Book reviews

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BOOK REVIEWS

S. Albeverio, M. Demuth, E. Schrohe, B.-W. Schulze (eds.): NONLINEAR HYPERBOLIC EQUATIONS, SPECTRAL THEORY, AND WAVELET TRANSFORMATIONS. A Volume of Advances in Partial Differential Equations 2003, Operator Theory Advances and Applications, Vol. 145, 446 pages, hardcover, ISBN 3-7643-2168-7, CHF 198.–/EUR 128.–.

This volume mostly consists of extensive articles originating from the work of the research group "Partial Differential Equations and Complex Analysis" at the University of Potsdam, i.e., P. Popivanov (Sofia), F. Hirosawa (Tsukuba) and M. Reissig (Freiberg), M. Dreher (Freiberg), A. Noll (Darmstadt), M. Holschneider (Potsdam) and B. Nazaret (Lyon). It is concentrated on recent developments in non-linear hyperbolic equations. The singularities of solutions of several classes of nonlinear partial differential equations are investigated. Applications concern the Monge-Ampère equation, quasilinear systems arising in fluid mechanics as well as integro-differential equations for media with memory. An article on $L^p - L^q$ decay estimates for Klein-Gordon equations with time-dependent coefficients explains, in particular, the influence of the relation between the mass term and the wave propagation speed. Some questions of local existence of solutions, blow-up criteria, and C^∞ regularity for quasilinear weakly hyperbolic equations are also addressed. The spectral theory of semibounded operators is another contribution, providing upper and lower bounds for the bottom eigenvalue as well as an upper bound for the second eigenvalue in terms of capacitary estimates. The wavelet transformation and the Gabor transformation are two distinguished tools in signal processing with a wide range of applications. The result presented here concerns the construction of an interpolating family between them. The volume is completed by other four papers concerning Weyl-Hörmander pseudo-differential calculus on manifolds, singular fibrations, analytic torsion forms and regularization of secondary characteristic classes and unusual index formulas for operator-valued symbols. The interested readership are specialists in the respective fields.

Ivan Straškraba, Praha

P. Chrusciel, H. Friedrich (eds.): THE EINSTEIN EQUATIONS AND THE LARGE SCALE BEHAVIOUR OF GRAVITATIONAL FIELDS. 50 Years of the Cauchy Problem in General Relativity. Birkhäuser, Basel, 2004, 496 pages, ISBN 3-7643-7130-7, EUR 98.–.

In 1952 Yvonne Choquet-Bruhat proved local existence of solutions to the Cauchy problem for the Einstein equations, making thus the fundamental breakthrough in the field. Based on the results of this paper, the initial value formulation of the theory became one of the most important methods for constructing and studying solutions of the Einstein equations.

To commemorate the fiftieth birthday of the local existence theorem a Cargese Summer School "50 years of the Cauchy problem", where participants could learn about recent progress in the field from the leading experts, was organized. This volume is partially based on the talks given there and some supporting material, audio and computer video files from several lectures can be found on the enclosed DVD.

The book contains introductory chapters as well as surveys written by the foremost researchers in the field. Some of the topics covered are the constraint equations, the global

existence problem in general relativity, smoothness at null infinity, the Penrose inequality, status quo and open problems in numerical relativity etc.

The authors made all effort to present the topics in a pedagogical and accessible way and thus not only young researchers but also the graduate students in relativity and related areas can profit from the access to the recent results in this field.

Vojtěch Pravda, Praha

P. Cannarsa, C. Sinestrari: SEMICONCAVE FUNCTIONS, HAMILTON-JACOBI EQUATIONS, AND OPTIMAL CONTROL. Progress in Nonlinear Differential Equations and Applications, Vol. 58, Birkhäuser, Boston, 2004, ix+304 pages, ISBN 0-8176-4804-3, CHF 224.–/EUR 142.–.

Semiconcavity is a natural extension of the concept of concavity that retains most of the good properties known in the convex analysis but arises in a wider range of applications. The book presents a comprehensive exposition of the theory of semiconcave functions as well as of its applications, primarily to control and control-related problems.

Chapter 1 is introductory to the whole text; it may be extremely useful as a source to teach a short course on calculus of variations. In Chapters 2, 3, and 4, general theory of semiconcave functions is developed without aiming at specific applications (Chapter 4, devoted to singularities, could be omitted at the first reading). The following two Chapters deal mostly with the output towards the PDE's; the Hamilton-Jacobi equations (Chapter 5) and the calculus of variations, where sharp results are obtained for solutions to certain classes of equations. A direct link to dynamic optimization is provided in Chapters 6 and 7, where finite time horizon optimal control problems and optimal exit time problems are considered.

The exposition is self-contained, which is extremely useful in the present case when prerequisites from numerous topics like convex analysis, nonsmooth analysis, or viscosity solutions, are needed. The book will be very useful to students (and teachers!) of related subjects and to researchers working in control and modern PDE theory.

Bohdan Maslowski, Praha

Victor Palamodov: RECONSTRUCTIVE INTEGRAL GEOMETRY. Birkhäuser, Basel, 2004, xii+164 pages, ISBN 3-7643-7129-3, EUR 68.–.

The book is based on a lecture course read at the Tel Aviv University and on several publications of the author concerned with integral geometry and its applications. The covered part of integral geometry is the reconstruction of functions in real affine or projective spaces from the values of their integrals over hyperplanes, spheres and lines in particular.

In the introductory chapter, a short overview of distributions and Fourier transform is carried out. The other chapters are devoted to Radon and Funk transforms and their inversions, to the reconstructions from line integrals, further to flat integral and spherical transforms and, finally, to algebraic integral transforms. The relations of spherical and algebraic integral transforms to partial differential equations are also covered. The last chapter entitled Notes contains references and short comments concerning applications of the theory presented to practical problems in radiology, radio astronomy, electron microscopy, seismic and X-ray tomography, gamma and positron radiography etc.

The book is a concise mathematical treatment of a rather broad range of topics related to integral transforms and will be appreciated by researchers in pure and applied mathematics and in the image and signal reconstructions.

Ivan Saxl, Praha

G. P. Galdi, J. G. Heywood, R. Rannacher (eds.): CONTRIBUTIONS TO CURRENT CHALLENGES IN MATHEMATICAL FLUID MECHANICS. Advances in Mathematical Fluid Mechanics, Birkhäuser, Basel, viii+151 pages, ISBN 3-7643-7104-8, EUR 78.–.

The volume consists of five research articles concerning the mathematical theory of the Navier-Stokes equations for compressible and incompressible fluids. In the first (by A. Byriuk), the Cauchy problem for a multidimensional Burgers type equation with periodic boundary condition is considered. Upper and lower bounds for derivatives of solutions in terms of powers of the viscosity are derived and their relation to the Kolmogorov-Obukhov spectral law is established. The Navier-Stokes equations are also discussed in this context.

In the second paper (by Dongho Chae and Jihoon Lee), the global well-posedness and stability in the scale-invariant Besov spaces for modified $3D$ Navier-Stokes equations with the dissipation term Δu replaced by $(-\Delta)^\alpha u$, $0 \leqslant \alpha < 5/4$) is studied. The dependence of the results on the parameter α is clarified.

The next paper (by A. Dunca, V. John and W. J. Layton) concerns Large Eddy Simulation of turbulent flows, where the Navier-Stokes equations are convolved with a filter and differentiation and convolution are interchanged, which is compensated by an extra commutation error term. It is shown that the commutation error vanishes as the averaging radius tends to zero *if and only if* the fluid and the boundary exert exactly zero force on each other.

In the fourth article (by T. Hishida), the nonstationary Stokes and Navier-Stokes flows in aperture domains are tackled. The $L^q - L^r$ estimates of the Stokes semigroup are developed and applied to the Navier-Stokes equations initial-value problem. As a result, the global existence of a unique strong solution satisfying a vanishing flux condition and a decay as $t \to \infty$ are established.

Finally, in the last paper (by T. Leinavičienė and K. Pileckas), steady compressible Navier-Stokes equations with zero velocity condition at infinity are studied in a three-dimensional exterior domain. The case of small perturbation of large potential forces is considered. By decomposition three linear problems are obtained which are solved in weighted function spaces. The results on existence, uniqueness and asymptotics for the linearized problem and for the nonlinear problem are proved.

All these research papers contain new results and may be recommended to specialists in the mathematical theory of fluids.

Ivan Straškraba, Praha

M. Kreck, W. Lück: THE NOVIKOV CONJECTURE: GEOMETRY AND ALGEBRA. Series Oberwolfach Seminars, Birkhäuser, Basel, 2005, ISBN 3-7643-7141-2, EUR 38.–.

One of central problems of geometry is classification of manifolds. Among various invariants invented to achieve this goal, two are classical—the Stiefel-Whitney classes $w_k(M) \in H^k(M, \mathbb{Z}/2)$ and the Pontrjagin classes $p_k(M) \in H^{4k}(M, \mathbb{Z})$. While the Stiefel-Whitney classes are invariants of the homotopy type of the manifold M, the Pontrjagin classes are diffeomorphism invariants only.

The Novikov conjecture states, roughly speaking, that certain very special linear combinations of the Pontrjagin classes are still homotopy invariant. More specifically, Novikov conjectured that the expression $\langle f^*(x) \cup L_i(M), [M] \rangle \in \mathbb{Q}$, where x in an element in the cohomology of the classifying space BG of a group G, $f\colon M \to BG$ a continuous map, and $L_i(M)$ the ith Hirzebruch polynomial of the manifold M, is homotopy invariant in an appropriate sense. This conjecture is a profound generalization of the classical Hirzebruch's signature theorem.

The book contains proofs of various special cases of the Novikov conjecture that have not been proved yet in full generality, as well as proofs of some related conjectures and statements. It is addressed to students and researchers interested in manifolds and related fields. It assumes a solid preliminary knowledge of manifolds, vector bundles, (co)homology and characteristic classes.

Martin Markl, Praha

M. A. Kaashoek, S. Seatzu, C. van der Mee (eds.): RECENT ADVANCES IN OPERATOR THEORY AND ITS APPLICATIONS. The Israel Gohberg Anniversary Volume, Operator Theory, Advances and Applications, Vol. 160, Birkhaüser, Basel, 2005, CHF 278.–.

The book contains selected papers which are related to lectures presented at the 14th International Workshop on Operator Theory and its Applications (IWOTA 2003) held at the University of Calgary, Italy, June 2005.

The volume contains more than 20 research papers concerning a wide variety of topics in modern operator theory and applications. It includes papers on the structure of operators, spectral theory, multivariable operator theory, pseudo-differential and integral operators and numerical methods for solving integral equations. Covered are also the mathematical system theory, Toeplitz systems and interpolation problems.

The book is dedicated to Israel Gohberg, the president of the IWOTA steering committee, on the occasion of his 75th birthday.

Vladimír Müller, Praha

O. Calin, D.-Ch. Chang: GEOMETRIC MECHANICS ON RIEMANNIAN MANIFOLDS, APPLICATIONS TO PARTIAL DIFFERENTIAL EQUATIONS. Birkhäuser, 2005, xv+278 pages, hardcover, ISBN 0-8176-4354-0, EUR 83.46.

The book represents a beautiful combination of several branches of mathematics concentrated around Lagrangian and Hamiltonian formalism of mechanics. These branches are differential geometry, calculus of variations and elliptic and parabolic partial differential equations. The authors assume that the reader is, at least to a certain extent, familiar with the basic physical principles. On the other hand, they included an introductory chapter where they explain the necessary notions of differential geometry. Their presentation is at first the invariant one, but they add always also the relevant coordinate expression. This combination of the invariant and the coordinate technique we can find then throughout the whole book. The main feature of the book is the geometric approach to variational principles of mechanics, and especially to partial differential equations. The geometric methods presented by the authors represent often new and simpler ways of solving the relevant equations. On the other hand, several results of differential geometry appear here in an interesting physical context. In the text of the book the reader can find many recommendations for further reading, and at the end of every chapter there are exercises. The book is very nicely and clearly written and I expect it will be interesting both for mathematicians and physicists. You are invited into the world of quantum harmonic oscillators, minimal surfaces, Schrödinger's, Einstein's and Newton's equations etc.

Jiří Vanžura, Brno

Radu Zaharopol: INVARIANT PROBABILITIES OF MARKOV-FELLER OPERATORS AND THEIR SUPPORTS. Frontiers in Mathematics, Birkhäuser, Basel, 2005, xiii+108 pages, ISBN 3-7643-7134-X, EUR 29.96.

The new Birkhäuser series *Frontiers in Mathematics* "is designed to be a repository for up-to-date research results which have been prepared for wider audience". Radu Zaharopol's slim monograph qualifies for such a series perfectly. Although the core of the book are hitherto unpublished results of the author, the presentation is careful, proofs are complete and detailed, and prerequisites for reading the book are rather modest.

The monograph is divided into four chapters. In the first of them, the object to be studied throughout the book—Feller Markov operators on locally compact separable metric state spaces and their invariant probability measures—are introduced. Moreover, several basic results on ergodic theory of Markov operators are recalled, mostly with proofs. Chapter 2 is devoted to decompositions of invariant measures of Krylov-Bogolyubov-Yosida type, these decompositions being a very important tool in subsequent chapters. "Formulae" for supports of invariant measures of uniquely ergodic Feller Markov operators, expressing the supports in terms of (generalized) orbits of suitable starting points, are proved in the third chapter. Finally, in Chapter 4 unique ergodicity is deduced from properties of supports of invariant measures for a narrower class of equicontinuous Markov operators; the developed techniques also yield mean ergodic theorems of several types.

The author's approach is purely operator-theoretic, the Markov chain corresponding to the transition operator under study is never used. At the same time, the author relies on elementary tools whenever possible and most of the employed results which are usually not included in introductory courses of measure theory or functional analysis are given a proof in the book, the few remaining exceptions being at least precisely stated. No particular class of Markov operators is discussed in the book, but there are many examples illustrating the scope of the theorems and sharpness of their hypotheses. This makes the book attractive not only for specialists, but for all who want to get acquainted with an interesting and less standard approach to Markov operators.

Bohdan Maslowski, Praha

T. Andreescu, Z. Feng: 103 TRIGONOMETRY PROBLEMS—FROM THE TRAINING OF THE USA IMO TEAM. Birkhäuser, Boston, 2005, 214 pages, ISBN 0-8176-4334-6, EUR 51.36.

This book is intended for students and all people who are interested in solving advanced problems of school mathematics. (IMO stands for International Mathematical Olympiad.)

Some fundamental ideas of trigonometry are translated at the beginning of the first chapter. The definitions of a function, of the trigonometric functions (including secant and cosecant) and relations between them are mentioned here. The trigonometric functions are defined in a rightangle triangle. Then some equations are proven which connect the parameters of a general triangle (e.g. the law of sines, the law of cosines, Ptolemy's, Ceva's and Menelaus's theorem etc.).

The plane with a coordinate system is studied in the next part of the first chapter. The authors introduce here the concept of the vector; then the length of a vector and the operations with vectors are studied.

All these considerations are crowned by showing the connection between vectors and complex numbers in the complex plane. Operation rules for complex numbers are illustrated with the aid of the vectors. In conclusion de Moivre's formula and the formulas for $\sin n\alpha$ and $\cos n\alpha$ are mentioned.

Problems for solving are included in the second and third chapter of the book. Algebraic and geometric exercises, proofs of equalities and inequalities, problems with binomial coefficients etc. are presented in these two chapters.

The next two chapters contain solutions of the problems from the previous chapters.

Rostislav Lenker, Praha

Ole Christensen, Khadija Laghrida Christensen: APPROXIMATION THEORY—FROM TAYLOR POLYNOMIALS TO WAVELETS. Applied and Numerical Harmonic Analysis, Birkhäuser, Boston, 2004, xi+156 pages, softcover, ISBN 0-8176-3600-5, EUR 40.66.

If you are a teacher intending to design or reshape your undergraduate course on approximation theory, or if you are a student searching for an introduction to approximation theory, then you should not miss this small book.

It is organized into five chapters. Chapter 1 focuses on approximation by polynomials. It is short, lucid, and encouraging less experienced readers; its pivots are the Weierstrass theorem and the Taylor theorem. The elements of infinite series form Chapter 2. The third chapter presents the basics of the Fourier series and of the Fourier transform. Chapter 4 informs the reader about wavelets in a lively form, while the final chapter uses a little more mathematics when dealing with wavelets, frames, and Gabor systems. In Appendix A, some of the theorems presented in Chapter 2 and Chapter 3 are proved. A few important power series expansions and Fourier series are collected in Appendix B.

The book, and especially the chapters on wavelets, concentrates on motivating the reader with leading ideas rather than on technical details. The presentation is accompanied by numerous helpful graphs and illuminating examples. The style is accessible even for less advanced undergraduates. Although the book is not primarily intended as a textbook, I would not hesitate to use it in an introductory course or to recommend it as supplementary reading.

Let me add that the third, corrected and enlarged edition of this book is now available from Birkhäuser (Springer, EUR 28.–).

Jan Chleboun, Praha

A. Voigh (ed.): MULTISCALE MODELING IN EPITAXIAL GROWTH. Internat. Series of Numer. Math., Vol. 149, Birkhäuser, Basel, 2005, 237 pages, ISBN 3-7643-7208-7, EUR 98.–.

The book contains referred original papers presented in the workshop "Multiscale Modeling in Epitaxial Growth" held at the Mathematishes Forschungsinstitut Oberwolfach from January 18 to 24, 2004. It is subdivided into three parts: Atomistic models, Stop flow models, and Continuum models. Each part starts with an introductory review article.

Part 1 is devoted to classical molecular-dynamics methods and kinetic Monte Carlo Methods for simulation epitaxial crystal growth. In Part 2 several efficient numerical algorithms (the finite element method, the fast Fourier transform, the Crank-Nicolson scheme, etc.) are applied to solve partial differential equations that describe various surface morphologies. Finally, Part 3 consists of papers dealing with continuum models for surface growth.

Modeling and numerical simulation of epitaxial growth is a challenging multi-scale problem: from fully atomistic models, via semi-discrete step flow models to continuum models for the height of the growing film. The book will contribute to the ongoing discussion in the field of epitaxial growth.

Michal Křížek, Praha