

Symplectic Group

For every even dimension $2n$, the symplectic group $Sp(2n)$ is the group of $2n \times 2n$ matrices which preserve a nondegenerate antisymmetric bilinear form ω , i.e., a symplectic form.

Every symplectic form can be put into a canonical form by finding a symplectic basis. So, up to conjugation, there is only one symplectic group, in contrast to the orthogonal group which preserves a nondegenerate symmetric bilinear form. As with the orthogonal group, the columns of a symplectic matrix form a symplectic basis.

Since ω^n is a volume form, the symplectic group preserves volume and vector space orientation. Hence, $Sp(2n) \subset SL(2n)$. In fact, $Sp(2)$ is just the group of matrices with determinant 1. The three symplectic $(0,1)$ -matrices are therefore

$$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}, \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}. \quad (1)$$

The matrices

Symplectic Groups

Ian R. Porteous



Symplectic Groups:

Symplectic Groups Onorato Timothy O'Meara, 1978 Based on lectures given at the University of Notre Dame 1974 75

The Orthogonal and Symplectic Groups Francis Dominic Murnaghan, 1958 *Classical Groups and Geometric Algebra*

Larry C. Grove, 2024-12-30 Classical groups named so by Hermann Weyl are groups of matrices or quotients of matrix groups by small normal subgroups Thus the story begins as Weyl suggested with Her All embracing Majesty the general linear group $GL_n V$ of all invertible linear transformations of a vector space V over a field F All further groups discussed are either subgroups of $GL_n V$ or closely related quotient groups Most of the classical groups consist of invertible linear transformations that respect a bilinear form having some geometric significance e g a quadratic form a symplectic form etc Accordingly the author develops the required geometric notions albeit from an algebraic point of view as the end results should apply to vector spaces over more or less arbitrary fields finite or infinite The classical groups have proved to be important in a wide variety of venues ranging from physics to geometry and far beyond In recent years they have played a prominent role in the classification of the finite simple groups This text provides a single source for the basic facts about the classical groups and also includes the required geometrical background information from the first principles It is intended for graduate students who have completed standard courses in linear algebra and abstract algebra The author L C Grove is a well known expert who has published extensively in the subject area **The Classical Groups** Hermann Weyl, 2016-06-02

In this renowned volume Hermann Weyl discusses the symmetric full linear orthogonal and symplectic groups and determines their different invariants and representations Using basic concepts from algebra he examines the various properties of the groups Analysis and topology are used wherever appropriate The book also covers topics such as matrix algebras semigroups commutators and spinors which are of great importance in understanding the group theoretic structure of quantum mechanics Hermann Weyl was among the greatest mathematicians of the twentieth century He made fundamental contributions to most branches of mathematics but he is best remembered as one of the major developers of group theory a powerful formal method for analyzing abstract and physical systems in which symmetry is present In *The Classical Groups* his most important book Weyl provided a detailed introduction to the development of group theory and he did it in a way that motivated and entertained his readers Departing from most theoretical mathematics books of the time he introduced historical events and people as well as theorems and proofs One learned not only about the theory of invariants but also when and where they were originated and by whom He once said of his writing My work always tried to unite the truth with the beautiful but when I had to choose one or the other I usually chose the beautiful Weyl believed in the overall unity of mathematics and that it should be integrated into other fields He had serious interest in modern physics especially quantum mechanics a field to which *The Classical Groups* has proved important as it has to quantum chemistry and other fields Among the five books Weyl published with Princeton Algebraic Theory of Numbers inaugurated the Annals of

Mathematics Studies book series a crucial and enduring foundation of Princeton's mathematics list and the most distinguished book series in mathematics

Simple Groups of Lie Type Roger W. Carter, 1989-01-18 Now available in paperback the standard introduction to the theory of simple groups of Lie type In 1955 Chevalley showed how to construct analogues of the complex simple Lie groups over arbitrary fields The present work presents the basic results in the structure theory of Chevalley groups and their twisted analogues Carter looks at groups of automorphisms of Lie algebras makes good use of Weyl group also discussing Lie groups over finite fields and develops the theory of Chevalley and Steinberg groups in the general context of groups with a BN pair This new edition contains a corrected proof of the simplicity of twisted groups a completed list of sporadic simple groups in the final chapter and a few smaller amendments otherwise this work remains the classic piece of exposition it was when it first appeared in 1971

Quantum Theory, Groups and Representations Peter Woit, 2017-11-01 This text systematically presents the basics of quantum mechanics emphasizing the role of Lie groups Lie algebras and their unitary representations The mathematical structure of the subject is brought to the fore intentionally avoiding significant overlap with material from standard physics courses in quantum mechanics and quantum field theory The level of presentation is attractive to mathematics students looking to learn about both quantum mechanics and representation theory while also appealing to physics students who would like to know more about the mathematics underlying the subject This text showcases the numerous differences between typical mathematical and physical treatments of the subject The latter portions of the book focus on central mathematical objects that occur in the Standard Model of particle physics underlining the deep and intimate connections between mathematics and the physical world While an elementary physics course of some kind would be helpful to the reader no specific background in physics is assumed making this book accessible to students with a grounding in multivariable calculus and linear algebra Many exercises are provided to develop the reader's understanding of and facility in quantum theoretical concepts and calculations

Infinite Dimensional Groups and Algebras in Quantum Physics Johnny T. Ottesen, 1995-04-18 The idea of writing this book appeared when I was working on some problems related to representations of physically relevant infinite dimensional groups of operators on physically relevant Hilbert spaces The considerations were local reducing the subject to dealing with representations of infinite dimensional Lie algebras associated with the associated groups There is a large number of specialized articles and books on parts of this subject but to our surprise only a few represent the point of view given in this book Moreover none of the written material was self contained At present the subject has not reached its final form and active research is still being undertaken I present this subject of growing importance in a unified manner and by a fairly simple approach I present a route by which students can absorb and understand the subject only assuming that the reader is familiar with functional analysis especially bounded and unbounded operators on Hilbert spaces Moreover I assume a little basic knowledge of algebras Lie algebras Lie groups and manifolds at least the definitions The contents are presented in

detail in the introduction in Chap The manuscript of this book has been successfully used by some advanced graduate students at Aarhus University Denmark in their A exam I thank them for comments Lie Group Machine Learning Fanzhang Li, Li Zhang, Zhao Zhang, 2018-11-05 This book explains deep learning concepts and derives semi supervised learning and nuclear learning frameworks based on cognition mechanism and Lie group theory Lie group machine learning is a theoretical basis for brain intelligence Neuromorphic learning NL advanced machine learning and advanced artificial intelligence The book further discusses algorithms and applications in tensor learning spectrum estimation learning Finsler geometry learning Homology boundary learning and prototype theory With abundant case studies this book can be used as a reference book for senior college students and graduate students as well as college teachers and scientific and technical personnel involved in computer science artificial intelligence machine learning automation mathematics management science cognitive science financial management and data analysis In addition this text can be used as the basis for teaching the principles of machine learning Li Fanzhang is professor at the Soochow University China He is director of network security engineering laboratory in Jiangsu Province and is also the director of the Soochow Institute of industrial large data He published more than 200 papers 7 academic monographs and 4 textbooks Zhang Li is professor at the School of Computer Science and Technology of the Soochow University She published more than 100 papers in journals and conferences and holds 23 patents Zhang Zhao is currently an associate professor at the School of Computer Science and Technology of the Soochow University He has authored and co authored more than 60 technical papers Clifford Algebras and the Classical Groups Ian R. Porteous, 1995-10-05 The Clifford algebras of real quadratic forms and their complexifications are studied here in detail and those parts which are immediately relevant to theoretical physics are seen in the proper broad context Central to the work is the classification of the conjugation and reversion anti involutions that arise naturally in the theory It is of interest that all the classical groups play essential roles in this classification Other features include detailed sections on conformal groups the eight dimensional non associative Cayley algebra its automorphism group the exceptional Lie group G_2 and the triality automorphism of $Spin(8)$ The book is designed to be suitable for the last year of an undergraduate course or the first year of a postgraduate course **Groups and Characters** Larry C. Grove, 2011-09-26 An authoritative full year course on both group theory and ordinary character theory essential tools for mathematics and the physical sciences One of the few treatments available combining both group theory and character theory Groups and Characters is an effective general textbook on these two fundamentally connected subjects Presuming only a basic knowledge of abstract algebra as in a first year graduate course the text opens with a review of background material and then guides readers carefully through several of the most important aspects of groups and characters concentrating mainly on finite groups Challenging yet accessible Groups and Characters features An extensive collection of examples surveying many different types of groups including Sylow subgroups of symmetric groups affine groups of fields the Mathieu groups and symplectic groups A thorough

easy to follow discussion of Polya Redfield enumeration with applications to combinatorics Inclusive explorations of the transfer function and normal complements induction and restriction of characters Clifford theory characters of symmetric and alternating groups Frobenius groups and the Schur index Illuminating accounts of several computational aspects of group theory such as the Schreier Sims algorithm Todd Coxeter coset enumeration and algorithms for generating character tables As valuable as Groups and Characters will prove as a textbook for mathematicians it has broader applications With chapters suitable for use as independent review units along with a full bibliography and index it will be a dependable general reference for chemists physicists and crystallographers

Theory of Lie Groups Claude Chevalley, 2000-01-10 This famous book was the first treatise on Lie groups in which a modern point of view was adopted systematically namely that a continuous group can be regarded as a global object To develop this idea to its fullest extent Chevalley incorporated a broad range of topics such as the covering spaces of topological spaces analytic manifolds integration of complete systems of differential equations on a manifold and the calculus of exterior differential forms The book opens with a short description of the classical groups unitary groups orthogonal groups symplectic groups etc These special groups are then used to illustrate the general properties of Lie groups which are considered later The general notion of a Lie group is defined and correlated with the algebraic notion of a Lie algebra the subgroups factor groups and homomorphisms of Lie groups are studied by making use of the Lie algebra The last chapter is concerned with the theory of compact groups culminating in Peter Weyl's theorem on the existence of representations Given a compact group it is shown how one can construct algebraically the corresponding Lie group with complex parameters which appears in the form of a certain algebraic variety associated algebraic group This construction is intimately related to the proof of the generalization given by Tannaka of Pontrjagin's duality theorem for Abelian groups The continued importance of Lie groups in mathematics and theoretical physics make this an indispensable volume for researchers in both fields

Finite Group Theory M. Aschbacher, 2000-06-26 During the last 40 years the theory of finite groups has developed dramatically The finite simple groups have been classified and are becoming better understood Tools exist to reduce many questions about arbitrary finite groups to similar questions about simple groups Since the classification there have been numerous applications of this theory in other branches of mathematics Finite Group Theory develops the foundations of the theory of finite groups It can serve as a text for a course on finite groups for students already exposed to a first course in algebra It could supply the background necessary to begin reading journal articles in the field For specialists it also provides a reference on the foundations of the subject This second edition has been considerably improved with a completely rewritten Chapter 15 considering the 2-Signalizer Functor Theorem and the addition of an appendix containing solutions to exercises

Conformal Groups in Geometry and Spin Structures Pierre Anglès, 2007-10-16 Conformal groups play a key role in geometry and spin structures This book provides a self-contained overview of this important area of mathematical physics beginning with its origins in the works of Cartan and Chevalley and

progressing to recent research in spinors and conformal geometry Key topics and features Focuses initially on the basics of Clifford algebras Studies the spaces of spinors for some even Clifford algebras Examines conformal spin geometry beginning with an elementary study of the conformal group of the Euclidean plane Treats covering groups of the conformal group of a regular pseudo Euclidean space including a section on the complex conformal group Introduces conformal flat geometry and conformal spinoriality groups followed by a systematic development of riemannian or pseudo riemannian manifolds having a conformal spin structure Discusses links between classical spin structures and conformal spin structures in the context of conformal connections Examines pseudo unitary spin structures and pseudo unitary conformal spin structures using the Clifford algebra associated with the classical pseudo unitary space Ample exercises with many hints for solutions Comprehensive bibliography and index This text is suitable for a course in mathematical physics at the advanced undergraduate and graduate levels It will also benefit researchers as a reference text Lie Groups And Lie Algebras For Physicists Ashok Das,Susumu Okubo,2014-09-03 The book is intended for graduate students of theoretical physics with a background in quantum mechanics as well as researchers interested in applications of Lie group theory and Lie algebras in physics The emphasis is on the inter relations of representation theories of Lie groups and the corresponding Lie algebras

A Survey of Lie Groups and Lie Algebras with Applications and Computational Methods Johan G. F. Belinfante,Bernard Kolman,1989-01-01 Introduces the concepts and methods of the Lie theory in a form accessible to the non specialist by keeping mathematical prerequisites to a minimum Although the authors have concentrated on presenting results while omitting most of the proofs they have compensated for these omissions by including many references to the original literature Their treatment is directed toward the reader seeking a broad view of the subject rather than elaborate information about technical details Illustrations of various points of the Lie theory itself are found throughout the book in material on applications In this reprint edition the authors have resisted the temptation of including additional topics Except for correcting a few minor misprints the character of the book especially its focus on classical representation theory and its computational aspects has not been changed Representations of Real and P-adic Groups Eng-chye Tan,Chen-bo Zhu,2004 The Institute for Mathematical Sciences at the National University of Singapore hosted a research program on Representation Theory of Lie Groups from July 2002 to January 2003 As part of the program tutorials for graduate students and junior researchers were given by leading experts in the field This invaluable volume collects the expanded lecture notes of those tutorials The topics covered include uncertainty principles for locally compact abelian groups fundamentals of representations of p adic groups the Harish Chandra Howe local character expansion classification of the square integrable representations modulo cuspidal data Dirac cohomology and Vogan s conjecture multiplicity free actions and Schur Weyl Howe duality The lecturers include Tomasz Przebinda from the University of Oklahoma USA Gordan Savin from the University of Utah USA Stephen DeBacker from Harvard University USA Marko Tadi from the University of Zagreb Croatia

Jing Song Huang from The Hong Kong University of Science and Technology Hong Kong Pavle Pandić from the University of Zagreb Croatia Chal Benson and Gail Ratcliff from East Carolina University USA and Roe Goodman from Rutgers University USA

Finite Groups I Bertram Huppert, 2025-05-05 Since its publication in 1967 Bertram Huppert's influential *Endliche Gruppen I* has remained a standard reference on group theory with its clear precise and complete exposition The present volume makes this classic text available in English for the first time updated with modern notation and notes In addition to foundational material the book contains the theory of permutation groups linear groups p groups nilpotent groups and solvable groups as well as the transfer homomorphism and ordinary representation theory All topics are fully developed and accessible to students with a basic knowledge of algebra Its comprehensive coverage and inclusion of more advanced topics make this self contained treatise an invaluable resource for graduate students and researchers

Bilinear Algebra Kazimierz Szymiczek, 2017-11-22 Giving an easily accessible elementary introduction to the algebraic theory of quadratic forms this book covers both Witt's theory and Pfister's theory of quadratic forms Leading topics include the geometry of bilinear spaces classification of bilinear spaces up to isometry depending on the ground field formally real fields Pfister forms the Witt ring of an arbitrary field characteristic two included prime ideals of the Witt ring Brauer group of a field Hasse and Witt invariants of quadratic forms and equivalence of fields with respect to quadratic forms Problem sections are included at the end of each chapter There are two appendices the first gives a treatment of Hasse and Witt invariants in the language of Steinberg symbols and the second contains some more advanced problems in 10 groups including the u invariant reduced and stable Witt rings and Witt equivalence of fields

The Geometry of Infinite-Dimensional Groups Boris Khesin, Robert Wendt, 2008-09-28 This monograph gives an overview of various classes of infinite dimensional Lie groups and their applications in Hamiltonian mechanics fluid dynamics integrable systems gauge theory and complex geometry The text includes many exercises and open questions

A Primer on Mapping Class Groups Benson Farb, Dan Margalit, 2012 The study of the mapping class group $\text{Mod } S$ is a classical topic that is experiencing a renaissance It lies at the juncture of geometry topology and group theory This book explains as many important theorems examples and techniques as possible quickly and directly while at the same time giving full details and keeping the text nearly self contained The book is suitable for graduate students A Primer on Mapping Class Groups begins by explaining the main group theoretical properties of $\text{Mod } S$ from finite generation by Dehn twists and low dimensional homology to the Dehn Nielsen Baer theorem Along the way central objects and tools are introduced such as the Birman exact sequence the complex of curves the braid group the symplectic representation and the Torelli group The book then introduces Teichmüller space and its geometry and uses the action of $\text{Mod } S$ on it to prove the Nielsen Thurston classification of surface homeomorphisms Topics include the topology of the moduli space of Riemann surfaces the connection with surface bundles pseudo-Anosov theory and Thurston's approach to the classification

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