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Editorial

Advanced Mathematical Methods: Theory and Applications

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The many technical and computational problems that appear to be constantly emerging in various branches of physics and engineering beg for a more detailed understanding of the fundamental mathematics that serves as the cornerstone of our way of understanding natural phenomena. The purpose of this Special Issue is to establish a brief collection of carefully selected articles authored by promising young scientists and the world's leading experts in pure and applied mathematics, highlighting the state-of-the-art of the various research lines focusing on the study of analytical and numerical mathematical methods for pure and applied sciences.

Our collection opens with a featured review article [1], by Yuri Luchko, aimed at providing a pedagogical discussion of the role of integral transforms in mathematical physics, with particular regard for the Laplace and Mellin transforms. We continue with another survey paper [2], by Roberto Garrappa, Eva Kaslik, and Marina Popolizio, dedicated to an in-depth analysis evaluation of fractional integrals and derivatives of some elementary functions. Similarly to the first article, the work of R. Garrappa et al. is very pedagogical in nature and can serve as an effective reference to those who wish to gradually approach the study of numerical aspects of fractional calculus.

This collection then continues with two important featured articles. Specifically, it starts with the work [3], by Emilia Bazhlekova and Ivan Bazhlekov, concerning a subordination approach to the multi-dimensional space–time fractional diffusion equation. In detail, the fundamental solution of this equation is studied by means of the subordination principle, which in turn provides a relation to the classical Gaussian function. We then move to the contribution [4], by Silvia Vitali, Iva Budimir, Claudio Runfola, and Gastone Castellani, dedicated to the study of the role of the central limit theorem within the framework of an heterogeneous ensemble of Brownian particles (dubbed the HEBP approach, for short).

The collection then closes with a series of eight very interesting original contributions. We begin this series with the work of Marina Popolizio [5] analyzing numerical properties and theoretical features of the Mittag–Leffler function with matrix arguments. It is then followed by an interesting note [6] on a generalization of the time-fractional relativistic diffusion equation based on the application of Caputo fractional derivatives of a function with respect to another function, by Luisa Beghin and Roberto Garra. We then move to biophysical modeling with the inspiring work [7] by Berardino D'Acunto, Luigi Frunzo, Vincenzo Luongo, and Maria Rosaria Mattei, in which the authors propose a mathematical model of heavy metal sorption and interaction in a multispecies biofilm. We then continue with a pedagogical article on space–time exterior calculus [8], and its relation to Maxwell's theory, by Ivano Colombaro, Josep Font-Segura, and Alfonso Martinez. One then finds an interesting proposal for a mathematical model of economic growth with fading memory and a continuous distribution of time-delay. This work [9], by Vasily E. Tarasov, and Valentina V. Tarasova, represents a generalization of the standard Keynesian macroeconomic model based on Abel-type integrals and integro-differential operators involving the confluent hypergeometric Kummer function in the kernel.

The collection then features a work [10] by Natalie Baddour on the discrete two-dimensional Fourier transform in polar coordinates, in which both the general theory and operational rules are discussed. One then finds a contribution by Giulio Starita and Alfonsina Tartaglione [11] analyzing the Fredholm property of trace operators associated with the elastic layer potentials. Finally, the collection is completed by the work of Michael D. Marcozzi [12] that discusses a probabilistic interpretation of the solutions of linear ultraparabolic equations.

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