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Book reviews

Dat, J.-F., Orlik, S., Rapoport, M.: *Period Domains over Finite and p-Adic Fields.* (Cambridge tracts in mathematics) XXII, 372 pp. Cambridge University Press, Cambridge New York Melbourne, 2010. £60,00

Der von Phillip Griffiths eingeführte Begriff der "Period Domains" hat seine klassischen Ursprünge beim Studium elliptischer Kurven und bestimmt dort kompakte Riemannsche Flächen. Die weitgehenden Verallgemeinerungen für endliche und p-adische Körper gehören zu den intellektuell faszinierendsten und anspruchsvollsten Konzepten des menschlichen Geistes, mit tiefliegenden Zusammenhängen zu Vermutungen beim p-adischen Langlandsprogramm, zur lokalen Langlands-Korrespondenz ℓ-adischer Darstellungen der Galoisgruppe p-adischer Körper und glatten Darstellungen p-adischer Liegruppen, zur p-adischen Hodgetheorie, zu einem von Grothendieck vermuteten und von Fontaine konstruierten mysteriösen Funktor, zu filtrierten Isokristallen und formalen Modulräumen p-teilbarer Gruppen u.v.a. Dem Leser wird hier ein Zugang zu einem zukunftsträchtigen bedeutenden und aufregenden Forschungsgebiet der letzten 15 Jahre ermöglicht. Manche Resultate wurden bereits angekündigt oder teilweise unbewiesen publiziert. Hier wird die Theorie als Ganzes mit vollständigen Beweisen angeboten, wobei es sich als sinnvoll erwies, die Grundlagen der Theorie etwas zu modifizieren. Es finden sich zahlreiche ausgearbeitete Beispiele und Querverweise zu grundlegenden Themen der algebraischen Geometrie über endlichen und p-adischen Körpern, sowie Bemerkungen zu offenen Fragen, historische Bezüge und Literaturhinweise am Ende jeden Abschnitts. Leider ist es sehr schwierig, wenn nicht unmöglich, einem größeren Leserkreis einen auch nur halbwegs adäquaten Einblick in die Tiefen und Schönheiten, Resultate und offenen Probleme dieses höchst anspruchsvollen Gebiets zu geben, das bei Kontakten mit überlegenen außerirdischen Intelligenzen auch diese sehr beeindrucken würde (im völligen Gegensatz zu vielen anderen menschlichen "Leistungen").

H. RINDLER, Wien

Vakil, N.: *Real Analysis through Modern Infinitesimals.* (Encyclopedia of Mathematics and Its Applications Vol. 140) XIX, 565 pp. Cambridge University Press, Cambridge New York Melbourne, 2011. £70,00

Dem Autor gelingt hier, wesentlich beeinflusst von Luxemburg, aber auch von seinem Lehrer Hewitt, eine hervorragende, bis ins kleinste Detail sorgfältig ausgeführte Einführung in die Nonstandard Analysis, mit allen Vorzügen eines Standardwerks. Der unvoreingenommene Leser wird Gödels Aussage, daß die Nonstandard Analysis die Analysis der Zukunft sein könnte gut nachvollziehen können. Den Einwand, daß die benötigten Grundlagen dazu formal schwieriger sind, gab es ja bereits bei der Umstellung auf den heute üblichen Zugang zur Analysis. Wer die Grundlagen versteht oder zumindest mit ihnen umgehen kann (viel mehr schaffen die meisten Mathematikstudenten ja auch bei üblichen Zugängen nicht) wird aber reich belohnt. Vieles wird konzeptuell einfacher und schlüssiger. Die Nachteile der Epsilontik (z.B. "Epsilon-Drittel-Beweise") treten nicht auf; man erkennt, daß beim üblichen Zugang viele ähnliche Beweise immer wieder auftreten, die hier vermieden bzw. abgekürzt werden können. Intuitive Argumente, wie sie z.B. Euler meisterhaft beherrschte sind exakt begründbar. Sehr hilfreich ist dabei natürlich das Transferprinzip. Aussagen über Limiten werden "klarer" indem man z.B. für konvergente Folgen unendliche Indexwerte einsetzt, unendliche Summen erweisen sich natürlich als Verallgemeinerung von endlichen. Es wird klarer, als beim Standardzugang, daß unendliche Reihen "mehr" sind als nur Limiten ihrer Partialsummen. Aussagen über Potenzreihen lassen sich auf solche über Polynome zurückführen, indem man für den Grad n eine unendlich große natürliche Zahl wählt. Definitionen wie Stetigkeit und Differenzierbarkeit werden in gewisser Hinsicht klarer und auch einfacher, vor allem im Geiste der Erfinder der Analysis. Wertvoll ist z.B. auch die Tatsache, daß es zu jeder standard reellen Zahl eine rationale Zahl gibt, die sich von dieser nur um "unendlich wenig" unterscheidet. Auch topologische Fragen werden konzeptuell einfacher, z.B. die Erkenntnis, daß kompakte Mengen "fast" endlich sind u.v.a. Neben den klassischen Resultaten finden sich hier auch viele interessante Details, die in den Standard-Analysisvorlesungen aus Platzmangel oder aus Unkenntnis weggelassen werden, hier aber ohne viel Beweisaufwand enthalten sind. Alle Kapitel enthalten ausreichend Übungsbeispiele. Inhaltsverzeichnis: Introduction, 1. Internal set theory, 2. The real number system, 3. Sequences and Series, 4. The Topology of the reals, 5. Limits and continuity, 6. Differentiation, 7. Integration, 8. Sequences and series of functions, 9. Infinite series, 10. Point set topology, 11. Metric spaces, 12. Complete metric spaces, 13. Some applications of completeness, 14. Linear operators, 15. Differential Calculus on n-dimensional Euclidean space, 16. Function space topologies, Appendix A. Vector Spaces, Appendix B. The b-adic representation of numbers, Appendix C. Finite, denumerable, and uncountable sets, Appendix D. The syntax of mathematical language.

H. RINDLER, Wien

Zehnder, E.: *Lectures on Dynamical Systems*. Hamiltonian Vector Fields and Symplectic Capacities. (EMS Textbooks in Mathematics) X, 353 pp. EMS, Zürich, 2010. EUR. 48,00

The first part of this monograph deals with discrete dynamical systems, i.e. dynamical systems generated by the iteration of a map. After the introduction of some basic notions, unstable and chaotic phenomena caused by a hyperbolic fixed point of a diffeomorphism are studied. The second part of the book is devoted to dynamical systems that are described by flows generated by smooth vector fields. The special class of Hamiltonian vector fields and the concepts of symplectic diffeomorphisms and manifolds are introduced. In a short chapter the author raises some questions before proceeding to the last part of the book devoted to the new field of symplectic topology. A special symplectic capacity, the so-called Hofer–Zehnder capacity, is constructed and applied to the problem of finding periodic orbits of a Hamiltonian vector field on a prescribed compact energy surface. All notions are carefully introduced, the proofs are presented in detail and each chapter ends with a short overview of the literature on the subject.

W. HUYER, Wien

Stein, E. M., Shakarchi, R.: *Functional Analysis*—Introduction to further topics in analysis. (Princeton Lectures in Analysis Vol. IV) XV, 423 pp. Princeton University Press, Princeton, 2011. £59,00

This is the fourth and final volume in the Princeton Lectures in Analysis. The topics selected are a bit unusual for a Functional Analysis course and form a natural continuation of the third volume: L^p spaces, distributions, connections with harmonic analysis, applications of the Baire category theorem, probability theory, Brownian motion, several complex variables, and oscillatory integrals. Functional analysis is not only studied in its own right, but also as a means of solving problems in other areas of mathematics. Hence, most chapters deal with sample applications and the book provides the reader with a nice overview of how (and where) functional analysis can be used. As with the previous volumes the material is presented in a clear but fast-paced fashion with complete proofs and an ample number of exercises/problems at the end of each chapter. Hence, while, due to the lack of some topics, it might not be sufficient as the sole basis of a course, it will nevertheless be a valuable resource for both students and teachers. There are no doubts that it will take a prominent place within the textbook literature just like the previous volumes.

G. TESCHL, Wien

Richter-Gebert, J.: *Perspectives on Projective Geometry*—A Guided Tour through Real and Complex Geometry. XXII, 571 pp. Springer, Berlin Heidelberg, 2011. EUR. 71,45

The author, known for the co-development of the interactive geometry software Cinderella, here presents a thorough introduction to real and complex, mostly plane geometry. Essentially he follows the classical approach due to Plücker and Klein but dressed up in a modern style. Besides he has digged up some almost forgotten gems, e.g. Plückers

so-called μ-trick. The contents are divided in three parts. The first is concerned with the basic concepts and tools: homogeneous coordinates, cross-ratios, projectivities and invariants, the little known determinantal approach. Part II on the one side deals with classical topics: conics (extensively) and special configurations; on the other side it contains a nice description of the objects of projective geometry in arbitrary dimensions by diagrams and tensors introduced just recently by J. F. Blinn. Part III which is entitled Measurement starts with the placement of Euclidean within projective geometry. A few chapters on Cayley–Klein geometries follow. Especially elementary hyperbolic geometry is dealt with more fully. A last chapter touches upon the usefulness of "projective thinking" for instance in quantum physics or dynamic geometry. Because of the detailed explanations—sometimes several proofs for a statement are provided—and the very readable style the book can be recommended warmly even to undergraduates as well as to computer scientists and physicists.

G. TESCHL, Wien

Cortés, V. (Editor): *Handbook of Pseudo-Riemannian Geometry and Supersymmetry*. (IRMA Lectures in Mathematics and Theoretical Physics Vol. 16) XVIII, 946 pp. European Mathematical Society, Zürich, 2010. EUR. 159,99

This is a collection of articles on various topics of current interest in pseudo-Riemannian geometry, many of them with close connections to theoretical physics. The book is intended to be accessible for both mathematicians and physicists. It features 25 articles by different authors, many of them of at least partly expository character, which are grouped into 8 parts. Apart from classical questions of pseudo-Riemannian geometry, like holonomy theory, pseudo-Riemannian symmetric spaces, and conformal geometry in indefinite signature, the articles are mainly devoted to additional geometric structures on pseudo-Riemannian manifolds. This includes special geometries and relations to supersymmetry, generalized geometries, geometries with torsion, and para-geometries.

A. CAP, Wien

Kopp, E.: *From Measures to Itô Integrals*. (AIMS Library Series) VII, 120 pp. Cambridge University Press, Cambridge New York Melbourne, 2011. £15,99

Stochastische Prozesse sind ja fundamental und von zunehmender Bedeutung in vielen Anwendungsgebieten wie in Physik, Biologie, Ingenieurs- und Finanzwissenschaften sowie der Elektronik. Dieser einem großen Leserkreis empfehlenswerte, preiswerte Band bietet, bei minimalen benötigten mathematischen Vorkenntnissen eine motivierende, wohl organisierte, mit gut integrierten Übungsbeispielen versehene Einführung in die Grundlagen der Maß-, Integrations- und Wahrscheinlichkeitstheorie. Weiters finden sich 3 zentrale Kapitel zu den Themen: Martingale in diskreter Zeit (mit fundamentalen Resultaten von Doob, Martingal-Konvergenz und einer Beweisskizze des Satzes von Radon–Nikodym), Brownsche Bewegung und Stochastische Integrale, mit den grundlegenden Resultaten von Itô und dem Optionspreismodell von Black–Scholes als Anwendung, wobei (durchaus sinnvoll) verschiedene Beweise nur skizziert bzw. weggelassen wurden. Seit Beginn dieses Jahrtausends ist ja aus einem Nachlaß

bekannt, daß der im 2. Weltkrieg gefallene Sohn des bekannten Schriftstellers Alfred Döblin, Wolfgang, ähnliche Resultate wie Itô erzielte.

H. RINDLER, Wien

Quarteroni, A., Saleri, F., Gervasio, P. (Eds.): *Scientific Computing with MATLAB and Octave* (*Third Edition*). (Texts in Computational Science and Engineering Vol. 2) XVI, 360 pp. Springer, Berlin Heidelberg, 2010. EUR. 54,95

This textbook deals with the main topics of numerical analysis (including nonlinear equations, approximation, numerical differentiation and integration, linear systems, and differential equations) and the programming environments MATLAB and Octave whose toolboxes are applied to these topics. Many examples (often arising from applications), exercises (with solutions at the end of the book), MATLAB programs (also to be downloaded from the web), and summaries of the material are included, and the presentation and layout of the book are appealing. Compared to the second edition of the book, slight changes in the presentation were made, and nearly all chapters contain some new material, particularly the last chapter about the numerical approximation of boundary-value problems.

W. HUYER, Wien

Scott, L. R.: *Numerical Analysis.* XIV, 325 pp. Princeton University Press, Princeton, 2011. £44,95

This textbook deals with the main topics of numerical analysis including linear and nonlinear (systems of) equations, interpolation, approximation, numerical quadrature, eigenvalue problems, and the numerical solution of ODEs. The material is divided into 18 quite short chapters, each of them ending with suggestions for further reading, exercises, and the solutions of selected exercises. The author regards numerical analysis as a means of introducing advanced undergraduates to many of the advanced concepts of modern analysis. Therefore the emphasis lies on theory and the presentation and analysis of computational algorithms, not on programming, and only the first chapter contains a few codes written in *octave*. Correspondingly most of the exercises are theoretical ones (i.e. proofs) and only few involve the use of a computer.

W. HUYER, Wien

O'Leary, D. P.: *Scientific Computing* with Case Studies. XVI, 383 pp. SIAM, Philadelphia, 2009. USD 92,00

This book is intended for a broad audience, for students of mathematics and students or researchers in the mathematical sciences alike. Presupposing general mathematical knowledge (analysis, linear algebra, ordinary and a little bit of partial differential equations) it describes numerical methods within the realm of the categories dense matrix computations, optimization and data fitting, Monte Carlo computations, nonlinear equations and sparse matrix computations. It does so after a chapter containing introductory material such as sensitivity analysis of algorithms, general design issues of programs, and the like. The philosophical standpoint is formulated in the preface: A master carpenter does not need to know what Newton's laws say about the force

that the hammer applies. But she does need to know how to use the hammer, when to use a ball-peen hammer instead, and what to do when things go wrong. It is in this vein that the book is written. That does imply that one simply cannot expect to find formal proofs in all cases. Yet, the author takes considerable care to motivate methods to such a degree that their gist can be grasped and possible limitations be understood in many cases. In such a way, the book presents a relatively large variety of numerical methods for solving problems. To cite just one example, by referring to simple special cases it is made plausible why interior point methods might work in the case of constrained optimization. Throughout the text, hints for further reading are sprinkled as are challenges which the reader is asked to work out by himself, either by applying more theoretical considerations or by writing (or using) MATLAB (TM) programs. A number of interesting applications from quite varied scientific, medical or technical areas are presented showing the power of the methods described. To sum up, this text does a very good job in presenting quite a lot of material in digestible a way within a volume of convenient size and will be, without doubt, helpful to the intended audience or to instructors.

H. MUTHSAM, Wien

Ogden, R. W., Steigmann, D. J. (Eds.): *Mechanics and Electrodynamics of Magneto- and Electro-Elastic Materials*. (CISM Courses and Lectures vol. 527) 266 pp. Springer, Wien New York, 2011. EUR. 130,90

This book has grown out of lectures as given at the Advanced School on Mechanics and Electrodynamics of Magneto-and Electro-elastic Materials (Udine 2009). Progress in material science seems to have spurred interest in elastomeric and polymeric materials which feel the effects of electromagnetic fields. In the first three chapters on electromagnetics in deformable solids the author (G. A. Maugin) sets out to explain basic principles. Given that the reader's acquaintance with electromagnetism, elasticity etc. are varied it is gratifying that the presentation starts from basic concepts and moves to various physical cases while, in doing so, does not develop into an encyclopedic reflection of cases (which probably would be quite possible in that area) which would easily lead to a loss of orientation. Similar remarks apply to the following two chapters (on interactions of deformable media with the electromagnetic field, including nonlinear cases). The closing chapters consider more specialized topics: membranes, numerical methods and certain elastomers. Overall, the volume provides a good introduction into the area which has a growing number of applications in the industrial domain.

H. MUTHSAM, Wien

Gustafson, St. J., Sigal, I. M.: *Mathematical Concepts of Quantum Mechanics*. Second Edition. XIII, 382 pp. Springer, Berlin Heidelberg, 2011. EUR. 64,15

This is the second edition of a readable introduction to modern mathematical topics in quantum mechanics intended for students of mathematics or physics. In comparison to the first edition the authors have tried to make the book more self-contained by adding further proofs and background material. In addition, the more advanced material

has been updated, extended, and partly reorganized. The mathematical supplements were combined in an appendix. The overall style has not changed and with the extra background material it is now even better suited as the basis of a graduate course.

G. TESCHL, Wien

Sakmann, K.: *Many-Body Schrödinger Dynamics of Bose–Einstein Condensates*. (Springer Theses Recognizing Outstanding Ph.D. Research) XII, 130 pp. Springer, Berlin Heidelberg, 2011. EUR. 106,95

The present Ph.D. thesis presents some advances on the numerical solution of the time-dependent many-body Schrödinger equation in connection with Bose–Einstein condensates. As one of the main results it is demonstrated that for a bosonic Josephson junction neither the Gross–Pitaevskii nor the Bose–Hubbard approximation give a satisfactory description. Moreover, it is shown how quantum mechanical lattice models of condensed matter physics based on Wannier functions can be optimized variationally.

G. TESCHL, Wien

Ringström, H.: *The Cauchy Problem in General Relativity*. (ESI Lectures in Mathematics and Physics) XIII, 294 pp. European Mathematical Society, Zürich, 2009. EUR. 51,09

For the larger part of its history, general relativity was studied as a geometric theory neglecting its PDE-aspects. In fact it was Yvonne Choquet-Bruhat in 1952 who established the formulation of Einstein equations as an initial value problem by proving a local existence result. However, diffeomorphism invariance of the theory makes it a formidable problem to go from local existence to the existence of a maximal development. So it took another almost 20 years until the existence of a unique so-called maximal globally hyperbolic development was proved again by Choquet-Bruhat together with Robert Geroch. Since then but especially during the last 15 years the focus of research on Einstein's equations has shifted to the initial value point of view. These results and a self-contained account on their proofs lie at the heart of the present book. Presuming only some mild knowledge from analysis and differential geometry it collects the necessary background from PDE-theory (in particular, symmetric hyperbolic systems, linear and non-linear wave equations) as well as on Lorentzian geometry (including recent results on characterizations of global hyperbolicity by Bernal and Sanchez). The initial value formulation of general relativity is presented in detail and the above mentioned existence results are proven with great care. In a final part the author discusses pathologies and the strong cosmic censorship hypothesis. This well-written book fills a real gap in the current literature on general relativity by combining both the geometric and the PDE-aspects of the theory into one self-contained monograph.

R. STEINBAUER, Wien

Forst, W., Hoffmann, D.: *Optimization*—Theory and Practice. (Springer Undergraduate Texts in Mathematics and Technology) XVIII, 402 pp. Springer, New York, 2010. EUR. 65,95

This textbook contains the central topics of finite-dimensional continuous optimization: optimality conditions, unconstrained, linearly constrained and nonlinearly con-

strained optimization, interior-point methods for linear optimization, semidefinite optimization, and a short chapter on global optimization. In addition, the reader is introduced to the optimization tools of *Maple* and *Matlab* already in the introduction, and an appendix lists the functions of the *Matlab* Optimization Toolbox, introduces SeDuMi (a *Matlab*-based free software package for linear optimization over self-dual cones; an acronym for "self-dual minimization") and gives a short description of the *Maple* optimization tools. The theory and the main algorithms are presented and accompanied by examples from different areas of application, also sometimes including the use of *Maple* or *Matlab*, and occasionally a *Matlab* program for an algorithm is presented. More than 100 theoretical and practical exercises at the end of the chapters complement the book.

W. HUYER, Wien