

# HARMONIC ANALYSIS ON COMPACT POLAR HOMOGENEOUS SPACES

JING-SONG HUANG

In this paper we are concerned with the existence of discrete series for semisimple homogeneous spaces. This leads to the definition of polar homogeneous spaces. We first study the harmonic analysis on compact polar homogeneous spaces. The proof of the existence of discrete series and the Plancherel formula for non-compact and non-symmetric polar homogeneous spaces will be given in a consequent paper.

## 1. Introduction.

One of the greatest achievements of mathematics in twentieth century is Harish-Chandra's work on discrete series for semisimple Lie groups. Suppose  $G$  is a semisimple Lie group with a maximal compact Lie group  $K$ . Harish-Chandra proved that  $G$  has discrete series if and only if the real rank of  $G$  is equal to the rank of  $K$  ([HC]). In other words,  $G$  has discrete series if and only if  $G$  has a compact Cartan subgroup. Harish-Chandra also obtained a classification of the discrete series for semisimple Lie groups. Harish-Chandra's results on discrete series have been generalized to semisimple symmetric spaces. Flensted-Jensen ([FJ]) proved that a semisimple symmetric space  $G/H$  has discrete series if

$$(1.1) \quad \text{rank of } G/H = \text{rank of } K/K \cap H.$$

Later on Oshima and Matsuki ([OM]) proved if  $G/H$  has discrete series then it must satisfy the rank condition (1.1). That is to say, the semisimple symmetric space  $G/H$  has discrete series if and only if it has a compact Cartan subspace. Oshima and Matsuki also gave a description of all discrete series for semisimple symmetric spaces. Since the group  $G$  can be regarded as symmetric space  $G \times G/d(G)$ , the results of Flensted-Jensen, Oshima and Matsuki are the generalizations of Harish-Chandra's work.

If  $G$  is a semisimple Lie group and  $H$  a closed reductive subgroup, it is very natural to ask the following question: when does the semisimple homogeneous space  $G/H$  has discrete series? Based on the observation of the results mentioned above, we would guess  $G/H$  has discrete series if

# Harmonic Analysis On Homogeneous Spaces

**Ali Baklouti, Takaaki Nomura**



## Harmonic Analysis On Homogeneous Spaces:

**Harmonic Analysis on Homogeneous Spaces** Calvin C. Moore, 1978 *Topics in Harmonic Analysis on Homogeneous Spaces* Sigurdur Helgason, 1981 *Harmonic Analysis on Homogeneous Spaces. [Edited by Calvin C. Moore].* Symposium in Pure Mathematics, Williams College, 1972, Calvin C. Moore (1936- Ed), Williams College, 1973 Harmonic Analysis on Homogeneous Spaces Nolan R. Wallach, 2018-12-12 This book is suitable for advanced undergraduate and graduate students in mathematics with a strong background in linear algebra and advanced calculus Early chapters develop representation theory of compact Lie groups with applications to topology geometry and analysis including the Peter Weyl theorem the theorem of the highest weight the character theory invariant differential operators on homogeneous vector bundles and Bott's index theorem for such operators Later chapters study the structure of representation theory and analysis of non compact semi simple Lie groups including the principal series intertwining operators asymptotics of matrix coefficients and an important special case of the Plancherel theorem Teachers will find this volume useful as either a main text or a supplement to standard one year courses in Lie groups and Lie algebras The treatment advances from fairly simple topics to more complex subjects and exercises appear at the end of each chapter Eight helpful Appendixes develop aspects of differential geometry Lie theory and functional analysis employed in the main text Harmonic Analysis on Homogeneous Spaces Nolan R. Wallach, 1973 *Harmonic Analysis on Homogeneous Spaces of  $SO(1,2)$*  Yi. A. Verdiyev, 1988 *Harmonic Analysis on Spaces of Homogeneous Type* Donggao Deng, Yongsheng Han, 2008-11-19 This book could have been entitled Analysis and Geometry The authors are addressing the following issue Is it possible to perform some harmonic analysis on a set Harmonic analysis on groups has a long tradition Here we are given a metric set  $X$  with a positive Borel measure and we would like to construct some algorithms which in the classical setting rely on the Fourier transformation Needless to say the Fourier transformation does not exist on an arbitrary metric set This endeavor is not a revolution It is a continuation of a line of research which was initiated a century ago with two fundamental papers that I would like to discuss briefly The first paper is the doctoral dissertation of Alfred Haar which was submitted at to University of Göttingen in July 1907 At that time it was known that the Fourier series expansion of a continuous function may diverge at a given point Haar wanted to know if this phenomenon happens for every 2 orthonormal basis of  $L^0_1$  He answered this question by constructing an orthonormal basis today known as the Haar basis with the property that the expansion in this basis of any continuous function uniformly converges to that function **Harmonic Analysis on Homogeneous Spaces**, 1973 **Harmonic Analysis on Homogeneous Spaces of  $SO(1,2)$**  Ī. A. Verdiev, 1988 HARMONIC ANALYSIS ON HOMOGENEOUS SPACES- BASED ON THE 19TH SUMMER RESEARCH INSTITUTE OF THE AMERICAN MATHEMATICAL SOCIETY., Geometric and Harmonic Analysis on Homogeneous Spaces and Applications Ali Baklouti, Hideyuki Ishi, 2021-10-29 This book collects a series of important works on noncommutative harmonic analysis on homogeneous spaces and related topics All the authors

participated in the 6th Tunisian Japanese conference Geometric and Harmonic Analysis on homogeneous spaces and Applications held at Djerba Island in Tunisia during the period of December 16 19 2019 The aim of this conference and the five preceding Tunisian Japanese meetings was to keep up with the active development of representation theory interrelated with various other mathematical fields such as number theory algebraic geometry differential geometry operator algebra partial differential equations and mathematical physics The present volume is dedicated to the memory of Takaaki Nomura who organized the series of Tunisian Japanese conferences with great effort and enthusiasm The book is a valuable resource for researchers and students working in various areas of analysis geometry and algebra in connection with representation theory

Representation Theory and Noncommutative Harmonic Analysis II Alexandre Kirillov, 2012-12-22 Two surveys introducing readers to the subjects of harmonic analysis on semi simple spaces and group theoretical methods and preparing them for the study of more specialised literature This book will be very useful to students and researchers in mathematics theoretical physics and those chemists dealing with quantum systems

Harmonic Analysis on Homogeneous Spaces and Representation Theory of Groups, 1991

*Geometric and Harmonic Analysis on Homogeneous Spaces and Applications* Ali Baklouti, Takaaki Nomura, 2018-02-09 This book provides the latest competing research results on non commutative harmonic analysis on homogeneous spaces with many applications It also includes the most recent developments on other areas of mathematics including algebra and geometry Lie group representation theory and harmonic analysis on Lie groups and on their homogeneous spaces form a significant and important area of mathematical research These areas are interrelated with various other mathematical fields such as number theory algebraic geometry differential geometry operator algebra partial differential equations and mathematical physics Keeping up with the fast development of this exciting area of research Ali Baklouti University of Sfax and Takaaki Nomura Kyushu University launched a series of seminars on the topic the first of which took place on November 2009 in Kerkennah Islands the second in Sousse on December 2011 and the third in Hammamet on December 2013 The last seminar which took place December 18th to 23rd 2015 in Monastir Tunisia has promoted further research in all the fields where the main focus was in the area of Analysis algebra and geometry and on topics of joint collaboration of many teams in several corners Many experts from both countries have been involved

**Geometric and Harmonic Analysis on Homogeneous Spaces and Applications** Ali Baklouti, Takaaki Nomura, 2017

Representation Theory and Noncommutative Harmonic Analysis II A.A. Kirillov, 2013-03-09 At first only elementary functions were studied in mathematical analysis Then new functions were introduced to evaluate integrals They were named special functions integral sine logarithms the exponential function the probability integral and so on Elliptic integrals proved to be the most important They are connected with rectification of arcs of certain curves The remarkable idea of Abel to replace these integrals by the corresponding inverse functions led to the creation of the theory of elliptic functions They are doubly periodic functions of a complex variable This periodicity has led to consideration of the lattice of periods and to linear

fractional transformations of the complex plane which leave this lattice invariant The group of these transformations is isomorphic to the quotient group of the group  $GL(2, \mathbb{Z})$  of unimodular matrices of the second order with integral elements with respect to its center Investigation of properties of elliptic functions led to the study of automorphic functions and forms This gave the first connection between the theory of groups and this important class of functions The further development of the theory of automorphic functions was related to geometric concepts connected with the fact that the group of linear fractional transformations with real elements can be realized as the group of motions of the Lobachevskij plane We also note that at the beginning of the 19 century Gauss used the group  $GL(2, \mathbb{Z})$  in his papers on the theory of indeterminate quadratic forms

*Geometric and Harmonic Analysis on Homogeneous Spaces* Ali Baklouti, Takaaki Nomura, 2019-08-31 This book presents a number of important contributions focusing on harmonic analysis and representation theory of Lie groups All were originally presented at the 5th Tunisian Japanese conference Geometric and Harmonic Analysis on Homogeneous Spaces and Applications which was held at Mahdia in Tunisia from 17 to 21 December 2017 and was dedicated to the memory of the brilliant Tunisian mathematician Majdi Ben Halima The peer reviewed contributions selected for publication have been modified and are without exception of a standard equivalent to that in leading mathematical periodicals Highlighting the close links between group representation theory and harmonic analysis on homogeneous spaces and numerous mathematical areas such as number theory algebraic geometry differential geometry operator algebra partial differential equations and mathematical physics the book is intended for researchers and students working in the area of commutative and non

commutative harmonic analysis as well as group representations **Geometric and Harmonic Analysis on Homogeneous Spaces and Application**, 2015 **Harmonic Analysis on Homogeneous Spaces Proceedings of the Symposium in Pure Mathematics, Williams College, 1972 Pure Mathematics** American Mathematical Society, 1973 **Groups & Geometric Analysis**, 1984-06-30 Groups Geometric Analysis

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## **Table of Contents Harmonic Analysis On Homogeneous Spaces**

1. Understanding the eBook Harmonic Analysis On Homogeneous Spaces
  - The Rise of Digital Reading Harmonic Analysis On Homogeneous Spaces
  - Advantages of eBooks Over Traditional Books
2. Identifying Harmonic Analysis On Homogeneous Spaces
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Harmonic Analysis On Homogeneous Spaces
  - User-Friendly Interface
4. Exploring eBook Recommendations from Harmonic Analysis On Homogeneous Spaces

- Personalized Recommendations
- Harmonic Analysis On Homogeneous Spaces User Reviews and Ratings
- Harmonic Analysis On Homogeneous Spaces and Bestseller Lists
- 5. Accessing Harmonic Analysis On Homogeneous Spaces Free and Paid eBooks
  - Harmonic Analysis On Homogeneous Spaces Public Domain eBooks
  - Harmonic Analysis On Homogeneous Spaces eBook Subscription Services
  - Harmonic Analysis On Homogeneous Spaces Budget-Friendly Options
- 6. Navigating Harmonic Analysis On Homogeneous Spaces eBook Formats
  - ePub, PDF, MOBI, and More
  - Harmonic Analysis On Homogeneous Spaces Compatibility with Devices
  - Harmonic Analysis On Homogeneous Spaces Enhanced eBook Features
- 7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Harmonic Analysis On Homogeneous Spaces
  - Highlighting and Note-Taking Harmonic Analysis On Homogeneous Spaces
  - Interactive Elements Harmonic Analysis On Homogeneous Spaces
- 8. Staying Engaged with Harmonic Analysis On Homogeneous Spaces
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Harmonic Analysis On Homogeneous Spaces
- 9. Balancing eBooks and Physical Books Harmonic Analysis On Homogeneous Spaces
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Harmonic Analysis On Homogeneous Spaces
- 10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
- 11. Cultivating a Reading Routine Harmonic Analysis On Homogeneous Spaces
  - Setting Reading Goals Harmonic Analysis On Homogeneous Spaces
  - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Harmonic Analysis On Homogeneous Spaces

- Fact-Checking eBook Content of Harmonic Analysis On Homogeneous Spaces
- Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
- 14. Embracing eBook Trends
  - Integration of Multimedia Elements
  - Interactive and Gamified eBooks

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