

Composition Operators And Classical Function Theory Universitext Universitext Tracts In Mathematics

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Journal of Operator Theory

Composition Operators on Hardy-Orlicz Spaces

The study of composition operators lies at the interface of analytic function theory and operator theory. *Composition Operators on Spaces of Analytic Functions* synthesizes the achievements of the past 25 years and brings into focus the broad outlines of the developing theory. It provides a comprehensive introduction to the linear operators of composition with a fixed function acting on a space of analytic functions. This new book both highlights the unifying ideas behind the major theorems and contrasts the differences between results for related spaces. Nine chapters introduce the main analytic techniques needed, Carleson measure and other integral estimates, linear fractional models, and kernel function techniques, and demonstrate their application to problems of boundedness, compactness, spectra, normality, and so on, of composition operators. Intended as a graduate-level textbook, the prerequisites are minimal. Numerous exercises illustrate

and extend the theory. For students and non-students alike, the exercises are an integral part of the book. By including the theory for both one and several variables, historical notes, and a comprehensive bibliography, the book leaves the reader well grounded for future research on composition operators and related areas in operator or function theory.

Linear Chaos

Mathematics is a poem. It is a lucid, sensual, precise exposition of beautiful ideas directed to specific goals. It is worthwhile to have as broad a cross-section of mankind as possible be conversant with what goes on in mathematics. Just as everyone knows that the Internet is a powerful and important tool for communication, so everyone should know that the Poincaré conjecture gives us important information about the shape of our universe. Just as every responsible citizen realizes that the mass-production automobile was pioneered by Henry Ford, so everyone should know that the P/NP problem has implications for security and data manipulation that will affect everyone. This book endeavors to tell the story of the modern impact of mathematics, of its trials and triumphs and insights, in language that can be appreciated by a broad audience. It endeavors to show what mathematics means for our lives, how it impacts all of us, and what new thoughts it should cause us to entertain. It introduces new vistas of mathematical ideas and shares the excitement of new ideas freshly minted. It discusses the significance and impact of these ideas, and gives them meaning that will travel well and cause people to reconsider their place in the universe. Mathematics is one of mankind's oldest disciplines. Along with philosophy, it has shaped the very modus of human thought. And it continues to do so. To be unaware of modern mathematics is to miss out on a large slice of life. It is to be left out of essential modern developments. We want to address this point, and do something about it. This is a book to make mathematics exciting for people of all interests and all walks of life. Mathematics is exhilarating, it is ennobling, it is uplifting, and it is fascinating. We want to show people this part of our world, and to get them to travel new paths.

Banach Spaces of Analytic Functions

Lectures on Hyperbolic Geometry

It is commonly believed that chaos is linked to non-linearity, however many (even quite natural) linear dynamical systems exhibit chaotic behavior. The study of these systems is a young and remarkably active field of research, which has seen many landmark results over the past two decades. Linear dynamics lies at the crossroads of several areas of mathematics including operator theory, complex analysis, ergodic theory and partial differential equations. At the same time its basic ideas can be easily understood by a wide audience. Written by two renowned specialists, Linear Chaos provides a welcome

introduction to this theory. Split into two parts, part I presents a self-contained introduction to the dynamics of linear operators, while part II covers selected, largely independent topics from linear dynamics. More than 350 exercises and many illustrations are included, and each chapter contains a further 'Sources and Comments' section. The only prerequisites are a familiarity with metric spaces, the basic theory of Hilbert and Banach spaces and fundamentals of complex analysis. More advanced tools, only needed occasionally, are provided in two appendices. A self-contained exposition, this book will be suitable for self-study and will appeal to advanced undergraduate or beginning graduate students. It will also be of use to researchers in other areas of mathematics such as partial differential equations, dynamical systems and ergodic theory.

Composition Operators on Spaces of Analytic Functions

This volume contains papers selected from the Wavelet Analysis and Multiresolution Methods Session of the AMS meeting held at the University of Illinois at Urbana-Champaign. The contributions cover: construction, analysis, computation and application of multiwavelets; scaling vectors; nonhomogenous refinement; multivariate orthogonal and biorthogonal wavelets; and other related topics.

Compact Composition Operators on Some Möbius Invariant Banach Spaces

The aim of this monograph is to give a thorough and self-contained account of functions of (generalized) bounded variation, the methods connected with their study, their relations to other important function classes, and their applications to various problems arising in Fourier analysis and nonlinear analysis. In the first part the basic facts about spaces of functions of bounded variation and related spaces are collected, the main ideas which are useful in studying their properties are presented, and a comparison of their importance and suitability for applications is provided, with a particular emphasis on illustrative examples and counterexamples. The second part is concerned with (sometimes quite surprising) properties of nonlinear composition and superposition operators in such spaces. Moreover, relations with Riemann-Stieltjes integrals, convergence tests for Fourier series, and applications to nonlinear integral equations are discussed. The only prerequisite for understanding this book is a modest background in real analysis, functional analysis, and operator theory. It is addressed to non-specialists who want to get an idea of the development of the theory and its applications in the last decades, as well as a glimpse of the diversity of the directions in which current research is moving. Since the authors try to take into account recent results and state several open problems, this book might also be a fruitful source of inspiration for further research.

Dynamics of Linear Operators

This book establishes the foundations of the theory of bounded and unbounded weighted composition operators in L^2 -spaces. It develops the theory in full generality, meaning that the corresponding composition operators are not assumed to be well defined. A variety of seminormality properties of unbounded weighted composition operators are characterized. The first-ever criteria for subnormality of unbounded weighted composition operators are provided and the subtle interplay between the classical moment problem, graph theory and the injectivity problem for weighted composition operators is revealed. The relationships between weighted composition operators and the corresponding multiplication and composition operators are investigated. The optimality of the obtained results is illustrated by a variety of examples, including those of discrete and continuous types. The book is primarily aimed at researchers in single or multivariable operator theory.

Linearization Models for Complex Dynamical Systems

Function Classes on the Unit Disc

Function Theory and l^p Spaces

This book provides a concise and self-contained introduction to the foundations of mathematics. The first part covers the fundamental notions of mathematical logic, including logical axioms, formal proofs and the basics of model theory. Building on this, in the second and third part of the book the authors present detailed proofs of Gödel's classical completeness and incompleteness theorems. In particular, the book includes a full proof of Gödel's second incompleteness theorem which states that it is impossible to prove the consistency of arithmetic within its axioms. The final part is dedicated to an introduction into modern axiomatic set theory based on the Zermelo's axioms, containing a presentation of Gödel's constructible universe of sets. A recurring theme in the whole book consists of standard and non-standard models of several theories, such as Peano arithmetic, Presburger arithmetic and the real numbers. The book addresses undergraduate mathematics students and is suitable for a one or two semester introductory course into logic and set theory. Each chapter concludes with a list of exercises.

Elementary Functional Analysis

The cyclic behavior of a composition operator is closely tied to the dynamical behavior of its inducing map. Based on analysis of fixed-point and orbital properties of inducing maps, Bourdon and Shapiro show that composition operators exhibit strikingly diverse types of cyclic behavior. The authors connect this behavior with classical problems involving

polynomial approximation and analytic functional equations. Features include: complete classification of the cyclic behavior of composition operators induced by linear-fractional mappings; application of linear-fractional models to obtain more general cyclicity results; and, information concerning the properties of solutions to Schroeder's and Abel's functional equations. This pioneering work forges new links between classical function theory and operator theory, and contributes new results to the study of classical analytic functional equations.

Composition Operators on the Dirichlet Space

Methods of Functional Analysis and Topology

Hilbert spaces of analytic functions are currently a very active field of complex analysis. The Hardy space is the most senior member of this family. However, other classes of analytic functions such as the classical Bergman space, the Dirichlet space, the de Branges-Rovnyak spaces, and various spaces of entire functions, have been extensively studied. These spaces have been exploited in different fields of mathematics and also in physics and engineering. For example, de Branges used them to solve the Bieberbach conjecture. Modern control theory is another place that heavily exploits the techniques of analytic function theory. This book grew out of a workshop held in December 2008 at the CRM in Montreal and provides an account of the latest developments in the field of analytic function theory. Titles in this series are co-published with the Centre de Recherches Mathematiques. (CRMP/51)

On the Hypercyclicity and Invariant Subspaces of Invertible Composition Operators

Gödel's Theorems and Zermelo's Axioms

Functional Calculi

This rigorous investigation of Hardy spaces and the invariant subspace problem is suitable for advanced undergraduates and graduates, covering complex functions, harmonic analysis, and functional analysis. 1962 edition.

Function Theory in the Unit Ball of \mathbb{C}^n

Composition Operators Induced by Absolutely Continuous Functions

Deals with various aspects of the theory of bounded linear operators on Hilbert space. This book offers information on weighted shift operators with scalar weights.

Mathematica Scandinavica

The classical l_p sequence spaces have been a mainstay in Banach spaces. This book reviews some of the foundational results in this area (the basic inequalities, duality, convexity, geometry) as well as connects them to the function theory (boundary growth conditions, zero sets, extremal functions, multipliers, operator theory) of the associated spaces l_pA of analytic functions whose Taylor coefficients belong to l_p . Relations between the Banach space l_p and its associated function space are uncovered using tools from Banach space geometry, including Birkhoff-James orthogonality and the resulting Pythagorean inequalities. The authors survey the literature on all of this material, including a discussion of the multipliers of l_pA and a discussion of the Wiener algebra l_1A . Except for some basic measure theory, functional analysis, and complex analysis, which the reader is expected to know, the material in this book is self-contained and detailed proofs of nearly all the results are given. Each chapter concludes with some end notes that give proper references, historical background, and avenues for further exploration.

Composition Operators

A functional calculus is a construction which associates with an operator or a family of operators a homomorphism from a function space into a subspace of continuous linear operators, i.e. a method for defining "functions of an operator". Perhaps the most familiar example is based on the spectral theorem for bounded self-adjoint operators on a complex Hilbert space. This book contains an exposition of several such functional calculi. In particular, there is an exposition based on the spectral theorem for bounded, self-adjoint operators, an extension to the case of several commuting self-adjoint operators and an extension to normal operators. The Riesz operational calculus based on the Cauchy integral theorem from complex analysis is also described. Finally, an exposition of a functional calculus due to H. Weyl is given.

Operator Theory in Function Spaces

The core of the book is the study of the space of the hyperbolic manifolds endowed with the Chabauty and the geometric topology, and in particular the proof of the hyperbolic surgery theorem in dimension three, based on the representation of three-manifolds as glued ideal tetrahedra. The development of this main theme requires setting a wide background forming

the body of the book: the classical geometry of the hyperbolic space, the Fenchel-Nielsen parametrization of the Teichmüller space, Mostow's rigidity theorem, Margulis' lemma. As a conclusion some features of bounded cohomology, flat fiber bundles and amenable groups are mentioned.

An Introduction to Operators on the Hardy-Hilbert Space

This book covers Toeplitz operators, Hankel operators, and composition operators on both the Bergman space and the Hardy space. The setting is the unit disk and the main emphasis is on size estimates of these operators: boundedness, compactness, and membership in the Schatten classes. Most results concern the relationship between operator-theoretic properties of these operators and function-theoretic properties of the inducing symbols. Thus a good portion of the book is devoted to the study of analytic function spaces such as the Bloch space, Besov spaces, and BMOA, whose elements are to be used as symbols to induce the operators we study. The book is intended for both research mathematicians and graduate students in complex analysis and operator theory. The prerequisites are minimal; a graduate course in each of real analysis, complex analysis, and functional analysis should sufficiently prepare the reader for the book. Exercises and bibliographical notes are provided at the end of each chapter. These notes will point the reader to additional results and problems. Kehe Zhu is a professor of mathematics at the State University of New York at Albany. His previous books include Theory of Bergman Spaces (Springer, 2000, with H. Hedenmalm and B. Korenblum) and Spaces of Holomorphic Functions in the Unit Ball (Springer, 2005). His current research interests are holomorphic function spaces and operators acting on them.

Unbounded Weighted Composition Operators in L²-Spaces

Fifteen years ago, most mathematicians who worked in the intersection of function theory and operator theory thought that progress on the Bergman spaces was unlikely, yet today the situation has completely changed. For several years, research interest and activity have expanded in this area and there are now rich theories describing the Bergman spaces and their operators. This book is a timely treatment of the theory, written by three of the major players in the field.

Wavelet Analysis and Multiresolution Methods

This textbook is a completely revised, updated, and expanded English edition of the important Analyse fonctionnelle (1983). In addition, it contains a wealth of problems and exercises (with solutions) to guide the reader. Uniquely, this book presents in a coherent, concise and unified way the main results from functional analysis together with the main results from the theory of partial differential equations (PDEs). Although there are many books on functional analysis and many on PDEs, this is the first to cover both of these closely connected topics. Since the French book was first published, it has been

translated into Spanish, Italian, Japanese, Korean, Romanian, Greek and Chinese. The English edition makes a welcome addition to this list.

Cyclic Phenomena for Composition Operators

This volume of the Mathematics Studies presents work done on composition operators during the last 25 years. Composition operators form a simple but interesting class of operators having interactions with different branches of mathematics and mathematical physics. After an introduction, the book deals with these operators on L_p -spaces. This study is useful in measurable dynamics, ergodic theory, classical mechanics and Markov process. The composition operators on functional Banach spaces (including Hardy spaces) are studied in chapter III. This chapter makes contact with the theory of analytic functions of complex variables. Chapter IV presents a study of these operators on locally convex spaces of continuous functions making contact with topological dynamics. In the last chapter of the book some applications of composition operators in isometries, ergodic theory and dynamical systems are presented. An interesting interplay of algebra, topology, and analysis is displayed. This comprehensive and up-to-date study of composition operators on different function spaces should appeal to research workers in functional analysis and operator theory, post-graduate students of mathematics and statistics, as well as to physicists and engineers.

Composition Operators on Function Spaces

Linearization models for discrete and continuous time dynamical systems are the driving forces for modern geometric function theory and composition operator theory on function spaces. This book focuses on a systematic survey and detailed treatment of linearization models for one-parameter semigroups, Schröder's and Abel's functional equations, and various classes of univalent functions which serve as intertwining mappings for nonlinear and linear semigroups. These topics are applicable to the study of problems in complex analysis, stochastic and evolution processes and approximation theory.

Singular Integral Operators and Related Topics

The authors investigate composition operators on Hardy-Orlicz spaces when the Orlicz function Ψ grows rapidly: compactness, weak compactness, to be p -summing, order bounded, \dots , and show how these notions behave according to the growth of Ψ . They introduce an adapted version of Carleson measure. They construct various examples showing that their results are essentially sharp. In the last part, they study the case of Bergman-Orlicz spaces.

The Product of a Composition Operator with the Adjoint of a Composition Operator

Topics in Complex Analysis and Operator Theory

This volume contains a selection of papers on modern operator theory and its applications, arising from a joint workshop on linear one-dimensional singular integral equations. The book is of interest to a wide audience in the mathematical and engineering sciences.

Hilbert Spaces of Analytic Functions

This book offers an elementary and engaging introduction to operator theory on the Hardy-Hilbert space. It provides a firm foundation for the study of all spaces of analytic functions and of the operators on them. Blending techniques from "soft" and "hard" analysis, the book contains clear and beautiful proofs. There are numerous exercises at the end of each chapter, along with a brief guide for further study which includes references to applications to topics in engineering.

Theory of Bergman Spaces

Functional analysis arose in the early twentieth century and gradually, conquering one stronghold after another, became a nearly universal mathematical doctrine, not merely a new area of mathematics, but a new mathematical world view. Its appearance was the inevitable consequence of the evolution of all of nineteenth-century mathematics, in particular classical analysis and mathematical physics. Its original basis was formed by Cantor's theory of sets and linear algebra. Its existence answered the question of how to state general principles of a broadly interpreted analysis in a way suitable for the most diverse situations. A.M. Vershik ([45], p. 438). This text evolved from the content of a one semester introductory course in functional analysis that I have taught a number of times since 1996 at the University of Virginia. My students have included first and second year graduate students preparing for thesis work in analysis, algebra, or topology, graduate students in various departments in the School of Engineering and Applied Science, and several undergraduate mathematics or physics majors. After a first draft of the manuscript was completed, it was also used for an independent reading course for several undergraduates preparing for graduate school.

A Mathematical Odyssey

The study of composition operators lies at the interface of analytic function theory and operator theory. Composition Operators on Spaces of Analytic Functions synthesizes the achievements of the past 25 years and brings into focus the broad outlines of the developing theory. It provides a comprehensive introduction to the linear operators of composition

with a fixed function acting on a space of analytic functions. This new book both highlights the unifying ideas behind the major theorems and contrasts the differences between results for related spaces. Nine chapters introduce the main analytic techniques needed, Carleson measure and other integral estimates, linear fractional models, and kernel function techniques, and demonstrate their application to problems of boundedness, compactness, spectra, normality, and so on, of composition operators. Intended as a graduate-level textbook, the prerequisites are minimal. Numerous exercises illustrate and extend the theory. For students and non-students alike, the exercises are an integral part of the book. By including the theory for both one and several variables, historical notes, and a comprehensive bibliography, the book leaves the reader well grounded for future research on composition operators and related areas in operator or function theory.

Functional Analysis, Sobolev Spaces and Partial Differential Equations

The first book to assemble the wide body of theory which has rapidly developed on the dynamics of linear operators. Written for researchers in operator theory, but also accessible to anyone with a reasonable background in functional analysis at the graduate level.

Topics in Operator Theory

C* Algebraic Relations and Component Structure of Composition Operators

Composition Operators on Spaces of Analytic Functions

The study of composition operators links some of the most basic questions you can ask about linear operators with beautiful classical results from analytic-function theory. The process invests old theorems with new meanings, and bestows upon functional analysis an intriguing class of concrete linear operators. Best of all, the subject can be appreciated by anyone with an interest in function theory or functional analysis, and a background roughly equivalent to the following twelve chapters of Rudin's textbook *Real and Complex Analysis* [Rdn '87]: Chapters 1-7 (measure and integration, LP spaces, basic Hilbert and Banach space theory), and 10-14 (basic function theory through the Riemann Mapping Theorem). In this book I introduce the reader to both the theory of composition operators, and the classical results that form its infrastructure. I develop the subject in a way that emphasizes its geometric content, staying as much as possible within the prerequisites set out in the twelve fundamental chapters of Rudin's book. Although much of the material on operators is quite recent, this book is not intended to be an exhaustive survey. It is, quite simply, an invitation to join in the fun. The story goes something

like this.

On the Norm of a Composition Operator

This book contains the lecture notes as well as some invited papers presented at the Third Winter School in Complex Analysis, Operator Theory and Applications held February 2-5, 2010, in Valencia, Spain. The book is divided into two parts. The first is an extended self-contained version of the mini-courses taught at the School. The papers in this first part are: Notes on real analytic functions and classical operators, by Pawel Domanski; Shining a Hilbertian lamp on the bidisk, by John E. McCarthy; Selected problems in perturbation theory, by Vladimir V. Peller; and Composition operators on Hardy-Orlicz spaces, by Luis Rodriguez-Piazza. The second part consists of several research papers on recent advances in the area and some survey articles of an expository character. The articles in this second part are: Remarks on weighted mixed norm spaces, by O. Blasco; Interpolation subspaces of L^1 of a vector measure and norm inequalities for the integration operator, by J.M. Calabuig, J. Rodriguez, and E.A. Sanchez-Perez; On the spectra of algebras of analytic functions, by D. Carando, D. Garcia, M. Maestre, and P. Sevilla-Peris; Holomorphic self-maps of the disk intertwining two linear fractional maps, by M.D. Contreras, S. Diaz-Madrigal, M.J. Martin, and D. Vukotic; ABC-type estimates via Garsia-type norms, by K.M. Dyakonov; and Volterra type operators on Bergman spaces with exponential weights, by J. Pau and J.A. Pelaez. The topics selected for the mini-courses cover several aspects of complex analysis and operator theory that play important roles in understanding connections between different areas that are considered in fashion these days. This part is aimed at graduate students and young researchers. The courses are self-contained, focusing on those aspects that are basic and that can lead the readers to a quick understanding of the theories presented in each topic. They start with the classical results and reach a selection of open problems in each case. The research and survey articles are aimed at young researchers in the area, as well as post-doc and senior researchers interested in complex analysis and operator theory. This book is published in cooperation with Real Sociedad Matematica Espanola.

Bounded Variation and Around

Around 1970, an abrupt change occurred in the study of holomorphic functions of several complex variables. Sheaves vanished into the back ground, and attention was focused on integral formulas and on the "hard analysis" problems that could be attacked with them: boundary behavior, complex-tangential phenomena, solutions of the $\bar{\partial}$ -problem with control over growth and smoothness, quantitative theorems about zero-varieties, and so on. The present book describes some of these developments in the simple setting of the unit ball of \mathbb{C}^n . There are several reasons for choosing the ball for our principal stage. The ball is the prototype of two important classes of regions that have been studied in depth, namely the strictly pseudoconvex domains and the bounded symmetric ones. The presence of the second structure (i.e., the existence

of a transitive group of automorphisms) makes it possible to develop the basic machinery with a minimum of fuss and bother. The principal ideas can be presented quite concretely and explicitly in the ball, and one can quickly arrive at specific theorems of obvious interest. Once one has seen these in this simple context, it should be much easier to learn the more complicated machinery (developed largely by Henkin and his co-workers) that extends them to arbitrary strictly pseudoconvex domains. In some parts of the book (for instance, in Chapters 14-16) it would, however, have been unnatural to confine our attention exclusively to the ball, and no significant simplifications would have resulted from such a restriction.

Tamkang Journal of Mathematics

This monograph contains a study on various function classes, a number of new results and new or easy proofs of old results (Fefferman-Stein theorem on subharmonic behavior, theorems on conjugate functions and fractional integration on Bergman spaces, Fefferman's duality theorem), which are interesting for specialists; applications of the Hardy-Littlewood inequalities on Taylor coefficients to (C, α) -maximal theorems and (C, α) -convergence; a study of BMOA, due to Knese, based only on Green's formula; the problem of membership of singular inner functions in Besov and Hardy-Sobolev spaces; a full discussion of g -function (all $p > 0$) and Calderón's area theorem; a new proof, due to Astala and Koskela, of the Littlewood-Paley inequality for univalent functions; and new results and proofs on Lipschitz spaces, coefficient multipliers and duality, including compact multipliers and multipliers on spaces with non-normal weights. It also contains a discussion of analytic functions and lacunary series with values in quasi-Banach spaces with applications to function spaces and composition operators. Sixteen open questions are posed. The reader is assumed to have a good foundation in Lebesgue integration, complex analysis, functional analysis, and Fourier series. Further information can be found at the author's website at <http://poincare.matf.bg.ac.rs/~pavlovic>.

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