

# Exponential sums for symplectic groups and their applications

by

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**1. Introduction.** Let  $\lambda$  be a nontrivial additive character of the finite field  $\mathbb{F}_q$ , and let  $r$  be a positive integer. Then we consider the exponential sum

$$(1.1) \quad \sum_{w \in \mathrm{Sp}(2n, q)} \lambda((\mathrm{tr} w)^r),$$

where  $\mathrm{Sp}(2n, q)$  is the symplectic group over  $\mathbb{F}_q$ , and  $\mathrm{tr} w$  is the trace of  $w$ . Also, we consider

$$(1.2) \quad \sum_{w \in \mathrm{GSp}(2n, q)} \lambda((\mathrm{tr} w)^r),$$

where  $\mathrm{GSp}(2n, q)$  denotes the symplectic similitude group over  $\mathbb{F}_q$ .

The main purpose of this paper is to find explicit expressions for the sums (1.1) and (1.2). It turns out that (1.1) is a polynomial in  $q$  times

$$(1.3) \quad \sum_{\gamma \in \mathbb{F}_q} \lambda(\gamma^r)$$

plus another polynomial in  $q$  involving certain exponential sums. On the other hand, the expression for (1.2) is similar to that for (1.1), except that the polynomial in  $q$  involving (1.3) is multiplied by  $q - 1$  and that the exponential sums appearing in the other polynomial in  $q$  are replaced by averages of those exponential sums.

In [8], the sums in (1.1) and (1.2) were studied for  $r = 1$  and the connection of the sum in (1.1) with Hodges' generalized Kloosterman sum over nonsingular alternating matrices was also investigated (cf. [4]–[6]). As the

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# Exponential Sums And Their Applications

**Harald Niederreiter**



## **Exponential Sums And Their Applications:**

**Exponential Sums and their Applications** N.M Korobov,2013-06-29 The method of exponential sums is a general method enabling the solution of a wide range of problems in the theory of numbers and its applications This volume presents an exposition of the fundamentals of the theory with the help of examples which show how exponential sums arise and how they are applied in problems of number theory and its applications The material is divided into three chapters which embrace the classical results of Gauss and the methods of Weyl Mordell and Vinogradov the traditional applications of exponential sums to the distribution of fractional parts the estimation of the Riemann zeta function and the theory of congruences and Diophantine equations Some new applications of exponential sums are also included It is assumed that the reader has a knowledge of the fundamentals of mathematical analysis and of elementary number theory **Van Der Corput's Method**

**of Exponential Sums** S. W. Graham,G. Kolesnik,1991-01-25 This book is a self contained account of the one and two dimensional van der Corput method and its use in estimating exponential sums These arise in many problems in analytic number theory It is the first cohesive account of much of this material and will be welcomed by graduates and professionals in analytic number theory The authors show how the method can be applied to problems such as upper bounds for the Riemann Zeta function the Dirichlet divisor problem the distribution of square free numbers and the Piatetski Shapiro prime number theorem *International Conference Automorphic Functions and Their Applications* ,1990 **Coding Theory And**

**Cryptology** Harald Niederreiter,2002-12-03 The inaugural research program of the Institute for Mathematical Sciences at the National University of Singapore took place from July to December 2001 and was devoted to coding theory and cryptology As part of the program tutorials for graduate students and junior researchers were given by world renowned scholars These tutorials covered fundamental aspects of coding theory and cryptology and were designed to prepare for original research in these areas The present volume collects the expanded lecture notes of these tutorials The topics range from mathematical areas such as computational number theory exponential sums and algebraic function fields through coding theory subjects such as extremal problems quantum error correcting codes and algebraic geometry codes to cryptologic subjects such as stream ciphers public key infrastructures key management authentication schemes and distributed system security [The Method of Trigonometrical Sums in the Theory of Numbers](#) I. M. Vinogradov,2013-10-30

This text investigates Waring's problem approximation by fractional parts of the values of a polynomial estimates for Weyl sums distribution of fractional parts of polynomial values Goldbach's problem more 1954 edition **Lecture Notes on the Mathematical Theory of the Boltzmann Equation** N. Bellomo,L. Arlotti,1995 This is a collection of four lectures on some mathematical aspects related to the nonlinear Boltzmann equation The following topics are dealt with derivation of kinetic equations qualitative analysis of the initial value problem singular perturbation analysis towards the hydrodynamic limit and computational methods towards the solution of problems in fluid dynamics **Sieve Methods, Exponential Sums, and**

**Their Applications in Number Theory** G. R. H. Greaves, G. Harman, M. N. Huxley, 1997 State of the art analytic number theory proceedings *Cryptography and Coding* Michael Walker, 2003-07-31 **Number Theory: Dreaming In Dreams - Proceedings Of The 5th China-japan Seminar** Shigeru Kanemitsu, Takashi Aoki, Jianya Liu, 2009-11-26 This volume aims at collecting survey papers which give broad and enlightening perspectives of various aspects of number theory Kitaoka's paper is a continuation of his earlier paper published in the last proceedings and pushes the research forward Browning's paper introduces a new direction of research on analytic number theory quantitative theory of some surfaces and Bruedern et al's paper details state of the art affairs of additive number theory There are two papers on modular forms Kohnen's paper describes generalized modular forms GMF which has some applications in conformal field theory while Liu's paper is very useful for readers who want to have a quick introduction to Maass forms and some analytic number theoretic problems related to them Matsumoto et al's paper gives a very thorough survey on functional relations of root system zeta functions Hoshi Miyake's paper is a continuation of Miyake's long and fruitful research on generic polynomials and gives rise to related Diophantine problems and Jia's paper surveys some dynamical aspects of a special arithmetic function connected with the distribution of prime numbers There are two papers of collections of problems by Shparlinski on exponential and character sums and Schinzel on polynomials which will serve as an aid for finding suitable research problems Yamamura's paper is a complete bibliography on determinant expressions for a certain class number and will be useful to researchers Thus the book gives a good balance of classical and modern aspects in number theory and will be useful to researchers including enthusiastic graduate students

**Sequences and Their Applications - SETA 2010** Claude Carlet, Alexander Pott, 2010-09 This volume contains the refereed proceedings of the Sixth International Conference on Sequences and Their Applications SETA 2010 held in Paris France September 13-17 2010 The previous five conferences were held in Singapore Republic of Singapore Bergen Norway Seoul South Korea Beijing China and Lexington USA Topics of SETA include Randomness of sequences Correlation periodic and aperiodic types and combinatorial aspects of quences difference sets Sequences with applications in coding theory and cryptography Sequences over finite fields rings function fields Linear and nonlinear feedback shift register sequences Sequences for radar distance ranging synchronization identification and hardware testing Sequences for wireless communication Pseudorandom sequence generators Boolean and vectorial functions for sequences coding and or cryptography Multidimensional sequences and their correlation properties Linear and nonlinear complexity of sequences The Technical Program Committee of SETA 2010 refereed 56 submitted papers Each paper was reviewed by at least 2 referees at least 3 when an author was a TPC member and the TPC selected 33 papers to be presented at the conference In addition we had 4 invited papers by Robert Calderbank Princeton University USA James Massey retired from ETH Zurich Switzerland Jong Seon No Seoul National University South Korea and Arne Winterhof Österreichische Akademie der Wissenschaften Austria The Co-chairs of the TPC were Claude Carlet Université Paris 8 France and Alexander Pott Otto von Guericke Universität

Magdeburg Germany They wish to thank the other members of the Program Committee Thierry P

**Differential Equations on Complex Manifolds** Boris Sternin, Victor Shatalov, 2013-03-09 The present monograph is devoted to the complex theory of differential equations Not yet a handbook neither a simple collection of articles the book is a first attempt to present a more or less detailed exposition of a young but promising branch of mathematics that is the complex theory of partial differential equations Let us try to describe the framework of this theory First simple examples show that solutions of differential equations are as a rule ramifying analytic functions and hence are not regular near points of their ramification Second bearing in mind these important properties of solutions we shall try to describe the method solving our problem Surely one has first to consider differential equations with constant coefficients The apparatus solving such problems is well known in the real theory of differential equations this is the Fourier transformation Unfortunately such a transformation had not yet been constructed for complex analytic functions and the authors had to construct by themselves This transformation is of course the key notion of the whole theory

**Characteristics of Distributed-Parameter Systems** A.G. Butkovskiy, L.M. Pustyl'nikov, 2012-12-06 This book is a continuation of the book Green's Functions and Transfer Functions 35 written some ten years ago However there is no overlap whatsoever in the contents of the two books and this book can be used quite independently of the previous one This series of books represents a new kind of handbook in which are collected data on the characteristics of systems with distributed and lumped parameters The present volume covers some two hundred problems Essentially this book should be considered as a desktop handbook intended like 35 to give rapid on line access to relevant data about problems For each problem the book lists all the main characteristics of the solution standardising functions Green's functions transfer functions or matrices eigenfunctions and eigenvalues with their asymptotics roots of characteristic equations and other data In addition to systems described by a single differential equation this volume also includes degenerate multiconnected systems systems for which no Green's function or matrix exists and other special cases which are important for applications

Spline Functions and Multivariate Interpolations Borislav D. Bojanov, H. Hakopian, B. Sahakian, 2013-06-29 Spline functions entered Approximation Theory as solutions of natural extremal problems A typical example is the problem of drawing a function curve through given  $n$   $k$  points that has a minimal norm of its  $k$ th derivative Isolated facts about the functions now called splines can be found in the papers of L Euler A Lebesgue G Birkhoff J Favard L Tschakaloff However the Theory of Spline Functions has developed in the last 30 years by the effort of dozens of mathematicians Recent fundamental results on multivariate polynomial interpolation and multivariate splines have initiated a new wave of theoretical investigations and variety of applications The purpose of this book is to introduce the reader to the theory of spline functions The emphasis is given to some new developments such as the general Birkhoff's type interpolation the extremal properties of the splines and their prominent role in the optimal recovery of functions multivariate interpolation by polynomials and splines The material presented is based on the lectures of the authors given to the students at the

University of Sofia and Yerevan University during the last 10 years Some more elementary results are left as exercises and detailed hints are given

**Encyclopaedia of Mathematics** Michiel Hazewinkel, 2012-12-06 This ENCYCLOPAEDIA OF MATHEMATICS aims to be a reference work for all parts of mathematics It is a translation with updates and editorial comments of the Soviet Mathematical Encyclopaedia published by Soviet Encyclopaedia Publishing House in five volumes in 1977 1985 The annotated translation consists of ten volumes including a special index volume There are three kinds of articles in this ENCYCLOPAEDIA First of all there are survey type articles dealing with the various main directions in mathematics where a rather fine subdivision has been used The main requirement for these articles has been that they should give a reasonably complete up to date account of the current state of affairs in these areas and that they should be maximally accessible On the whole these articles should be understandable to mathematics students in their first specialization years to graduates from other mathematical areas and depending on the specific subject to specialists in other domains of science engineers and teachers of mathematics These articles treat their material at a fairly general level and aim to give an idea of the kind of problems techniques and concepts involved in the area in question They also contain background and motivation rather than precise statements of precise theorems with detailed definitions and technical details on how to carry out proofs and constructions The second kind of article of medium length contains more detailed concrete problems results and techniques

**Prospects in Mathematics** Hugo Rossi, In celebration of Princeton University's 250th anniversary the mathematics department held a conference entitled Prospects in Mathematics The purpose of the conference was to speculate on future directions of research in mathematics This collection of articles provides a rich panorama of current mathematical activity in many research areas From Gromov's lecture on quantitative differential topology to Witten's discussion of string theory new ideas and techniques transfixed the audience of international mathematicians The volume contains 11 articles by leading mathematicians including historical presentations by J Milnor and D Spencer It provides a guide to some of the most significant mathematical work of the past decade

Difference Sets, Sequences and their Correlation Properties A. Pott, V Kumaran, Tor Helleseth, Dieter Jungnickel, 1999-09-30 The explanation of the formal duality of Kerdock and Preparata codes is one of the outstanding results in the field of applied algebra in the last few years This result is related to the discovery of large sets of quadriphase sequences over  $\mathbb{Z}_4$  whose correlation properties are better than those of the best binary sequences Moreover the correlation properties of sequences are closely related to difference properties of certain sets in cyclic groups It is the purpose of this book to illustrate the connection between these three topics Most articles grew out of lectures given at the NATO Advanced Study Institute on Difference sets sequences and their correlation properties This workshop took place in Bad Windsheim Germany in August 1998 The editors thank the NATO Scientific Affairs Division for the generous support of this workshop Without this support the present collection of articles would not have been realized

*Featured Reviews in Mathematical Reviews 1997-1999* Donald G. Babbitt, Jane E. Kister, 2000-05-05

This second volume of Featured Reviews makes available special detailed reviews of some of the most important mathematical articles and books published from 1997 through 1999 Also included are excellent reviews of several classic books and articles published prior to 1970 Among those reviews for example are the following Homological Algebra by Henri Cartan and Samuel Eilenberg reviewed by G Hochschild Faisceaux algebriques coherents by Jean Pierre Serre reviewed by C Chevalley and On the Theory of General Partial Differential Operators by Lars Hormander reviewed by J L Lions In particular those seeking information on current developments outside their own area of expertise will find the volume very useful By identifying some of the best publications papers and books that have had or are expected to have a significant impact in applied and pure mathematics this volume will serve as a comprehensive guide to important new research across all fields covered by MR

Public-Key Cryptography Daniel Lieman, 2005 This collection of articles grew out of an expository and tutorial conference on public key cryptography held at the Joint Mathematics Meetings Baltimore The book provides an introduction and survey on public key cryptography for those with considerable mathematical maturity and general mathematical knowledge Its goal is to bring visibility to the cryptographic issues that fall outside the scope of standard mathematics These mathematical expositions are intended for experienced mathematicians who are not well acquainted with the subject The book is suitable for graduate students researchers and engineers interested in mathematical aspects and applications of public key cryptography

The Riemann Hypothesis Peter B. Borwein, 2008 The Riemann Hypothesis has become the Holy Grail of mathematics in the century and a half since 1859 when Bernhard Riemann one of the extraordinary mathematical talents of the 19th century originally posed the problem While the problem is notoriously difficult and complicated even to state carefully it can be loosely formulated as the number of integers with an even number of prime factors is the same as the number of integers with an odd number of prime factors The Hypothesis makes a very precise connection between two seemingly unrelated mathematical objects namely prime numbers and the zeros of analytic functions If solved it would give us profound insight into number theory and in particular the nature of prime numbers This book is an introduction to the theory surrounding the Riemann Hypothesis Part I serves as a compendium of known results and as a primer for the material presented in the 20 original papers contained in Part II The original papers place the material into historical context and illustrate the motivations for research on and around the Riemann Hypothesis Several of these papers focus on computation of the zeta function while others give proofs of the Prime Number Theorem since the Prime Number Theorem is so closely connected to the Riemann Hypothesis The text is suitable for a graduate course or seminar or simply as a reference for anyone interested in this extraordinary conjecture

**Surveys in Number Theory** Bruce Berndt, 2002-11-20 This volume based on fourteen papers from the Millennial Conference on Number Theory represents surveys of topics in number theory and provides an outlook into the future of number theory research It serves as an inspiration to graduate students and as a reference for research mathematicians

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