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Spinning Tops

A Course on
Integrable Systems

MICHELE AUDIN



Spinning Tops A Course On Integrable Systems

**Jean-François Ganghoffer, Ivailo
Mladenov**



Spinning Tops A Course On Integrable Systems:

Spinning Tops M. Audin, 1999-11-13 Since the time of Lagrange and Euler it has been well known that an understanding of algebraic curves can illuminate the picture of rigid bodies provided by classical mechanics A modern view of the role played by algebraic geometry has been established by many mathematicians This book presents some of these techniques which fall within the orbit of finite dimensional integrable systems The main body of the text presents a rich assortment of methods and ideas from algebraic geometry prompted by classical mechanics whilst in appendices the general abstract theory is described The methods are given a topological application to the study of Liouville tori and their bifurcations The book is based on courses for graduate students given by the author at Strasbourg University but the wealth of original ideas will make it also appeal to researchers

Spinning Tops Michèle Audin, 1996 Integrable Systems in the Realm of Algebraic Geometry Pol Vanhaecke, 2001-07-31 This book treats the general theory of Poisson structures and integrable systems on affine varieties in a systematic way Special attention is drawn to algebraic completely integrable systems Several integrable systems are constructed and studied in detail and a few applications of integrable systems to algebraic geometry are worked out In the second edition some of the concepts in Poisson geometry are clarified by introducing Poisson cohomology the Mumford systems are constructed from the algebra of pseudo differential operators which clarifies their origin a new explanation of the multi Hamiltonian structure of the Mumford systems is given by using the loop algebra of sl_2 and finally Goedeck flow on SO_4 is added to illustrate the linearization algorithm and to give another application of integrable systems to algebraic geometry

Integrable Systems, Topology, and Physics Martin A. Guest, Reiko Miyaoka, Yoshihiro Ohnita, 2002 Ideas and techniques from the theory of integrable systems are playing an increasingly important role in geometry Thanks to the development of tools from Lie theory algebraic geometry symplectic geometry and topology classical problems are investigated more systematically New problems are also arising in mathematical physics A major international conference was held at the University of Tokyo in July 2000 It brought together scientists in all of the areas influenced by integrable systems This book is the second of three collections of expository and research articles This volume focuses on topology and physics The role of zero curvature equations outside of the traditional context of differential geometry has been recognized relatively recently but it has been an extraordinarily productive one and most of the articles in this volume make some reference to it Symplectic geometry Floer homology twistor theory quantum cohomology and the structure of special equations of mathematical physics such as the Toda field equations all of these areas have gained from the integrable systems point of view and contributed to it Many of the articles in this volume are written by prominent researchers and will serve as introductions to the topics It is intended for graduate students and researchers interested in integrable systems and their relations to differential geometry topology algebraic geometry and physics The first volume from this conference also available from the AMS is Differential Geometry and Integrable Systems Volume 308 CONM 308 in the Contemporary

Mathematics series The forthcoming third volume will be published by the Mathematical Society of Japan and will be available outside of Japan from the AMS in the Advanced Studies in Pure Mathematics series

Geometry and Dynamics of Integrable Systems Alexey Bolsinov, Juan J. Morales-Ruiz, Nguyen Tien Zung, 2016-10-27 Based on lectures given at an advanced course on integrable systems at the Centre de Recerca Matemàtica in Barcelona these lecture notes address three major aspects of integrable systems obstructions to integrability from differential Galois theory the description of singularities of integrable systems on the basis of their relation to bi-Hamiltonian systems and the generalization of integrable systems to the non-Hamiltonian settings All three sections were written by top experts in their respective fields Native to actual problem solving challenges in mechanics the topic of integrable systems is currently at the crossroads of several disciplines in pure and applied mathematics and also has important interactions with physics The study of integrable systems also actively employs methods from differential geometry Moreover it is extremely important in symplectic geometry and Hamiltonian dynamics and has strong correlations with mathematical physics Lie theory and algebraic geometry including mirror symmetry As such the book will appeal to experts with a wide range of backgrounds

Elements of Classical and Quantum Integrable Systems Gleb Arutyunov, 2019-07-23 Integrable models have a fascinating history with many important discoveries that dates back to the famous Kepler problem of planetary motion Nowadays it is well recognised that integrable systems play a ubiquitous role in many research areas ranging from quantum field theory string theory solvable models of statistical mechanics black hole physics quantum chaos and the AdS/CFT correspondence to pure mathematics such as representation theory harmonic analysis random matrix theory and complex geometry Starting with the Liouville theorem and finite dimensional integrable models this book covers the basic concepts of integrability including elements of the modern geometric approach based on Poisson reduction classical and quantum factorised scattering and various incarnations of the Bethe Ansatz Applications of integrability methods are illustrated in vast detail on the concrete examples of the Calogero-Moser Sutherland and Ruijsenaars-Schneider models the Heisenberg spin chain and the one-dimensional Bose gas interacting via a delta function potential This book has intermediate and advanced topics with details to make them clearly comprehensible

Hamiltonian Systems and Their Integrability Michèle Audin, 2008 Hamiltonian systems began as a mathematical approach to the study of mechanical systems As the theory developed it became clear that the systems that had a sufficient number of conserved quantities enjoyed certain remarkable properties These are the completely integrable systems In time a rich interplay arose between integrable systems and other areas of mathematics particularly topology geometry and group theory This book presents some modern techniques in the theory of integrable systems viewed as variations on the theme of action-angle coordinates These techniques include analytical methods coming from the Galois theory of differential equations as well as more classical algebro-geometric methods related to Lax equations Audin has included many examples and exercises Most of the exercises build on the material in the text None of the

important proofs have been relegated to the exercises Many of the examples are classical rather than abstract This book would be suitable for a graduate course in Hamiltonian systems

Integrability and Nonintegrability of Dynamical Systems Alain Goriely, 2001 This invaluable book examines qualitative and quantitative methods for nonlinear differential equations as well as integrability and nonintegrability theory Starting from the idea of a constant of motion for simple systems of differential equations it investigates the essence of integrability its geometrical relevance and dynamical consequences Integrability theory is approached from different perspectives first in terms of differential algebra then in terms of complex time singularities and finally from the viewpoint of phase geometry for both Hamiltonian and non Hamiltonian systems As generic systems of differential equations cannot be exactly solved the book reviews the different notions of nonintegrability and shows how to prove the nonexistence of exact solutions and or a constant of motion Finally nonintegrability theory is linked to dynamical systems theory by showing how the property of complete integrability partial integrability or nonintegrability can be related to regular and irregular dynamics in phase space

Symplectic Geometry of Integrable Hamiltonian Systems Michèle Audin, Ana Cannas da Silva, Eugene Lerman, 2012-12-06 Among all the Hamiltonian systems the integrable ones have special geometric properties in particular their solutions are very regular and quasi periodic The quasi periodicity of the solutions of an integrable system is a result of the fact that the system is invariant under a semi global torus action It is thus natural to investigate the symplectic manifolds that can be endowed with a global torus action This leads to symplectic toric manifolds Part B of this book Physics makes a surprising come back in Part A to describe Mirror Symmetry one looks for a special kind of Lagrangian submanifolds and integrable systems the special Lagrangians Furthermore integrable Hamiltonian systems on punctured cotangent bundles are a starting point for the study of contact toric manifolds Part C of this book

Differential Algebra and Related Topics Li Guo, 2002 Differential algebra explores properties of solutions of systems of ordinary or partial linear or non linear differential equations from an algebraic point of view It includes as special cases algebraic systems as well as differential systems with algebraic constraints This algebraic theory of Joseph F Ritt and Ellis R Kolchin is further enriched by its interactions with algebraic geometry Diophantine geometry differential geometry model theory control theory automatic theorem proving combinatorics and difference equations Differential algebra now plays an important role in computational methods such as symbolic integration and symmetry analysis of differential equations These proceedings consist of tutorial and survey papers presented at the Second International Workshop on Differential Algebra and Related Topics at Rutgers University Newark in April 2007 As a sequel to the proceedings of the First International Workshop this volume covers more related subjects and provides a modern and introductory treatment to many facets of differential algebra including surveys of known results open problems and new emerging directions of research It is therefore an excellent companion and reference text for graduate students and researchers

Differential Algebra And Related Topics - Proceedings Of The International Workshop Phyllis J Cassidy, Li

Guo, William F Keigher, William Y Sit, 2002-05-30 Differential algebra explores properties of solutions to systems of ordinary or partial linear or nonlinear differential equations from an algebraic point of view It includes as special cases algebraic systems as well as differential systems with algebraic constraints This algebraic theory of Joseph F Ritt and Ellis R Kolchin is further enriched by its interactions with algebraic geometry Diophantine geometry differential geometry model theory control theory automatic theorem proving combinatorics and difference equations Differential algebra now plays an important role in computational methods such as symbolic integration and symmetry analysis of differential equations This volume includes tutorial and survey papers presented at workshop

Algebraic Structures In Integrability: Foreword
By Victor Kac Vladimir V Sokolov, 2020-06-05 Relationships of the theory of integrable systems with various branches of mathematics are extremely deep and diverse On the other hand the most fundamental exactly integrable systems often have applications in theoretical physics Therefore many mathematicians and physicists are interested in integrable models The book is intelligible to graduate and PhD students and can serve as an introduction to separate sections of the theory of classical integrable systems for scientists with algebraic inclinations For the young the book can serve as a starting point in the study of various aspects of integrability while professional algebraists will be able to use some examples of algebraic structures which appear in the theory of integrable systems for wide ranging generalizations The statements are formulated in the simplest possible form However some ways of generalization are indicated In the proofs only essential points are mentioned while for technical details references are provided The focus is on carefully selected examples In addition the book proposes many unsolved problems of various levels of complexity A deeper understanding of every chapter of the book may require the study of more rigorous and specialized literature

Analytical Mechanics Sergio Cecotti, 2024-10-01 This textbook is based on the author's lecture notes held at Qiuzhen College Tsinghua University Beijing renowned for its rapid scientific growth of its excellent students The book offers a remarkable combination of characteristics that are both exceptional and seemingly contradictory It is designed to be entirely self contained starting from the basics and building a strong foundation in geometric and algebraic tools Simultaneously topics are infused with mathematical elegance and profundity employing contemporary language and techniques From a physicist's perspective the content delves deeply into the physical aspects emphasizing the underlying principles This book bridges the gap between students and cutting edge research with a special focus on symplectic geometry integrability and recent developments in the field It is designed to engage and captivate the reader A conscious selection of topics ensures a more relevant and contemporary approach compared to traditional textbooks The book addresses common misconceptions offering clarity and precision In its quest for brevity this book is tailored for a one semester course offering a comprehensive and concise resource The author's dedication is evident throughout this volume encapsulating these goals within roughly 300 pages

Torus Actions on Symplectic Manifolds Michèle Audin, 2012-12-06 How I have re written this book The book the reader has in hand was supposed to be a

new edition of 14 I have hesitated quite a long time before deciding to do the re writing work the first edition has been sold out for a few years There was absolutely no question of just correcting numerous misprints and a few mathematical errors When I wrote the first edition in 1989 the convexity and Duistermaat Heckman theorems together with the irruption of toric varieties on the scene of symplectic geometry due to Delzant around which the book was organized were still rather recent less than ten years I myself was rather happy with a small contribution I had made to the subject I was giving a post graduate course on all that and well these were lecture notes just lecture notes By chance the book turned out to be rather popular during the years since then I had the opportunity to meet quite a few people 1 who kindly pretended to have learnt the subject in this book However the older book does not satisfy at all the idea I have now of what a good book should be So that this new edition is indeed another book

Rigid Body Dynamics Alexey Borisov,Ivan S. Mamaev,2018-12-03 This book provides an up to date overview of results in rigid body dynamics including material concerned with the analysis of nonintegrability and chaotic behavior in various related problems The wealth of topics covered makes it a practical reference for researchers and graduate students in mathematics physics and mechanics Contents Rigid Body Equations of Motion and Their Integration The Euler Poisson Equations and Their Generalizations The Kirchhoff Equations and Related Problems of Rigid Body Dynamics Linear Integrals and Reduction Generalizations of Integrability Cases Explicit Integration Periodic Solutions Nonintegrability and Transition to Chaos Appendix A Derivation of the Kirchhoff Poincar Zhukovskii and Four Dimensional Top Equations Appendix B The Lie Algebra e_4 and Its Orbits Appendix C Quaternion Equations and L A Pair for the Generalized Goryachev Chaplygin Top Appendix D The Hess Case and Quantization of the Rotation Number Appendix E Ferromagnetic Dynamics in a Magnetic Field Appendix F The Landau Lifshitz Equation Discrete Systems and the Neumann Problem Appendix G Dynamics of Tops and Material Points on Spheres and Ellipsoids Appendix H On the Motion of a Heavy Rigid Body in an Ideal Fluid with Circulation Appendix I The Hamiltonian Dynamics of Self gravitating Fluid and Gas Ellipsoids

Similarity and Symmetry Methods Jean-François Ganghoffer,Ivailo Mladenov,2014-07-19 The principle aim of the book is to present a self contained modern account of similarity and symmetry methods which are important mathematical tools for both physicists engineers and applied mathematicians The idea is to provide a balanced presentation of the mathematical techniques and applications of symmetry methods in mathematics physics and engineering That is why it includes recent developments and many examples in finding systematically conservation laws local and nonlocal symmetries for ordinary and partial differential equations The role of continuous symmetries in classical and quantum field theories is exposed at a technical level accessible even for non specialists The importance of symmetries in continuum mechanics and mechanics of materials is highlighted through recent developments such as the construction of constitutive models for various materials combining Lie symmetries with experimental data As a whole this book is a unique collection of contributions from experts in the field including specialists in the mathematical treatment of symmetries researchers using

symmetries from a fundamental applied or numerical viewpoint The book is a fascinating overview of symmetry methods aimed for graduate students in physics mathematics and engineering as well as researchers either willing to enter in the field or to capture recent developments and applications of symmetry methods in different scientific fields Handbook of Differential Geometry Franki J.E. Dillen, Leopold C.A. Verstraelen, 2005-11-29 In the series of volumes which together will constitute the Handbook of Differential Geometry we try to give a rather complete survey of the field of differential geometry The different chapters will both deal with the basic material of differential geometry and with research results old and recent All chapters are written by experts in the area and contain a large bibliography In this second volume a wide range of areas in the very broad field of differential geometry is discussed as there are Riemannian geometry Lorentzian geometry Finsler geometry symplectic geometry contact geometry complex geometry Lagrange geometry and the geometry of foliations Although this does not cover the whole of differential geometry the reader will be provided with an overview of some its most important areas Written by experts and covering recent research Extensive bibliography Dealing with a diverse range of areas Starting from the basics **Lectures on Symplectic Geometry** Ana Cannas da Silva, 2004-10-27 The goal of these notes is to provide a fast introduction to symplectic geometry for graduate students with some knowledge of differential geometry de Rham theory and classical Lie groups This text addresses symplectomorphisms local forms contact manifolds compatible almost complex structures Kaehler manifolds hamiltonian mechanics moment maps symplectic reduction and symplectic toric manifolds It contains guided problems called homework designed to complement the exposition or extend the reader s understanding There are by now excellent references on symplectic geometry a subset of which is in the bibliography of this book However the most efficient introduction to a subject is often a short elementary treatment and these notes attempt to serve that purpose This text provides a taste of areas of current research and will prepare the reader to explore recent papers and extensive books on symplectic geometry where the pace is much faster For this reprint numerous corrections and clarifications have been made and the layout has been improved *The Unity of Mathematics* Pavel Etingof, Vladimir S. Retakh, I. M. Singer, 2007-05-31 Tribute to the vision and legacy of Israel Moiseevich Gel fand Written by leading mathematicians these invited papers reflect the unity of mathematics as a whole with particular emphasis on the many connections among the fields of geometry physics and representation theory Topics include conformal field theory K theory noncommutative geometry gauge theory representations of infinite dimensional Lie algebras and various aspects of the Langlands program **Lectures on Poisson Geometry** Marius Crainic, Rui Loja Fernandes, Ioan Mărcuț, 2021-10-14 This excellent book will be very useful for students and researchers wishing to learn the basics of Poisson geometry as well as for those who know something about the subject but wish to update and deepen their knowledge The authors philosophy that Poisson geometry is an amalgam of foliation theory symplectic geometry and Lie theory enables them to organize the book in a very coherent way Alan Weinstein University of California at Berkeley This well written book is an

excellent starting point for students and researchers who want to learn about the basics of Poisson geometry The topics covered are fundamental to the theory and avoid any drift into specialized questions they are illustrated through a large collection of instructive and interesting exercises The book is ideal as a graduate textbook on the subject but also for self study Eckhard Meinrenken University of Toronto

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Spinning Tops A Course On Integrable Systems Introduction

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