fractal and fractional

Editorial

Editorial for Special Issue "Fractional Behavior in Nature 2019"

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The presence of fractional behavior in nature is unquestionable. Many signals caught when observing many natural systems have spectra that exhibit increasing/decreasing slopes in Bode diagrams that are not multiples of 20 dB per decade (characteristic of integer order models). This can be found, for example, in ECG, speech, electronic noise in junctions, network traffic, and others. The aim of this Special Issue is to promote further development and application of fractional calculus and fractional system theory, in order to better understand and model natural phenomena. The great confusion between the derivative and system notions verified in recent years has brought some difficulties in the adoption of fractional tools. However, it did not prevent the development of models and applications related to natural phenomena. This statement is confirmed by the papers in this Special Issue. The variety of topics addressed herein reveals the importance of fractional calculus in different fields and provides good coverage in order to appeal to each reader's interest.

Eva-H. Dulf et al. [1] present an application for biochemical process modelling. They obtain fractional models for erythritol and mannitol synthesis performed by lactic acid bacteria. Such models are useful for both optimisation and prediction. They are validated with regard to real data and compared with integer order models.

In [2], Peter Béda studies material instability problems, such as shear band or neck formation, and uses the information gathered to obtain constitutive modeling. The obtained model together with the equations of motion and the kinematic equation, form a system which has generic bifurcation at loss of stability. This bifurcation is studied and applied in the study of visco-elasto-plastic and fractional gradient materials.

We remain in the materials field. Harry Esmonde introduces a methodology for fractal structure development so that it approaches the fractional model of phase changing materials [3]. The transfer functions and corresponding frequency responses are used to describe the topology of the structure. Phase transformations in liquid/solid transitions in physical processes are studied and experimentally tested.

Agneta Balint and Stefan Balint raise a very important question in modelling a real phenomenon: the objectivity of the mathematical representation [4]. The underlying idea is the lack of coherence among the results that different observers using the same type of description obtain. Such results cannot be transformed into each other using only formulas that link the numbers representing a moment in time for two different choices from the origin of time measurement. The authors analyse the mathematical description of the groundwater flow and that of the impurity spread obtained with the use of temporal Caputo or Riemann–Liouville partial derivatives defined on a finite interval. They show that the models are non-objective.

Epidemic models are, for obvious reasons, the order of the day. Their importance is increasingly unquestionable and justified. This was exactly the idea of Caterina Balzotti et al. [5], who present a fractional susceptible–infectious–susceptible (SIS) epidemic model for the case of a constant size population. The explicit solution to the fractional model is obtained and illustrated numerically. A comparison is also made with the integer order model.

In [6], Thomas Michelitsch et al. present a study on the continuous-time random walks with Mittag–Leffler jumps with application to digraphs. They consider the *space-time*

Mittag–Leffler process and its usefulness in the "well-scaled" diffusion. Applications to Poisson processes and digraphs are also considered.

Jacek Gulgowski et al. [7] use the two-sided fractional derivative to model an electromagnetic wave propagation in fractional media. This involves causality problems that are investigated and numerically illustrated.

This set of papers and their diversity show that fractional calculus is a promising tool for a wide range of problems encountered in the study of natural phenomena and in science generally.

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