularization of the problem is achieved.

Geometric methods also arise from the need to treat the free boundary. These methods involve the concepts of bi-variational stress and of variation fields. The main new analytic method arises from the need to handle the singular integrals appearing in the energy identities. Shocks being an ubiquitous phenomenon, occuring also in magnetohydrodynamics, nonlinear elasticity, and the electrodynamics of noninear media, the methods developed in this monograph are likely to be found relevant in these fields as well.

Boundary Behavior of Solutions to Elliptic Equations in General Domains

EMS Tracts in Mathematics Vol. 30

Vladimir G. Maz'ya (Linköping University, Sweden and University of Liverpool, UK)

The present book is a detailed exposition of the author and his collaborators' work on boundedness, continuity, and differentiability properties of solutions to elliptic equations in general domains, that is, in domains that are not a priori restricted by assumptions such as "piecewise smoothness" or being a "Lipschitz graph". The description of the boundary behavior of such solutions is one of the most difficult problems in the theory of partial differential equations. After the famous Wiener test, the main contributions to this area were made by the author. In particular, necessary and sufficient conditions for the validity of imbedding theorems are given, which provide criteria for the unique solvability of boundary value problems of second and higher order elliptic equations. Another striking result is a test for the regularity of a boundary point for polyharmonic equations.

The book will be interesting and useful for a wide audience. It is intended for specialists and graduate students working in the theory of partial differential equations.

European Congress of Mathematics
Berlin, July 18–22, 2016

The European Congress of Mathematics, held every four years, is a well-established major international mathematical event. Following those in Paris (1992), Budapest (1996), Barcelona (2000), Stockholm (2004), Amsterdam (2008), and Kraków (2012), the Seventh European Congress of Mathematics (7ECM) took place in Berlin, Germany, July 18–22, 2016, with about 1100 participants from all over the world.

Ten plenary, thirty-three invited and four special lectures formed the core of the program. As at all the previous EMS congresses, ten outstanding young mathematicians received the EMS prizes in recognition of their research achievements. In addition, two more prizes were awarded: The Felix Klein prize for a remarkable solution of an industrial problem, and – for the second time – the Otto Neugebauer Prize for a

highly original and influential piece of work in the history of mathematics. The program was complemented by forty-three minisymposia with about 160 talks as well as contributed talks, spread over all areas of mathematics. Several panel discussions and meetings were organized, covering a variety of issues ranging from the future of mathematical publishing to public awareness of mathematics.

These proceedings present extended versions of most of the plenary and invited lectures which were delivered during the congress, providing a permanent record of the best what mathematics offers today.

An Introduction to Kac–Moody Groups over Fields

EMS Textbooks in Mathematics

The interest for Kac–Moody algebras and groups has grown exponentially in the past decades, both in the mathematical and physics communities, and with it also the need for an introductory textbook on the topic. The aims of this book are twofold:

- to offer an accessible, reader-friendly and self-contained introduction to Kac–Moody algebras and groups;

- to clean the foundations and to provide a unified treatment of the theory.

The book starts with an outline of the classical Lie theory, used to set the scene. Part II provides a self-contained introduction to Kac–Moody algebras. The

heart of the book is Part III, which develops an intuitive approach to the construction and fundamental properties of Kac–Moody groups. It is complemented by two appendices, respectively offering introductions to affine group schemes and to the theory of buildings. Many exercises are included, accompanying the readers throughout their journey.

The book assumes only a minimal background in linear algebra and basic topology, and is addressed to anyone interested in learning about Kac–Moody algebras and/or groups, from graduate (master) students to specialists.

Non-Linear Partial Differential Equations, Mathematical Physics, and Stochastic Analysis
The Helge Holden Anniversary Volume

Edited by:
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This volume is dedicated to Helge Holden on the occasion of his 60th anniversary. It collects contributions by numerous scientists with expertise in non-linear partial differential equations (PDEs), mathematical physics, and stochastic analysis, reflecting to a large degree Helge Holden's longstanding research interests. Accordingly, the problems addressed in the contributions deal with a large range of topics, including, in particular, infinite-dimensional analysis, linear and nonlinear PDEs, stochastic analysis, spectral theory, completely integrable systems, random matrix theory, and chaotic dynamics and sestina poetry. They represent to some extent the lectures presented at the conference Non-linear PDEs, Mathematical Physics and Stochastic Analysis, held at NTNU, Trondheim, July 4–7, 2016 (https://wiki.math.ntnu.no/holden60).

The mathematical tools involved draw from a wide variety of techniques in functional analysis, operator theory, and probability theory.

This collection of research papers will be of interest to any active scientist working in one of the above mentioned areas.

A Brief Introduction to Spectral Graph Theory

Bogdan Nica (McGill University, Montreal, Canada)

Spectral graph theory starts by associating matrices to graphs – notably, the adjacency matrix and the Laplacian matrix. The general theme is then, firstly, to compute or estimate the eigenvalues of such matrices, and secondly, to relate the eigenvalues to structural properties of graphs. As it turns out, the spectral perspective is a powerful tool. Some of its loveliest applications concern facts that are, in principle, purely graph theoretic or combinatorial.

This text is an introduction to spectral graph theory, but it could also be seen as an invitation to algebraic graph theory. The first half is devoted to graphs, finite fields, and how they come together. This part provides an appealing motivation and context of the second, spectral, half. The text is enriched by many exercises and their solutions.

The target audience are students from the upper undergraduate level onwards. We assume only a familiarity with linear algebra and basic group theory. Graph theory, finite fields, and character theory for abelian groups receive a concise overview and render the text essentially self-contained.

Regular, Quasi-regular and Induced Representations of Infinite-dimensional Groups

Almost all harmonic analysis on locally compact groups is based on the existence (and uniqueness) of a Haar measure. Therefore, it is very natural to attempt a similar construction for non-locally compact groups. The essential idea is to replace the non-existing Haar measure on an infinite-dimensional group by a suitable quasi-invariant measure on an appropriate completion of the initial group or on the completion of a homogeneous space.

The aim of the book is a systematic development, by example, of noncommutative harmonic analysis on infinite-dimensional (non-locally compact) matrix groups. We generalize the notion of regular, quasi-regular and induced representations for arbitrary infinite-dimensional groups. The central idea to verify the irreducibility is the Ismagilov conjecture. We also extend the Kirillov orbit method for the group of upper triangular matrices of infinite order.

In order to make the content accessible to a wide audience of nonspecialists, the exposition is essentially self-contained and very few prerequisites are needed. The book is aimed at graduate and advanced undergraduate students, as well as mathematicians who wish an introduction to representations of infinite-dimensional groups.

Geometric and Topological Aspects of Coxeter Groups and Buildings

Coxeter groups are groups generated by reflections, and they appear throughout mathematics. Tits developed the general theory of Coxeter groups in order to develop the theory of buildings. Buildings have interrelated algebraic, combinatorial and geometric structures, and are powerful tools for understanding the groups which act on them.

These notes focus on the geometry and topology of Coxeter groups and buildings, especially nonspherical cases. The emphasis is on geometric intuition, and there are many examples and illustrations. Part I describes Coxeter groups and their geometric realisations, particularly the Davis complex, and Part II gives a concise introduction to buildings.

This book will be suitable for mathematics graduate students and researchers in geometric group theory, as well as algebra and combinatorics. The assumed background is basic group theory, including group actions, and basic algebraic topology, together with some knowledge of Riemannian geometry.

Local Representation Theory and Simple Groups

EMS Series of Lectures in Mathematics

Edited by:
Radha Kessar (City University of London, UK)
Gunter Malle (Universität Kaiserslautern, Germany)
Donna Testerman (EPF Lausanne, Switzerland)

The book contains extended versions of seven short lecture courses given during a semester programme on "Local Representation Theory and Simple Groups" held at the Centre Interfacultaire Bernoulli of the EPF Lausanne. These focussed on modular representation theory of finite groups, modern Clifford theoretic methods, the representation theory of finite reductive groups, as well as on various applications of character theory and representation theory, for example to base sizes and to random walks.

These lectures are intended to form a good starting point for graduate students and researchers who wish to familiarize themselves with the foundations of the topics covered here. Furthermore they give an introduction to current research directions, including the state of some open problems in the field.

Lectures in Model Theory

Münster Lectures in Mathematics

Edited by:
Franziska Jahnke (Universität Münster, Germany)
Daniel Palacín (The Hebrew University of Jerusalem, Israel)
Katrin Tent (Universität Münster, Germany)

Model theory is a thriving branch of mathematical logic with strong connections to other fields of mathematics. Its versatility has recently led to spectacular applications in areas ranging from diophantine geometry, algebraic number theory and group theory to combinatorics.

This volume presents lecture notes from a spring school in model theory which took place in Münster, Germany.

The notes are aimed at PhD students but should also be accessible to undergraduates with some basic knowledge in model theory. They contain the core of stability theory (Bays, Palacín), two chapters connecting generalized stability theory with group theory (Clausen and Tent, Simon), as well as introductions to the model theory of valued fields (Hils, Jahnke) and motivic integration (Halupczok).

Linear Forms in Logarithms and Applications

IRMA Lectures in Mathematics and Theoretical Physics Vol. 28

Yann Bugeaud (Université de Strasbourg, France)

The aim of this book is to serve as an introductory text to the theory of linear forms in the logarithms of algebraic numbers, with a special emphasis on a large variety of its applications. We wish to help students and researchers to learn what is hidden inside the blackbox ‚Baker's theory of linear forms in logarithms' (in complex or in p-adic logarithms) and how this theory applies to many Diophantine problems, including the e ffective resolution of Diophantine equations, the abc-conjecture, and upper bounds for the irrationality measure of some real numbers.

Written for a broad audience, this accessible and self-contained book can be used for graduate courses (some 30 exercises are supplied). Specialists will appreciate the inclusion of over 30 open problems and the rich bibliography of over 450 references.

Shape Variation and Optimization
A Geometrical Analysis

EMS Tracts in Mathematics Vol. 28

Antoine Henrot (Université de Lorraine, Vandœuvre-lès-Nancy, France)
Michel Pierre (ENS Cachan Bretagne, Bruz, France)

Optimizing the shape of an object to make it the most efficient, resistant, streamlined, lightest, noiseless, stealthy or the cheapest is clearly a very old task. But the recent explosion of modeling and scientific computing have given this topic new life. Many new and interesting questions have been asked. A mathematical topic was born – shape optimization (or optimum design).

This book provides a self-contained introduction to modern mathematical approaches to shape optimization, relying only on undergraduate level prerequisite but allowing to tackle open questions in this vibrant field. The analytical and geometrical tools and methods for the study of shapes are developed. In particular, the text presents a systematic treatment of shape variations and optimization associated with the Laplace operator and the classical capacity. Emphasis is also put on differentiation with respect to domains and a FAQ on the usual topologies of domains is provided. The book ends with geometrical properties of optimal shapes, including the case where they do not exist.

Foundations of Rigid Geometry I

Kazuhiro Fujiwara (Nagoya University, Japan)
Fumiharu Kato (Tokyo Institute of Technology, Japan)

Rigid geometry is one of the modern branches of algebraic and arithmetic geometry. It has its historical origin in J. Tate's rigid analytic geometry, which aimed at developing an analytic geometry over non-archimedean valued fields. Nowadays, rigid geometry is a discipline in its own right and has acquired vast and rich structures, based on discoveries of its relationship with birational and formal geometries.

In this research monograph, foundational aspects of rigid geometry are discussed, putting emphasis on birational and topological features of rigid spaces.

Besides the rigid geometry itself, topics include the general theory of formal schemes and formal algebraic spaces, based on a theory of complete rings which are not necessarily Noetherian. Also included is a discussion on the relationship with Tate's original rigid analytic geometry, V.G. Berkovich's analytic geometry and R. Huber's adic spaces. As a model example of applications, a proof of Nagata's compactification theorem for schemes is given in the appendix. The book is encyclopedic and almost self-contained.

Schubert Varieties, Equivariant Cohomology and Characteristic Classes
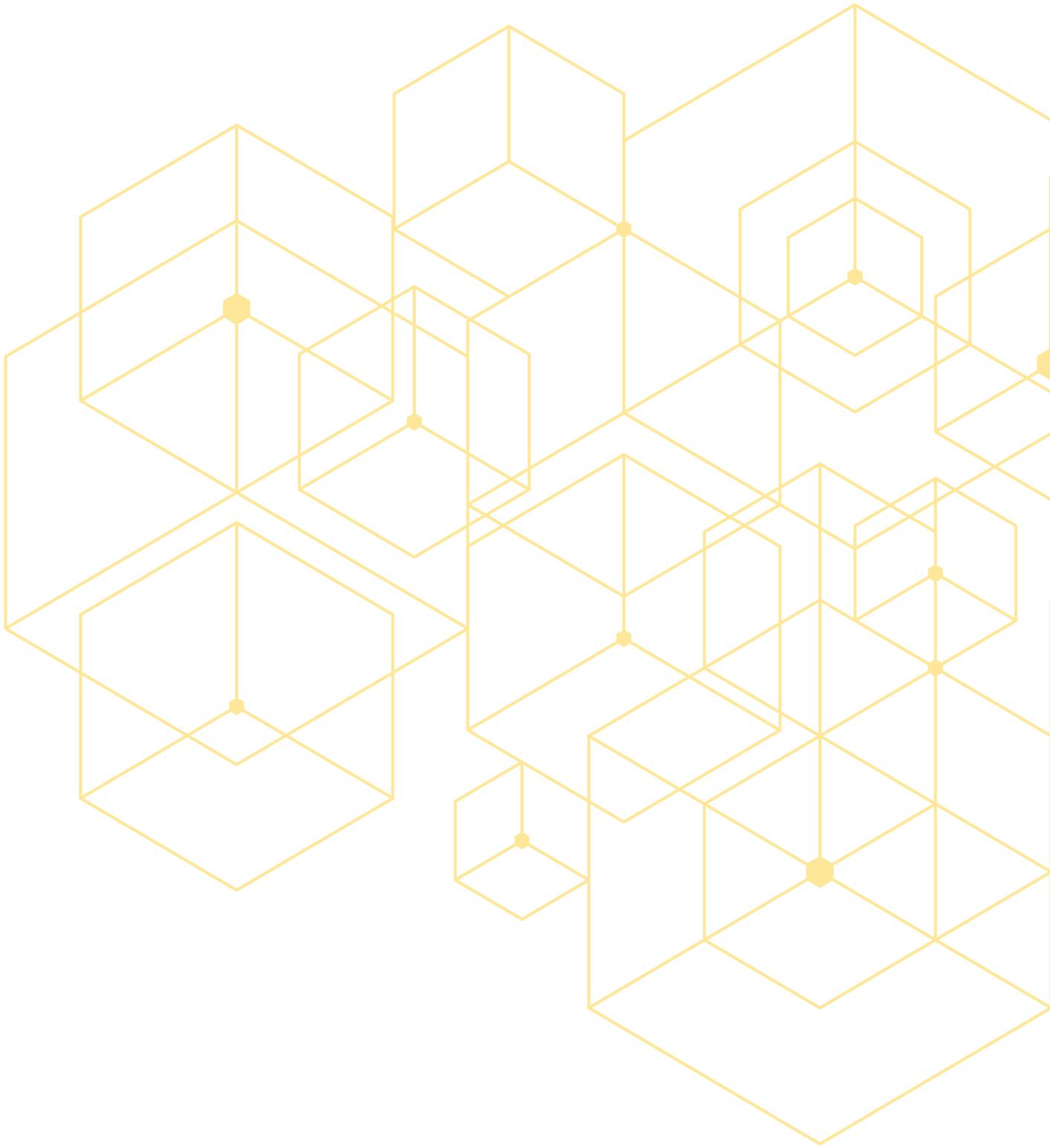## Impanga 15

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IMPANGA stands for the activities of Algebraic Geometers at the Institute of Mathematics, Polish Academy of Sciences, including one of the most important seminars in algebraic geometry in Poland. The topics of the lectures usually fit within the framework of complex algebraic geometry and neighboring areas of mathematics.

This volume is a collection of contributions by the participants of the conference IMPANGA15, organized by participants of the seminar, as well as notes from the major lecture series of the seminar in the period 2010–2015. Both original research papers and self-contained expository surveys can be found here. The articles circulate around a broad range of topics within algebraic geometry such as vector bundles, Schubert varieties, degeneracy loci, homogeneous spaces, equivariant cohomology, Thom polynomials, characteristic classes, symmetric functions and polynomials, and algebraic geometry in positive characteristic.