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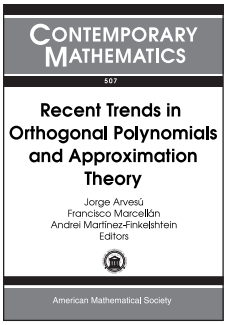
Algebra and Algebraic Geometry



Recent Trends in Orthogonal Polynomials and Approximation Theory

Jorge Arvesú and **Francisco Marcellán**, *Universidad Carlos III de Madrid, Leganés, Spain*, and **Andrei Martínez-Finkelshtein**, *Universidad de Almería, Spain*, Editors

This volume contains invited lectures and selected contributions from the International Workshop on Orthogonal Polynomials and Approximation Theory, held at Universidad Carlos III de Madrid on September 8–12, 2008, and which honored Guillermo López Lagomasino on his 60th birthday.

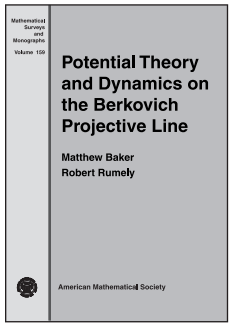
This book presents the state of the art in the theory of orthogonal polynomials and rational approximation with a special emphasis on their applications in random matrices, integrable systems, and numerical quadrature. New results and methods are presented in the papers as well as a careful choice of open problems, which can foster interest in research in these mathematical areas. This volume also includes a brief account of the scientific contributions by Guillermo López Lagomasino.

This item will also be of interest to those working in analysis.

Contents: F. Marcellán and **A. Martínez-Finkelshtein**, Guillermo López Lagomasino: Mathematical life; **B. de la Calle Ysern**, A walk through approximation theory; **L. Baratchart** and **M. Yattselev**, Asymptotic uniqueness of best rational approximants to complex Cauchy transforms in L^2 of the circle; **L. Garza** and **F. Marcellán**, Quadrature rules on the unit circle. A survey.; **A. Ibort**, **P. Linares**, and **J. G. Llavona**, On the multilinear trigonometric problem of moments; **A. B. J. Kuijlaars**, Multiple orthogonal polynomial ensembles; **E. Levin** and **D. S. Lubinsky**, Some equivalent formulations of universality limits in the bulk; **A. López García**, Greedy energy points with external fields; **A. Martínez-Finkelshtein** and **E. A. Rakhmanov**, On asymptotic behavior of Heine-Stieltjes and Van Vleck polynomials; **E. B. Saff**, Remarks on relative asymptotics for general orthogonal polynomials; **B. Simon**, Fine structure of the zeros of orthogonal polynomials: A progress report; **H. Stahl**, A potential-theoretic problem connected with complex orthogonality; **W. Van Assche**, Orthogonal polynomials and approximation theory: Some open problems.

Contemporary Mathematics, Volume 507

March 2010, 298 pages, Softcover, ISBN: 978-0-8218-4803-6, LC 2009040384, 2000 *Mathematics Subject Classification:* 15A52, 26C10, 30E10, 31A15, 31C15, 33C47, 41A20, 42C05, 44A60, 65D32, **AMS members US$71**, List US$89, Order code CONM/507



Potential Theory and Dynamics on the Berkovich Projective Line

Matthew Baker, *Georgia Institute of Technology, Atlanta, GA*, and **Robert Rumely**, *University of Georgia, Athens, GA*

The purpose of this book is to develop the foundations of potential theory and rational dynamics on the Berkovich projective line over an arbitrary complete, algebraically closed non-Archimedean field. In addition to providing a concrete and "elementary" introduction to Berkovich analytic spaces and to potential theory and rational iteration on the Berkovich line, the book contains applications to arithmetic geometry and arithmetic dynamics. A number of results in the book are new, and most have not previously appeared in book form. Three appendices—on analysis, $\mathbb{R}$-trees, and Berkovich's general theory of analytic spaces—are included to make the book as self-contained as possible.

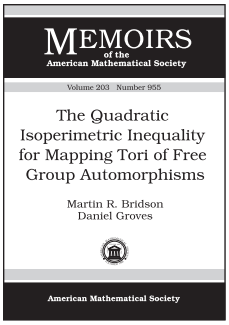
The authors first give a detailed description of the topological structure of the Berkovich projective line and then introduce the Hsia kernel, the fundamental kernel for potential theory. Using the theory of metrized graphs, they define a Laplacian operator on the Berkovich line and construct theories of capacities, harmonic and subharmonic functions, and Green's functions, all of which are strikingly similar to their classical complex counterparts. After developing a theory of multiplicities for rational functions, they

give applications to non-Archimedean dynamics, including local and global equidistribution theorems, fixed point theorems, and Berkovich space analogues of many fundamental results from the classical Fatou-Julia theory of rational iteration. They illustrate the theory with concrete examples and exposit Rivera-Letelier's results concerning rational dynamics over the field of p-adic complex numbers. They also establish Berkovich space versions of arithmetic results such as the Fekete-Szegö theorem and Bilu's equidistribution theorem.

Contents: The Berkovich unit disc; The Berkovich projective line; Metrized graphs; The Hsia kernel; The Laplacian on the Berkovich projective line; Capacity theory; Harmonic functions; Subharmonic functions; Multiplicities; Applications to the dynamics of rational maps; Some results from analysis and topology; $\mathbb{R}$-trees and Gromov hyperbolicity; Brief overview of Berkovich's theory; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 159

March 2010, approximately 454 pages, Hardcover, ISBN: 978-0-8218-4924-8, LC 2009036372, 2000 *Mathematics Subject Classification:* 14G20; 14G22, 14G40, 37F10, 37F99, 31C05, 31C15, 31C45, **AMS members US$88**, List US$110, Order code SURV/159



The Quadratic Isoperimetric Inequality for Mapping Tori of Free Group Automorphisms

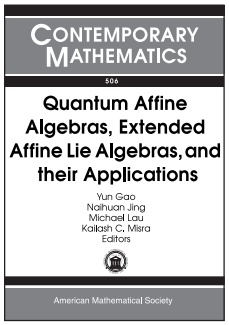
Martin R. Bridson, *Mathematical Institute, Oxford, England*, and **Daniel Groves**, *University of Illinois at Chicago, IL*

This item will also be of interest to those working in geometry and topology.

Contents: Positive automorphisms; Train tracks and the beaded decomposition; The general case; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 203, Number 955

January 2010, 152 pages, Softcover, ISBN: 978-0-8218-4631-5, LC 2009042849, 2000 *Mathematics Subject Classification:* 20F65; 20F06, 20E36, 57M07, **Individual member US$44**, List US$74, Institutional member US$59, Order code MEMO/203/955



Quantum Affine Algebras, Extended Affine Lie Algebras, and their Applications

Yun Gao, *York University, Toronto, ON, Canada*, **Naihuan Jing**, *North Carolina State University, Raleigh, NC*, **Michael Lau**, *University of Windsor, ON, Canada*, and **Kailash C. Misra**, *North Carolina State University, Raleigh, NC*, Editors

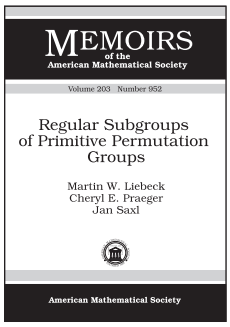
This volume contains the proceedings of the conference on Quantum Affine Algebras, Extended Affine Lie Algebras, and Applications, which was held at the Banff International Research Station, Banff, Canada, from March 2–7, 2008.

Many of the papers include new results on different aspects of quantum affine algebras, extended affine Lie algebras, and their applications in other areas of mathematics and physics. Any reader interested in learning about the recent developments in quantum affine algebras and extended affine Lie algebras will benefit from this book.

Contents: B. Allison and **G. Benkart**, Unitary Lie algebras and Lie tori of type $BC_r, r \geq 3$; **V. Chari** and **D. Hernandez**, Beyond Kirillov–Reshetikhin modules; **X. Chen** and **K.-B. Nam**, Root vectors and an integral PBW basis of composition algebra of the valued graph $A_2^{(2)}$; **B. Cox**, **V. Futorny**, and **K. C. Misra**, Imaginary Verma modules and Kashiwara algebras for $U_q(\widehat{\mathfrak{sl}(2)})$; **G. Fourier**, **M. Okado**, and **A. Schilling**, Perfectness of Kirillov–Reshetikhin crystals for nonexceptional types; **Y. Pei**, **N. Hu**, and **M. Rosso**, Multiparameter quantum groups and quantum shuffles, (I); **J. Morita**, Tilings, Lie theory and combinatorics; **E. Mukhin**, **V. Tarasov**, and **A. Varchenko**, The $\mathfrak{gl}_2$ Bethe algebra associated with a nilpotent element; **M. Igarashi** and **T. Nakashima**, Affine geometric crystal of type $D_4^{(3)}$; **K.-H. Neeb**, Unitary highest weight modules of locally affine Lie algebras; **P. Senesi**, Finite-dimensional representation theory of loop algebras: A survey; **Y. Yoshii**, Locally extended affine root systems.

Contemporary Mathematics, Volume 506

February 2010, approximately 303 pages, Softcover, ISBN: 978-0-8218-4507-3, LC 2009037983, 2000 *Mathematics Subject Classification:* 17B10, 17B37, 17B65, 17B67, **AMS members US$71**, List US$89, Order code CONM/506



Regular Subgroups of Primitive Permutation Groups

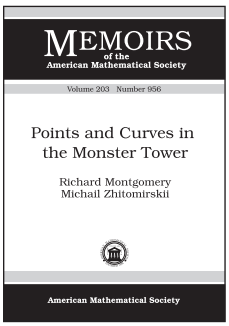
Martin W. Liebeck, *Imperial College, London, England*, **Cheryl E. Praeger**, *University of Western Australia, Crawley, Australia*, and **Jan Saxl**, *University of Cambridge, England*

Contents: Introduction; Preliminaries; Transitive and antiflag transitive linear groups; Subgroups of classical groups transitive on

subspaces; Proof of Theorem 1.1: Linear groups; Proof of Theorem 1.1: Unitary groups; Proof of Theorem 1.1: Orthogonal groups in odd dimension; Proof of Theorem 1.1: Orthogonal groups of minus type; Proof of Theorem 1.1: Some special actions of symplectic and orthogonal groups; Proof of Theorem 1.1: Remaining symplectic cases; Proof of Theorem 1.1: Orthogonal groups of plus type; Proof of Theorem 1.1: Exceptional groups of Lie type; Proof of Theorem 1.1: Alternating groups; Proof of Theorem 1.1: Sporadic groups; Proof of Theorem 1.4 and Corollary 1.3; The tables in Theorem 1.1; References.

Memoirs of the American Mathematical Society, Volume 203, Number 952

January 2010, 74 pages, Softcover, ISBN: 978-0-8218-4654-4, LC 2009041395, 2000 *Mathematics Subject Classification:* 20B15, 05C25, **Individual member US$38**, List US$64, Institutional member US$51, Order code MEMO/203/952



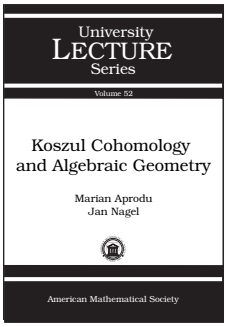
Points and Curves in the Monster Tower

Richard Montgomery, *University of California, Santa Cruz, CA*, and **Michail Zhitomirskii**, *Technion–Israel Institute of Technology, Haifa, Israel*

Contents: Introduction; Prolongations of integral curves. Regular, vertical, and critical curves and points; RVT classes. RVT codes of plane curves. RVT and Puiseux; Monsterization and Legendrization. Reduction theorems; Reduction algorithm. Examples of classification results; Determination of simple points; Local coordinate systems on the Monster; Prolongations and directional blow-up. Proof of Theorems A and B; Open questions; Appendix A. Classification of integral Engel curves; Appendix B. Contact classification of Legendrian curves; Appendix C. Critical, singular and rigid curves; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 203, Number 956

January 2010, 137 pages, Softcover, ISBN: 978-0-8218-4818-0, LC 2009041682, 2000 *Mathematics Subject Classification:* 58A30; 58A17, 53A55, 58K55, **Individual member US$43**, List US$72, Institutional member US$58, Order code MEMO/203/956



Koszul Cohomology and Algebraic Geometry

Marian Aprodu, *Institute of Mathematics 'Simion Stoilow' of the Romanian Academy, Bucharest, Romania*, and **Jan Nagel**, *Université de Bourgogne, Dijon, France*

The systematic use of Koszul cohomology computations in algebraic geometry can be traced back to the foundational work of Mark Green in the 1980s. Green connected classical results concerning the ideal of a projective variety with vanishing theorems for Koszul cohomology. Green and Lazarsfeld also stated two conjectures that relate the Koszul cohomology of algebraic curves with the existence of special divisors on the curve. These conjectures became an important guideline for future research. In the intervening years, there has been a growing interaction between Koszul cohomology and algebraic geometry. Green and Voisin applied Koszul cohomology to a number of Hodge-theoretic problems, with remarkable success. More recently, Voisin achieved a breakthrough by proving Green's conjecture for general curves; soon afterwards, the Green-Lazarsfeld conjecture for general curves was proved as well.

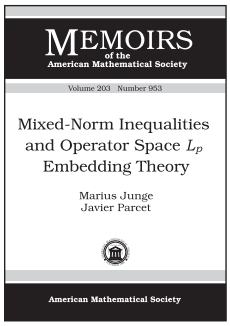
This book is primarily concerned with applications of Koszul cohomology to algebraic geometry, with an emphasis on syzygies of complex projective curves. The authors' main goal is to present Voisin's proof of the generic Green conjecture, and subsequent refinements. They discuss the geometric aspects of the theory and a number of concrete applications of Koszul cohomology to problems in algebraic geometry, including applications to Hodge theory and to the geometry of the moduli space of curves.

Contents: Basic definitions; Basic results; Syzygy schemes; The conjectures of Green and Green-Lazarsfeld; Koszul cohomology and the Hilbert scheme; Koszul cohomology of a $K3$ surface; Specific versions of the syzygy conjectures; Applications; Bibliography; Index.

University Lecture Series, Volume 52

January 2010, 125 pages, Softcover, ISBN: 978-0-8218-4964-4, LC 2009042378, 2000 *Mathematics Subject Classification:* 14H51, 14C20, 14H60, 14J28, 13D02, 16E05, **AMS members US$31**, List US$39, Order code ULECT/52

Analysis



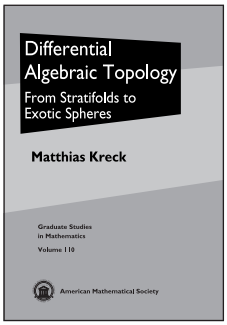
Mixed-Norm Inequalities and Operator Space L_p Embedding Theory

Marius Junge, *University of Illinois at Urbana-Champaign, IL*, and **Javier Parcet**, *Instituto de Ciencias Mathemáticas CSIC-UAM-UC3M-UCM, Madrid, Spain*

Contents: Introduction; Noncommutative integration; Amalgamated L_p spaces; An interpolation theorem; Conditional L_p spaces; Intersections of L_p spaces; Factorization of $\mathcal{J}^n_{p,q}(\mathcal{M}, \mathsf{E})$; Mixed-norm inequalities; Operator space L_p embeddings; Bibliography.

Memoirs of the American Mathematical Society, Volume 203, Number 953

January 2010, 155 pages, Softcover, ISBN: 978-0-8218-4655-1, LC 2009041393, 2000 *Mathematics Subject Classification:* 46L07, 46L09, 46L51, 46L52, 46L53, **Individual member US$44**, List US$74, Institutional member US$59, Order code MEMO/203/953



Differential Algebraic Topology

From Stratifolds to Exotic Spheres

Matthias Kreck, *Hausdorff Research Institute for Mathematics, Bonn, Germany*

This book presents a geometric introduction to the homology of topological spaces and the cohomology of smooth manifolds. The author introduces a new class of stratified spaces, so-called stratifolds. He derives basic concepts from differential topology such as Sard's theorem, partitions of unity and transversality. Based on this, homology groups are constructed in the framework of stratifolds and the homology axioms are proved. This implies that for nice spaces these homology groups agree with ordinary singular homology. Besides the standard computations of homology groups using the axioms, straightforward constructions of important homology classes are given. The author also defines stratifold cohomology groups following an idea of Quillen. Again, certain important cohomology classes occur very naturally in this description, for example, the characteristic classes which are constructed in the book and applied later on. One of the most fundamental results, Poincaré duality, is almost a triviality in this approach.

Some fundamental invariants, such as the Euler characteristic and the signature, are derived from (co)homology groups. These invariants play a significant role in some of the most spectacular results in differential topology. In particular, the author proves a special case of Hirzebruch's signature theorem and presents as a highlight Milnor's exotic 7-spheres.

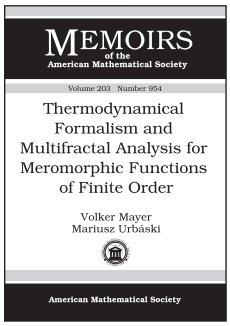
This book is based on courses the author taught in Mainz and Heidelberg. Readers should be familiar with the basic notions of point-set topology and differential topology. The book can be used for a combined introduction to differential and algebraic topology, as well as for a quick presentation of (co)homology in a course about differential geometry.

This item will also be of interest to those working in geometry and topology.

Contents: A quick introduction to stratifolds; Smooth manifolds revisited; Stratifolds; Stratifolds with boundary: c-stratifolds; $\mathbb{Z}/2$-homology; The Mayer-Vietoris sequence and homology groups of spheres; Brouwer's fixed point theorem, separation, invariance of dimension; Homology of some important spaces and the Euler characteristic; Integral homology and the mapping degree; A comparison theorem for homology theories and CW-complexes; Künneth's theorem; Some lens spaces and quaternionic generalizations; Cohomology and Poincaré duality; Induced maps and the cohomology axioms; Products in cohomology and the Kronecker pairing; The signature; The Euler class; Chern classes and Stiefel-Whitney classes; Pontrjagin classes and applications to bordism; Exotic 7-spheres; Relation to ordinary singular (co)homology; Appendix A: Constructions of stratifolds; Appendix B: The detailed proof of the Mayer-Vietoris sequence; Appendix C: The tensor product; Bibliography; Index.

Graduate Studies in Mathematics, Volume 110

March 2010, approximately 215 pages, Hardcover, ISBN: 978-0-8218-4898-2, 2000 *Mathematics Subject Classification:* 55-01, 55R40, 57-01, 57R20, 57R55, **AMS members US$44**, List US$55, Order code GSM/110



Thermodynamical Formalism and Multifractal Analysis for Meromorphic Functions of Finite Order

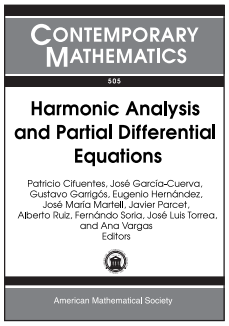
Volker Mayer, *Université de Lille I, Villeneuve d'Ascq, France*, and **Mariusz Urbański**, *University of North Texas, Denton, TX*

Contents: Introduction; Balanced functions; Transfer operator and Nevanlinna theory; Preliminaries, Hyperbolicity and distortion properties; Perron-Frobenius operators and generalized conformal measures; Finer properties of Gibbs states; Regularity of Perron-Frobenius operators and topological pressure; Multifractal analysis; Multifractal analysis of analytic families of dynamically regular functions; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 203, Number 954

January 2010, 107 pages, Softcover, ISBN: 978-0-8218-4659-9, LC 2009041681, 2000 *Mathematics Subject Classification:* 30D05, 37F10, **Individual member US$41**, List US$68, Institutional member US$54, Order code MEMO/203/954

Differential Equations



Harmonic Analysis and Partial Differential Equations

Patricio Cifuentes, **José García-Cuerva**, **Gustavo Garrigós**, **Eugenio Hernández**, **José María Martell**, **Javier Parcet**, **Alberto Ruiz**, **Fernándo Soria**, **José Luis Torrea**, and **Ana Vargas**, *Universidad Autónoma de Madrid, Spain*, editors

This volume contains the proceedings of the 8th International Conference on Harmonic Analysis and Partial Differential Equations, held in El Escorial, Madrid, Spain, on June 16–20, 2008.

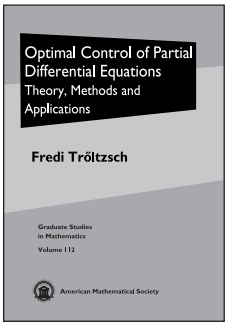
Featured in this book are papers by Steve Hoffmann and Carlos Kenig, which are based on two mini-courses given at the conference. These papers present topics of current interest, which assume minimal background from the reader, and represent state-of-the-art research in a useful way for young researchers. Other papers in this

volume cover a range of fields in Harmonic Analysis and Partial Differential Equations and, in particular, illustrate well the fruitful interplay between these two fields.

Contents: **A. Cohen**, **W. Dahmen**, and **R. DeVore**, Instance optimal decoding by thresholding in compressed sensing; **S. Hofmann**, Local $T(b)$ theorems and applications in PDE; **C. E. Kenig**, The global behavier of solutions to critical nonlinear dispersive and wave equations; **P. Auscher** and **J. M. Martell**, Weighted norm inequalities, off-diagonal estimates and elliptic operators; **J. Bennett**, Heat-flow monotonicity related to some inequalities in euclidean analysis; **A. Carbery**, A uniform sublevel set estimate; **P. Auscher**, **A. Axelsson**, and **A. McIntosh**, On a quadratic estimate related to the Kato conjecture and boundary value problems; **C. Muscalu**, Flag paraproducts; **J. Ortega-Cerdà** and **B. Pridhnani**, The Pólya-Tchebotaröv problem; **M. T. Lacey**, **S. Petermichl**, **J. C. Pipher**, and **B. D. Wick**, Iterated Riesz commutators: A simple proof of boundedness; **G. Garrigós** and **A. Seeger**, A mixed norm variant of Wolff's inequality for paraboloids; **S. Thangavelu**, On the unreasonable effectiveness of Gutzmer's formula; **L. Vega**, Bilinear virial identities and oscillatory integrals; **E. Hernández**, **H. Šikić**, **G. Weiss**, and **E. Wilson**, On the properties of the integer translates of a square integrable function.

Contemporary Mathematics, Volume 505

February 2010, 249 pages, Softcover, ISBN: 978-0-8218-4770-1, LC 2009036374, 2000 *Mathematics Subject Classification:* 35-XX, 42-XX, 47-XX, 52-XX, 53-XX, 58-XX, 65-XX, 94-XX, 30-XX, 26-XX, **AMS members US$63**, List US$79, Order code CONM/505



Optimal Control of Partial Differential Equations

Theory, Methods and Applications

Fredi Tröltzsch, *Technische Universität Berlin, Germany*
Translated by Jürgen Sprekels

Optimal control theory is concerned with finding control functions that minimize cost functions for systems described by differential equations. The methods have found widespread applications in aeronautics, mechanical engineering, the life sciences, and many other disciplines.

This book focuses on optimal control problems where the state equation is an elliptic or parabolic partial differential equation. Included are topics such as the existence of optimal solutions, necessary optimality conditions and adjoint equations, second-order sufficient conditions, and main principles of selected numerical techniques. It also contains a survey on the Karush-Kuhn-Tucker theory of nonlinear programming in Banach spaces.

The exposition begins with control problems with linear equation, quadratic cost function and control constraints. To make the book self-contained, basic facts on weak solutions of elliptic and parabolic equations are introduced. Principles of functional analysis are introduced and explained as they are needed. Many simple examples illustrate the theory and its hidden difficulties. This start to the book makes it fairly self-contained and suitable for advanced undergraduates or beginning graduate students.

Advanced control problems for nonlinear partial differential equations are also discussed. As prerequisites, results on boundedness and continuity of solutions to semilinear elliptic and parabolic equations are addressed. These topics are not yet readily available in books on PDEs, making the exposition also interesting for researchers.

Alongside the main theme of the analysis of problems of optimal control, Tröltzsch also discusses numerical techniques. The exposition is confined to brief introductions into the basic ideas in order to give the reader an impression of how the theory can be realized numerically. After reading this book, the reader will be familiar with the main principles of the numerical analysis of PDE-constrained optimization.

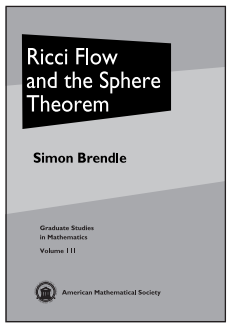
This item will also be of interest to those working in applications.

Contents: Introduction and examples; Linear-quadratic elliptic control problems; Linear-quadratic parabolic control problems; Optimal control of semilinear elliptic equations; Optimal control of semilienar parabolic equations; Optimization problems in Banach spaces; Supplementary results on partial differential equations; Bibliography; Index.

Graduate Studies in Mathematics, Volume 112

February 2010, approximately 408 pages, Hardcover, ISBN: 978-0-8218-4904-0, LC 2009037756, 2000 *Mathematics Subject Classification:* 49-01, 49K20, 35J65, 35K60, 90C48, 35B37, **AMS members US$55**, List US$69, Order code GSM/112

Geometry and Topology



Ricci Flow and the Sphere Theorem

Simon Brendle, *Stanford University, CA*

In 1982, R. Hamilton introduced a nonlinear evolution equation for Riemannian metrics with the aim of finding canonical metrics on manifolds. This evolution equation is known as the Ricci flow, and it has since been used widely and with great success, most notably in Perelman's solution of the Poincaré conjecture. Furthermore, various convergence theorems have been established.

This book provides a concise introduction to the subject as well as a comprehensive account of the convergence theory for the Ricci flow. The proofs rely mostly on maximum principle arguments. Special emphasis is placed on preserved curvature conditions, such as positive isotropic curvature. One of the major consequences of this theory is the Differentiable Sphere Theorem: a compact Riemannian manifold whose sectional curvatures all lie in the interval (1,4] is diffeomorphic to a spherical space form. This question has a long history, dating back to a seminal paper by H. E. Rauch in 1951, and it was resolved in 2007 by the author and Richard Schoen.

This text originated from graduate courses given at ETH Zürich and Stanford University, and is directed at graduate students and researchers. The reader is assumed to be familiar with basic Riemannian geometry, but no previous knowledge of Ricci flow is required.

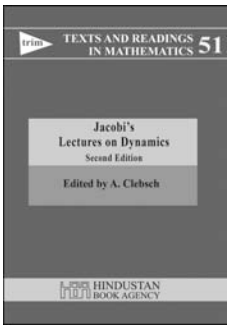
Contents: A survey of sphere theorems in geometry; Hamilton's Ricci flow; Interior estimates; Ricci flow on S^2; Pointwise curvature estimates; Curvature pinching in dimension 3; Preserved curvature conditions in higher dimensions; Convergence results in higher dimensions; Rigidity results; Convergence of evolving metrics; Results from complex linear algebra; Problems; Bibliography; Index.

Graduate Studies in Mathematics, Volume 111

February 2010, 176 pages, Hardcover, ISBN: 978-0-8218-4938-5, LC 2009037261, 2000 *Mathematics Subject Classification:* 53C20, 53C21, 53C44, **AMS members US$38**, List US$47, Order code GSM/111

New AMS-Distributed Publications

Differential Equations



Jacobi's Lectures on Dynamics

Second Edition

A. Clebsch, Editor

The name of C. G. J. Jacobi is familiar to every student of mathematics, thanks to the Jacobion determinant, the Hamilton-Jacobi equations in dynamics, and the Jacobi identity for vector fields. Best known for his contributions to the theory of elliptic and abelian functions, Jacobi is also known for his innovative teaching methods and for running the first research seminar in pure mathematics.

A record of his lectures on Dynamics given in 1842–43 at Königsberg, edited by A. Clebsch, has been available in the original German. This is an English translation. It is not just a historical document; the modern reader can learn much about the subject directly from one of its great masters.

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Contents: Introduction; The differential equations of motion; Conservation of motion of centre of gravity; The principle of conservation of 'vis viva'; Conservation of surface area; The principle of least action; Further considerations on the principle of least action—The Lagrange multipliers; Hamilton's integral and Lagrange's second form of dynamical equations; Hamilton's form of the equation of motion; The principle of the last multiplier; Survey of those properties of determinants that are used in the theory of the last multiplier; The multiplier for systems of differential equations with an arbitrary number of variables; Functional determinants. Their application in setting up the partial differential equation for the multiplier; The second form of the equation defining the multiplier. The multipliers of step wise reduced differential equations. The multiplier by the use of particular integrals; The multiplier for systems of differential equations with higher differential coefficients. Applications to a system of mass points without constraints; Examples of the search for multipliers. Attraction of a point by a fixed centre in a resisting medium and in empty space; The multiplier of the equations of motion of a system under constraint in the first Langrange form; The multiplier for the equations of motion of a constrained system in Hamiltonian form; Hamilton's partial differential equation and its extension to the isoperimetric problem; Proof that the integral equations derived from a complete solution of Hamilton's partial differential equation actually satisfy the system of ordinary differential equations. Hamilton's equation for free motion; Investigation of the case in which t does not occur explicitly; Lagrange's method of integration of first order partial differential equations in two independent variables. Application to problems of mechanics which depend only on two defining parameters. The free motion of a point on a plane and the shortest line on a surface; The reduction of the partial differential equation for those problems in which the principle of conservation of centre of gravity holds; Motion of a planet around the sun—Solution in polar coordinates; Solution of the same problem by introducing the distances of the planet from two fixed points; Elliptic coordinates; Geometric significance of elliptic coordinates on the plane and in space. Quadrature of the surface of an ellipsoid. Rectification of its lines of curvature; The shortest line on the tri-axial ellipsoid. The problem of map projection; Attraction of a point by two fixed centres; Abel's theorem; General investigations of the partial differential equations of the first order. Different forms of the integrability conditions; Direct proof of the most general form of the integrability condition. Introduction of the function H, which set equal to an arbitrary constant determines the p as functions of the q; On the simultaneous solutions of two linear partial differential equations; Application of the preceding investigation to the integration of partial differential equations of the first order, and in particular, to the case of mechanics. The theorem on the third integral derived from two given integrals of differential equations of dynamics; The two classes of integrals which one obtains according to Hamilton's method for problems of mechanics. Determination of the value of (φ, ψ) for them; Perturbation theory. Supplement.

Hindustan Book Agency

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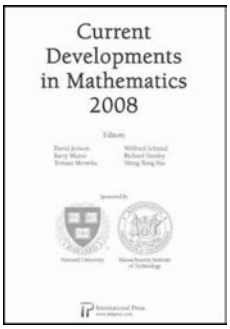
General and Interdisciplinary



Current Developments in Mathematics, 2008

Barry Mazur, **Wilfried Schmid**, and **Shing-Tung Yau**, *Harvard University, Cambridge, MA*, and **David Jerison**, **Tomasz Mrowka**, and **Richard P. Stanley**, *Massachusetts Institute of Technology, Cambridge, MA*, Editors

The Current Developments in Mathematics (CDM) conference is an annual seminar, jointly hosted by Harvard University and the Massachusetts Institute of Technology, devoted to surveying the most recent developments in mathematics. In choosing speakers, the hosts take a broad look at the field of geometry and select geometers who transcend classical perceptions within their field. All speakers are prominent specialists in the fields of algebraic geometry, mathematical physics, and other areas.

A publication of International Press. Distributed worldwide by the American Mathematical Society.

Contents: M. Dafermos, The evolution problem in general relativity; **L. Lovász**, Very large graphs; **J. Lurie**, On the classification of topological field theories; **W. H. Meeks III** and **J. Pérez**, Properly embedded minimal planar domains with infinite topology are Riemann minimal examples; **K. Ono**, Unearthing the visions of a master: Harmonic Maass forms and number theory.

International Press

October 2009, 454 pages, Softcover, ISBN: 978-1-57146-139-1, 2000 *Mathematics Subject Classification:* 53C44, **AMS members US$47**, List US$59, Order code INPR/84

Hans Freudenthal: Selecta

Tonny A. Springer and **Dirk van Dalen**, *Utrecht University, The Netherlands*, Editors

Hans Freudenthal (1905–1990) was a Dutch mathematician, born in Luckenwalde, Germany. His scientific activities were of a rich variety. Enrolling at the University of Berlin as a student in the 1920s, he followed in the footsteps of his teachers and became a topologist, but with a lively interest in group theory. After a long journey through the realm of mathematics, working on almost all subjects that drew his interest, he turned toward the practical and methodological issues of the didactics of mathematics.

The present Selecta are devoted to Freudenthal's mathematical oeuvre. They contain a selection of his major contributions, including his fundamental contributions to topology such as the foundation of the theory of ends (in the thesis of 1931) as well as the introduction (in 1937) of the suspension and its use in stability results for homotopy groups of spheres. In group theory there is work on topological groups (of the 1930s) and on various aspects of the theory of Lie groups, such as a paper on automorphisms of 1941. From the later work of the 1950s and 1960s, papers on geometric aspects of Lie theory (geometries associated to exceptional groups, space problems) have been included.

Freudenthal's versatility is further demonstrated by selections from his foundational and historical work: papers on intuitionistic logic and topology, a paper on axiomatic geometry reappraising Hilbert's Grundlagen, and a paper summarizing his development of Lincos, a universal ("cosmic") language.

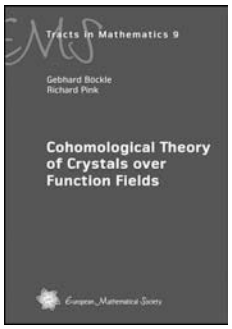
A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: Biographical note; Ph.D. students of Hans Freudenthal; Über die Enden topologischer Räume und Gruppen; Einige Sätze über topologische Gruppen; Topologische Gruppen mit genügend vielen fastperiodischen Funktionen; Teilweise geordnete Moduln; Über die Friedrichssche Fortsetzung halbbeschränkter Hermitescher Operatoren; Zum intuitionistischen Raumbegriff; Zur intuitionistischen Deutung logischer Formelnm; Entwicklungen von Räumen und Gruppen; Alexanderscher und Gordonscher Ring und ihre Isomorphie; Zum Hopfschen Umkehrhomomorphismus; Über die Klassen der Sphärenabbildungen. I. Große Dimensionen; Die Topologie der Lieschen Gruppen als algebraisches Phänomen; Simplizialzerlegungen von beschränkter Flachheit; Über die Enden diskreter Räume und Gruppen; Oktaven, Ausnahmegruppen und Oktavengeometrie; Sur le groupe exceptionnel E_7; Sur des invariants caractéristiques des groupes semi-simples; Sur le groupe exceptionnel E_8; Zur ebenen Oktavengeometrie; Beziehungen der E_7 und E_8 zur Oktavenebene I; Beziehungen der $\mathbb{E}_7$ und $\mathbb{E}_8$ zur Oktavenebene II–XI; Zur Berechnung der Charaktere der halbeinfachen Lieschen Gruppen I–III; Neuere Fassungen des Riemann–Helmholtz–Lieschen Raumproblems; Grundzüge eines Entwurfes einer kosmischen Verkehrssprache; Zur Geschichte der Grundlagen der Geometrie; Zur Klassifikation der einfachen Lie–Gruppen; Symplektische und metasymplektische Geometrien; Bericht über die Theorie der Rosenfeldschen elliptischen Ebenen; Das Helmholtz-Liesche Raumproblem bei indefiniter Metrik; Lie groups in the foundation of geometry; Comments; Acknowledgements; Bibliography.

Heritage of European Mathematics, Volume 3

October 2009, 661 pages, Hardcover, ISBN: 978-3-03719-058-6, 2000 *Mathematics Subject Classification:* 00B60, 01A75, **AMS members US$150**, List US$188, Order code EMSHEM/3

Number Theory



Cohomological Theory of Crystals over Function Fields

Gebhard Böckle, *University of Duisburg-Essen, Germany*, and **Richard Pink**, *ETH-Zürich, Switzerland*

This book develops a new cohomological theory for schemes in positive characteristic p and it applies this theory to give a purely algebraic proof of a conjecture of Goss on the rationality of certain L-functions arising in the arithmetic of function fields. These L-functions are power series over a certain ring A, associated to any family of Drinfeld A-modules or, more generally, of A-motives on a variety of finite type over the finite field $\mathbb{F}_p$. By analogy to the Weil conjecture, Goss conjectured that these L-functions are in fact rational functions. In 1996 Taguchi and Wan gave a first proof of Goss's conjecture by analytic methods à la Dwork.

The present text introduces A-crystals, which can be viewed as generalizations of families of A-motives, and studies their cohomology. While A-crystals are defined in terms of coherent sheaves together with a Frobenius map, in many ways they actually behave like constructible ètale sheaves. A central result is a Lefschetz trace formula for L-functions of A-crystals, from which the rationality of these L-functions is immediate. Beyond its application to Goss's L-functions, the theory of A-crystals is closely related to the work of Emerton and Kisin on unit root F-crystals, and it is essential in an Eichler – Shimura type isomorphism for Drinfeld modular forms as constructed by the first author.

The book is intended for researchers and advanced graduate students interested in the arithmetic of function fields and/or cohomology theories for varieties in positive characteristic. It assumes a good working knowledge in algebraic geometry as well as familiarity with homological algebra and derived categories, as provided by standard textbooks. Beyond that the presentation is largely self contained.

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: Introduction; Categorical preparations; Fundamental concepts; Functors; Derived categories; Derived functors; Flatness; Naive L-functions; Crystalline L-functions; Étale cohomology; Bibliography; List of notation; Index.

EMS Tracts in Mathematics, Volume 9

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