

# Applications of Quantum Probability to Classical Stochastics

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New nonexplosion conditions for Markov processes are derived from the general operator form of the conservativity condition for a quantum dynamical semigroup.

## 1 Introduction

In this paper an operator-valued generalization of the Kolmogorov – Feller equation is discussed. The most remarkable feature of this generalization is that it also covers diffusion and Heisenberg equations as particular cases [L]. It is known that if intensity of jumps (or drift velocity, or diffusion coefficient) as a function on the phase space  $X$  of the corresponding Markov process is unbounded, then the probability measure of trajectories hitting singularities of the coefficients may be positive. If there exist a number of different ways to define the behaviour of the process after hitting a singular point then the formal evolution equation for the transition probability of the Markov jump process has a linear manifold of solutions. In the class of solutions  $P(x, t|\Gamma)$  satisfying the initial condition  $P(x, 0|\Gamma) = I_\Gamma(x)$  there exists a minimal solution such that

$$P^{\min}(x, t|X) < 1$$

(see [F]). A similar phenomenon exists for the operator-valued generalization of the Kolmogorov – Feller equation. Examples of Markov jump processes which explode or escape to infinity with positive probability are given in section 2 following [C1], [CF1]. In section 3 we describe an algebraic structure of operator-valued extensions of the basic evolution equations for Markov processes. Section 4 contains domain assumptions for coefficients of infinitesimal maps of semigroups in von Neumann algebras. In section 5 we introduce conditions which are necessary and sufficient for conservation of the total probability by the minimal solution for evolution equation [C2]. We call them *conservativity conditions*. If the minimal solution of the evolution equation is conservative (i.e. it preserves identity) then the corresponding Markov process is called *regular*. Section 6 contains a constructive form of sufficient conservativity conditions and give some applications to classical stochastic processes [C3], [CF2]. In Section 7 we present some new examples of regularity conditions derived for Markov processes from the general operator form of the conservativity condition for a quantum dynamical semigroup.

# Stochastics Algebra And Analysis In Classical And Quantum Dynamics

**Dan Crisan**



## **Stochastics Algebra And Analysis In Classical And Quantum Dynamics:**

**Stochastics, Algebra and Analysis in Classical and Quantum Dynamics** Sergio Albeverio, Philip Blanchard, D. Testard, 2012-12-06 Et moi f si j avait su comment en revenir One service mathematics has rendered the je n y serais point aile human race It has put common sense back Jules Verne where it belongs 011 the topmost shelf next to the dusty canister labelled discarded non The series is divergent therefore we may be able to do something with it Eric T Bell o Heaviside Mathematics is a tool for thought A highly necessary tool in a world where both feedback and non linearities abound Similarly all kinds of parts of mathematics serve as tools for other parts and for other sciences Applying a simple rewriting rule to the quote on the right above one finds such statements as One service topology has rendered mathematical physics One service logic has rendered computer science One service category theory has rendered mathematics All arguably true And all statements obtainable this way form part of the raison d etre of this series\_ This series Mathematics and Its Applications started in 1977 Now that over one hundred volumes have appeared it seems opportune to reexamine its scope At the time I wrote Growing specialization and diversification have brought a host of monographs and textbooks on increasingly specialized topics However the tree of knowledge of mathematics and related fields does not grow only by putting forth new branches

**Stochastic Analysis and Mathematical Physics (SAMP/ANESTOC 2002)** Richard Phillips Feynman, Rolando Rebolledo, Jorge Rezende, 2004 The book collects a series of papers centered on two main streams Feynman path integral approach to Quantum Mechanics and statistical mechanics of quantum open systems Key authors discuss the state of the art within their fields of expertise In addition the volume includes a number of contributed papers with new results which have been thoroughly refereed The contributions in this volume highlight emergent research in the area of stochastic analysis and mathematical physics focusing in particular on Feynman functional integral approach and on the other hand in quantum probability The book is addressed to an audience of mathematical physicists as well as specialists in probability theory stochastic analysis and operator algebras The proceedings have been selected for coverage in OCo Index to Scientific Technical Proceedings ISTP CDROM version ISI Proceedings OCo CC Proceedings OCo Engineering Physical Sciences

Stochastic Analysis and Mathematical Physics A.B. Cruzeiro, J.-C. Zambrini, 2012-12-06 This volume represents the outgrowth of an ongoing workshop on stochastic analysis held in Lisbon The nine survey articles in the volume extend concepts from classical probability and stochastic processes to a number of areas of mathematical physics It is a good reference text for researchers and advanced students in the fields of probability stochastic processes analysis geometry mathematical physics and physics Key topics covered include nonlinear stochastic wave equations completely positive maps Mehler type semigroups on Hilbert spaces entropic projections and many others

**Mathematical Physics and Stochastic Analysis** Sergio Albeverio, 2000 In October 1998 a conference was held in Lisbon to celebrate Ludwig Streit s 60th birthday This book collects some of the papers presented at the conference as well as other essays contributed by the

many friends and collaborators who wanted to honor Ludwig Streit's scientific career and personality. The contributions cover many aspects of contemporary mathematical physics. Of particular importance are new results on infinite dimensional stochastic analysis and its applications to a wide range of physical domains.

List of Contributors: S. Albeverio, T. Hida, L. Accardi, I. Ya. Aref'eva, I. V. Volovich, A. Daletskii, Y. Kondratiev, W. Karwowski, N. Asai, I. Kubo, H. H. Kuo, J. Beckers, Ph. Blanchard, G. F. Dell'Antonio, D. Gandolfo, M. Sirugue Collin, A. Böhm, H. Kaldass, D. Boll, G. Jongen, G. M. Shim, J. Bornaes, C. C. Bernido, M. V. Carpio Bernido, G. Burdet, Ph. Combe, H. Nencka, P. Cartier, C. DeWitt Morette, H. Ezawa, K. Nakamura, K. Watanabe, Y. Yamanaka, R. Figari, F. Gesztesy, H. Holden, R. Gielerak, G. A. Goldin, Z. Haba, M. O. Hongler, Y. Hu, B. Oksendal, A. Sulem, J. R. Klauder, C. B. Lang, V. I. Man'ko, H. Ouerdiane, J. Potthoff, E. Smajlovic, M. R. Ckner, E. Scacciatelli, J. L. Silva, J. Stochel, F. H. Szafraniec, L. V. Zquez, D. N. Kozakevich, S. Jimenez, V. R. Vieira, P. D. Sacramento, R. Vilela Mendes, D. Voln, P. Samek.

**Stochastic Analysis And Applications: Proceedings Of The Fifth Gregynog Symposium** Ian M. Davies, K. David Elworthy, Aubrey Truman, 1996-03-20. This volume contains papers which were presented at a meeting entitled Stochastic Analysis and Applications held at Gregynog Hall, Powys, from the 9th-14th July 1995. The meeting consisted of a mixture of plenary review talks and special interest sessions covering most of the current areas of activity in stochastic analysis. The meeting was jointly organized by the Department of Mathematics, University of Wales Swansea and the Mathematics Institute, University of Warwick, in connection with the Stochastic Analysis year of activity. The papers contained herein are accessible to workers in the field of stochastic analysis and give a good coverage of topics of current interest in the research community.

Stochastic Processes and Operator Calculus on Quantum Groups U. Franz, René Schott, 2013-03-14. This book aims to present several new developments on stochastic processes and operator calculus on quantum groups. Topics which are treated include operator calculus, dual representations, stochastic processes and diffusions, Appell polynomials and systems in connection with evolution equations.

Audience: This volume contains introductory material for graduate students who are new to the field, as well as more advanced material for specialists in probability theory, algebraic structures, representation theory, mathematical physics and theoretical physics.

**Seminar on Stochastic Analysis, Random Fields and Applications** Erwin Bolthausen, Marco Dozzi, Francesco Russo, 2012-12-06. Pure and applied stochastic analysis and random fields form the subject of this book. The collection of articles on these topics represent the state of the art of the research in the field, with particular attention being devoted to stochastic models in finance. Some are review articles, others are original papers. Taken together, they will apprise the reader of much of the current activity in the area.

*Mathematical Methods in Queuing Theory* Vladimir V. Kalashnikov, 1993-12-31. The material of this book is based on several courses which have been delivered for a long time at the Moscow Institute for Physics and Technology. Some parts have formed the subject of lectures given at various universities throughout the world: Freie Universität of Berlin, Chalmers University of Technology and the University of Göteborg, University of California at Santa Barbara and others. The subject of the book is the theory of queues. This theory, as a mathematical discipline, begins

with the work of A Erlang who examined a model of a telephone station and obtained the famous formula for the distribution of the number of busy lines which is named after him Queueing theory has been applied to the study of numerous models emergency aid road traffic computer systems etc Besides it has lead to several related disciplines such as reliability and inventory theories which deal with similar models Nevertheless many parts of the theory of queues were developed as a pure science with no practical applications The aim of this book is to give the reader an insight into the mathematical methods which can be used in queueing theory and to present examples of solving problems with the help of these methods Of course the choice of the methods is quite subjective Thus many prominent results have not even been mentioned

*Stochastic Processes in Epidemic Theory* Jean-Pierre Gabriel, Claude Lefevre, Philippe Picard, 2014-03-11 This collection of papers gives a representative cross selectional view of recent developments in the field After a survey paper by C Lef vre 17 other research papers look at stochastic modeling of epidemics both from a theoretical and a statistical point of view Some look more specifically at a particular disease such as AIDS malaria schistosomiasis and diabetes

Stochastic Analysis 2010 Dan Crisan, 2010-11-26 Stochastic Analysis aims to provide mathematical tools to describe and model high dimensional random systems Such tools arise in the study of Stochastic Differential Equations and Stochastic Partial Differential Equations Infinite Dimensional Stochastic Geometry Random Media and Interacting Particle Systems Super processes Stochastic Filtering Mathematical Finance etc Stochastic Analysis has emerged as a core area of late 20th century Mathematics and is currently undergoing a rapid scientific development The special volume Stochastic Analysis 2010 provides a sample of the current research in the different branches of the subject It includes the collected works of the participants at the Stochastic Analysis section of the 7th ISAAC Congress organized at Imperial College London in July 2009

*Probability Theory, Random Processes and Mathematical Statistics* Y. Rozanov, 2012-12-06 Probability Theory Theory of Random Processes and Mathematical Statistics are important areas of modern mathematics and its applications They develop rigorous models for a proper treatment for various random phenomena which we encounter in the real world They provide us with numerous tools for an analysis prediction and ultimately control of random phenomena Statistics itself helps with choice of a proper mathematical model e g by estimation of unknown parameters on the basis of statistical data collected by observations This volume is intended to be a concise textbook for a graduate level course with carefully selected topics representing the most important areas of modern Probability Random Processes and Statistics The first part Ch 1 3 can serve as a self contained elementary introduction to Probability Random Processes and Statistics It contains a number of relatively simple and typical examples of random phenomena which allow a natural introduction of general structures and methods Only knowledge of elements of real complex analysis linear algebra and ordinary differential equations is required here The second part Ch 4 6 provides a foundation of Stochastic Analysis gives information on basic models of random processes and tools to study them Here a familiarity with elements of functional analysis is necessary Our intention to make this course fast moving made it

necessary to present important material in a form of examples      Stochastic Analysis in Discrete and Continuous Settings Nicolas Privault, 2009-07-14 This monograph is an introduction to some aspects of stochastic analysis in the framework of normal martingales in both discrete and continuous time The text is mostly self contained except for Section 5.7 that requires some background in geometry and should be accessible to graduate students and researchers having already received a basic training in probability Prereq sites are mostly limited to a knowledge of measure theory and probability namely algebras expectations and conditional expectations A short introduction to stochastic calculus for continuous and jump processes is given in Chapter 2 using normal martingales whose predictable quadratic variation is the Lebesgue measure There already exists several books devoted to stochastic analysis for continuous diffusion processes on Gaussian and Wiener spaces cf e.g. [51, 63, 65, 72, 83, 84, 92, 128, 134, 143, 146, 147] The particular feature of this text is to simultaneously consider continuous processes and jump processes in the unified framework of normal martingales      *Operations Research and Discrete Analysis* Aleksei D. Korshunov, 2012-12-06 The contributions to this volume have all been translated from the second volume of the Russian journal Discrete Analysis and Operational Research published at the Sobolev Institute of Mathematics Siberian Branch of the Russian Academy of Sciences Novosibirsk Russia in 1995 The papers collected here give an excellent overview of recent Russian research in such topics as analysis of algorithms combinatorics coding theory graphs lower bounds for complexity of Boolean functions and scheduling theory and can be seen as an update of the book Discrete Analysis and Operational Research published by Kluwer in 1996 Audience This book will be of interest to specialists in discrete mathematics and computer science and engineers      *Unbiased Estimators and Their Applications* V.G. Voinov, M.S. Nikulin, 2012-12-06 Statistical inferential methods are widely used in the study of various physical biological social and other phenomena Parametric estimation is one such method Although there are many books which consider problems of statistical point estimation this volume is the first to be devoted solely to the problem of unbiased estimation It contains three chapters dealing respectively with the theory of point statistical estimation techniques for constructing unbiased estimators and applications of unbiased estimation theory These chapters are followed by a comprehensive appendix which classifies and lists in the form of tables all known results relating to unbiased estimators of parameters for univariate distributions About one thousand minimum variance unbiased estimators are listed The volume also contains numerous examples and exercises This volume will serve as a handbook on point unbiased estimation for researchers whose work involves statistics It can also be recommended as a supplementary text for graduate students      **Stochastic Point Processes** S. Kidambi Srinivasan, A. Vijayakumar, 2003 Stochastic Point Processes are interesting from many points of view From an abstract point of view point process is a simple version of random measure these processes have acquired importance mainly due to their viability in modeling a variety of phenomena spanning physical biological economic and engineering sciences This volume with contributions from leading probabilists contains besides surveys on the state of art of the theory papers dealing with

problems of queues inventory reliability and population evolution There are also papers dealing with practical aspects like statistical inference and nonlinear filtering The book will be of interest to a wide spectrum of people including those working in the area of operations research signal processing electrical communications control and neural network *Global Analysis of Dynamical Systems* H.W Broer,B Krauskopf,Gert Vegter,2001-06-18 Contributed by close colleagues friends and former students of Floris Takens Global Analysis of Dynamical Systems is a liber amicorum dedicated to Takens for his 60th birthday The first chapter is a reproduction of Takens s 1974 paper Forced oscillators and bifurcations that was previously available only as a preprint of the University of Utrecht Among other important results it contains the unfolding of what is now known as the Bogdanov Takens bifurcation The remaining chapters cover topics as diverse as bifurcation theory Hamiltonian mechanics homoclinic bifurcations routes to chaos ergodic theory renormalization theory and time series analysis In its entirety the book bears witness to the influence of Takens on the modern theory of dynamical systems and its applications This book is a must read for anyone interested in this active and exciting field Random Fields and Stochastic Partial Differential Equations Y. Rozanov,2013-04-17 This book considers some models described by means of partial differential equations and boundary conditions with chaotic stochastic disturbance In a framework of stochastic Partial Differential Equations an approach is suggested to generalize solutions of stochastic Boundary Problems The main topic concerns probabilistic aspects with applications to well known Random Fields models which are representative for the corresponding stochastic Sobolev spaces The term stochastic in general indicates involvement of appropriate random elements It assumes certain knowledge in general Analysis and Probability Hilbert space methods Schwartz distributions Fourier transform I A very general description of the main problems considered can be given as follows Suppose we are considering a random field in a region  $T \subset \mathbb{R}^d$  which is associated with a chaotic stochastic source by means of the differential equation in  $T$  A typical chaotic source can be represented by an appropriate random field with independent values i.e generalized random function  $\varphi(T)$   $\varphi(E \subset T)$  with independent random variables  $\varphi(f)$  for any test functions  $\varphi$  with disjoint supports The property of having independent values implies a certain roughness of the random field which can only be treated functionally as a very irregular Schwarz distribution With the lack of a proper development of non linear analyses for generalized functions let us limit ourselves to the 1 For related material see for example J L Lions E **Stochastic Analysis and Related Topics VIII** Ulug Capar,2003-04 Over the last years stochastic analysis has had an enormous progress with the impetus originating from different branches of mathematics PDE s and the Malliavin calculus quantum physics path space analysis on curved manifolds via probabilistic methods and more This volume contains selected contributions which were presented at the 8th Silivri Workshop on Stochastic Analysis and Related Topics held in September 2000 in Gazimagusa North Cyprus The topics include stochastic control theory generalized functions in a nonlinear setting tangent spaces of manifold valued paths with quasi invariant measures and applications in game theory theoretical biology and theoretical

physics Contributors A E Bashirov A Bensoussan and J Frehse U Capar and H Aktuglul A B Cruzeiro and Kai Nan Xiang E Hausenblas Y Ishikawa N Mahmudov P Malliavin and U Taneri N Privault A S st nel      Theory of U-Statistics Vladimir S. Korolyuk, Y.V. Borovskich, 2013-03-09 The theory of U statistics goes back to the fundamental work of Hoeffding 1 in which he proved the central limit theorem During last forty years the interest to this class of random variables has been permanently increasing and thus the new intensively developing branch of probability theory has been formed The U statistics are one of the universal objects of the modern probability theory of summation On the one hand they are more complicated algebraically than sums of independent random variables and vectors and on the other hand they contain essential elements of dependence which display themselves in the martingale properties In addition the U statistics as an object of mathematical statistics occupy one of the central places in statistical problems The development of the theory of U statistics is stipulated by the influence of the classical theory of summation of independent random variables The law of large numbers central limit theorem invariance principle and the law of the iterated logarithm we re proved the estimates of convergence rate were obtained etc      Asymptotic Behaviour of Linearly Transformed Sums of Random Variables V.V. Buldygin, Serguei Solntsev, 2012-12-06 Limit theorems for random sequences may conventionally be divided into two large parts one of them dealing with convergence of distributions weak limit theorems and the other with almost sure convergence that is to say with asymptotic properties of almost all sample paths of the sequences involved strong limit theorems Although either of these directions is closely related to another one each of them has its own range of specific problems as well as the own methodology for solving the underlying problems This book is devoted to the second of the above mentioned lines which means that we study asymptotic behaviour of almost all sample paths of linearly transformed sums of independent random variables vectors and elements taking values in topological vector spaces In the classical works of P Levy A Ya Khintchine A N Kolmogorov P Hartman A Wintner W Feller Yu V Prokhorov and M Loeve the theory of almost sure asymptotic behaviour of increasing scalar normed sums of independent random variables was constructed This theory not only provides conditions of the almost sure convergence of series of independent random variables but also studies different versions of the strong law of large numbers and the law of the iterated logarithm One should point out that even in this traditional framework there are still problems which remain open while many definitive results have been obtained quite recently



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