

# POSITIVE LINEAR OPERATORS IN SEMI-ORDERED LINEAR SPACES

By

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Since in 1907 O. PERRON [9] discovered a remarkable spectral property of positive matrices and shortly later G. FROBENIUS [1], [2] and R. JENTZSCH [4] investigated and generalized it further, many authors have considered special properties of positive linear operators. Especially M. KREIN and M. A. RUTMAN [5]<sup>\*</sup> considered with success a generalization to Banach spaces with a cone. They obtained particularly important results, when the space is lattice ordered or the cone has an interior point. In this paper, we consider spectral properties of positive compact (=completely continuous) linear operators on a universally continuous Banach space (= conditionally complete Banach lattice). Our main aim is to generalize the results of G. FROBENIUS [2] to infinite dimensional spaces.

In §1 preliminary definitions are summarized. In §2 the fundamental theorem on the maximum positive spectrum is proved (Theorem 2.1). In §3 we define *completely positive* linear operators. The operators of this class play a similar rôle as strongly positive operators in [5]. In §4 we obtain under some additional conditions a necessary and sufficient condition for that a positive compact linear operator is quasinilpotent (Theorem 4.7). In §5 the proper values with maximum modulus of a positive compact linear operator are determined (Theorem 5.2).

§ 1. Preliminaries. We recall briefly definitions from the theory of semi-ordered linear spaces and linear operators. A lattice ordered linear space (with real scalar)  $R$  is said to be *universally continuous*, if for any  $\alpha_\lambda \geq 0$  ( $\lambda \in A$ ) there exists  $\bigcap_{\lambda \in A} \alpha_\lambda$ . A linear manifold  $N$  of  $R$  is said to be *normal* if there exists a positive linear projection  $[N]$  of  $R$  onto  $N$  such that  $|x - [N]x| \wedge |y| = 0$  for  $x \in R$  and  $y \in N$ . The projection

<sup>\*</sup> The author of the present paper expresses his thanks to Dr. S. YAMAMURO at Institute for Advanced Study, Princeton, who kindly communicated the main results of [5], which was not available to him.

# Semi Ordered Linear Spaces

**Graham Jameson**



## **Semi Ordered Linear Spaces:**

*Modulared Semi-ordered Linear Spaces* Hidegorō Nakano,1955      **Semi-ordered Linear Spaces** Hidegoro Nakano,1985      **Semi-ordered linear spaces** 半順序線性空間,1955      *Semi-ordered linear spaces* Hidegorō Nakano,1955

**Ordered Linear Spaces** Graham Jameson,2006-11-15      *Riesz Spaces* Adriaan Cornelis Zaanen,1983      **Riesz Spaces** II A.C. Zaanen,1983-05-01 While Volume I by W A J Luxemburg and A C Zaanen NHML Volume 1 1971 is devoted to the algebraic aspects of the theory this volume emphasizes the analytical theory of Riesz spaces and operators between these spaces Though the numbering of chapters continues on from the first volume this does not imply that everything covered in Volume I is required for this volume however the two volumes are to some extent complementary      *Locally Solid Riesz Spaces with Applications to Economics* Charalambos D. Aliprantis,Owen Burkinshaw,2025-05-14 Riesz space or a vector lattice is an ordered vector space that is simultaneously a lattice A topological Riesz space also called a locally solid Riesz space is a Riesz space equipped with a linear topology that has a base consisting of solid sets Riesz spaces and ordered vector spaces play an important role in analysis and optimization They also provide the natural framework for any modern theory of integration This monograph is the revised edition of the authors book Locally Solid Riesz Spaces 1978 Academic Press It presents an extensive and detailed study with complete proofs of topological Riesz spaces The book starts with a comprehensive exposition of the algebraic and lattice properties of Riesz spaces and the basic properties of order bounded operators between Riesz spaces Subsequently it introduces and studies locally solid topologies on Riesz spaces the main link between order and topology used in this monograph Special attention is paid to several continuity properties relating the order and topological structures of Riesz spaces the most important of which are the Lebesgue and Fatou properties A new chapter presents some surprising applications of topological Riesz spaces to economics In particular it demonstrates that the existence of economic equilibria and the supportability of optimal allocations by prices in the classical economic models can be proven easily using techniques from the theory of topological Riesz spaces At the end of each chapter there are exercises that complement and supplement the material in the chapter The last chapter of the book presents complete solutions to all exercises Prerequisites are the fundamentals of real analysis measure theory and functional analysis This monograph will be useful to researchers and graduate students in mathematics It will also be an important reference tool to mathematical economists and to all scientists and engineers who use order structures in their research      *Canadian Mathematical Bulletin* ,1969      Normed Linear Spaces Mahlon M. Day,2013-12-01      Dominated Operators A.G. Kusraev,2013-03-09 The notion of a dominated or rnajorized operator rests on a simple idea that goes as far back as the Cauchy method of majorants Loosely speaking the idea can be expressed as follows If an operator equation under study is dominated by another operator equation called a dominant or majorant then the properties of the latter have a substantial influence on the properties of the former Thus operators or equations that have nice dominants must possess nice properties In other words an operator with a

somehow qualified dominant must be qualified itself Mathematical tools putting the idea of domination into a natural and complete form were suggested by L V Kantorovich in 1935 36 He introduced the fundamental notion of a vector space normed by elements of a vector lattice and that of a linear operator between such spaces which is dominated by a positive linear or monotone sublinear operator He also applied these notions to solving functional equations In the succeeding years many authors studied various particular cases of lattice normed spaces and different classes of dominated operators However research was performed within and in the spirit of the theory of vector and normed lattices So it is not an exaggeration to say that dominated operators as independent objects of investigation were beyond the reach of specialists for half a century As a consequence the most important structural properties and some interesting applications of dominated operators have become available since recently

**Orlicz Spaces and Modular Spaces** J. Musielak, 2006-11-14 *Riesz Spaces* W.A.J. Luxemburg, 2000-04-01 *Riesz Spaces* **Finite Elements in Vector Lattices** Martin R. Weber, 2014-08-20 The book is the first systematical treatment of the theory of finite elements in Archimedean vector lattices and contains the results known on this topic up to the year 2013 It joins all important contributions achieved by a series of mathematicians that can only be found in scattered in literature

**Theory of Lattice-Ordered Groups** Michael Darnel, 2021-12-16 Provides a thorough discussion of the orderability of a group The book details the major developments in the theory of lattice ordered groups delineating standard approaches to structural and permutation representations A radically new presentation of the theory of varieties of lattice ordered groups is offered This work is intended for pure and applied mathematicians and algebraists interested in topics such as group order number and lattice theory universal algebra and representation theory and upper level undergraduate and graduate students in these disciplines College or university bookstores may order five or more copies at a special student price which is available from Marcel Dekker Inc upon request

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**Convexity** Victor Klee, American Mathematical Society, 1963 **Positivity and Noncommutative Analysis** Gerard Buskes, Marcel de Jeu, Peter Dodds, Anton Schep, Fedor Sukochev, Jan van Neerven, Anthony Wickstead, 2019-08-09 Capturing the state of the art of the interplay between positivity noncommutative analysis and related areas including partial differential equations harmonic

analysis and operator theory this volume was initiated on the occasion of the Delft conference in honour of Ben de Pagter's 65th birthday. It will be of interest to researchers in positivity, noncommutative analysis and related fields. Contributions by Shavkat Ayupov, Amine Ben Amor, Karim Boulabiar, Qingying Bu, Gerard Buskes, Martijn Caspers, Jurie Conradie, Garth Dales, Marcel de Jeu, Peter Dodds, Theresa Dodds, Julio Flores, Jochen Glück, Jacobus Grobler, Wolter Groenevelt, Markus Haase, Klaas Pieter Hart, Francisco Hernández, Jamel Jaber, Rien Kaashoek, Turabay Kalandarov, Anke Kalauch, Arkady Kitover, Erik Koelink, Karimbergen Kudaybergenov, Louis Labuschagne, Yongjin Li, Nick Lindemulder, Emiel Lorist, Qi L. Miek, Messerschmidt, Susumu Okada, Mehmet Orhon, Denis Potapov, Werner Ricker, Stephan Roberts, Pablo Román, Anton Schep, Claud Steyn, Fedor Sukochev, James Sweeney, Guido Sweers, Pedro Tradacete, Jan Harm van der Walt, Onno van Gaans, Jan van Neerven, Arnoud van Rooij, Freek van Schagen, Dominic Vella, Mark Veraar, Anthony Wickstead, Marten Wortel, Ivan Yaroslavl'tsev, and Dmitriy Zanin. **Canadian Journal of Mathematics**, 1951. *Evolution PDEs with Nonstandard Growth Conditions*, Stanislav Antontsev, Sergey Shmarev, 2015-04-01. This monograph offers the reader a treatment of the theory of evolution PDEs with nonstandard growth conditions. This class includes parabolic and hyperbolic equations with variable or anisotropic nonlinear structure. We develop methods for the study of such equations and present a detailed account of recent results. An overview of other approaches to the study of PDEs of this kind is provided. The presentation is focused on the issues of existence and uniqueness of solutions in appropriate function spaces and on the study of the specific qualitative properties of solutions such as localization in space and time, extinction in a finite time, and blow up or nonexistence of global in time solutions. Special attention is paid to the study of the properties intrinsic to solutions of equations with nonstandard growth.

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