

<<分数维动力学>>

图书基本信息

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前言

Fractional calculus is a theory of integrals and derivatives of any arbitrary real (or complex) order. It has a long history from 30 September 1695, when the derivative of order $\alpha = 1/2$ was mentioned by Leibniz. The fractional differentiation and fractional integration go back to many great mathematicians such as Leibniz, Liouville, Grfinwald, Letnikov, Riemann, Abel, Riesz and Weyl. The integrals and derivatives of non-integer order, and the fractional integro-differential equations have found many applications in recent studies in theoretical physics, mechanics and applied mathematics. New possibilities in mathematics and theoretical physics appear, when the order α of the differential operator $D^\alpha x$ or the integral operator $I^\alpha x$ becomes an arbitrary parameter. The fractional calculus is a powerful tool to describe physical systems that have long-term memory and long-range spatial interactions. In general, many usual properties of the ordinary (first-order) derivative Dx are not realized for fractional derivative operators D^α . For example, a product rule, chain rule and semi-group property have strongly complicated analogs for the operators $D^{\sim\alpha}$. Most of the processes associated with complex systems have nonlocal dynamics and it can be characterized by long-term memory in time. The fractional integration and fractional differentiation operators allow one to consider some of those characteristics. Using fractional calculus, it is possible to obtain useful dynamical models, where fractional integro-differential operators in the time and space variables describe the long-term memory and nonlocal spatial properties of the complex media and processes. We should note that close connections exist between fractional differential and integral equations, and the dynamics of many complex systems, anomalous processes and fractal media. There are many interesting books about fractional calculus, fractional differential equations, and their physical applications. The first book dedicated specifically to the theory of fractional integrals and derivatives, is the one by Oldham and Spanier published in 1974. There exists the remarkably comprehensive encyclopedic-type monograph by Samko, Kilbas and Marichev, which was published in Russian in 1987 and in English in 1993.

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内容概要

Nonlinear Physical Science focuses on the recent advances of fundamental theories and principles , analytical and symbolic approaches , as well as computational techniques in nonlinear physical science and nonlinear mathematics with engineering applications.

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章节摘录

插图：Statistical mechanics is the application of probability theory to study the dynamics of systems of arbitrary number of particles (Gibbs, 1960; Bogoliubov, 1960; Bogolyubov, 1970). Equations with derivatives of non-integer order have many applications in physical kinetics (see, for example, (Zaslavsky, 2002, 2005; Uchaikin, 2008) and (Zaslavsky, 1994; Saichev and Zaslavsky, 1997; Weitzner and Zaslavsky, 2001; Chechkin et al., 2002; Saxena et al., 2002; Zelenyi and Milovanov, 2004; Zaslavsky and Edelman, 2004; Nigmatullin, 2006; Tarasov and Zaslavsky, 2008; Rastovic, 2008)). Fractional calculus is used to describe anomalous diffusion, and transport theory (Montroll and Shlesinger, 1984; Metzler and Klafter, 2000; Zaslavsky, 2002; Uchaikin, 2003a,b; Metzler and Klafter, 2004). Application of fractional integration and differentiation in statistical mechanics was also considered in (Tarasov, 2006a, 2007a) and (Tarasov, 2004, 2005b,a, 2006b, 2007b). Fractional kinetic equations usually appear from some phenomenological models. We suggest fractional generalizations of some basic equations of statistical mechanics. To obtain these equations, the probability conservation in a fractional differential volume element of the phase space can be used (Tarasov, 2006a, 2007a). This element can be considered as a small part of the phase space set with non-integer-dimension. We derive the Liouville equation with fractional derivatives with respect to coordinates and momenta. The fractional Liouville equation (Tarasov, 2006a, 2007a) is obtained from the conservation of probability to find a system in a fractional volume element. This equation is used to derive fractional Bogolyubov and fractional kinetic equations with fractional derivatives. Statistical mechanics of fractional generalization of the Hamiltonian systems is discussed. Liouville and Bogolyubov equations with fractional coordinate and momenta derivatives are considered as a basis to derive fractional kinetic equations. The Vlasov equation with derivatives of non-integer order is obtained. The Fokker-Planck equation that has fractional phase space derivatives is derived from fractional Bogolyubov equation.

编辑推荐

《分数维动力学:分数阶积分在粒子、场及介质动力学中的应用》: Fractional Dynamics: Applications of Fractional Calculus to Dynamics of Particles, Fields and Media presents applications of fractional calculus, integral and differential equations of non-integer orders in describing systems with long-time memory, non-local spatial and fractal properties. Mathematical models of fractal media and distributions, generalized dynamical systems and discrete maps, non-local statistical mechanics and kinetics, dynamics of open quantum systems, the hydrodynamics and electrodynamics of complex media with non-local properties and memory are considered. This book is intended to meet the needs of scientists and graduate students in physics, mechanics and applied mathematics who are interested in electro-dynamics, statistical and condensed matter physics, quantum dynamics, complex media theories and kinetics, discrete maps and lattice models, and nonlinear dynamics and chaos. Dr. Vasily E. Tarasov is a Senior Research Associate at Nuclear Physics Institute of Moscow State University and an Associate Professor at Applied Mathematics and Physics Department of Moscow Aviation Institute.

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