



CONTENTS OF Volume 22, No 6 (2019)

SPECIAL ISSUE

– In Memory of Late Professor Wen Chen

Guest-Editors:

YangQuan Chen, Changpin Li,  
Igor Podlubny, Hongguang Sun

---

---

<b>Editorial: FCAA SPECIAL ISSUE – IN MEMORY OF LATE PROFESSOR WEN CHEN</b> (FCAA–Volume 22–6–2019) .....	1437
<b>Y.N. Wang, Y.Q. Chen, X.Z. Liao</b> STATE-OF-ART SURVEY OF FRACTIONAL ORDER MODELING AND ESTIMATION METHODS FOR LITHIUM-ION BATTERIES .....	1449
<b>Z.P. Li, H.G. Sun, R.T. Sibatov</b> AN INVESTIGATION ON CONTINUOUS TIME RANDOM WALK MODEL FOR BEDLOAD TRANSPORT .....	1480
<b>I. Podlubny</b> POROUS FUNCTIONS .....	1502
<b>Y. Liang, N. Su, W.Chen</b> A TIME-SPACE HAUSDORFF DERIVATIVE MODEL FOR ANOMALOUS TRANSPORT IN POROUS MEDIA .....	1517
<b>H.F. Ding, C.P. Li</b> HIGH-ORDER ALGORITHMS FOR RIESZ DERIVATIVE AND THEIR APPLICATIONS (IV) .....	1537
<b>A. Lischke, J.F. Kelly, M.M. Meerschaert</b> MASS-CONSERVING TEMPERED FRACTIONAL DIFFUSION IN A BOUNDED INTERVAL .....	1561

(Continued on back cover page)

CONTENTS, continued:

**S. Holm**  
DISPERSION ANALYSIS FOR WAVE EQUATIONS  
WITH FRACTIONAL LAPLACIAN LOSS OPERATORS ..... 1596

**Y. Zhang, H.G. Sun, C.M. Zheng**  
LAGRANGIAN SOLVER FOR VECTOR FRACTIONAL  
DIFFUSION IN BOUNDED ANISOTROPIC AQUIFERS:  
DEVELOPMENT AND APPLICATION ..... 1607

**D. Baleanu, G.C. Wu**  
SOME FURTHER RESULTS OF THE LAPLACE  
TRANSFORM FOR VARIABLE-ORDER FRACTIONAL  
DIFFERENCE EQUATIONS ..... 1641

**C.H. Wang, Y. Guo, S.Q. Zheng, Y.Q. Chen**  
ROBUST STABILITY ANALYSIS OF LTI SYSTEMS  
WITH FRACTIONAL DEGREE GENERALIZED  
FREQUENCY VARIABLES ..... 1655

**P.P. Mehta, G. Pang, F. Song, G.E. Karniadakis**  
DISCOVERING A UNIVERSAL VARIABLE-ORDER  
FRACTIONAL MODEL FOR TURBULENT COUETTE  
FLOW USING A PHYSICS-INFORMED  
NEURAL NETWORK ..... 1675

---

---

## ABOUT “FCAA” JOURNAL

The “FCAA” journal, abbreviated as “**Fract. Calc. Appl. Anal.**”, Print ISSN 1311-0454, Electronic ISSN 1314-2224, is a specialized international journal for theory and applications of an important branch of Mathematical Analysis (Calculus), where the differentiations and integrations can be of arbitrary non-integer order. A peer-reviewed journal with high standards guaranteed by the Editorial Board’s list and carefully selected external referees and proven by the achieved high values in SCI of Clarivate Analytics (Thomson Reuters): **Impact Factor (JIF) = 2.974 (2013), 2.245 (2014), 2.246 (2015), 2.034 (2016), 2.865 (2017), 3.514 (2018)**; **CiteScore = 3.44**; in Scopus: **Impact Rang (SJR) = 2.106 (2013), 1.433 (2014), 1.551 (2015), 1.553 (2016), 1.967 (2017), 1.891 (2018)**. These are launching “FCAA” always to **Q1** and Top 10 places in the ranking lists for Math., Math. Appl., Math. Interdisc.

### **Abstracted / Indexed in:**

ISI Science Citation Index Expanded and Journal Citation Reports/Science Ed. (Clarivate Analytics/Thomson Reuters); Scopus (Elsevier); SCImago (SJR); WorldCat (OCLC); Mathematical Reviews (MathSciNet); Zentralblatt Math.; Summon (Serials Solutions / ProQuest); Primo Central (ExLibris); Celdes; JournalTOCs; Google Scholar; etc.

---

### **Established in 1998, Founding Publisher:** (Vol. 1–Vol. 13, 2010)

Institute of Mathematics and Informatics – Bulgarian Academy of Sciences. Contents and abstracts of all volumes, back volumes 2005–2010, and journal’s details are available at **Editor’s websites:**

<http://www.math.bas.bg/complan/fcaa>, <http://www.diogenes.bg/fcaa>.

### **Published now with the kind assistance and cooperation of:**

Institute of Mathematics and Informatics – Bulgarian Academy of Sciences.

### **Co-published in the period 2011–2014, Vol. 14–Vol. 17, by:**

Versita = De Gruyter Open, Warsaw and Springer-Verlag, Wien,

**Website (former):** <http://http://degruyteropen.com/serial/fcaa/>

and **Online Electronic version then was at SpringerLink.**

### **Current Publisher – since 2015, Vol. 18:**

Walter de Gruyter GmbH, Berlin / Boston,

**Publisher’s website:** <http://www.degruyter.com/view/j/fca>  
= <http://www.degruyter.com/fcaa>

with all journal’s details and online electronic version (Vols. 14–17, free).

### **To Order:** Contact Kathrin Müllenbach, LL. M., De Gruyter,

Genthiner Strasse 13, 10785 Berlin, Germany; Tel.: +49 (0) 30 260 05-350,

Fax: +49 (0) 30 260 05-264, E-mail: [kathrin.muellenbach@degruyter.com](mailto:kathrin.muellenbach@degruyter.com)

**To Submit:** Electronically to Editor-in-Chief, [virginia@diogenes.bg](mailto:virginia@diogenes.bg) (Virginia Kiryakova). Follow Instructions to Authors, use **Authors’ Kit.**

### **Publisher and Distributor, since 2015:**

Walter de Gruyter GmbH, Berlin / Boston



## EDITORIAL BOARD

**Editor-in-Chief: Virginia Kiryakova**

### Editorial Office:

Institute of Mathematics and Informatics - Bulgarian Academy of Sciences  
“Acad. Georgi Bontchev” Str., Block 8, Sofia – 1113, Bulgaria  
E-mail: virginia@diogenes.bg , fcaa@math.bas.bg ; Fax: +359-2-9478608

### Honorary Founding Editors † were:

Wen Chen<sup>†</sup> (China), Rudolf Gorenflo<sup>†</sup> (Germany), Anatoly A. Kilbas<sup>†</sup> (Belarus), Eric R. Love<sup>†</sup> (Australia), Danuta Przeworska-Rolewicz<sup>†</sup> (Poland), Gary F. Roach<sup>†</sup> (UK), Ian N. Sneddon<sup>†</sup> (UK), Bogoljub Stankovic<sup>†</sup> (Serbia)

### Honorary Editors:

Paul L. Butzer (Germany), Michele Caputo (Italy), Ivan Dimovski (Bulgaria), Mourad E.H. Ismail (USA), Shyam L. Kalla (India), Francesco Mainardi (Italy), Oleg Marichev (USA), Peter Rusev (Bulgaria), Megumi Saigo (Japan), Stefan Samko (Portugal), Jerome Spanier (USA), Hari M. Srivastava (Canada)

### Associate Editors:

Kai Diethelm (Germany), Yuri Luchko (Germany), Juan J. Nieto (Spain), Ivo Petras (Slovak R.), J.A. Tenreiro Machado (Portugal)

### Editorial Board:

Teodor Atanackovic (Serbia), Boris Baeumer (N. Zealand), Dumitru Baleanu (Turkey), Emilia Bazhlekova (Bulgaria), Lyubomir Boyadjiev (USA), Yury Brychkov (Russia), Alberto Cabada (Spain), YangQuan Chen (USA), Mark Edelman (USA), Neville Ford (UK), Alan Freed (USA), Rudolf Hilfer (Germany), Niels Jacob (UK), Ravi N. Kalia (USA), Mokhtar Kirane (France), Malgorzata Klimek (Poland), Anatoly Kochubei (Ukraine), Vassili Kolokoltsov (UK), Raytcho Lazarov (USA), Changpin Li (China), Richard Magin (USA), Ralf Metzler (Germany), Piotr Mikusinski (USA), Donal O'Regan (Ireland), Igor Podlubny (Slovak R.), Sergei Rogosin (Belarus), Boris Rubin (USA), Jocelyn Sabatier (France), Enrico Scalas (UK), Vasily Tarasov (Russia), Stepan Tersian (Bulgaria), Juan Trujillo (Spain), Sabir Umarov (USA), Blas Vinagre (Spain), Vu Kim Tuan (USA), Masahiro Yamamoto (Japan), Ahmed Zayed (USA)

### Board of Assisting Editors:

Anatoly A. Alikhanov (Russia), Riccardo Caponetto (Italy), Christophe Farges (France), Roberto Garra (Italy), Roberto Garrappa (Italy), Bangti Jin (UK), Gianni Pagnini (Spain), Andrew W. Wharmby (USA)

## AIMS AND SCOPE

### Primary topics of FCAA:

- Fractional Calculus (FC)
- Special Functions and Integral Transforms, *iff* related to FC
- Fractional Order Differential and Integral Equations and Systems
- Mathematical Models of Phenomena, described by the above tools

### Secondary topics of Applied Mathematical Analysis, *iff* closely related to FC:

- Algebraic Analysis, Operational and Convolutional Calculi
- Generalized Functions, Harmonic Analysis
- Numerical and Approximation Methods, Computational Procedures and Algorithms, related to the Primary FCAA topics
- Fractional Stochastic Processes
- Fractal and Integral Geometry (if related to FC)

### Applications of these techniques to:

- Differential and Integral Equations
- Problems of Mathematical Physics
- Control Theory, Mechanics, Probability and Statistics, Finances, Engineering, Biomedicine, etc.

### Other contributions:

- *Iff* revealing connections between FC and the above-mentioned topics to model problems of the real physical and social world

### Suggested MSC 2010 entries:

- 26A33; 33E12, 34A08, 34K37, 35R11, 60G22 (primary)
- 30C45, 30E15, 31B15, 33C60, 33E30, 34A25, 42A45, 42C10, 44A20, 44A35, 44A40, 45E10, 93B60, 93D09, 05C72, etc.

### FCAA journal publishes articles in the following categories:

- Research Papers
- Survey Papers
- Discussion Surveys and Notes, Short Papers and Communications
- Archives (renewal publication of old, hardly accessible or in other languages stuff of significant interest for the journal's audience)
- Reviews on Books and Proceedings, Open Problems, etc.
- Editorial Notes – information for New Books, Recent and Coming Meetings, Anniversaries and other events related to FCAA

### Submissions:

All submissions (pdf-file) and queries should be sent electronically, to:  
Ed.-in-Chief, V. Kiryakova, [virginia@diogenes.bg](mailto:virginia@diogenes.bg) , [fcaa@math.bas.bg](mailto:fcaa@math.bas.bg)

**Instructions:** L<sup>A</sup>T<sub>E</sub>X typesetting obligatory, use Authors' Kit