

## OPERATOR IDEALS AND OPERATOR SPACES

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**ABSTRACT.** We prove that every full symmetrically normed ideal of operators on a Hilbert space is realizable as the set of completely bounded maps between two homogeneous operator Hilbert spaces, with the c.b. norm equivalent to (but in general not equal to) the symmetric norm. We show that one can have equality of the c.b. norm and the symmetric norm if one leaves the category of operator spaces and passes to a slightly larger category.

### 1. PRELIMINARIES

In Gohberg and Krein's text *Introduction to the theory of linear nonselfadjoint operators*, the reader may find a nice exposition on the theory of *symmetrically normed (s.n.) ideals*, and since we will be dealing with this theory extensively, we have adopted their text as a reader's companion to this article. Consequently, we have attempted to duplicate their notation wherever possible. We also will frequently use objects that are not defined here but whose definition may be found in [3].

Let  $\mathcal{H}$  be a separable Hilbert space, and let  $B(\mathcal{H})$  be the Banach algebra of operators on  $\mathcal{H}$ . In our exposition we will need the following elementary piece of folklore, whose proof we leave to the reader. If  $\mathcal{C}$  is an arbitrary s.n. ideal, we define

$$\mathcal{C}' = \{Y \in B(\mathcal{H}) \mid XY \in \mathcal{C}_1 \text{ for all } X \in \mathcal{C}\}.$$

We call  $\mathcal{C}$  a *full* s.n. ideal in case  $\mathcal{C}' = \mathcal{C}$ .

**1.1. Lemma.** *Let  $\Phi$  be an s.n. function. If  $\Phi$  is equivalent to the maximal s.n. function, then  $\mathcal{C}_\Phi = B(\mathcal{H})$ . If  $\Phi$  is not equivalent to the maximal s.n. function, then  $\mathcal{C}_\Phi = \mathcal{C}_\Phi'$ .*

In addition to the content of [3], we need to assume that the reader is familiar with the basic ideas and definitions of abstract operator spaces and their completely bounded (c.b.) mappings. These basics may be found in [1] or [2]. The essence of our paper is that, as a set, every full symmetrically normed ideal of operators on a Hilbert space is realizable as the set of completely bounded

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# Operator Spaces

**Philippe Biane, Luc Bouten, Fabio  
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## **Operator Spaces:**

Operator Spaces Edward G. Effros, Zhong-Jin Ruan, 2000 This book is essential reading for experts in the theory of operator spaces and for those who want to learn the Banach space style advances of the last decade in operator spaces Bulletin of the LMS This book combines an elementary introduction to the theory of quantized Banach spaces with a discussion of some of its most surprising non classical aspects Only elementary notions of functional analysis are used hence the book will be accessible to a wide range of researchers in analysis mathematical physics and quantum computation

Introduction to Operator Space Theory Gilles Pisier, 2003-08-25 The theory of operator spaces is very recent and can be described as a non commutative Banach space theory An operator space is simply a Banach space with an embedding into the space  $B(H)$  of all bounded operators on a Hilbert space  $H$  The first part of this book is an introduction with emphasis on examples that illustrate various aspects of the theory The second part is devoted to applications to  $C^*$  algebras with a systematic exposition of tensor products of  $C^*$  algebras The third and shorter part of the book describes applications to non self adjoint operator algebras and similarity problems In particular the author's counterexample to the Halmos problem is presented as well as work on the new concept of length of an operator algebra Graduate students and professional mathematicians interested in functional analysis operator algebras and theoretical physics will find that this book has much to offer

**Operator Algebras and Their Modules** David P. Blecher, Christian Le Merdy, 2004-10-07 This invaluable reference is the first to present the general theory of algebras of operators on a Hilbert space and the modules over such algebras The new theory of operator spaces is presented early on and the text assembles the basic concepts theory and methodologies needed to equip a beginning researcher in this area A major trend in modern mathematics inspired largely by physics is toward noncommutative or quantized phenomena In functional analysis this has appeared notably under the name of operator spaces which is a variant of Banach spaces which is particularly appropriate for solving problems concerning spaces or algebras of operators on Hilbert space arising in noncommutative mathematics The category of operator spaces includes operator algebras selfadjoint that is  $C^*$  algebras or otherwise Also most of the important modules over operator algebras are operator spaces A common treatment of the subjects of  $C^*$  algebras nonselfadjoint operator algebras and modules over such algebras such as Hilbert  $C^*$  modules together under the umbrella of operator space theory is the main topic of the book A general theory of operator algebras and their modules naturally develops out of the operator space methodology Indeed operator space theory is a sensitive enough medium to reflect accurately many important noncommutative phenomena Using recent advances in the field the book shows how the underlying operator space structure captures very precisely the profound relations between the algebraic and the functional analytic structures involved The rich interplay between spectral theory operator theory  $C^*$  algebra and von Neumann algebra techniques and the influx of important ideas from related disciplines such as pure algebra Banach space theory Banach algebras and abstract function

theory is highlighted Each chapter ends with a lengthy section of notes containing a wealth of additional information

*Theory of Operator Spaces* Edward G. Effros, Zhong-Jin Ruan, 2022-03-25 This book provides the main results and ideas in the theories of completely bounded maps operator spaces and operator algebras along with some of their main applications It requires only a basic background in functional analysis to read through the book The descriptions and discussions of the topics are self explained It is appropriate for graduate students new to the subject and the field The book starts with the basic representation theorems for abstract operator spaces and their mappings followed by a discussion of tensor products and the analogue of Grothendieck's approximation property Next the operator space analogues of the nuclear integral and absolutely summing mappings are discussed In what is perhaps the deepest part of the book the authors present the remarkable non classical phenomena that occur when one considers local reflexivity and exactness for operator spaces This is an area of great beauty and depth and it represents one of the triumphs of the subject In the final part of the book the authors consider applications to non commutative harmonic analysis and non self adjoint operator algebra theory Operator space theory provides a synthesis of Banach space theory with the non commuting variables of operator algebra theory and it has led to exciting new approaches in both disciplines This book is an indispensable introduction to the theory of operator spaces

*Complex Interpolation between Hilbert, Banach and Operator Spaces* Gilles Pisier, 2010-10-07 Motivated by a question of Vincent Lafforgue the author studies the Banach spaces  $X$  satisfying the following property there is a function  $\delta_X(\epsilon)$  tending to zero with  $\epsilon > 0$  such that every operator  $T: L_2 \rightarrow L_2$  with  $\|T\| \leq \delta_X(\epsilon)$  that is simultaneously contractive i.e. of norm  $\leq 1$  on  $L_1$  and on  $L_\infty$  must be of norm  $\leq \epsilon$  on  $X$  The author shows that  $\delta_X(\epsilon) = O(\epsilon^\alpha)$  for some  $\alpha > 0$  iff  $X$  is isomorphic to a quotient of a subspace of an ultraproduct of  $\theta$  Hilbertian spaces for some  $\theta > 0$  see Corollary 6.7 where  $\theta$  Hilbertian is meant in a slightly more general sense than in the author's earlier paper 1979

*Tensor Products of  $C^*$ -algebras and Operator Spaces* Gilles Pisier, 2020-02-27 Presents an important open problem on operator algebras in a style accessible to young researchers or Ph.D. students

*Geometry of State Spaces of Operator Algebras* Erik Magnus Alfsen, Frederic W. Shultz, 2003 This book provides a complete and self contained solution to the long standing problem of giving a geometric description of state spaces of  $C^*$  algebras and von Neumann algebras and of their Jordan algebraic analogs JB algebras and JBW algebras This material which has previously only appeared in research papers based on substantial prerequisites is made accessible to a broad mathematical audience The necessary prerequisites on  $C^*$  algebras and von Neumann algebras are summarized in an appendix which contains all relevant definitions and results All necessary background on Jordan algebras is given in the present book and the first part of the book may be of independent interest for those wanting a quick introduction to Jordan algebras This work will be of interest to researchers and students in operator algebras

*The Calculus of One-Sided  $M$ -Ideals and Multipliers in Operator Spaces* David P. Blecher, Vrej Zarikian, 2006 The theory of one sided  $M$  ideals and

multipliers of operator spaces is simultaneously a generalization of classical  $M$  ideals in operator algebras and aspects of the theory of Hilbert  $C$  modules and their maps. Here we give a systematic exposition of this theory. The main part of this memoir consists of a calculus for one sided  $M$  ideals and multipliers i.e. a collection of the properties of one sided  $M$  ideals and multipliers with respect to the basic constructions met in functional analysis. This is intended to be a reference tool for noncommutative functional analysts who may encounter a one sided  $M$  ideal or multiplier in their work.

**Handbook of the Geometry of Banach Spaces** William B. Johnson, Joram Lindenstrauss, 2001. The Handbook presents an overview of most aspects of modern Banach space theory and its applications. The up to date surveys authored by leading research workers in the area are written to be accessible to a wide audience. In addition to presenting the state of the art of Banach space theory the surveys discuss the relation of the subject with such areas as harmonic analysis, complex analysis, classical convexity, probability theory, operator theory, combinatorics, logic, geometric measure theory and partial differential equations. The Handbook begins with a chapter on basic concepts in Banach space theory which contains all the background needed for reading any other chapter in the Handbook. Each of the twenty one articles in this volume after the basic concepts chapter is devoted to one specific direction of Banach space theory or its applications. Each article contains a motivated introduction as well as an exposition of the main results, methods and open problems in its specific direction. Most have an extensive bibliography. Many articles contain new proofs of known results as well as expositions of proofs which are hard to locate in the literature or are only outlined in the original research papers. As well as being valuable to experienced researchers in Banach space theory the Handbook should be an outstanding source for inspiration and information to graduate students and beginning researchers. The Handbook will be useful for mathematicians who want to get an idea of the various developments in Banach space theory.

**State Spaces of Operator Algebras** Erik M. Alfsen, Frederik W. Shultz, 2012-12-06. The topic of this book is the theory of state spaces of operator algebras and their geometry. The states are of interest because they determine representations of the algebra and its algebraic structure is in an intriguing and fascinating fashion encoded in the geometry of the state space. From the beginning the theory of operator algebras was motivated by applications to physics but recently it has found unexpected new applications to various fields of pure mathematics like foliations and knot theory and in the Jordan algebra case also to Banach manifolds and infinite dimensional holomorphy. This makes it a relevant field of study for readers with diverse backgrounds and interests. Therefore this book is not intended solely for specialists in operator algebras but also for graduate students and mathematicians in other fields who want to learn the subject. We assume that the reader starts out with only the basic knowledge taught in standard graduate courses in real and complex variables, measure theory and functional analysis. We have given complete proofs of basic results on operator algebras so that no previous knowledge in this field is needed. For discussion of some topics more advanced prerequisites are needed. Here we have included all necessary definitions and statements of results but in some cases proofs are referred to standard texts. In those

cases we have tried to give references to material that can be read and understood easily in the context of our book

**Operator Theory in Function Spaces** Kehe Zhu, 2007 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 Birkhoff-James Orthogonality and Geometry of Operator Spaces Arpita Mal, Kallol

Paul, Debmalya Sain, 2024-02-19 This book provides an insight into the geometric aspects of the spaces of operators studied by using the notion of Birkhoff James orthogonality It studies the norm attainment set of an operator and its properties the notion of which plays a very important role in the characterization of B J orthogonality of operators The structure of the norm attainment set is studied for Hilbert space operators and is yet to be understood completely for operators between Banach spaces The book explores the interrelation between B J orthogonality in the ground space and in the space of operators in its fullest generality The book further explores the concept of approximate B J orthogonality and investigated its geometry both in the ground space as well as in the space of operators It highlights important geometric properties like smoothness and k smoothness of bounded linear operators extreme contractions and symmetricity of bounded linear operators defined between Hilbert spaces as well as Banach spaces **Handbook of the Geometry of Banach Spaces**, 2003-05-06 Handbook of the Geometry of Banach Spaces

**Lectures on Amenability** Volker Runde, 2002-01-10 The notion of amenability has its origins in the beginnings of modern measure theory Does a finitely additive set function exist which is invariant under a certain group action Since the 1940s amenability has become an important concept in abstract harmonic analysis or rather more generally in the theory of semitopological semigroups In 1972 B E Johnson showed that the amenability of a locally compact group  $G$  can be characterized in terms of the Hochschild cohomology of its group algebra  $L^1(G)$  this initiated the theory of amenable Banach algebras Since then amenability has penetrated other branches of mathematics such as von Neumann algebras operator spaces and even differential geometry Lectures on Amenability introduces second year graduate

students to this fascinating area of modern mathematics and leads them to a level from where they can go on to read original papers on the subject Numerous exercises are interspersed in the text

**One-sided M-structure of Operator Spaces and Operator Algebras** Sonia Sharma,2009       **$C^*$ -Algebras: 1943-1993** ,1994      **Quantum Potential Theory** Philippe Biane,Luc Bouten,Fabio Cipriani,Norio Konno,Quanhua Xu,2008-10-16 This book offers the revised and completed notes of lectures given at the 2007 conference Quantum Potential Theory Structures and Applications to Physics These lectures provide an introduction to the theory and discuss various applications

**Introduction to Model Spaces and their Operators** Stephan Ramon Garcia,Javad Mashreghi,William T. Ross,2016-05-17 The study of model spaces the closed invariant subspaces of the backward shift operator is a vast area of research with connections to complex analysis operator theory and functional analysis This self contained text is the ideal introduction for newcomers to the field It sets out the basic ideas and quickly takes the reader through the history of the subject before ending up at the frontier of mathematical analysis Open questions point to potential areas of future research offering plenty of inspiration to graduate students wishing to advance further

*Multipliers and Algebrizations of Operator Spaces* Masayoshi Kaneda,2003      **Operator-Valued Measures, Dilations, and the Theory of Frames** Deguang Han, David R. Larson,Bai Liu,Rui Liu,2014-04-07 The authors develop elements of a general dilation theory for operator valued measures Hilbert space operator valued measures are closely related to bounded linear maps on abelian von Neumann algebras and some of their results include new dilation results for bounded linear maps that are not necessarily completely bounded and from domain algebras that are not necessarily abelian In the non cb case the dilation space often needs to be a Banach space They give applications to both the discrete and the continuous frame theory There are natural associations between the theory of frames including continuous frames and framings the theory of operator valued measures on sigma algebras of sets and the theory of continuous linear maps between algebras In this connection frame theory itself is identified with the special case in which the domain algebra for the maps is an abelian von Neumann algebra and the map is normal i e ultraweakly or weakly or w continuous

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