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# Linear Canonical Transforms

## Theory and Applications

# Linear Canonical Transforms Applications Springer

**Vasudevan Lakshminarayanan,María L. Calvo,Tatiana Alieva**

**Linear Canonical Transforms Applications Springer:**

Linear Canonical Transforms John J. Healy,M. Alper Kutay,Haldun M. Ozaktas,John T. Sheridan,2015-11-26 This book provides a clear and accessible introduction to the essential mathematical foundations of linear canonical transforms from a signals and systems perspective Substantial attention is devoted to how these transforms relate to optical systems and wave propagation There is extensive coverage of sampling theory and fast algorithms for numerically approximating the family of transforms Chapters on topics ranging from digital holography to speckle metrology provide a window on the wide range of applications This volume will serve as a reference for researchers in the fields of image and signal processing wave propagation optical information processing and holography optical system design and modeling and quantum optics It will be of use to graduate students in physics and engineering as well as for scientists in other areas seeking to learn more about this important yet relatively unfamiliar class of integral transformations Time Frequency Analysis of Some Generalized Fourier Transforms Mohammad Younus Bhat,2023-09-13 In the world of physical science important physical quantities like sound pressure electrical current voltage and electromagnetic fields vary with time Such quantities are labeled as signals waveforms and include oral signals optical signals acoustic signals biomedical signals radar and sonar Time frequency analysis is a vital aid in signal analysis which is concerned with how the frequency of a function or signal behaves in time and it has evolved into a widely recognized applied discipline of signal processing This book discusses the Fourier transform FT which is one of the most valuable and widely used integral transforms that converts a signal from time versus amplitude to frequency versus amplitude It is one of the oldest tools in the time frequency analysis of signals The book includes five chapters that discuss general Fourier transforms as well as new and novel transforms such as hybrid transforms quadratic phase Fourier transforms fractional Fourier transforms linear canonical transforms and more Fast Algorithms for the Digital Computation of Linear Canonical Transforms Aykut Koc,2011 Although it is straightforward to determine the relationship between the in focus image and the object of a simple optical system such as a lens it is far more challenging to compute the input output relationships of general first order and astigmatic optical systems Such optical systems are known as quadratic phase systems QPS and they include the Fresnel propagation in free space propagation in graded index media passage through thin lenses and arbitrary concatenations of any number of these including anamorphic astigmatic nonorthogonal elements Such computation is accomplished by representing the physical system with a general mathematical framework of integrations against kernels and then distilling the entire system into one input output relationship that can be represented by a linear integral transform The underlying mathematical integral transforms can be applied to a wider field of signal processing where they are known as the linear canonical transform LCT of a signal Conventional numerical integration methods have a computational complexity of $O N 2$ where N is the space bandwidth product of the sampling scheme e g the number of pixels in the field for an optical system The algorithms described here yield a complexity of only $O Nlog N$ The key

is the use of different decompositions or factorizations of a given input output relationship into simpler ones Instead of following the general physical subparts in cascaded systems and computing input output relations separately these algorithms use the simplest possible decompositions to represent the entire system in terms of least possible number of steps The algorithms are Fast Fourier Transform FFT based methods and the only essential deviation from exactness arises from approximating a continuous Fourier transform FT with the discrete Fourier transform DFT Thus the algorithms work with a performance similar to that of the fast Fourier transform algorithm in computing the Fourier transform both in terms of speed and accuracy Unlike conventional techniques these algorithms also track and control the space bandwidth products in order to achieve information that is theoretically sufficient but not wastefully redundant **Fractional Integral Transforms** Ahmed I. Zayed,2024-03-28 Fractional Integral Transforms Theory and Applications presents over twenty five integral transforms many of which have never before been collected in one single volume Some transforms are classic such as Laplace Fourier etc and some are relatively new such as the Fractional Fourier Gyrator Linear Canonical Special Affine Fourier Transforms as well as continuous Wavelet Ridgelet and Shearlet transforms The book provides an overview of the theory of fractional integral transforms with examples of such transforms before delving deeper into the study of important fractional transforms including the fractional Fourier transform Applications of fractional integral transforms in signal processing and optics are highlighted The book s format has been designed to make it easy for readers to extract the essential information they need to learn the about the fundamental properties of each transform Supporting proofs and explanations are given throughout Features Brings together integral transforms never before collected into a single volume A useful resource on fractional integral transforms for researchers and graduate students in mathematical analysis applied mathematics physics and engineering Written in an accessible style with detailed proofs and emphasis on providing the reader with an easy access to the essential properties of important fractional integral transforms Ahmed I Zayed is a Professor of Mathematics at the Department of Mathematical Sciences DePaul University Chicago and was the Chair of the department for 20 years from 2001 until 2021 His research interests varied over the years starting with generalized functions and distributions to sampling theory applied harmonic analysis special functions and integral transforms He has published two books and edited seven research monographs He has written 22 book chapters published 118 research articles and reviewed 173 publications for the Mathematical Review and 81 for the Zentralblatt f r Mathematik zbMath He has served on the Editorial Boards of 22 scientific research journals and has refereed over 200 research papers submitted to prestigious journals among them are IEEE SIAM Amer Math Soc Math Physics and Optical Soc Journals *Towards Intelligent Systems Modeling and Simulation* Samsul Ariffin Abdul Karim,Afza Shafie,2021-09-17 This book creates the emergence of disruptive technologies that have led to a significant change in the role of mathematics and statistics for problem solving with the use of sophisticated software and hardware in solving complex systems and process In the era of digital technology mathematics

and statistics need to be highly relevant to be able to cater for the needs of IR4 0 such as big data analytics simulation autonomous system and cloud computing Motivated by this development a total of 26 chapters are contributed by respectable experts for this book The main scope of the book is to conduct a new system of modeling and simulations on solving differential equations nonlinear equations energy epidemiology and risk assessment This book is of interest for postgraduate students researchers as well as other scientists who are working in numerical modeling and simulations based on efficient mathematical and statistical techniques      **Encyclopedia of Modern Optics** Bob D. Guenther,Duncan Steel,2018-02-14 The Encyclopedia of Modern Optics Second Edition Five Volume Set provides a wide ranging overview of the field comprising authoritative reference articles for undergraduate and postgraduate students and those researching outside their area of expertise Topics covered include classical and quantum optics lasers optical fibers and optical fiber systems optical materials and light emitting diodes LEDs Articles cover all subfields of optical physics and engineering such as electro optical design of modulators and detectors This update contains contributions from international experts who discuss topics such as nano photonics and plasmonics optical interconnects photonic crystals and 2D materials such as graphene or holy fibers Other topics of note include solar energy high efficiency LED s and their use in illumination orbital angular momentum quantum optics and information metamaterials and transformation optics high power fiber and UV fiber lasers random lasers and bio imaging Addresses recent developments in the field and integrates concepts from fundamental physics with applications for manufacturing and engineering design Provides a broad and interdisciplinary coverage of specialist areas Ensures that the material is appropriate for new researchers and those working in a new sub field as well as those in industry Thematically arranged and alphabetically indexed with cross references added to facilitate ease of use

*Wavelet Transforms* Firdous A. Shah,Azhar Y. Tantary,2022-11-28 Wavelet Transforms Kith and Kin serves as an introduction to contemporary aspects of time frequency analysis encompassing the theories of Fourier transforms wavelet transforms and their respective offshoots This book is the first of its kind totally devoted to the treatment of continuous signals and it systematically encompasses the theory of Fourier transforms wavelet transforms geometrical wavelet transforms and their ramifications The authors intend to motivate and stimulate interest among mathematicians computer scientists engineers and physical chemical and biological scientists The text is written from the ground up with target readers being senior undergraduate and first year graduate students and it can serve as a reference for professionals in mathematics engineering and applied sciences Features Flexibility in the book s organization enables instructors to select chapters appropriate to courses of different lengths emphasis and levels of difficulty Self contained the text provides an impetus to the contemporary developments in the signal processing aspects of wavelet theory at the forefront of research A large number of worked out examples are included Every major concept is presented with explanations limitations and subsequent developments with emphasis on applications in science and engineering A wide range of exercises are

incoporated in varying levels from elementary to challenging so readers may develop both manipulative skills in theory wavelets and deeper insight Answers and hints for selected exercises appear at the end The origin of the theory of wavelet transforms dates back to the 1980s as an outcome of the intriguing efforts of mathematicians physicists and engineers Owing to the lucid mathematical framework and versatile applicability the theory of wavelet transforms is now a nucleus of shared aspirations and ideas    Theory and Applications of Fractional Differential Equations A.A. Kilbas,H. M. Srivastava,J.J. Trujillo,2006-02-16 This work aims to present in a systematic manner results including the existence and uniqueness of solutions for the Cauchy Type and Cauchy problems involving nonlinear ordinary fractional differential equations

   *Quantum Mechanics In Phase Space: An Overview With Selected Papers* Thomas L Curtright,David B Fairlie,Cosmas K Zachos,2005-12-09 Wigner s quasi probability distribution function in phase space is a special Weyl representation of the density matrix It has been useful in describing quantum transport in quantum optics nuclear physics decoherence quantum computing and quantum chaos It is also important in signal processing and the mathematics of algebraic deformation A remarkable aspect of its internal logic pioneered by Groenewold and Moyal has only emerged in the last quarter century it furnishes a third alternative formulation of quantum mechanics independent of the conventional Hilbert space or path integral formulations In this logically complete and self standing formulation one need not choose sides coordinate or momentum space It works in full phase space accommodating the uncertainty principle and it offers unique insights into the classical limit of quantum theory This invaluable book is a collection of the seminal papers on the formulation with an introductory overview which provides a trail map for those papers an extensive bibliography and simple illustrations suitable for applications to a broad range of physics problems It can provide supplementary material for a beginning graduate course in quantum mechanics    **Global Dynamics, Phase Space Transport, Orbits Homoclinic to Resonances, and Applications** Stephen Wiggins, This monograph which grew out of a series of lectures delivered by Stephen Wiggins at the Fields Institute in early 1993 is concerned with the geometrical viewpoint of the global dynamics of nonlinear dynamical systems With appropriate examples and concise explanations Wiggins unites many different topics into one volume and makes a unique contribution to the field Engineers physicists chemists and mathematicians who work on issues related to the global dynamics of nonlinear dynamical systems will find these lectures very useful    **Quantum Group Symmetry and Q-tensor Algebras** L. C. Biedenharn,M. A. Lohe,1995 Quantum groups are a generalization of the classical Lie groups and Lie algebras and provide a natural extension of the concept of symmetry fundamental to physics This monograph is a survey of the major developments in quantum groups using an original approach based on the fundamental concept of a tensor operator Using this concept properties of both the algebra and co algebra are developed from a single uniform point of view which is especially helpful for understanding the noncommuting co ordinates of the quantum plane which we interpret as elementary tensor operators Representations of the q deformed angular momentum group are discussed including the case

where q is a root of unity and general results are obtained for all unitary quantum groups using the method of algebraic induction Tensor operators are defined and discussed with examples and a systematic treatment of the important 3j series of operators is developed in detail This book is a good reference for graduate students in physics and mathematics

**Quaternion and Clifford Fourier Transforms** Eckhard Hitzer,2021-09-21 Quaternion and Clifford Fourier Transforms describes the development of quaternion and Clifford Fourier transforms in Clifford geometric algebra over the last 30 years It is the first comprehensive self contained book covering this vibrant new area of pure and applied mathematics in depth The book begins with a historic overview followed by chapters on Clifford and quaternion algebra and geometric vector differential calculus part of Clifford analysis The core of the book consists of one chapter on quaternion Fourier transforms and one on Clifford Fourier transforms These core chapters and their sections on more special topics are reasonably self contained so that readers already somewhat familiar with quaternions and Clifford algebra will hopefully be able to begin reading directly in the chapter and section of their particular interest without frequently needing to skip back and forth The topics covered are of fundamental interest to pure and applied mathematicians physicists and engineers signal and color image processing electrical engineering computer science computer graphics artificial intelligence geographic information science aero space engineering navigation etc Features Intuitive real geometric approach to higher dimensional Fourier transformations A comprehensive reference suitable for graduate students and researchers Includes detailed definitions properties and many full step by step proofs Many figures and tables a comprehensive biography and a detailed index make it easy to locate information     Mathematical Optics Vasudevan Lakshminarayanan,María L. Calvo,Tatiana Alieva,2018-10-08 Going beyond standard introductory texts Mathematical Optics Classical Quantum and Computational Methods brings together many new mathematical techniques from optical science and engineering research Profusely illustrated the book makes the material accessible to students and newcomers to the field Divided into six parts the text presents state of the art mathematical methods and applications in classical optics quantum optics and image processing Part I describes the use of phase space concepts to characterize optical beams and the application of dynamic programming in optical waveguides Part II explores solutions to paraxial linear and nonlinear wave equations Part III discusses cutting edge areas in transformation optics such as invisibility cloaks and computational plasmonics Part IV uses Lorentz groups dihedral group symmetry Lie algebras and Liouville space to analyze problems in polarization ray optics visual optics and quantum optics Part V examines the role of coherence functions in modern laser physics and explains how to apply quantum memory channel models in quantum computers Part VI introduces super resolution imaging and differential geometric methods in image processing As numerical symbolic computation is an important tool for solving numerous real life problems in optical science many chapters include Mathematica code in their appendices The software codes and notebooks as well as color versions of the book s figures are available at www crcpress com     On Klauder's Path Gⴰrard G. Emch,G. C. Hegerfeldt,Ludwig Streit,1994

This volume contains contributions by friends colleagues and associates of John R Klauder on the occasion of his 60th birthday Klauder s scientific work embraces vast territories from quantum theories to general relativity optics and chaotic dynamics A recurrent theme in his research is the role played by coherent states in particular in connection with path integral formulations of quantization Perhaps at a less lofty level this concept has had at least two spectacular applications as a powerful investigative tool in quantum optics and as a precursor to wavelets In a different vein Klauder also attacked specific non renormalizable but exactly soluble hard core models in field theory where he uncovered what has since been called the Klauder phenomenon The contributors to this volume represent the special brand of mathematicians and physicists John Klauder helped define throughout his seminal career in the industrial and academic worlds    Recent Trends in Formal and Analytic Solutions of Diff. Equations Galina Filipuk,Alberto Lastra,Sławomir Michalik,2023-02-09 This volume contains the proceedings of the conference on Formal and Analytic Solutions of Diff Equations held from June 28 July 2 2021 and hosted by University of Alcal Alcal de Henares Spain The manuscripts cover recent advances in the study of formal and analytic solutions of different kinds of equations such as ordinary differential equations difference equations q difference equations partial differential equations moment differential equations etc Also discussed are related topics such as summability of formal solutions and the asymptotic study of their solutions The volume is intended not only for researchers in this field of knowledge but also for students who aim to acquire new techniques and learn recent results    Ba?cklund Transformations and Their Applications Rogers,1982-06-18 Ba cklund Transformations and Their Applications    **Nonlinear Dynamics of Rotating Shallow Water: Methods and Advances** ,2007-04-03 The rotating shallow water RSW model is of wide use as a conceptual tool in geophysical fluid dynamics GFD because in spite of its simplicity it contains all essential ingredients of atmosphere and ocean dynamics at the synoptic scale especially in its two or multi layer version The book describes recent advances in understanding in the framework of RSW and related models of some fundamental GFD problems such as existence of the slow manifold dynamical splitting of fast inertia gravity waves and slow vortices Rossby waves motions nonlinear geostrophic adjustment and wave emission the role of essentially nonlinear wave phenomena The specificity of the book is that analytical numerical and experimental approaches are presented together and complement each other Special attention is paid on explaining the methodology e g multiple time scale asymptotic expansions averaging and removal of resonances in what concerns theory high resolution finite volume schemes in what concerns numerical simulations and turntable experiments with stratified fluids in what concerns laboratory simulations A general introduction into GFD is given at the beginning to introduce the problematics for non specialists At the same time recent new results on nonlinear geostrophic adjustment nonlinear waves and equatorial dynamics including some exact results on the existence of the slow manifold wave breaking and nonlinear wave solutions are presented for the first time in a systematic manner Incorporates analytical numerical and experimental approaches in the geophysical fluid dynamics context Combination of

essentials in GFD of the description of analytical numerical and experimental methods tutorial part and new results obtained by these methods original part Provides the link between GFD and mechanics averaging method the method of normal forms GFD and nonlinear physics shocks solitons modons anomalous transport periodic nonlinear waves **Handbook of Linear Algebra, Second Edition** Leslie Hogben,2013-11-26 With a substantial amount of new material the Handbook of Linear Algebra Second Edition provides comprehensive coverage of linear algebra concepts applications and computational software packages in an easy to use format It guides you from the very elementary aspects of the subject to the frontiers of current research Along with revisions and updates throughout the second edition of this bestseller includes 20 new chapters New to the Second Edition Separate chapters on Schur complements additional types of canonical forms tensors matrix polynomials matrix equations special types of matrices generalized inverses matrices over finite fields invariant subspaces representations of quivers and spectral sets New chapters on combinatorial matrix theory topics such as tournaments the minimum rank problem and spectral graph theory as well as numerical linear algebra topics including algorithms for structured matrix computations stability of structured matrix computations and nonlinear eigenvalue problems More chapters on applications of linear algebra including epidemiology and quantum error correction New chapter on using the free and open source software system Sage for linear algebra Additional sections in the chapters on sign pattern matrices and applications to geometry Conjectures and open problems in most chapters on advanced topics Highly praised as a valuable resource for anyone who uses linear algebra the first edition covered virtually all aspects of linear algebra and its applications This edition continues to encompass the fundamentals of linear algebra combinatorial and numerical linear algebra and applications of linear algebra to various disciplines while also covering up to date software packages for linear algebra computations *Representations of Finite Dimensional Algebras and Related Topics in Lie Theory and Geometry* Vlastimil Dlab,Claus Michael Ringel, These proceedings are from the Tenth International Conference on Representations of Algebras and Related Topics ICRA X held at The Fields Institute In addition to the traditional instructional workshop preceding the conference there were also workshops on Commutative Algebra Algebraic Geometry and Representation Theory Finite Dimensional Algebras Algebraic Groups and Lie Theory and Quantum Groups and Hall Algebras These workshops reflect the latest developments and the increasing interest in areas that are closely related to the representation theory of finite dimensional associative algebras Although these workshops were organized separately their topics are strongly interrelated The workshop on Commutative Algebra Algebraic Geometry and Representation Theory surveyed various recently established connections such as those pertaining to the classification of vector bundles or Cohen Macaulay modules over Noetherian rings coherent sheaves on curves or ideals in Weyl algebras In addition methods from algebraic geometry or commutative algebra relating to quiver representations and varieties of modules were presented The workshop on Finite Dimensional Algebras Algebraic Groups and Lie Theory surveyed developments in finite dimensional algebras and

infinite dimensional Lie theory especially as the two areas interact and may have future interactions The workshop on Quantum Groups and Hall Algebras dealt with the different approaches of using the representation theory of quivers and species in order to construct quantum groups working either over finite fields or over the complex numbers In particular these proceedings contain a quite detailed outline of the use of perverse sheaves in order to obtain canonical bases The book is recommended for graduate students and researchers in algebra and geometry *Nonstandard Methods in Stochastic Analysis and Mathematical Physics* Sergio Albeverio,Jens Erik Fenstad,Raphael Høegh-Krohn,Tom Lindstrøm,2009-02-26 Two part treatment begins with a self contained introduction to the subject followed by applications to stochastic analysis and mathematical physics A welcome addition Bulletin of the American Mathematical Society 1986 edition

Whispering the Techniques of Language: An Emotional Journey through **Linear Canonical Transforms Applications Springer**

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