

Fractional Calculus: Applications, 2015, pages 1-21

---

# The heuristic power of the non integer differential operator in physics: From chaos to emergence, auto-organisations and holistic rules

Le Mehaute A.

Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

---

## Abstract

© 2015 by Nova Science Publishers, Inc. All rights reserved. The use of fractional differential equations raises a paradox due to the non-respect of the space time noetherian axioms. In environments characterized by scaling laws (hyperbolic geometry associated with fractional differential integral) energy is no more the invariant of the dynamics. Nevertheless the experimental action requiring the use of energy, the relevant representation of the fractional process, must be extended. The extension is carried out using the canonical transfer functions in Fourier space and explained by their links with the Riemann zeta function. Category theory informs the extension problem. Ultimately the extension can be expressed by a simple change of referential. It leads to embed the time in the complex space. This change unveils the presence of a time singularity at infinity. The paradox of the energy in the fractality illuminates the heuristic power of the fractional differential equations. In this mathematical frame, it is shown that the dual requirement of the frequency response to differential equations of non-integer order and of the noetherian constraints make gushing out a source of negentropic likely to formalize the emergence of macroscopic correlations into self-organized structures as well as holistic rules of behaviour.

---