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Communications in Mathematical Physics

Lyapunov Exponent, Universality and Phase Transition for Products of Random Matrices

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Abstract: Products of M i.i.d. random matrices of size $N \times N$ are related to classical limit theorems in probability theory ($N = 1$ and large M), to Lyapunov exponents in dynamical systems (finite N and large M), and to universality in random matrix theory (finite M and large N). Under the two different limits of $M \to \infty$ and $N \to \infty$, the local singular value statistics display Gaussian and random matrix theory universality, respectively. However, it is unclear what happens if both M and N go to infinity. This problem, proposed by Akemann et al. (J Phys A 47(39):395202, 2014) and Deift (SIGMA Symmetry Integr Geom Methods Appl 13, 2017), lies at the heart of understanding both kinds of universal limits. In the case of complex Gaussian random matrices, we prove that there exists a crossover phenomenon as the relative ratio of M and N changes from 0 to ∞: sine and Airy kernels from the Gaussian Unitary Ensemble (GUE) when $M/N \to 0$, Gaussian fluctuation when $M/N \to \infty$, and new critical phenomena when $M/N \to \gamma \in (0, \infty)$. Accordingly, we further prove that the largest singular value undergoes a phase transition between the Gaussian and GUE Tracy–Widom distributions.

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P. Bougerol,Lacroix

Lyapunov Exponents Of Products Of Random Matrices:

Products of Random Matrices and Lyapunov Exponents Chi Shing Sidney Tsang,2010 Products of Random Matrices Andrea Crisanti,Giovanni Paladin,Angelo Vulpiani,2012-12-06 At the present moment after the success of the renormalization group in providing a conceptual framework for studying second order phase tran sitions we have a nearly satisfactory understanding of the statistical me chanics of classical systems with a non random Hamiltonian The situation is completely different if we consider the theory of systems with a random Hamiltonian or of chaotic dynamical systems The two fields are connected in fact in the latter the effects of deterministic chaos can be modelled by an appropriate stochastic process Although many interesting results have been obtained in recent years and much progress has been made we still lack a satisfactory understanding of the extremely wide variety of phenomena which are present in these fields The study of disordered or chaotic systems is the new frontier where new ideas and techniques are being developed More interesting and deep results are expected to come in future years The properties of random matrices and their products form a basic tool whose importance cannot be underestimated They playa role as important as Fourier transforms for differential equations This book is extremely interesting as far as it presents a unified approach for the main results which have been obtained in the study of random ma trices It will become a reference book for people working in the subject The book is written by physicists uses the language of physics and I am sure that many physicists will read it with great pleasure *Lyapunov Exponents* Ludwig Arnold,Hans Crauel,Jean-Pierre Eckmann,2006-11-14 Since the predecessor to this volume LNM 1186 Eds L Arnold V Wihstutz appeared in 1986 significant progress has been made in the theory and applications of Lyapunov exponents one of the key concepts of dynamical systems and in particular pronounced shifts towards nonlinear and infinite dimensional systems and engineering applications are observable This volume opens with an introductory survey article Arnold Crauel followed by 26 original fully refereed research papers some of which have in part survey character From the Contents L Arnold H Crauel Random Dynamical Systems I Ya Goldscheid Lyapunov exponents and asymptotic behaviour of the product of random matrices Y Peres Analytic dependence of Lyapunov exponents on transition probabilities O Knill The upper Lyapunov exponent of Sl 2 R cocycles Discontinuity and the problem of positivity Yu D Latushkin A M Stepin Linear skew product flows and semigroups of weighted composition operators P Baxendale Invariant measures for nonlinear stochastic differential equations Y Kifer Large deviationsfor random expanding maps P Thieullen Generalisation du theoreme de Pesin pour l entropie S T Ariaratnam W C Xie Lyapunov exponents in stochastic structural mechanics F Colonius W Kliemann Lyapunov exponents of control flows **Products of Random Matrices with Applications to Schrödinger Operators** P. Bougerol,Lacroix,2012-12-06 CHAPTER I THE DETERMINISTIC SCHRODINGER OPERATOR 187 1 The difference equation Hyperbolic structures 187 2 Self adjointness of H Spectral properties 190 3 Slowly increasing generalized eigenfunctions 195 4 Approximations of the spectral measure 196 200 5 The pure point spectrum A criterion 6

Singularity of the spectrum 202 CHAPTER II ERGODIC SCHR DINGER OPERATORS 205 1 Definition and examples 205 2 General spectral properties 206 3 The Lyapunov exponent in the general ergodie case 209 4 The Lyapunov exponent in the independent eas e 211 5 Absence of absolutely continuous spectrum 221 224 6 Distribution of states Thouless formula 232 7 The pure point spectrum Kotani s criterion 8 Asymptotic properties of the conductance in 234 the disordered wire CHAPTER III THE PURE POINT SPECTRUM 237 238 1 The pure point spectrum First proof 240 2 The Laplace transform on SI 2 JR 247 3 The pure point spectrum Second proof 250 4 The density of states CHAPTER IV SCHR DINGER OPERATORS IN A STRIP 2 3 1 The deterministic Schr dinger operator in 253 a strip 259 2 Ergodie Schr dinger operators in a strip 3 Lyapunov exponents in the independent case 262 The pure point spectrum first proof 267 4 The Laplace transform on Sp JR 272 5 The pure point spectrum second proof vii APPENDIX 275 BIBLIOGRAPHY 277 viii PREFACE This book presents two elosely related series of leetures Part A due to P **Random Matrices and Their Applications** Joel E. Cohen,Harry Kesten,Charles Michael Newman,1986 Features twenty six expository papers on random matrices and products of random matrices This work reflects both theoretical and applied concerns in fields as diverse as computer science probability theory mathematical physics and population biology *Lectures on Lyapunov Exponents* Marcelo Viana,2014-07-24 The theory of Lyapunov exponents originated over a century ago in the study of the stability of solutions of differential equations Written by one of the subject s leading authorities this book is both an account of the classical theory from a modern view and an introduction to the significant developments relating the subject to dynamical systems ergodic theory mathematical physics and probability It is based on the author s own graduate course and is reasonably self contained with an extensive set of exercises provided at the end of each chapter This book makes a welcome addition to the literature serving as a graduate text and a valuable reference for researchers in the field **Recent Trends in Dynamical Systems** Andreas Johann,Hans-Peter Kruse,Florian Rupp,Stephan Schmitz,2013-09-24 This book presents the proceedings of a conference on dynamical systems held in honor of J rgen Scheurle in January 2012 Through both original research papers and survey articles leading experts in the field offer overviews of the current state of the theory and its applications to mechanics and physics In particular the following aspects of the theory of dynamical systems are covered Stability and bifurcation Geometric mechanics and control theory Invariant manifolds attractors and chaos Fluid mechanics and elasticity Perturbations and multiscale problems Hamiltonian dynamics and KAM theory Researchers and graduate students in dynamical systems and related fields including engineering will benefit from the articles presented in this volume New Trends in Lyapunov Exponents João Lopes Dias,Pedro Duarte,José Pedro Gaivão,Silvius Klein,Telmo Peixe,Jaqueline Siqueira,Maria Joana Torres,2023-10-28 This volume presents peer reviewed surveys on new developments in the study of Lyapunov exponents in dynamical systems and its applications to other areas such as mathematical physics Written by leading experts in their fields the contributions are based upon the presentations given by invited speakers at the New Trends in Lyapunov Exponents

workshop held in Lisbon Portugal February 7 11 2022 The works focus on the concept of Lyapunov exponents in their various manifestations in dynamical systems along with their applications to mathematical physics and other areas of mathematics The papers reflect the spirit of the conference of promoting new connections among different subjects in dynamical systems This volume aims primarily at researchers and graduate students working in dynamical systems and related fields serving as an introduction to active fields of research and as a review of recent results as well *A First Course in Random Matrix Theory* Marc Potters,Jean-Philippe Bouchaud,2020-12-03 The real world is perceived and broken down as data models and algorithms in the eyes of physicists and engineers Data is noisy by nature and classical statistical tools have so far been successful in dealing with relatively smaller levels of randomness The recent emergence of Big Data and the required computing power to analyse them have rendered classical tools outdated and insufficient Tools such as random matrix theory and the study of large sample covariance matrices can efficiently process these big data sets and help make sense of modern deep learning algorithms Presenting an introductory calculus course for random matrices the book focusses on modern concepts in matrix theory generalising the standard concept of probabilistic independence to non commuting random variables Concretely worked out examples and applications to financial engineering and portfolio construction make this unique book an essential tool for physicists engineers data analysts and economists **Spectral Theory of Random Schrödinger Operators** R. Carmona,J. Lacroix,2012-12-06 Since the seminal work of P Anderson in 1958 localization in disordered systems has been the object of intense investigations Mathematically speaking the phenomenon can be described as follows the self adjoint operators which are used as Hamiltonians for these systems have a ten dency to have pure point spectrum especially in low dimension or for large disorder A lot of effort has been devoted to the mathematical study of the random self adjoint operators relevant to the theory of localization for disordered systems It is fair to say that progress has been made and that the un derstanding of the phenomenon has improved This does not mean that the subject is closed Indeed the number of important problems actually solved is not larger than the number of those remaining Let us mention some of the latter A proof of localization at all energies is still missing for two dimen sional systems though it should be within reachable range In the case of the two dimensional lattice this problem has been approached by the investigation of a finite discrete band but the limiting pro cedure necessary to reach the full two dimensional lattice has never been controlled The smoothness properties of the density of states seem to escape all attempts in dimension larger than one This problem is particularly serious in the continuous case where one does not even know if it is continuous *Scientific and Technical Aerospace Reports* ,1989 **Smart Grid using Big Data Analytics** Robert C. Qiu,Paul Antonik,2017-01-23 This book is aimed at students in communications and signal processing who want to extend their skills in the energy area It describes power systems and why these backgrounds are so useful to smart grid wireless communications being very different to traditional wireline communications *Cellular Automata and Complex Systems* E. Goles,Servet Martínez,2013-11-27 This

book contains the courses given at the Fifth School on Complex Systems held at Santiago Chile from 9th to 13th December 1996 At this school met researchers working on areas related with recent trends in Complex Systems which include dynamical systems cellular automata symbolic dynamics spatial systems statistical physics and thermodynamics Scientists working in these subjects come from several areas pure and applied mathematics physics biology computer science and electrical engineering Each contribution is devoted to one of the above subjects In most cases they are structured as surveys presenting at the same time an original point of view about the topic and showing mostly new results The paper of Bruno Durand presents the state of the art on the relationships between the notions of surjectivity injectivity and reversibility in cellular automata when finite infinite or periodic configurations are considered also he discusses decidability problems related with the classification of cellular automata as well as global properties mentioned above The paper of Eric Goles and Martin Matamala gives a uniform presentation of simulations of Turing machines by cellular automata The main ingredient is the encoding function which must be fixed for all Turing machine In this context known results are revised and new results are presented **Probability Models In Mathematical Physics - Proceedings Of The Conference** Gregory J Morrow,W S Yang,1991-01-14 The conference proceedings includes discussions on state of the art developments in an area being cross fertilized by both probability and mathematical physics The physics emphasis represents a vision of exciting interplay between physics and probability Important new results on the following areas are presented self avoiding random walk stochastic geometry on loop groups percolation spin systems magnetism spin glasses static disorder gauge field theory functional integration and quantum field theory **Physical and Numerical Models in Knot Theory** Jorge Alberto Calvo,2005 The physical properties of knotted and linked configurations in space have long been of interest to mathematicians More recently these properties have become significant to biologists physicists and engineers among others Their depth of importance and breadth of application are now widely appreciated and valuable progress continues to be made each year This volume presents several contributions from researchers using computers to study problems that would otherwise be intractable While computations have long been used to analyze problems formulate conjectures and search for special structures in knot theory increased computational power has made them a staple in many facets of the field The volume also includes contributions concentrating on models researchers use to understand knotting linking and entanglement in physical and biological systems Topics include properties of knot invariants knot tabulation studies of hyperbolic structures knot energies the exploration of spaces of knots knotted umbilical cords studies of knots in DNA and proteins and the structure of tight knots Together the chapters explore four major themes physical knot theory knot theory in the life sciences computational knot theory and geometric knot theory **Progress on the Study of the Ginibre Ensembles** Sung-Soo Byun,Peter J. Forrester,2024-08-20 This open access book focuses on the Ginibre ensembles that are non Hermitian random matrices proposed by Ginibre in 1965 Since that time they have enjoyed prominence within random

matrix theory featuring for example the first book on the subject written by Mehta in 1967 Their status has been consolidated and extended over the following years as more applications have come to light and the theory has developed to greater depths This book sets about detailing much of this progress Themes covered include eigenvalue PDFs and correlation functions fluctuation formulas sum rules and asymptotic behaviors normal matrix models and applications to quantum many body problems and quantum chaos There is a distinction between the Ginibre ensemble with complex entries GinUE and those with real or quaternion entries GinOE and GinSE respectively First the eigenvalues of GinUE form a determinantal point process while those of GinOE and GinSE have the more complicated structure of a Pfaffian point process Eigenvalues on the real line in the case of GinOE also provide another distinction On the other hand the increased complexity provides new opportunities for research This is demonstrated in our presentation which details several applications and contains not previously published theoretical advances The areas of application are diverse with examples being diffusion processes and persistence in statistical physics and equilibria counting for a system of random nonlinear differential equations in the study of the stability of complex systems *Mathematical Constants II* Steven R. Finch,2018-12-06 Famous mathematical constants include the ratio of circular circumference to diameter 3 14 and the natural logarithm base e 2 718 Students and professionals can often name a few others but there are many more buried in the literature and awaiting discovery How do such constants arise and why are they important Here the author renews the search he began in his book Mathematical Constants adding another 133 essays that broaden the landscape Topics include the minimality of soap film surfaces prime numbers elliptic curves and modular forms Poisson Voronoi tessellations random triangles Brownian motion uncertainty inequalities Prandtl Blasius flow from fluid dynamics Lyapunov exponents knots and tangles continued fractions Galton Watson trees electrical capacitance from potential theory Zermelo s navigation problem and the optimal control of a pendulum Unsolved problems appear virtually everywhere as well This volume continues an outstanding scholarly attempt to bring together all significant mathematical constants in one place **Hyperbolic Dynamics, Fluctuations and Large Deviations** D. Dolgopyat, Y. Pesin,M. Pollicott, L. Stoyanov,2015-04-01 This volume contains the proceedings of the semester long special program on Hyperbolic Dynamics Large Deviations and Fluctuations which was held from January June 2013 at the Centre Interfacultaire Bernoulli cole Polytechnique F d rale de Lausanne Switzerland The broad theme of the program was the long term behavior of dynamical systems and their statistical behavior During the last 50 years the statistical properties of dynamical systems of many different types have been the subject of extensive study in statistical mechanics and thermodynamics ergodic and probability theories and some areas of mathematical physics The results of this study have had a profound effect on many different areas in mathematics physics engineering and biology The papers in this volume cover topics in large deviations and thermodynamics formalism and limit theorems for dynamic systems The material presented is primarily directed at researchers and graduate students in the very broad area of dynamical systems and ergodic theory but

will also be of interest to researchers in related areas such as statistical physics spectral theory and some aspects of number theory and geometry *Stochastic Modeling and Analysis of Manufacturing Systems* David D. Yao,2012-12-06 Manufacturing systems have become increasingly complex over recent years This volume presents a collection of chapters which reflect the recent developments of probabilistic models and methodologies that have either been motivated by manufacturing systems research or been demonstrated to have significant potential in such research The editor has invited a number of leading experts to present detailed expositions of specific topics These include Jackson networks fluid models diffusion and strong approximations the GSMP framework stochastic convexity and majorization perturbation analysis scheduling via Brownian models and re entrant lines and dynamic scheduling Each chapter has been written with graduate students in mind and several have been used in graduate courses that teach the modeling and analysis of manufacturing systems *Topology and Condensed Matter Physics* Somendra Mohan Bhattacharjee,Mahan Mj,Abhijit Bandyopadhyay,2017-12-20 This book introduces aspects of topology and applications to problems in condensed matter physics Basic topics in mathematics have been introduced in a form accessible to physicists and the use of topology in quantum statistical and solid state physics has been developed with an emphasis on pedagogy The aim is to bridge the language barrier between physics and mathematics as well as the different specializations in physics Pitched at the level of a graduate student of physics this book does not assume any additional knowledge of mathematics or physics It is therefore suited for advanced postgraduate students as well A collection of selected problems will help the reader learn the topics on one s own and the broad range of topics covered will make the text a valuable resource for practising researchers in the field The book consists of two parts one corresponds to developing the necessary mathematics and the other discusses applications to physical problems The section on mathematics is a quick but more or less complete review of topology The focus is on explaining fundamental concepts rather than dwelling on details of proofs while retaining the mathematical flavour There is an overview chapter at the beginning and a recapitulation chapter on group theory The physics section starts with an introduction and then goes on to topics in quantum mechanics statistical mechanics of polymers knots and vertex models solid state physics exotic excitations such as Dirac quasiparticles Majorana modes Abelian and non Abelian anyons Quantum spin liquids and quantum information processing are also covered in some detail

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