MATHEMATICS

Random Quantization of Hamiltonian Systems

J. Gough[a], Yu. N. Orlov[b,c], V. Zh. Sakbaev[b,d,*], and O. G. Smolyanov[e]
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Abstract—A quantization of a Hamiltonian system is an ambiguous procedure. Accordingly, we introduce the notion of random quantization, related random variables with values in the set of self-adjoint operators, and random processes with values in the group of unitary operators. The procedures for the averaging of random unitary groups and averaging of randoms self-adjoint operators are defined. The generalized weak convergence of a sequence of measures and the corresponding generalized convergence in distribution of a sequence of random variables are introduced. The generalized convergence in distribution for some sequences of compositions of random mappings is obtained. In the case of a sequence of compositions of shifts by independent random vectors of Euclidean space, the obtained convergence coincides with the statement of the central limit theorem for a sum of independent random vectors. The results are applied to the dynamics of quantum systems arising in random quantization of a Hamiltonian system.

Keywords: random linear operator, random operator-valued function, operator-valued random process, law of large numbers, central limit theorem, Markovian process, Kolmogorov equation

A quantization of a Hamiltonian system is an ambiguous procedure. For this reason, we introduce the concept of randomized (random) quantization. The random quantization of a Hamiltonian system is a mapping of a linear space of Hamiltonian functions defined on the symplectic phase space such that each Hamiltonian function is taken to a random variable with values in the set of self-adjoint operators acting on the Hilbert space of the quantum system. This scheme covers all known quantization methods, since the value of a random variable at each element of a probability space describes some quantization. Moreover, the random semigroup generated by a random Hamiltonian is a random process with values in the group of unitary operators.

In this paper, we consider the linear quantizations of Hamiltonian systems introduced in [1] and developed in [2]. The linear quantization is a linear mapping of a vector space of Hamiltonian functions defined on the symplectic phase space to a vector space of quantum Hamiltonians representing self-adjoint operators in the Hilbert space of the quantum system.

Interest in the study of random variables with values in the set of unbounded operators in Banach spaces and in the study of random processes with values in the Banach space of bounded linear operators is motivated by some problems of mathematical physics [3—5]. For example, if a Hamiltonian function can be a random variable in functional mechanics [6], then the quantum analogue of functional mechanics is a quantum system with a Hamiltonian representing a random variable with values in the set of self-adjoint operators [7]. The randomness of the Hamiltonian of the quantum system follows from the ambiguity of the quantization procedure for classical Hamiltonian systems [1, 7]. Thus, there are two sources of randomness in the dynamics of quantum systems.

1. The Hamiltonian of a classical system is a random variable with values in the set of continuously differentiable functions on the phase space.

2. Quantization of a classical Hamiltonian system is a random variable with values in the set of linear mappings of the linear manifold of the space of smooth functions on the phase space to a linear man-

[a] Aberystwyth University, Wales, United Kingdom
[b] Federal Research Center Keldysh Institute of Applied Mathematics, Russian Academy of Sciences, Moscow, 125047 Russia
[c] Blagonravov Institute of Machines Science, Russian Academy of Sciences, Moscow, 101990 Russia
[d] Moscow Institute of Physics and Technology (National Research University), Dolgoprudnyi, Moscow oblast, 141701 Russia
[e] Faculty of Mechanics and Mathematics, Lomonosov Moscow State University, Moscow, 119991 Russia
*e-mail: fumi2003@mail.ru

Random Perturbations Of Hamiltonian Systems

Vladas Sidoravicius

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Random Perturbations of Hamiltonian Systems Mark Iosifovich Freĭdlin,Alexander D. Wentzell,1994 Random perturbations of Hamiltonian systems in Euclidean spaces lead to stochastic processes on graphs and these graphs are defined by the Hamiltonian In the case of white noise type perturbations the limiting process will be a diffusion process on the graph Its characteristics are expressed through the Hamiltonian and the characteristics of the noise Freidlin and Wentzell calculate the process on the graph under certain conditions and develop a technique which allows consideration of a number of asymptotic problems The Dirichlet problem for corresponding elliptic equations with a small parameter are connected with boundary problems on the graph   Random Perturbations of Hamiltonian Systems Mark Iosifovich Freĭdlin,2014-08-31 Random perturbations of Hamiltonian systems in Euclidean spaces lead to stochastic processes on graphs and these graphs are defined by the Hamiltonian In the case of white noise type perturbations the limiting process will be a diffusion process on the graph Its characteristics are expressed through the Hamiltonian and the characteristics of the noise Freidlin and Wentzell calculate the process on the graph under certain conditions and develop a technique which allows consideration of a number of asymptotic problems The Dirichlet problem for corresponding elliptic equations with a small parameter are connected with boundary problems on the graph   Random Perturbations of Dynamical Systems Mark I. Freidlin,Alexander D. Wentzell,2012-05-31 Many notions and results presented in the previous editions of this volume have since become quite popular in applications and many of them have been rediscovered in applied papers In the present 3rd edition small changes were made to the chapters in which long time behavior of the perturbed system is determined by large deviations Most of these changes concern terminology In particular it is explained that the notion of sub limiting distribution for a given initial point and a time scale is identical to the idea of metastability that the stochastic resonance is a manifestation of metastability and that the theory of this effect is a part of the large deviation theory The reader will also find new comments on the notion of quasi potential that the authors introduced more than forty years ago and new references to recent papers in which the proofs of some conjectures included in previous editions have been obtained Apart from the above mentioned changes the main innovations in the 3rd edition concern the averaging principle A new Section on deterministic perturbations of one degree of freedom systems was added in Chapter 8 It is shown there that pure deterministic perturbations of an oscillator may lead to a stochastic in a certain sense long time behavior of the system if the corresponding Hamiltonian has saddle points The usefulness of a joint consideration of classical theory of deterministic perturbations together with stochastic perturbations is illustrated in this section Also a new Chapter 9 has been inserted in which deterministic and stochastic perturbations of systems with many degrees of freedom are considered Because of the resonances stochastic regularization in this case is even more important   *On Random Perturbations of Hamiltonian Systems with Many Degrees of Freedom* Mark I. Frejdlin,Matthias Weber,2000   *Topics in Stochastic Analysis and*

Nonparametric Estimation Pao-Liu Chow,Boris S. Mordukhovich,G. George Yin,2010-07-19 This IMA Volume in Mathematics and its Applications TOPICS IN STOCHASTIC ANALYSIS AND NONPARAMETRIC ESTIMATION contains papers that were presented at the IMA Participating Institution conference on Asymptotic Analysis in Stochastic Processes Nonparamet ric Estimation and Related Problems held on September 15 17 2006 at Wayne State University The conference which was one of approximately ten selected each year for partial support by the IMA through its affiliates program was dedicated to Professor Rafail Z Khasminskii on the occasion th of his 75 birthday in recognition of his profound contributions to the field of stochastic processes and nonparametric estimation theory We are grateful to the participants and especially to the conference organizers for making the event so successful Pao Liu Chow Boris Mor dukhovich and George Yin of the Department of Mathematics at Wayne State University did a superb job organizing this first rate event and in editing these proceedings We take this opportunity to thank the Nation al Science Foundation for its support of the IMA   *New Trends in Mathematical Physics* Vladas Sidoravicius,2009-08-31 This book collects selected papers written by invited and plenary speakers of the 15th International Congress on Mathematical Physics ICMP in the aftermath of the conference In extensive review articles and expository texts as well as advanced research articles the world leading experts present the state of the art in modern mathematical physics New mathematical concepts and ideas are introduced by prominent mathematicalphysicists and mathematicians covering among others the fields of Dynamical Systems Operator Algebras Partial Differential Equations Probability Theory Random Matrices Condensed Matter Physics Statistical Mechanics General Relativity Quantum Mechanics Quantum Field Theory Quantum Information and String Theory All together the contributions in this book give a panoramic view of the latest developments in mathematical physics They will help readers with a general interest in mathematical physics to get an update on the most recent developments in their field and give a broad overview on actual and future research directions in this fascinating and rapidly expanding area   **Stochastic Averaging** Wei-Qiu Zhu,Mao-Lin Deng,Guo-Qiang Cai,2025-06-19 The stochastic averaging methods are among the most effective and widely applied approximate methods for studying nonlinear stochastic dynamics Upon an overview of global research on the subject the book highlights a comprehensive summary of research results obtained by the group led by Professor Weiqiu Zhu at Zhejiang University in China and the group led by Professors Y K Lin and G Q Cai at Florida Atlantic University in the USA over the past three decades The books are structured to progress logically from foundational principles to simple problems and then to increasingly complex applications To facilitate understanding and mastery of the methods the books offer essential preliminary knowledge and a wealth of examples The book comprises two volumes Volume 1 introduces the basic principles of stochastic averaging methods and their applications to single degree of freedom systems under various random excitations It also covers stochastic averaging methods for quasi Hamiltonian systems subjected to different random excitations including Gaussian white noise combined Gaussian and Poisson white noises and fractional Gaussian noise

Volume 2 explores stochastic averaging methods for quasi integrable Hamiltonian systems under colored noise excitation quasi integrable Hamiltonian systems with genetic effects under Gaussian white noise and colored noise excitations and quasi generalized Hamiltonian systems under Gaussian white noise excitation Additionally it covers applications of these methods in ecosystems and some other natural science and engineering scenarios These books serve as both introductory texts and valuable reference resources for readers in higher education and research institutions who are interested in or actively engaged in research involving nonlinear stochastic dynamics The fields covered include mechanics physics chemistry biology ecology astronautics and aeronautics oceanography civil engineering mechanical engineering and electrical engineering **Lyapunov Exponents for Small Random Perturbations of Nilpotent and Hamiltonian Systems** Levon Goukasian,2001 **Deutsche Nationalbibliographie und Bibliographie der im Ausland erschienenen deutschsprachigen Veröffentlichungen** ,1996 *Issues in General Science and Scientific Theory and Method: 2011 Edition* ,2012-01-09 Issues in General Science and Scientific Theory and Method 2011 Edition is a ScholarlyEditions eBook that delivers timely authoritative and comprehensive information about General Science and Scientific Theory and Method The editors have built Issues in General Science and Scientific Theory and Method 2011 Edition on the vast information databases of ScholarlyNews You can expect the information about General Science and Scientific Theory and Method in this eBook to be deeper than what you can access anywhere else as well as consistently reliable authoritative informed and relevant The content of Issues in General Science and Scientific Theory and Method 2011 Edition has been produced by the world s leading scientists engineers analysts research institutions and companies All of the content is from peer reviewed sources and all of it is written assembled and edited by the editors at ScholarlyEditions and available exclusively from us You now have a source you can cite with authority confidence and credibility More information is available at http www ScholarlyEditions com Beyond Peaceful Coexistence; The Emergence Of Space, Time And Quantum Ignazio Licata,2016-03-30 It may be that a real synthesis of quantum and relativity theories requires not just technical developments but radical conceptual renewal J S BellBeyond Peaceful Coexistence The Emergence of Space Time and Quantum brings together leading academics in mathematics and physics to address going beyond the peaceful coexistence of space time descriptions local and continuous ones and quantum events discrete and non commutative ones Formidable challenges waiting beyond the Standard Model require a new semantic consistency within the theories in order to build new ways of understanding working and relating to them The original A Shimony meaning of the peaceful coexistence the collapse postulate and non locality appear to be just the tip of the iceberg in relation to more serious fundamental issues across physics as a whole Chapters in this book present perspectives on emergent discrete geometrodynamic and topological approaches as well as a new interpretative spectrum of quantum theories after Copenhagen discrete time theories time less approaches and super fluid pictures of space time As well as stimulating further research among established theoretical

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