TENSORIAL UPPER AND LOWER BOUNDS FOR TAYLOR'S EXPANSION OF FUNCTIONS OF SELFADJOINT OPERATORS IN HILBERT SPACES

SILVESTRU SEVER DRAGOMIR[1,2]

ABSTRACT. Let H be a Hilbert space. In this paper we show among others that, if f is of class C^{2m} on the open interval I and such that $\gamma_{2m} \leq f^{(2m)} \leq \Gamma_{2m}$ for some constants γ_{2m}, Γ_{2m}, A and B are selfadjoint operators with $\mathrm{Sp}(A), \mathrm{Sp}(B) \subset I$, then we have the inequalities

$$\frac{1}{(2m)!} (A \otimes 1 - 1 \otimes B)^{2m} \gamma_{2m}$$

$$\leq f(A) \otimes 1 - \sum_{k=0}^{2m-1} \frac{1}{k!} (A \otimes 1 - 1 \otimes B)^k \left(1 \otimes f^{(k)}(B) \right)$$

$$\leq \frac{1}{(2m)!} (A \otimes 1 - 1 \otimes B)^{2m} \Gamma_{2m}.$$

Some examples for logarithm and exponential functions are also provided.

1. INTRODUCTION

The following theorem is well known in the literature as Taylor's formula or Taylor's theorem with the integral remainder.

Theorem 1. *Let $I \subset \mathbb{R}$ be a closed interval, $c \in I$ and let n be a positive integer. If $f : I \longrightarrow \mathbb{C}$ is such that the n-derivative $f^{(n)}$ is absolutely continuous on I, then for each $y \in I$*

$$(1.1) \qquad f(y) = T_n(f; c, y) + R_n(f; c, y),$$

where $T_n(f; c, y)$ is Taylor's polynomial, i.e.,

$$(1.2) \qquad T_n(f; c, y) := \sum_{k=0}^{n} \frac{(y-c)^k}{k!} f^{(k)}(c).$$

Note that $f^{(0)} := f$ and $0! := 1$ and the remainder is given by

$$(1.3) \qquad R_n(f; c, y) := \frac{1}{n!} \int_c^y (y-t)^n f^{(n+1)}(t) \, dt.$$

A simple proof of this theorem can be achieved by mathematical induction using the integration by parts formula in the Lebesgue integral.

In order to extend this result for tensorial products of selfadjoint operators and norms, we need the following preparations.

Selfadjoint Operators In Spaces Of Funct

Jussi Behrndt

Selfadjoint Operators In Spaces Of Funct:

   Selfadjoint Operators in Spaces of Functions of Infinitely Many Variables I_Uri_ Makarovich Berezanski_,1986-12-31 Questions in the spectral theory of selfadjoint and normal operators acting in spaces of functions of infinitely many variables are studied in this book and in particular the theory of expansions in generalized eigenfunctions of such operators Both individual operators and arbitrary commuting families of them are considered A theory of generalized functions of infinitely many variables is constructed The circle of questions presented has evolved in recent years especially in connection with problems in quantum field theory This book will be useful to mathematicians and physicists interested in the indicated questions as well as to graduate students and students in advanced university courses   Self-Adjoint Operators W.G. Faris,2006-11-15   *Compact and Finite Rank Perturbations of Selfadjoint Operators in Krein Spaces with Applications to Boundary Eigenvalue Problems* Jussi Behrndt,2005   Hardy Spaces Associated to Non-Negative Self-Adjoint Operators Satisfying Davies-Gaffney Estimates Steve Hofmann,2011 Let X be a metric space with doubling measure and L be a non negative self adjoint operator satisfying Davies Gaffney bounds on L 2 X In this article the authors present a theory of Hardy and BMO spaces associated to L including an atomic or molecular decomposition square function characterization and duality of Hardy and BMO spaces Further specializing to the case that L is a Schrodinger operator on mathbb R n with a non negative locally integrable potential the authors establish additional characterizations of such Hardy spaces in terms of maximal functions Finally they define Hardy spaces H p_L X for p 1 which may or may not coincide with the space L p X and show that they interpolate with H 1_L X spaces by the complex method   Unbounded Self-adjoint Operators on Hilbert Space Konrad Schmüdgen,2012-07-09 The book is a graduate text on unbounded self adjoint operators on Hilbert space and their spectral theory with the emphasis on applications in mathematical physics especially Schr dinger operators and analysis Dirichlet and Neumann Laplacians Sturm Liouville operators Hamburger moment problem Among others a number of advanced special topics are treated on a text book level accompanied by numerous illustrating examples and exercises The main themes of the book are the following Spectral integrals and spectral decompositions of self adjoint and normal operators Perturbations of self adjointness and of spectra of self adjoint operators Forms and operators Self adjoint extension theory boundary triplets Krein Birman Vishik theory of positive self adjoint extension   *Essential Results of Functional Analysis* Robert J. Zimmer,1990-01-15 Functional analysis is a broad mathematical area with strong connections to many domains within mathematics and physics This book based on a first year graduate course taught by Robert J Zimmer at the University of Chicago is a complete concise presentation of fundamental ideas and theorems of functional analysis It introduces essential notions and results from many areas of mathematics to which functional analysis makes important contributions and it demonstrates the unity of perspective and technique made possible by the functional analytic approach Zimmer provides an introductory chapter summarizing measure theory and the elementary theory of Banach and Hilbert

spaces followed by a discussion of various examples of topological vector spaces seminorms defining them and natural classes of linear operators He then presents basic results for a wide range of topics convexity and fixed point theorems compact operators compact groups and their representations spectral theory of bounded operators ergodic theory commutative C algebras Fourier transforms Sobolev embedding theorems distributions and elliptic differential operators In treating all of these topics Zimmer s emphasis is not on the development of all related machinery or on encyclopedic coverage but rather on the direct complete presentation of central theorems and the structural framework and examples needed to understand them Sets of exercises are included at the end of each chapter For graduate students and researchers in mathematics who have mastered elementary analysis this book is an entr e and reference to the full range of theory and applications in which functional analysis plays a part For physics students and researchers interested in these topics the lectures supply a thorough mathematical grounding   Functional Analysis Balmohan Vishnu Limaye,1996 This Book Is An Introductory Text Written With Minimal Prerequisites The Plan Is To Impose A Distance Structure On A Linear Space Exploit It Fully And Then Introduce Additional Features Only When One Cannot Get Any Further Without Them The Book Naturally Falls Into Two Parts And Each Of Them Is Developed Independently Of The Other The First Part Deals With Normed Spaces Their Completeness And Continuous Linear Maps On Them Including The Theory Of Compact Operators The Much Shorter Second Part Treats Hilbert Spaces And Leads Upto The Spectral Theorem For Compact Self Adjoint Operators Four Appendices Point Out Areas Of Further Development Emphasis Is On Giving A Number Of Examples To Illustrate Abstract Concepts And On Citing Varirous Applications Of Results Proved In The Text In Addition To Proving Existence And Uniqueness Of A Solution Its Apprroximate Construction Is Indicated Problems Of Varying Degrees Of Difficulty Are Given At The End Of Each Section Their Statements Contain The Answers As Well   Non-Selfadjoint Operators in Quantum Physics Fabio Bagarello,Jean-Pierre Gazeau,Franciszek Hugon Szafraniec,Miloslav Znojil,2015-09-09 A unique discussion of mathematical methods with applications to quantum mechanics Non Selfadjoint Operators in Quantum Physics Mathematical Aspects presents various mathematical constructions influenced by quantum mechanics and emphasizes the spectral theory of non adjoint operators Featuring coverage of functional analysis and algebraic methods in contemporary quantum physics the book discusses the recent emergence of unboundedness of metric operators which is a serious issue in the study of parity time symmetric quantum mechanics The book also answers mathematical questions that are currently the subject of rigorous analysis with potentially significant physical consequences In addition to prompting a discussion on the role of mathematical methods in the contemporary development of quantum physics the book features Chapter contributions written by well known mathematical physicists who clarify numerous misunderstandings and misnomers while shedding light on new approaches in this growing area An overview of recent inventions and advances in understanding functional analytic and algebraic methods for non selfadjoint operators as well as the use of Krein space theory and perturbation theory Rigorous

support of the progress in theoretical physics of non Hermitian systems in addition to mathematically justified applications in various domains of physics such as nuclear and particle physics and condensed matter physics An ideal reference Non Selfadjoint Operators in Quantum Physics Mathematical Aspects is useful for researchers professionals and academics in applied mathematics and theoretical and or applied physics who would like to expand their knowledge of classical applications of quantum tools to address problems in their research Also a useful resource for recent and related trends the book is appropriate as a graduate level and or PhD level text for courses on quantum mechanics and mathematical models in physics   Operator Inequalities of the Jensen, Čebyšev and Grüss Type Silvestru Sever Dragomir,2011-11-12 The main aim of this book is to present recent results concerning inequalities of the Jensen eby ev and Gr ss type for continuous functions of bounded selfadjoint operators on complex Hilbert spaces In the introductory chapter the author portrays fundamental facts concerning bounded selfadjoint operators on complex Hilbert spaces The generalized Schwarz s inequality for positive selfadjoint operators as well as some results for the spectrum of this class of operators are presented This text introduces the reader to the fundamental results for polynomials in a linear operator continuous functions of selfadjoint operators as well as the step functions of selfadjoint operators The spectral decomposition for this class of operators which play a central role in the rest of the book and its consequences are introduced At the end of the chapter some classical operator inequalities are presented as well Recent new results that deal with different aspects of the famous Jensen operator inequality are explored through the second chapter These include but are not limited to the operator version of the Dragomir Ionescu inequality the Slater type inequalities for operators and its inverses Jensen s inequality for twice differentiable functions whose second derivatives satisfy some upper and lower bound conditions and Jensen s type inequalities for log convex functions Hermite Hadamard s type inequalities for convex functions and the corresponding results for operator convex functions are also presented The eby ev Chebyshev inequality that compares the integral discrete mean of the product with the product of the integral discrete means is famous in the literature devoted to Mathematical Inequalities The sister inequality due to Gr ss which provides error bounds for the magnitude of the difference between the integral mean of the product and the product of the integral means has also attracted much interest since it has been discovered in 1935 with more than 200 papers published so far The last part of the book is devoted to the operator versions of these famous results for continuous functions of selfadjoint operators on complex Hilbert spaces Various particular cases of interest and related results are presented as well This book is intended for use by both researchers in various fields of Linear Operator Theory and Mathematical Inequalities domains which have grown exponentially in the last decade as well as by postgraduate students and scientists applying inequalities in their specific areas   **Operator Theory and Related Topics** V.M. Adamyan,Israel Gohberg,Myroslav L. Gorbachuk,Valentina Gorbachuk,Marinus A. Kaashoek,H. Langer,G. Popov,2000-03-01 The present book is the second of the two volume Proceedings of the Mark Krein International Conference on Operator Theory and

Applications This conference which was dedicated to the 90th Anniversary of the prominent mathematician Mark Krein was held in Odessa Ukraine from 18 22 August 1997 The conference focused on the main ideas methods results and achievements of M G Krein This second volume is devoted to operator theory and related topics It opens with the bibliography of M G Krein and a number of survey papers about his work The main part of the book consists of original research papers presenting the state of the art in operator theory and its applications The first volume of these proceedings entitled Differential Operators and related Topics concerns the other aspects of the conference The two volumes will be of interest to a wide range of readership in pure and applied mathematics physics and engineering sciences Table of Contents Preface v Table of Contents vii Bibliography of Mark Grigorevich Krein ix Review papers M G Krein s Contributions to Prediction Theory H Dym M G Krein s Contribution to the Moment 17 AA Nudelman Research Papers Solution of the Truncated Matrix Hamburger Moment Problem according to M G Krein 33 Y M Adamyan and I M Tkachenko Extreme Points of a Positive Operator Ball 53 T Ando M accretive Extensions of Sectorial Operators and Krein Spaces 67 Y M Arlinskii A Simple Proof of the Continuous Commutant Lifting Theorem 83 R Bruzual and M **Elements of Functional Analysis** Francis Hirsch,Gilles Lacombe,1999-03-26 This book presents the fundamental function spaces and their duals explores operator theory and finally develops the theory of distributions up to significant applications such as Sobolev spaces and Dirichlet problems Includes an assortment of well formulated exercises with answers and hints collected at the end of the book *Expansions in Eigenfunctions of Selfadjoint Operators* ĪŪriĭ Makarovich Berezanskiĭ,1968 **Lectures on Functional Analysis and Applications** Vladimir Semenovich Pugachev,Igor? Nikolaevich Sinit?s?yn,1999 This book is intended for those having only a moderate background in mathematics who need to increase their mathematical knowledge for development in their areas of work and to read the related mathematical literature The material covered which includes practically all the information on functional analysis that may be necessary for those working in various areas of applications of mathematics as well as the simplicity of presentation differentiates this book from others About 300 examples and more than 500 problems are provided to help readers understand and master the theories presented The list of references enables readers to explore those topics in which they are interested and gather further information about applications used as examples in the book Applications Probability Theory and Statistics Signal and Image Processing Systems Analysis and Design **Applied Functional Analysis, Second Edition** J. Tinsley Oden,Leszek Demkowicz,1996-02-06 Functional analysis the study of the properties of mathematical functions is widely used in modern scientific and engineering disciplines particularly in mathematical modeling and computer simulation Applied Functional Analysis the only textbook of its kind is designed specifically for the graduate student in engineering and science who has little or no training in advanced mathematics Comprehensive and easy to understand this innovative textbook progresses from the essentials of preparatory mathematics to sophisticated functional analysis This self contained presentation requires few mathematical prerequisites

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book is a sequel to Functional analysis and two point differential operators 1986 Annotation copyrighted by Book News Inc Portland OR   Encyclopaedia of Mathematics Michiel Hazewinkel,2013-12-20

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