

# Preface: Recent Advances in Fractional Dynamics

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## Preface: Recent Advances in Fractional Dynamics

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The currently widely- and extensively-investigated concept of *fractional calculus* (that is, calculus of integrals and derivatives of any arbitrary real or complex order) seems to have stemmed from a question raised in the year 1695 by Marquis de l'Hôpital (1661–1704) to Gottfried Wilhelm Leibniz (1646–1716), which sought the meaning of Leibniz's *modern* notation  $\frac{d^n y}{dx^n}$  for the derivative of order  $n \in \mathbb{N}_0 := \{0, 1, 2, \dots\}$  when  $n = \frac{1}{2}$  (What if  $n = \frac{1}{2}$ ?). In his reply, dated 30 September 1695, Leibniz wrote to l'Hôpital as follows:

“...This is an apparent paradox from which, one day, useful consequences will be drawn....”

In addition, of course, to the theories of differential, integral, and integro-differential equations, and special functions of mathematical physics as well as their extensions and generalizations in one and more variables, some of the areas of present-day applications of fractional calculus include and so on (see, for details, Refs. 1–3).

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The first work, devoted exclusively to the subject of fractional calculus, is the book by Oldham and Spanier.<sup>4</sup> One of the most recent works on the subject of fractional calculus is the book by Podlubny.<sup>2</sup> Some of the latest (but certainly not the last) works on the subject of fractional calculus and its applications are the volume edited by Hilfer<sup>1</sup> and the monograph emphasizing upon the theory and applications of fractional differential equations by Kilbas *et al.*<sup>3</sup> Indeed, in the meantime, numerous other works (books, edited volumes, and conference proceedings) have also appeared (see, for example, Refs. 5–8). And, indeed, today there exist **at least six** international scientific research journals which are devoted *almost entirely* to the subject of fractional calculus and its applications:

- (i) **Journal of Fractional Calculus**
- (ii) **Fractional Calculus and Applied Analysis**
- (iii) **Fractional Differential Calculus**
- (iv) **Journal of Fractional Calculus and Applications**
- (v) **Communications in Fractional Calculus and**
- (vi) **Progress in Fractional Differentiation and Applications.**

A fairly common practice for scientific research journals and scientific research periodicals is indeed to publish special issues as well as conference proceedings. Quite frequently, these special issues are devoted exclusively to specific topics and/or are dedicated respectfully to commemorate the celebrated works of renowned research scientists. The present Special Focus Issue, entitled “**Recent Advances in Fractional Dynamics**” (RAFD), contains a collection of several peer-reviewed and duly edited articles dealing with various applications of the Riemann-Liouville, Liouville-Caputo, and other related operators of fractional calculus in problems involving dynamical systems. The subject-matter of each of these articles is described reasonably adequately by the title of the article. With this purpose in view, a listing of the articles in this Special Focus Issue is provided below (see Refs. 9–21).

- <sup>1</sup>R. Hilfer (Editor), *Applications of Fractional Calculus in Physics* (World Scientific Publishing Company, Singapore, 2000).
- <sup>2</sup>I. Podlubny, *Fractional Differential Equations: An Introduction to Fractional Derivatives, Fractional Differential Equations, to Methods of Their Solution and Some of Their Applications*, Mathematics in Science and Engineering Vol. 198 (Academic Press, New York, 1999).
- <sup>3</sup>A. A. Kilbas, H. M. Srivastava, and J. J. Trujillo, *Theory and Applications of Fractional Differential Equations*, North-Holland Mathematical Studies Vol. 204 (Elsevier (North-Holland) Science Publishers, Amsterdam, 2006).
- <sup>4</sup>K. B. Oldham and J. Spanier, *The Fractional Calculus: Theory and Applications of Differentiation and Integration to Arbitrary Order* (Academic Press, New York, 1974).
- <sup>5</sup>*Advanced Topics in Fractional Dynamics*, in Advances in Mathematical Physics, edited by D. Baleanu, H. M. Srivastava, V. Daftardar-Gejji, C. Li, and J. A. T. Machado (Hindawi Publishing Corporation, Cairo, 2013).
- <sup>6</sup>*Fractional Dynamics*, edited by C. Cattani, H. M. Srivastava, and X.-J. Yang (Emerging Science Publishers (De Gruyter Open), Berlin and Warsaw, 2015).
- <sup>7</sup>C. Li and F. Zheng, *Numerical Methods for Fractional Calculus*, Series on Numerical Analysis and Scientific Computing (Chapman and Hall, CRC Press, Boca Raton, 2015).
- <sup>8</sup>X.-J. Yang, D. Baleanu, and H. M. Srivastava, *Local Fractional Integral Transforms and Their Applications* (Academic Press, Elsevier Science Publishers, Amsterdam, 2016).
- <sup>9</sup>Q. Xu, M. Shi, and Z. Wang, "Stability and delay sensitivity of neutral fractional-delay systems," *Chaos* **26**, 084301 (2016).
- <sup>10</sup>Y. Yang, W. Xua, G. Yang, and W. Jia, "Response analysis of a class of quasi-linear systems with fractional derivative excited by Poisson white noise," *Chaos* **26**, 084302 (2016).
- <sup>11</sup>L. Chen, W. Pan, R. Wu, J. A. T. Machado, and A. M. Lopes, "Design and implementation of grid multi-scroll fractional-order chaotic attractors," *Chaos* **26**, 084303 (2016).
- <sup>12</sup>X. Liu, L. Hong, and J. Jiang, "Global bifurcations in fractional-order chaotic systems with an extended generalized cell mapping method," *Chaos* **26**, 084304 (2016).
- <sup>13</sup>E. F. D. Goufo, "Chaotic processes using the two-parameter derivative with non-singular and non-local kernel: Basic theory and applications," *Chaos* **26**, 084305 (2016).
- <sup>14</sup>S. Bhalekar, "Stability and bifurcation analysis of a generalized scalar delay differential equation," *Chaos* **26**, 084306 (2016).
- <sup>15</sup>Y. Liu, J. Guan, C. Ma, and S. Guo, "Generation of  $2N+1$ -scroll existence in new three-dimensional chaos systems," *Chaos* **26**, 084307 (2016).
- <sup>16</sup>W. Ma, C. Li, and Y. Wu, "Impulsive synchronization of fractional Takagi-Sugeno fuzzy complex networks," *Chaos* **26**, 084311 (2016).
- <sup>17</sup>G.-C. Wu, D. Baleanu, and H.-P. Xie, "Riesz Riemann-Liouville difference on discrete domains," *Chaos* **26**, 084308 (2016).
- <sup>18</sup>S.-F. Wen, Y.-J. Shen, X.-N. Wang, S.-P. Yang, and H.-J. Xing, "Dynamical analysis of strongly nonlinear fractional-order Mathieu-Duffing equation," *Chaos* **26**, 084309 (2016).
- <sup>19</sup>C. Zeng, Q. Yang, and Y. Chen, "Bifurcation dynamics of the tempered fractional Langevin equation," *Chaos* **26**, 084310 (2016).
- <sup>20</sup>X.-J. Yang, J. A. T. Machado, D. Baleanu, and C. Cattani, "On exact traveling-wave solutions for local fractional Korteweg-de Vries equation," *Chaos* **26**, 084312 (2016).
- <sup>21</sup>M.-L. Deng and W.-Q. Zhu, "Response of MDOF strongly nonlinear systems to fractional Gaussian noises," *Chaos* **26**, 084313 (2016).