

The bispectral problem and polynomial solutions

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Abstract

Some properties and relations satisfied by the polynomial solutions of the bispectral problem are studied. Given a differential operator, under certain restrictions its polynomial eigenfunctions are explicitly obtained, as well as the corresponding eigenvalues. Also the inverse problem is approached, giving conditions for the existence of a differential operator from its eigenpolynomials and eigenvalues.

1 Introduction

We consider the ordinary differential operator

$$L = \sum_{i=0}^N a_i(x) \partial_x^i \quad (1)$$

where $a_i(x)$ are polynomials, $\deg(a_i) \leq i$, and $\partial_x^i = \frac{d^i}{dx^i}$, $i = 1, \dots, N$. We also consider a sequence $\{\lambda_n\} \subset \mathbb{C}$ of its eigenvalues and the corresponding sequence of eigenfunctions $\{P_n\}$, which we assume that are monic polynomials with $\deg(P_n) = n$ for each $n \in \mathbb{N}$. This is,

$$\sum_{i=0}^N a_i(x) \partial_x^i P_n(x) = \lambda_n P_n(x), \quad \forall n \in \mathbb{N}. \quad (2)$$

The polynomials P_n verifying (2) are called *eigenpolynomials* in this work. The Sturm-Liouville polynomial problem deals with the relations between the operator L and its eigenvalues and eigenpolynomials. We are interested in families of such eigenpolynomials that are at the same time eigenfunctions of a certain difference operator D . More precisely,

$$D \begin{pmatrix} P_0(x) \\ P_1(x) \\ \vdots \end{pmatrix} = x \begin{pmatrix} P_0(x) \\ P_1(x) \\ \vdots \end{pmatrix}. \quad (3)$$

Bispectral Problem

Erik P. van den Ban, Johan A.C. Kolk



Bispectral Problem:

Partial Differential Equations and Inverse Problems Carlos Conca, 2004 This proceedings volume is a collection of articles from the Pan American Advanced Studies Institute on partial differential equations nonlinear analysis and inverse problems held in Santiago Chile Interactions among partial differential equations nonlinear analysis and inverse problems have produced remarkable developments over the last couple of decades This volume contains survey articles reflecting the work of leading experts who presented minicourses at the event Contributors include J Busca Y Capdeboscq M S Vogelius F A Grunbaum L F Matusevich M de Hoop and P Kuchment The volume is suitable for graduate students and researchers interested in partial differential equations and their applications in nonlinear analysis and inverse problems The Kowalevski Property Vadim B. Kuznetsov, 2002 This book is a collection of survey articles on several topics related to the general notion of integrability It stems from a workshop on Mathematical Methods of Regular Dynamics dedicated to Sophie Kowalevski Leading experts introduce corresponding areas in depth The book provides a broad overview of research from the pioneering work of the nineteenth century to the developments of the 1970s through the present The book begins with two historical papers by R L Cooke on Kowalevski s life and work Following are 15 research surveys on integrability issues in differential and algebraic geometry classical complex analysis discrete mathematics spinning tops Painleve equations global analysis on manifolds special functions etc It concludes with Kowalevski s famous paper published in Acta Mathematica in 1889 Sur le probleme de la rotation d un corps solide autour d un point fixe The book is suitable for graduate students in pure and applied mathematics the general mathematical audience studying integrability and research mathematicians interested in differential and algebraic geometry analysis and special functions **The Bispectral Problem** John P. Harnad, Alex Kasman, The central theme of this book is the search for solutions to eigenvalue problems that satisfy additional equations in the spectral parameter for example pairs of eigenvalue equations This problem which looks very simple at first has turned out to be both deep and difficult Moreover this concept of bispectrality has been shown to be useful in many active areas of current research in mathematics and physics **Algebraic Methods and Q-special Functions** Jan Felipe Van Diejen, Luc Vinet, 1999-01-01 There has been revived interest in recent years in the study of special functions Many of the latest advances in the field were inspired by the works of R A Askey and colleagues on basic hypergeometric series and I G Macdonald on orthogonal polynomials related to root systems Significant progress was made by the use of algebraic techniques involving quantum groups Hecke algebras and combinatorial methods The CRM organized a workshop for key researchers in the field to present an overview of current trends This volume consists of the contributions to that workshop Topics include basic hypergeometric functions algebraic and representation theoretic methods combinatorics of symmetric functions root systems and the connections with integrable systems Special Functions 2000: Current Perspective and Future Directions Joaquin Bustoz, Mourad E.H. Ismail, Sergei Suslov, 2012-12-06 The Advanced Study Institute brought

together researchers in the main areas of special functions and applications to present recent developments in the theory review the accomplishments of past decades and chart directions for future research Some of the topics covered are orthogonal polynomials and special functions in one and several variables asymptotic continued fractions applications to number theory combinatorics and mathematical physics integrable systems harmonic analysis and quantum groups Painlevé classification *Toeplitz Operators and Random Matrices* Estelle Basor, Albrecht Böttcher, Torsten Ehrhardt, Craig A.

Tracy, 2023-01-01 This volume is dedicated to the memory of Harold Widom 1932 2021 an outstanding mathematician who has enriched mathematics with his ideas and ground breaking work since the 1950s until the present time It contains a biography of Harold Widom personal notes written by his former students or colleagues and also his last previously unpublished paper on domain walls in a Heisenberg Ising chain Widom's most famous contributions were made to Toeplitz operators and random matrices While his work on random matrices is part of almost all the present day research activities in this field his work in Toeplitz operators and matrices was done mainly before 2000 and is therefore described in a contribution devoted to his achievements in just this area The volume contains 18 invited and refereed research and expository papers on Toeplitz operators and random matrices These present new results or new perspectives on topics related to Widom's work

Orthogonal Polynomials Mama Foupouagnigni, Wolfram Koepf, 2020-03-11 This book presents contributions of international and local experts from the African Institute for Mathematical Sciences AIMS Cameroon and also from other local universities in the domain of orthogonal polynomials and applications The topics addressed range from univariate to multivariate orthogonal polynomials from multiple orthogonal polynomials and random matrices to orthogonal polynomials and Painlevé equations The contributions are based on lectures given at the AIMS Volkswagen Stiftung Workshop on Introduction of Orthogonal Polynomials and Applications held on October 5 12 2018 in Douala Cameroon This workshop funded within the framework of the Volkswagen Foundation Initiative Symposia and Summer Schools was aimed globally at promoting capacity building in terms of research and training in orthogonal polynomials and applications discussions and development of new ideas as well as development and enhancement of networking including south south cooperation

Modern Signal Processing Daniel N. Rockmore, Dennis M. Healy, 2004-04-05 A description of the mathematical basis of signal processing and many areas of application

Geometric Aspects of Analysis and Mechanics Erik P. van den Ban, Johan A.C. Kolk, 2011-06-28 Hans Duistermaat an influential geometer analyst made substantial contributions to the theory of ordinary and partial differential equations symplectic differential and algebraic geometry minimal surfaces semisimple Lie groups mechanics mathematical physics and related fields Written in his honor the invited and refereed articles in this volume contain important new results as well as surveys in some of these areas clearly demonstrating the impact of Duistermaat's research and in addition exhibiting interrelationships among many of the topics

Symmetries and Integrability of Difference Equations Peter A. Clarkson, Frank W. Nijhoff, 1999-02-04 This volume comprises state of

the art articles in discrete integrable systems European Congress of Mathematics Antal Balog, Domokos Szasz, András Recski, Gyula O.H. Katona, 2012-12-06 This is the second volume of the proceedings of the second European Congress of Mathematics Volume I presents the speeches delivered at the Congress the list of lectures and short summaries of the achievements of the prize winners Together with volume II it contains a collection of contributions by the invited lecturers Finally volume II also presents reports on some of the Round Table discussions This two volume set thus gives an overview of the state of the art in many fields of mathematics and is therefore of interest to every professional mathematician Contributors Vol I N Alon L Ambrosio K Astala R Benedetti Ch Bessenrodt F Bethuel P Bj rstad E Bolthausen J Bricmont A Kupiainen D Burago L Caporaso U Dierkes I Dynnikov L H Eliasson W T Gowers H Hedenmalm A Huber J Kaczorowski J Koll r D O Kramkov A N Shiryaev C Lescop R M rz Vol II J Matousek D McDuff A S Merkurjev V Milman St M ller T Nowicki E Olivieri E Scoppola V P Platonov J P schel L Polterovich L Pyber N Sim nyi J P Solovej A Stipsicz G Tardos J P Tignol A P Veselov E Zuazua **Orthogonal Polynomials and Special Functions** Francisco Marcellàn, 2006-06-19 Special functions and orthogonal polynomials in particular have been around for centuries Can you imagine mathematics without trigonometric functions the exponential function or polynomials In the twentieth century the emphasis was on special functions satisfying linear differential equations but this has now been extended to difference equations partial differential equations and non linear differential equations The present set of lecture notes contains seven chapters about the current state of orthogonal polynomials and special functions and gives a view on open problems and future directions The topics are computational methods and software for quadrature and approximation equilibrium problems in logarithmic potential theory discrete orthogonal polynomials and convergence of Krylov subspace methods in numerical linear algebra orthogonal rational functions and matrix orthogonal rational functions orthogonal polynomials in several variables Jack polynomials and separation of variables a classification of finite families of orthogonal polynomials in Askey s scheme using Leonard pairs and non linear special functions associated with the Painlevé equations *Computational Intelligence and Soft Computing Applications in Healthcare Management Science* Gul, Muhammet, Celik, Erkan, Mete, Suleyman, Serin, Faruk, 2020-03-06 In today s modernized world the field of healthcare has seen significant practical innovations with the implementation of computational intelligence approaches and soft computing methods These two concepts present various solutions to complex scientific problems and imperfect data issues This has made both very popular in the medical profession There are still various areas to be studied and improved by these two schemes as healthcare practices continue to develop Computational Intelligence and Soft Computing Applications in Healthcare Management Science is an essential reference source that discusses the implementation of soft computing techniques and computational methods in the various components of healthcare telemedicine and public health Featuring research on topics such as analytical modeling neural networks and fuzzy logic this book is ideally designed for software engineers information scientists medical professionals researchers

developers educators academicians and students Recent Progress in Special Functions Galina Filipuk, 2024-11-02 This volume contains a collection of papers that focus on recent research in the broad field of special functions The articles cover topics related to differential equations dynamic systems integrable systems billiards and random matrix theory Linear classical special functions such as hypergeometric functions Heun functions and various orthogonal polynomials and nonlinear special functions e g the Painlevé transcendents and their generalizations are studied from different perspectives This volume serves as a useful reference for a large audience of mathematicians and mathematical physicists interested in modern theory of special functions It is suitable for both graduate students and specialists in the field **Electronic**

Communication - II Mr. Rohit Manglik, 2024-07-30 Advanced communication systems are covered Guides students to analyze digital signals fostering expertise in electronics through practical experiments and theoretical analysis **Bilinear**

Integrable Systems: from Classical to Quantum, Continuous to Discrete Ludwig Faddeev, Pierre Van Moerbeke, Franklin Lambert, 2007-05-16 On April 29 1814 Napoleon landed on the island of Elba surrounded with a personal army of 1200 men The allies Russia Prussia England and Austria had forced him into exile after a number of very costly defeats he was deprived of all his titles but could keep the title of Emperor of Elba History tells us that each morning he took long walks in the sun reviewed his army each midday and discussed world matters with newly appointed advisors following the same pattern everyday to the great surprise of Campbell the British officer who was to keep an eye on him All this made everyone believe he was settled there for good Napoleon once said Elba is beautiful but a bit small Elba was definitely a source of inspiration indeed the early morning March 6 1815 Metternich the chancellor of Austria was woken up by one of his aides with the stunning news that Napoleon had left Elba with his 1200 men and was marching to Paris with little resistance A few days later he took up his throne again in the Tuileries In spite of his insatiable hunger for battles and expansion he is remembered as an important statesman He was a pioneer in setting up much of the legal administrative and political machinery in large parts of continental Europe We gathered here in a lovely and quaint shing port Marciana Marina on the island of Elba to celebrate one of the pioneers of integrable systems Hirota Sensei and this at the occasion of his seventieth birthday Trained as a physicist in his home university Kyushu University Professor Hirota earned his PhD in 61 at Northwestern University with Professor Siegert in the field of Quantum Statistical mechanics He wrote a widely appreciated Doctoral dissertation on Functional Integral representation of the grand partition function **Algebraic and Geometric Aspects of Integrable Systems and Random Matrices** Anton Dzhamay, Ken'ichi Maruno, Virgil U. Pierce, 2013-06-26 This volume contains the proceedings of the AMS Special Session on Algebraic and Geometric Aspects of Integrable Systems and Random Matrices held from January 6 7 2012 in Boston MA The very wide range of topics represented in this volume illustrates

Nonlinearity, Integrability And All That: Twenty Years After Needs '79 - Proceedings Of The Workshop M Boiti, Luigi Martina, F Pempinelli, Barbara Prinari, Giulio Soliani, 2000-05-12 This book discusses achievements in the last 20 years recent

developments and future perspectives in nonlinear science Both continuous and discrete systems classical and quantum are considered

Bispectral Methods of Signal Processing Alexander V. Totsky, Alexander A. Zelensky, Victor F. Kravchenko, 2014-12-11 By studying applications in radar telecommunications and digital image restoration this monograph discusses signal processing techniques based on bispectral methods Improved robustness against different forms of noise as well as preservation of phase information render this method a valuable alternative to common power spectrum analysis used in radar object recognition digital wireless communications and jitter removal in images Rapport ,2002

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