LYAPUNOV EXPONENTS AND EIGENVALUES OF PRODUCTS OF RANDOM MATRICES

NANDA KISHORE REDDY

ABSTRACT. Let $X_1, X_2, \ldots$ be a sequence of i.i.d real (complex) $d \times d$ invertible random matrices with common distribution μ and $\sigma_1(n), \sigma_2(n), \ldots, \sigma_d(n)$ be the singular values, $\lambda_1(n), \lambda_2(n), \ldots, \lambda_d(n)$ be the eigenvalues of $X_n X_{n-1} \cdots X_1$ in the decreasing order of their absolute values for every n. It is known that if $\mathbf{E}(\log^+ \|X_1\|) < \infty$, then with probability one for all $1 \leq p \leq d$,

$$\lim_{n \to \infty} \frac{1}{n} \log \sigma_p(n) = \gamma_p,$$

where $\gamma_1, \gamma_2 \cdots \gamma_d$ are the Lyapunov exponents associated with μ. In this paper we show that under certain support and moment conditions on μ, the absolute values of eigenvalues also exhibit the same asymptotic behaviour. In fact, a stronger asymptotic relation holds between the singular values and the eigenvalues i.e. for any $r > 0$ with probability one for all $1 \leq p \leq d$,

$$\lim_{n \to \infty} \frac{1}{n^r} \log \left(\frac{|\lambda_p(n)|}{\sigma_p(n)} \right) = 0,$$

which implies that the fluctuations of the eigenvalues have the same asymptotic distribution as that of the corresponding singular values. Isotropic random matrices and also random matrices with i.i.d real elements, which have some finite moment and bounded density whose support contains an open set, are shown to satisfy the moment and support conditions under which the above relations hold.
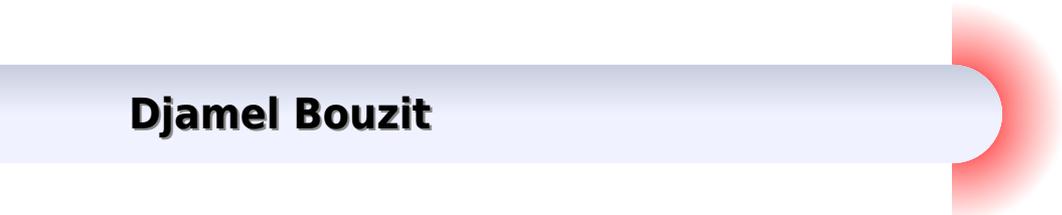
1. INTRODUCTION

Lyapunov exponents and singular values of products of i.i.d random matrices of fixed order have been studied extensively (see [3], [4]). Only recently, the study of eigenvalues of such matrices has begun, though they have been considered first in the setting of dynamical systems in [6] and there the absolute values of eigenvalues have been conjectured to show the same asymptotic behaviour as that of singular values. Recent comparative studies [1], [7] of singular values and eigenvalues in the case of Ginibre matrix ensembles have verified the conjecture to be true in the respective cases. And also [5] mentions this in the case of random truncated unitary matrices. For a summary of results on this topic, we refer the reader to [2]. In [1], asymptotic distributions of first order fluctuations of (logarithm of) both the singular values and the absolute values of eigenvalues for product of Ginibre matrices have been computed and shown to be equal and also a proof of this conjecture in the case of 2×2 isotropic random matrices has been given. Recently, a full proof in the case of isotropic random matrices has been obtained in [8]. In this paper we obtain a proof in more generality with only few conditions on the moments and support of the distribution of the random matrices involved.

Lyapunov Exponents Of Products Of Random Matrices

Djamel Bouzit

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   **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

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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   International Conference on Disorder and Chaos A. Vulpiani,1998

Resenhas IME-USP ,1997   *Dynamical Symmetries and Chaotic Behaviour in Physical Systems, ENEA, Bologna, Italy, 20-21 June 1989* Giuseppe Maino,Leone Fronzoni,Marco Pettini,1991   **Proceedings of the ENEA Workshops on Nonlinear Dynamics: Dynamical symmetries and chaotic behaviour in physical systems** Giuseppe Maino,Leone Fronzoni,Marco Pettini,1991 Workshops held June 20 21 and Oct 23 24 1989 Bologna Italy   Journal of Mathematical Systems, Estimation, and Control ,1995

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web may 11 2023   table 57 referenced by rule 16 210 6 and table 5a provides allowable ampacities for class 2 copper conductors based on the size of the conductor and whether it is a single conductor in free air or not more than three copper conductors in raceway or cable and an ambient temperature of 30 degrees centigrade

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5c for vertical layers of insulated conductors in ventilated ladder type trays

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web feb 1 2021 by william bill burr rule 28 000 scope states that section 28 motors and generators is a supplementary or amendatory section of the code and provides additional and specific requirements for the installation wiring methods conductors protection and control of all motors and generators

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web may 1 2020 although as per 90 c column of table 2 the ampacity of such no 3 awg conductor is 115 a in accordance with provisions of rule 4 006 the ampacity of this conductor would be assigned based on 75 c column of

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web table 2 b maximum amperage for common wire sizes per canadian electrical code cec canada copper wire aluminum or copper size clad aluminum temperature 60 c 75 c 90 c 60 c 75 c 85 90 c rating 15 15 15 14 20 20 20 12 15 15 15 30 30 30 10 25 25 25 40 45 45 8 30 30 30 55 65 65 6 40 50 55 70 85 4 55 65

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web mar 14 2017 rule 4 004 ampacity of wires and cables contains 7 items each in subrules 1 and 2 covering scenario options each for copper and aluminum that need to be studied and chosen in addition there are 21 other factors in

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web table 2 and 4 allowable ampacities of less than 4 insulated conductors rated 0 2000 volts based on 30 c ambient temperature and in a raceway or cable this table provides ampacity values for various sizes of copper and aluminum conductors based on their insulation type and the termination temperature rating

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web for example a 10 awg 3c 600 v cable with xhhw singles would have an ampacity of 35 amps if using the 75 c column in nec 2014 table 310 15 b 16 allowable ampacities of insulated conductors rated up to and including 2000 volts 60 c through 90 c not more than three current carrying conductors in raceway cable

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