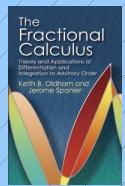
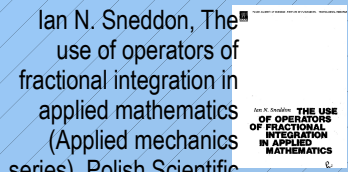




Michele Caputo, Elasticità e Dissipazione, Zanichelli, Bologna, 1969.



Keith B. Oldham, Jerome Spanier, The Fractional Calculus: Theory and Application of Differentiation and Integration to Arbitrary Order, Dover Books on Mathematics, 1974.



Ian N. Sneddon, The use of operators of fractional integration in applied mathematics (Applied mechanics series), Polish Scientific Publishers, 1979.



B. Ross (Editor), Fractional Calculus and Its Applications: Proceedings of the Int. Conf. held at the University of New Haven, June 1974 (Lecture Notes in Mathematics), 1975.

Only since the Seventies has fractional calculus been the object of specialized conferences and treatises. For the first conference the merit is due to B. Ross who, shortly after his Ph.D. dissertation on fractional calculus, organized the First Conference on Fractional Calculus and its Applications at the University of New Haven in June 1974, and edited the proceedings. For the first monograph the merit is ascribed to K. B. Oldham and I. Spanier who, after a joint collaboration begun in 1968, published a book devoted to fractional calculus in 1974.

The fractional calculus started from some speculations of G.W. Leibniz (1695, 1697) and L. Euler (1730), and it has been developed progressively up to now. A list of mathematicians, who have provided important contributions up to the middle of the twentieth century, includes P.S. Laplace (1812), S. F. Lacroix (1819), J. B. J. Fourier (1822), N. H. Abel (1823–1826), J. Liouville (1832–1873), B. Riemann (1847), H. Holmgren (1865–1867), A. K. Grunwald (1867–1872), A. V. Letnikov (1868–1872), H. Laurent (1884), P. A. Nekrassov (1888), A. Krug (1890), J. Hadamard (1892), O. Heaviside (1892–1912), S. Pincherle (1902), G. H. Hardy and J. E. Littlewood (1917-1928), H. Weyl (1917), P. Lévy (1923), A. Marchaud (1927), H. T. Davis (1924-1936), E. L. Post (1930), A. Zygmund (1935-1945), E. R. Love (1938-1996), A. Erdelyi (1939-1965), H. Kober (1940), D. V. Widder (1941), M. Riesz (1949), W. Feller (1952).

# Recent History of Fractional Calculus

September 2010

J. Tenreiro Machado, Virginia Kiryakova, Francesco Mainardi

In recent years considerable interest in fractional calculus has been stimulated by the applications it finds in different areas of applied sciences like physics and engineering, possibly including fractal phenomena. Now there are more books of proceedings and special issues of journals published that refer to the applications of fractional calculus in several scientific areas including special functions, control theory, chemical physics, stochastic processes, anomalous diffusion, rheology. Several special issues appeared in the last decade which contain selected and improved papers presented at conferences and advanced schools, concerning various applications of fractional calculus. Already since several years, there exist two international journals devoted almost exclusively to the subject of fractional calculus: Journal of Fractional Calculus (Editor-in-Chief: K. Nishimoto, Japan) started in 1992, and Fractional Calculus and Applied Analysis (Managing Editor: V. Kiryakova, Bulgaria) started in 1998. Recently the new journal Fractional Dynamic Systems has been announced to start in 2010.

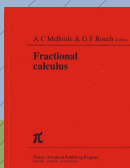
The authors believe that the volume of research in the area of fractional calculus will continue to grow in the forthcoming years and that it will constitute an important tool in the scientific progress of mankind.

Stefan G. Samko, Anatoly A. Kilbas, Oleg I. Marichev, Fractional Integrals and Derivatives: Theory and Applications, Nauka i Tekhnika, Minsk, 1987 and Gordon and Breach, 1993.

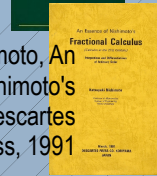
Alain Oustaloup, La Commande CRONE: Commande Robuste d'Ordre Non Entier, Hermes, 1991.



Katsuyuki Nishimoto, An Essence of Nishimoto's Fractional Calculus, Descartes Press, 1991

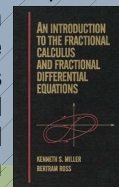


A. C. McBride, G.F. Roach (Editors), Fractional Calculus, Research Notes in Mathematics No. 138, Pitman, 1985.

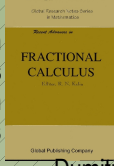


Virginia S. Kiryakova, Generalized Fractional Calculus and Applications, Pitman Research Notes in Mathematics, vol. 301, Chapman & Hall, 1993,

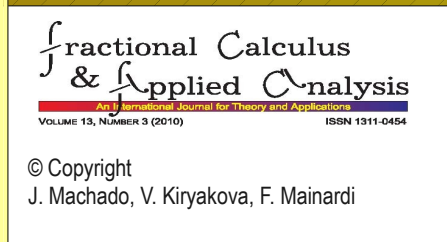
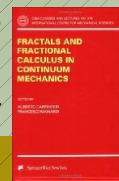
Kenneth S. Miller, Bertram Ross, An Introduction to the Fractional Calculus and Fractional Differential Equations, John Wiley and Sons, 1993.



R. N. Kalia (Editor), Recent Advances in Fractional Calculus (Global Research Notes in Mathematics Ser.), Global Pub Co, 1993.



Alberto Carpinteri, Francesco Mainardi (Editors), Fractals and Fractional Calculus in Continuum Mechanics (CISM International Centre for Mechanical Sciences), Springer, 1997.



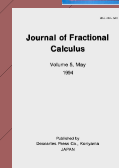
Int. Conference on Fractional calculus and its applications, Tokyo, 1989.



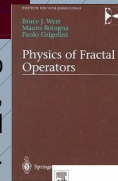
Fractional Calculus & Applied Analysis, IMI - Bulg.Acad.Sci., Managing Editor: Virginia Kiryakova.



Journal of Fractional Calculus, Descartes Press Co, Editor-in-Chief: Katsuyuki Nishimoto



Bruce West, Mauro Bologna, Paolo Grigolini, Physics of Fractal Operators, Springer, 2003.



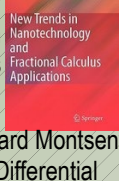
A. A. Kilbas, H. M. Srivastava, J. J. Trujillo, Theory and Applications of Fractional Differential Equations, Volume 204 (North-Holland Mathematics Studies), Elsevier, 2006.



Rudolf Hilfer (Editor), Applications of Fractional Calculus in Physics, World Scientific Publishing Company, 2000.



Dumitru Baleanu, J. Tenreiro Machado, Ziya B. Guevenc (Editors), New Trends in Nanotechnology and Fractional Calculus Applications, Springer, 2001.



Denis Matignon, Gérard Montseny (Editors), Fractional Differential Systems: Models, Methods and Applications, European Society for Applied and Industrial Mathematics (ESAIM), Vol. 5, 1998.



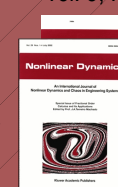
Mathematica Balkanica., Special Issue "Proc. 4th Int. Symp. Transform Methods & Special Functions, Borovets'2003", vol. 18, No 3-4, 2004.



Physics Reports, The random walk's guide to anomalous diffusion: a fractional dynamics approach, vol. 339, Issue 1, Dec. 2000.



Nonlinear Dynamics, Special Issues: - Fractional Order Systems, vol. 29, n. 1-4, July 2002. - Fractional Derivatives and Their Applications, vol. 38, n. 1-4, Dec. 2004.



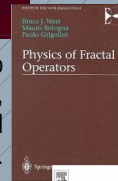
Chemical Physics, Elsevier, Strange Kinetics, vol. 284, n. 1, pp. 1-541, Nov. 2002.



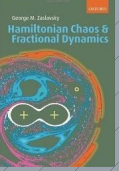
Alain Le Méhauté, Raoul R. Nigmatullin, Laurent Nivaren, Flèches du temps et géométrie fractale, Hermes, 2 éd, 1998.



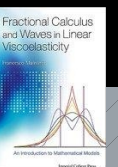
Igor Podlubny, Fractional Differential Equations, Volume 198: An Introduction to Fractional Derivatives, Academic Press, 1999.



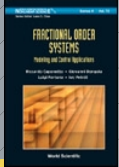
George M. Zaslavsky, Hamiltonian Chaos and Fractional Dynamics, Oxford Univ. Press, 2008.



Francesco Mainardi, Fractional Calculus and Waves in Linear Viscoelasticity: An Introduction to Mathematical Models, Imperial College Press, 2010.



Riccardo Caponetto, Giovanni Dongola, Luigi Fortuna, Ivo Petráš, Fractional Order Systems: Modeling and Control Applications, World Scientific Publishing Company, 2010.



A. M. Mathai, Ram K. Saxena, Hans J. Haubold, The H-Function: Theory and Applications, Springer, 2009.



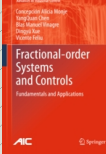
A. M. Mathai, Hans J. Haubold, Special Functions for Applied Scientists, Springer, 2008.



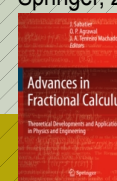
George A. Anastassiou, Fractional Differentiation Inequalities, Springer, 2009.



Concepción A. Monje, YangQuan Chen, Blas M. Vinagre, Dingyu Xue, Vicente Feliu, Fractional-order Systems and Controls: Fundamentals and Applications 2010.



Kai Diethelm, The Analysis of Fractional Differential Equations: An Application-Oriented Exposition Using Differential Operators of Caputo Type, Springer, 2010



ENOC:FDTA 2005, 2008, 2011.

ASME-IDETC: FDTA 2003, 2005, 2007, 2009.

ASME-IDETC: CFD, 2007, 2009.

IFAC FDA, 2004, 2006, 2008, 2010.

AMADE: 1999, 2001, 2003, 2006, 2009.

TMSF: 1994, 1996, 1999, 2003.

Journal of Vibration and Control, Special Issue: Fractional Differentiation and its Applications, vol. 14, Sept. 2008.



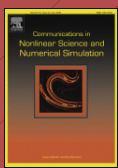
ASME Journal of Computational and Nonlinear Dynamics, Special Issue: Discontinuous and Fractional Dynamical Systems, vol. 3, Issue 2, April 2008.



JESA, Special Issue on Fractional-order systems: Applications in modelling, identification and control, vol. 42, n° 6-7-8, Aug-Out/2008



Physica Scripta, Fractional Differentiation and its Applications, T136, 2009.



Communication in Nonlinear Science and Numerical Simulation

1975

1980

1985

1990

2000

2010

Signal Processing, Special Issues: - Fractional Signal Processing and Applications, vol. 83, Issue 11, Nov. 2003. - Fractional Calculus Applications in Signals and Systems, vol. 86, Issue 10, Oct. 2006.