

# Ratner's Theorems on Unipotent Flows

Dave Witte Morris

# Ratners Theorems On Unipotent Flows Chicago Lectures In Mathematics

**J.H. Silverman**



## **Ratners Theorems On Unipotent Flows Chicago Lectures In Mathematics:**

Ratner's Theorems on Unipotent Flows Dave Witte Morris, 2005-08-15 The theorems of Berkeley mathematician Marina Ratner have guided key advances in the understanding of dynamical systems Unipotent flows are well behaved dynamical systems and Ratner has shown that the closure of every orbit for such a flow is of a simple algebraic or geometric form In Ratner s Theorems on Unipotent Flows Dave Witte Morris provides both an elementary introduction to these theorems and an account of the proof of Ratner s measure classification theorem A collection of lecture notes aimed at graduate students the first four chapters of Ratner s Theorems on Unipotent Flows can be read independently The first chapter intended for a fairly general audience provides an introduction with examples that illustrate the theorems some of their applications and the main ideas involved in the proof In the following chapters Morris introduces entropy ergodic theory and the theory of algebraic groups The book concludes with a proof of the measure theoretic version of Ratner s Theorem With new material that has never before been published in book form Ratner s Theorems on Unipotent Flows helps bring these important theorems to a broader mathematical readership *Mathematics of Complexity and Dynamical Systems* Robert A. Meyers, 2011-10-05 Mathematics of Complexity and Dynamical Systems is an authoritative reference to the basic tools and concepts of complexity systems theory and dynamical systems from the perspective of pure and applied mathematics Complex systems are systems that comprise many interacting parts with the ability to generate a new quality of collective behavior through self organization e g the spontaneous formation of temporal spatial or functional structures These systems are often characterized by extreme sensitivity to initial conditions as well as emergent behavior that are not readily predictable or even completely deterministic The more than 100 entries in this wide ranging single source work provide a comprehensive explication of the theory and applications of mathematical complexity covering ergodic theory fractals and multifractals dynamical systems perturbation theory solitons systems and control theory and related topics Mathematics of Complexity and Dynamical Systems is an essential reference for all those interested in mathematical complexity from undergraduate and graduate students up through professional researchers Geodesic and Horocyclic Trajectories Françoise Dal'Bo, 2010-11-12 Geodesic and Horocyclic Trajectories presents an introduction to the topological dynamics of two classical flows associated with surfaces of curvature 1 namely the geodesic and horocycle flows Written primarily with the idea of highlighting in a relatively elementary framework the existence of gateways between some mathematical fields and the advantages of using them historical aspects of this field are not addressed and most of the references are reserved until the end of each chapter in the Comments section Topics within the text cover geometry and examples of Fuchsian groups topological dynamics of the geodesic flow Schottky groups the Lorentzian point of view and Trajectories and Diophantine approximations Ergodic Theory and Dynamical Systems in their Interactions with Arithmetics and Combinatorics Sébastien Ferenczi, Joanna Kułaga-Przymus, Mariusz Lemańczyk, 2018-06-15 This book concentrates on the

modern theory of dynamical systems and its interactions with number theory and combinatorics The greater part begins with a course in analytic number theory and focuses on its links with ergodic theory presenting an exhaustive account of recent research on Sarnak's conjecture on Möbius disjointness Selected topics involving more traditional connections between number theory and dynamics are also presented including equidistribution homogeneous dynamics and Lagrange and Markov spectra In addition some dynamical and number theoretical aspects of aperiodic order some algebraic systems and a recent development concerning tame systems are described

*Birational Geometry and Moduli Spaces* Elisabetta Colombo, Barbara Fantechi, Paola Frediani, Donatella Iacono, Rita Pardini, 2020-02-25 This volume collects contributions from speakers at the INdAM Workshop Birational Geometry and Moduli Spaces which was held in Rome on 11-15 June 2018 The workshop was devoted to the interplay between birational geometry and moduli spaces and the contributions of the volume reflect the same idea focusing on both these areas and their interaction In particular the book includes both surveys and original papers on irreducible holomorphic symplectic manifolds Severi varieties degenerations of Calabi-Yau varieties uniruled threefolds toric Fano threefolds mirror symmetry canonical bundle formula the Lefschetz principle birational transformations and deformations of diagrams of algebras The intention is to disseminate the knowledge of advanced results and key techniques used to solve open problems The book is intended for all advanced graduate students and researchers interested in the new research frontiers of birational geometry and moduli spaces

**Elements of Dynamical Systems** Anima Nagar, Riddhi Shah, Shrihari Sridharan, 2022-11-11 This book stems from lectures that were delivered at the three week Advanced Instructional School on Ergodic Theory and Dynamical Systems held at the Indian Institute of Technology Delhi from 4-23 December 2017 with the support of the National Centre for Mathematics National Board for Higher Mathematics Department of Atomic Energy Government of India The book discusses various aspects of dynamical systems Each chapter of this book specializes in one aspect of dynamical systems and thus begins at an elementary level and goes on to cover fairly advanced material The book helps researchers be familiar with and navigate through different parts of ergodic theory and dynamical systems

**The Arithmetic of Dynamical Systems** J.H. Silverman, 2010-05-05 This book is designed to provide a path for the reader into an amalgamation of two venerable areas of mathematics Dynamical Systems and Number Theory Many of the motivating theorems and conjectures in the new subject of Arithmetic Dynamics may be viewed as the transposition of classical results in the theory of Diophantine equations to the setting of discrete dynamical systems especially to the iteration theory of maps on the projective line and other algebraic varieties Although there is no precise dictionary connecting the two areas the reader will gain a flavor of the correspondence from the following associations Diophantine Equations Dynamical Systems rational and integral rational and integral points on varieties points in orbits torsion points on periodic and preperiodic abelian varieties points of rational maps There are a variety of topics covered in this volume but inevitably the choice reflects the author's tastes and interests Many related areas that also fall under the heading

of arithmetic or algebraic dynamics have been omitted in order to keep the book to a manageable length. A brief list of some of these omitted topics may be found in the introduction. Online Resources The reader will find additional material references and errata at <http://www.math.brown.edu/jhs/ADSHome.html>. Acknowledgments The author has consulted a great many sources in writing this book. Every attempt has been made to give proper attribution for all but the most standard results.

**An Introduction to Probabilistic Number Theory** Emmanuel Kowalski, 2021-05-06 Despite its seemingly deterministic nature, the study of whole numbers, especially prime numbers, has many interactions with probability theory, the theory of random processes and events. This surprising connection was first discovered around 1920, but in recent years the links have become much deeper and better understood. Aimed at beginning graduate students, this textbook is the first to explain some of the most modern parts of the story. Such topics include the Chebychev bias, universality of the Riemann zeta function, exponential sums, and the bewitching shapes known as Kloosterman paths. Emphasis is given throughout to probabilistic ideas in the arguments, not just the final statements, and the focus is on key examples over technicalities. The book develops probabilistic number theory from scratch, with short appendices summarizing the most important background results from number theory, analysis, and probability, making it a readable and incisive introduction to this beautiful area of mathematics.

**Geometry, Groups and Dynamics** C. S. Aravinda, William M. Goldman, Krishnendu Gongopadhyay, Alexander Lubotzky, Mahan Mj, Anthony Weaver, 2015-05-01 This volume contains the proceedings of the ICTS Program Groups Geometry and Dynamics held December 3-16, 2012, at CEMS, Almora, India. The activity was an academic tribute to Ravi S. Kulkarni on his turning seventy. Articles included in this volume, both introductory and advanced surveys, represent the broad area of geometry that encompasses a large portion of group theory, finite or otherwise, and dynamics in its proximity. These areas have been influenced by Kulkarni's ideas and are closely related to his work and contribution. *Geometry, Rigidity, and Group Actions* Benson Farb, David Fisher, 2011-04-15 The study of group actions is more than a hundred years old, but remains to this day a vibrant and widely studied topic in a variety of mathematical fields. A central development in the last fifty years is the phenomenon of rigidity, whereby one can classify actions of certain groups, such as lattices in semi-simple Lie groups. This provides a way to classify all possible symmetries of important spaces and all spaces admitting given symmetries. Paradigmatic results can be found in the seminal work of George Mostow, Gergory Margulis, and Robert J. Zimmer, among others. The papers in *Geometry, Rigidity, and Group Actions* explore the role of group actions and rigidity in several areas of mathematics, including ergodic theory, dynamics, geometry, topology, and the algebraic properties of representation varieties. In some cases, the dynamics of the possible group actions are the principal focus of inquiry. In other cases, the dynamics of group actions are a tool for proving theorems about algebra, geometry, or topology. This volume contains surveys of some of the main directions in the field, as well as research articles on topics of current interest. *Dynamics and Analytic Number Theory* Dzmitry Badziahin, Alexander Gorodnik, Norbert Peyerimhoff, 2016-11-10 Written by leading experts, this book explores

several directions of current research at the interface between dynamics and analytic number theory Topics include Diophantine approximation exponential sums Ramsey theory ergodic theory and homogeneous dynamics The origins of this material lie in the Dynamics and Analytic Number Theory Easter School held at Durham University in 2014 Key concepts cutting edge results and modern techniques that play an essential role in contemporary research are presented in a manner accessible to young researchers including PhD students This book will also be useful for established mathematicians The areas discussed include ubiquitous systems and Cantor type sets in Diophantine approximation flows on nilmanifolds and their connections with exponential sums multiple recurrence and Ramsey theory counting and equidistribution problems in homogeneous dynamics and applications of thin groups in number theory Both dynamical and classical approaches towards number theoretical problems are also provided

**Foliations, Geometry, and Topology** Nicolau Corção Saldanha, 2009 Presents the proceedings of the conference on Foliations Geometry and Topology held August 6-10 2007 in Rio de Janeiro Brazil in honor of the 70th birthday of Paul Schweitzer The papers focus on the theory of foliations and related areas such as dynamical systems group actions on low dimensional manifolds and geometry of hypersurfaces

**Geometric Methods in Physics** Piotr Kielanowski, Pierre Bieliavsky, Anatol Odziejewicz, Martin Schlichenmaier, Theodore Voronov, 2015-09-21 This book presents a selection of papers based on the XXXIII Bia owie a Workshop on Geometric Methods in Physics 2014 The Bia owie a Workshops are among the most important meetings in the field and attract researchers from both mathematics and physics The articles gathered here are mathematically rigorous and have important physical implications addressing the application of geometry in classical and quantum physics Despite their long tradition the workshops remain at the cutting edge of ongoing research For the last several years each Bia owie a Workshop has been followed by a School on Geometry and Physics where advanced lectures for graduate students and young researchers are presented some of the lectures are reproduced here The unique atmosphere of the workshop and school is enhanced by its venue framed by the natural beauty of the Bia owie a forest in eastern Poland The volume will be of interest to researchers and graduate students in mathematical physics theoretical physics and mathematics

*Rationality of Varieties* Gavril Farkas, Gerard van der Geer, Mingmin Shen, Lenny Taelman, 2021-10-19 This book provides an overview of the latest progress on rationality questions in algebraic geometry It discusses new developments such as universal triviality of the Chow group of zero cycles various aspects of stable birationality cubic and Fano fourfolds rationality of moduli spaces and birational invariants of group actions on varieties contributed by the foremost experts in their fields The question of whether an algebraic variety can be parametrized by rational functions of as many variables as its dimension has a long history and played an important role in the history of algebraic geometry Recent developments in algebraic geometry have made this question again a focal point of research and formed the impetus to organize a conference in the series of conferences on the island of Schiermonnikoog The book follows in the tradition of earlier volumes which originated from conferences on the islands Texel and Schiermonnikoog

**Ergodic Theory** Cesar E. Silva, Alexandre I. Danilenko, 2023-07-31 This volume in the Encyclopedia of Complexity and Systems Science Second Edition covers recent developments in classical areas of ergodic theory including the asymptotic properties of measurable dynamical systems spectral theory entropy ergodic theorems joinings isomorphism theory recurrence nonsingular systems It enlightens connections of ergodic theory with symbolic dynamics topological dynamics smooth dynamics combinatorics number theory pressure and equilibrium states fractal geometry chaos In addition the new edition includes dynamical systems of probabilistic origin ergodic aspects of Sarnak s conjecture translation flows on translation surfaces complexity and classification of measurable systems operator approach to asymptotic properties interplay with operator algebras

**Ergodic Theory** Manfred Einsiedler, Thomas Ward, 2010-09-11 This text is a rigorous introduction to ergodic theory developing the machinery of conditional measures and expectations mixing and recurrence Beginning by developing the basics of ergodic theory and progressing to describe some recent applications to number theory this book goes beyond the standard texts in this topic Applications include Weyl s polynomial equidistribution theorem the ergodic proof of Szemerédi s theorem the connection between the continued fraction map and the modular surface and a proof of the equidistribution of horocycle orbits Ergodic Theory with a view towards Number Theory will appeal to mathematicians with some standard background in measure theory and functional analysis No background in ergodic theory or Lie theory is assumed and a number of exercises and hints to problems are included making this the perfect companion for graduate students and researchers in ergodic theory homogenous dynamics or number theory

**Structure and Randomness** Terence Tao, In 2007 Terry Tao began a mathematical blog as an outgrowth of his own website at UCLA This book is based on a selection of articles from the first year of that blog These articles discuss a wide range of mathematics and its applications ranging from expository articles on quantum mechanics Einstein s equation  $E=mc^2$  or compressed sensing to open problems in analysis combinatorics geometry number theory and algebra to lecture series on random matrices Fourier analysis or the dichotomy between structure and randomness that is present in many subfields of mathematics to more philosophical discussions on such topics as the interplay between finitary and infinitary in analysis Some selected commentary from readers of the blog has also been included at the end of each article

**Dynamics and Randomness II** Alejandro Maass, Servet Martínez, Jaime San Martín, 2004-05-31 This book contains the lectures given at the Second Conference on Dynamics and Randomness held at the Centro de Modelamiento Matemático of the Universidad de Chile from December 9-13 2003 This meeting brought together mathematicians theoretical physicists theoretical computer scientists and graduate students interested in fields related to probability theory ergodic theory symbolic and topological dynamics The courses were on Some Aspects of Random Fragmentations in Continuous Times Metastability of Ageing in Stochastic Dynamics Algebraic Systems of Generating Functions and Return Probabilities for Random Walks Recurrent Measures and Measure Rigidity Stochastic Particle Approximations for Two Dimensional Navier Stokes Equations and

Random and Universal Metric Spaces The intended audience for this book is Ph D students on Probability and Ergodic Theory as well as researchers in these areas The particular interest of this book is the broad areas of problems that it covers We have chosen six main topics and asked six experts to give an introductory course on the subject touching the latest advances on each problem

**Rigidity in Higher Rank Abelian Group Actions: Volume 1, Introduction and Cocycle Problem** Anatole Katok, Viorel Nițică, 2011-06-16 This self contained monograph presents rigidity theory for a large class of dynamical systems differentiable higher rank hyperbolic and partially hyperbolic actions This first volume describes the subject in detail and develops the principal methods presently used in various aspects of the rigidity theory Part I serves as an exposition and preparation including a large collection of examples that are difficult to find in the existing literature Part II focuses on cocycle rigidity which serves as a model for rigidity phenomena as well as a useful tool for studying them The book is an ideal reference for applied mathematicians and scientists working in dynamical systems and a useful introduction for graduate students interested in entering the field Its wealth of examples also makes it excellent supplementary reading for any introductory course in dynamical systems

**Translation Surfaces** Jayadev S. Athreya, Howard Masur, 2024-04-17 This textbook offers an accessible introduction to translation surfaces Building on modest prerequisites the authors focus on the fundamentals behind big ideas in the field ergodic properties of translation flows counting problems for saddle connections and associated renormalization techniques Proofs that go beyond the introductory nature of the book are deftly omitted allowing readers to develop essential tools and motivation before delving into the literature Beginning with the fundamental example of the flat torus the book goes on to establish the three equivalent definitions of translation surface An introduction to the moduli space of translation surfaces follows leading into a study of the dynamics and ergodic theory associated to a translation surface Counting problems and group actions come to the fore in the latter chapters giving a broad overview of progress in the 40 years since the ergodicity of the Teichmüller geodesic flow was proven Exercises are included throughout inviting readers to actively explore and extend the theory along the way Translation Surfaces invites readers into this exciting area providing an accessible entry point from the perspectives of dynamics ergodicity and measure theory Suitable for a one or two semester graduate course it assumes a background in complex analysis measure theory and manifolds while some familiarity with Riemann surfaces and ergodic theory would be beneficial



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