

# Symmetry Properties and Exact Solutions of the Fokker-Planck Equation

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## Abstract

Symmetry properties of some Fokker-Planck equations are studied. In the one-dimensional case, when symmetry groups turn out to be six-parameter ones, this allows to find changes of variables to reduce such Fokker-Planck equations to the one-dimensional heat equation. The symmetry and the family of exact solutions of the Kramers equation are obtained.

The one-dimensional Fokker-Planck (FP) equation has the form

$$\frac{\partial u}{\partial t} = -\frac{\partial}{\partial x} [A(x, t)u] + \frac{1}{2} \frac{\partial^2}{\partial x^2} [B(x, t)u], \quad (1)$$

where  $u = u(x, t)$  is the probability density;  $A$  and  $B$  are differentiable functions. This is the basic equation in the theory of continuous Markovian processes. The following FP equations are of special interest [1, 2]:

(a) diffusion in a gravitational field

$$\frac{\partial u}{\partial t} = \frac{\partial}{\partial x} (gu) + \frac{1}{2} D \frac{\partial^2 u}{\partial x^2}, \quad (2)$$

(b) the Ornstein-Uhlenbeck process

$$\frac{\partial u}{\partial t} = \frac{\partial}{\partial x} (kxu) + \frac{1}{2} D \frac{\partial^2 u}{\partial x^2}, \quad (3)$$

(c) the Rayleigh-type process

$$\frac{\partial u}{\partial t} = \frac{\partial}{\partial x} \left[ \left( \gamma x - \frac{\mu}{x} \right) u \right] + \frac{1}{2} \mu \frac{\partial^2 u}{\partial x^2}, \quad (4)$$

(d) models in population genetics [2]

$$\frac{\partial u}{\partial t} = \frac{\alpha}{2} \frac{\partial^2}{\partial x^2} [(x-c)^2 u] + \beta \frac{\partial}{\partial x} [(x-c)u], \quad (5)$$

$$\frac{\partial u}{\partial t} = \frac{\partial^2}{\partial x^2} [(1-x^2)^2 u], \quad (6)$$

$$\frac{\partial u}{\partial t} = \frac{\alpha}{2} \frac{\partial^2}{\partial x^2} [x^2 (1-x^2)^2 u], \quad (7)$$

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# Symmetry Analysis And Exact Solutions Of Equations Of Nonlinear Mathematical Physics

**Anatoly Kochubei, Yuri Luchko**



## **Symmetry Analysis And Exact Solutions Of Equations Of Nonlinear Mathematical Physics:**

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Vil'gel'm Il'ich Fushchich, Vladimir Mikhaïlovich Shtelen', Nikolaï Ivanovich Serov, 1993-02-28 This volume presents an account of the current state of algebraic theoretic methods as applied to linear and nonlinear multidimensional equations of mathematical and theoretical physics Equations are considered that are invariant under Euclid Galilei Schrödinger Poincaré conformal and some other Lie groups with special emphasis being given to the construction of wide classes of exact solutions of concrete nonlinear partial differential equations such as d'Alembert Liouville Monge Ampère Hamilton Jacobi eikonal Schrödinger Navier Stokes gas dynamics Dirac Maxwell Dirac Yang Mills etc Ansatz for spinor as well as scalar and vector fields are described and formulae for generating solutions via conformal transformations are found explicitly for scalar spinor vector and tensor fields with arbitrary conformal degree The classical three body problem is considered for the group theoretic point of view The symmetry of integro differential equations is also studied and the method of finding final nonlocal transformations is described Furthermore the concept of conditional symmetry is introduced and is used to obtain new non Lie Ansatz for nonlinear heat and acoustic equations The volume comprises an Introduction which presents a brief account of the main ideas followed by five chapters appendices and a comprehensive bibliography This book will be of interest to researchers and graduate students in physics and mathematics interested in algebraic theoretic methods in mathematical and theoretical physics

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spectral theory of Schrödinger operators      **Journal of Nonlinear Mathematical Physics Vol. 14** ,      *Functional Analysis and its Applications* Vladimir Kadets, Wiesław Tadeusz Zelazko, 2004-07-31 The conference took place in Lviv Ukraine and was dedicated to a famous Polish mathematician Stefan Banach the most outstanding representative of the Lviv mathematical school Banach spaces introduced by Stefan Banach at the beginning of twentieth century are familiar now to every mathematician The book contains a short historical article and scientific contributions of the conference participants mostly in the areas of functional analysis general topology operator theory and related topics      *Symmetries in Fundamental Physics* Kurt Sundermeyer, 2014-07-23 Over the course of the last century it has become clear that both elementary particle physics and relativity theories are based on the notion of symmetries These symmetries become manifest in that the laws of nature are invariant under spacetime transformations and or gauge transformations The consequences of these symmetries were analyzed as early as in 1918 by Emmy Noether on the level of action functionals Her work did not receive due recognition for nearly half a century but can today be understood as a recurring theme in classical mechanics electrodynamics and special relativity Yang Mills type quantum field theories and in general relativity As a matter of fact as shown in this monograph many aspects of physics can be derived solely from symmetry considerations This substantiates the statement of E P Wigner if we knew all the laws of nature or the ultimate Law of nature the invariance properties of these laws would not furnish us new information Thanks to Wigner we now also understand the implications of quantum physics and symmetry considerations Poincaré invariance dictates both the characteristic properties of particles mass spin and the wave equations of spin 0 1 2 1 objects Further the work of C N Yang and R Mills reveals the consequences of internal symmetries as exemplified in the symmetry group of elementary particle physics Given this pivotal role of symmetries it is thus not surprising that current research in fundamental physics is to a great degree motivated and inspired by considerations of symmetry The treatment of symmetries in this monograph ranges from classical physics to now well established theories of fundamental interactions to the latest research on unified theories and quantum gravity      **Applied Analysis in Biological and Physical Sciences** Jim M. Cushing, M. Saleem, H. M. Srivastava, Mumtaz Ahmad Khan, M. Merajuddin, 2016-12-01 The book contains recent developments and contemporary research in mathematical analysis and in its application to problems arising from the biological and physical sciences The book is of interest to readers who wish to learn of new research in such topics as linear and nonlinear analysis mathematical biology and ecology dynamical systems graph theory variational analysis and inequalities functional analysis differential and difference equations partial differential equations approximation theory and chaos All papers were prepared by participants at the International Conference on Recent Advances in Mathematical Biology Analysis and Applications ICMBAA 2015 held during 4-6 June 2015 in Aligarh India A focal theme of the conference was the application of mathematics to the biological sciences and on current research in areas of theoretical mathematical analysis that can be used as sophisticated tools for the study of scientific problems The

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