

# Journal of Applied Nonlinear Dynamics

---

## Editors

### Albert C.J. Luo

Department of Mechanical and Industrial Engineering  
Southern Illinois University Edwardsville  
Edwardsville, IL 62026-1805, USA  
Email: [aluo@siue.edu](mailto:aluo@siue.edu)

### Miguel A. F. Sanjuan

Department of Physics  
Universidad Rey Juan Carlos  
28933 Mostoles, Madrid, Spain  
Email: [miguel.sanjuan@urjc.es](mailto:miguel.sanjuan@urjc.es)

## Associate Editors

### Hongjun Cao

Department of Mathematics  
School of Science  
Beijing Jiaotong University  
Shang Yuan Cun 3, Haidian District  
Beijing 100044  
China  
Email: [hjcao@bjtu.edu.cn](mailto:hjcao@bjtu.edu.cn)

### Lock Yue Chew

Division of Physics & Applied Physics  
School of Physical & Mathematical  
Sciences  
Nanyang Technological University  
21 Nanyang Link, SPMS-PAP-04-04  
Singapore 637371  
Email: [lockyue@ntu.edu.sg](mailto:lockyue@ntu.edu.sg)

### Jorge Duarte

ISEL-Engineering Superior Institute of  
Lisbon  
Mathematics Department  
Rua Conselheiro Emídio Navarro  
1949-014 Lisboa  
Portugal  
Email: [jduarte@adm.isel.pt](mailto:jduarte@adm.isel.pt)

### Lyudmila Efremova

Institute of Information Technologies  
Mathematics and Mechanics  
University of Nizhni Novgorod  
Gagarin ave., 23a  
Nizhni Novgorod, 603950  
Russia  
Email: [lefunn@gmail.com](mailto:lefunn@gmail.com)

### Yurij Holovatch

Laboratory for Statistical Physics of  
Complex Systems  
Institute for Condensed Matter Physics  
National Acad. Sci. of Ukraine, Lviv  
Ukraine  
Email: [hol@icmp.lviv.ua](mailto:hol@icmp.lviv.ua)

### Nikolay V. Kuznetsov

Mathematics and Mechanics Faculty  
Saint-Petersburg State University  
Saint-Petersburg, 198504, Russia  
Email: [n.v.kuznetsov@spbu.ru](mailto:n.v.kuznetsov@spbu.ru)

### Edson Denis Leonel

Departamento de Física  
UNESP - Univ Estadual Paulista  
Av. 24A, 1515 - Rio Claro - SP  
Brazil - 13.506-900  
Email: [edleonel@rc.unesp.br](mailto:edleonel@rc.unesp.br)

### Antonio M Lopes

UISPA-LAETA/INEGI  
Faculty of Engineering  
University of Porto  
Rua Doutor Roberto Frias, s/n, 4200-465  
Porto, Portugal  
Email: [aml@fe.up.pt](mailto:aml@fe.up.pt)

### J. A. Tenreiro Machado

ISEP-Institute of Engineering of Porto  
Dept. of Electrical Engineering  
Rua Dr. Antonio Bernardino de  
Almeida 431, 4200-072 Porto Portugal  
Email: [jtm@isep.ipp.pt](mailto:jtm@isep.ipp.pt)

### Vladimir I. Nekorkin

Institute of Applied Physics of RAS  
46 Ulyanov Street, 603950  
Nizhny Novgorod  
Russia  
Email: [vnekorkin@appl.sci-nnov.ru](mailto:vnekorkin@appl.sci-nnov.ru)

### Minvydas Ragulskis

Center for Nonlinear Systems  
Department of Mathematical Modelling  
Kaunas University of Technology  
Studentu 50-146,  
Kaunas LT-51368, Lithuania  
Email: [minvydas.ragulskis@ktu.lt](mailto:minvydas.ragulskis@ktu.lt)

### Shanmuganathan Rajasekar

School of Physics  
Bharathidasan University  
Tiruchirappalli - 620 024  
Tamilnadu, India  
Email: [srj.bdu@gmail.com](mailto:srj.bdu@gmail.com);  
[srj@bdu.ac.in](mailto:srj@bdu.ac.in)

### Gonzalo Marcelo Ramírez-Ávila

Nonlinear Dynamics and Complex  
Systems Group  
Instituto de Investigaciones Físicas  
Universidad Mayor de San Andrés  
Campus Universitario Cota-Cota  
Calle 27, La Paz, Bolivia  
Email: [mravila@fiumsa.edu.bo](mailto:mravila@fiumsa.edu.bo),  
[gramirez@ulb.ac.be](mailto:gramirez@ulb.ac.be)

### Lev Ryashko

Department of the Theoretical and  
Mathematical Physics  
Ural Federal University  
Lenina, 51, 620000, Ekaterinburg  
Russia  
Email: [lev.ryashko@urfu.ru](mailto:lev.ryashko@urfu.ru)

### Vsevolod Sakbaev

Moscow Institute of Physics and  
Technology  
Institutskiy per. 9, Dolgoprudny  
Moscow region, 141701  
Russia  
Email: [sakbaev.vzh@mipt.ru](mailto:sakbaev.vzh@mipt.ru)

# Journal of Applied Nonlinear Dynamics

Volume 10, Issue 3, September 2021

Editors

Albert Chao-Jun Luo

Miguel A. F. Sanjuan



L&H Scientific Publishing, LLC, USA

## **Publication Information**

*Journal of Applied Nonlinear Dynamics* (ISSN 2164-6457 (print), eISSN 2164-6473 (online)) is published quarterly (March, June, September, and December) by L & H Scientific Publishing, LLC, 25 Glen Ed Professional Park, Glen Carbon, IL62034, USA. Subscription prices are available upon request from the publisher or from this journal website. Subscriptions are accepted on a prepaid basis only and entered on a calendar year basis. Issues are sent by standard mail (Surface in North America, air delivery outside North America). Priority rates are available upon request. Claims for missing issues should be made within six months of the date of dispatch.

## **Changes of Address**

Send address changes to L&H Scientific Publishing, LLC, 25 Glen Ed Professional Park, Glen Carbon, IL62034, USA. Changes of address must be received at L&H Scientific Publishing eight weeks before they are effective.

## **Authors Inquiries**

For inquiries relative to the submission including electronic submission where available, please visit journal website or contact journal Editors-in-Chief.

## **Advertising Information**

If you are interested in advertising or other commercial opportunities, please email via [lhscientificpublishing@gmail.com](mailto:lhscientificpublishing@gmail.com) and your enquiry will be handled as soon as possible.

## **© 2021 L&H Scientific Publishing, LLC. All rights reserved**

L&H Scientific Publishing, LLC requires the authors to sign a Journal Copyright Transfer Agreement for all articles published in L&H Scientific. The Copyright Transfer Agreement is an agreement under which the author retains copyright in the work but grants L & H Scientific Publishing LLC the sole and exclusive right and license to publish the full legal term of copyright.

Authors are responsible for obtaining permission from copyright holders for reproducing any illustrations, tables, figures or lengthy quotations published somewhere previously.

For authorization to photocopy materials for internal or personal use under those circumstances not falling within the fair use provisions of Copyright Act, requests for reprints and translations should be addressed to the permission office of L&H Scientific Publishing, LLC via [lhscientificpublishing@gmail.com](mailto:lhscientificpublishing@gmail.com) or call: +1-618-402-2267. Permission of the Publisher and payment of a fee are required for all other photocopying, including multiple or systematic copying, copying for advertising or promotional purposes, resale, and forms of document delivery. Special rates are available for educational institutions to make photocopies for non-profit educational classroom use.

Subscribers may reproduce tables of contents or prepare lists of articles including abstracts for internal circulation within their institutions. Permission of the publisher is required for resale or distribution outside the institution.

Permission of the Publisher is required to store or use electronically any materials contained in this journal, including any entire or partial article, please contact the publisher for advice. Otherwise, no part of this publication can be reproduced, stored in retrieval systems or transmitted in any form or by means, electronic, mechanical, photocopying, recording or without prior written permission of the Publisher.

## **Disclaimer**

The authors, editors and publisher will not accept any legal responsibility for any errors or omissions that may be made in this publication. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Printed in USA on acid-free paper.

## Aims and Scope

The Journal of Applied Nonlinear Dynamics is a journal aiming at increasing the basic and applied knowledge in the interdisciplinary field of nonlinear sciences, including nonlinear dynamics, chaos and complex systems, and focusing on physics, applied mathematics, engineering and other applied disciplines. The aim of the journal is to stimulate research in nonlinear phenomena in science and engineering. Manuscripts in complex dynamical systems with nonlinearity and chaos are solicited, which includes physical mechanisms of complex systems and engineering applications of nonlinear dynamics. The journal provides a place to researchers for the rapid exchange of ideas and techniques in nonlinear dynamics.

No length limitations for contributions are set, but only concisely written manuscripts are published. Brief papers are published, either as technical notes or concise new results. Discussions of previous published papers are also welcome. The journal aims to be a forum of exchange of new research results for physicists, applied mathematicians, and engineers involved in Nonlinear Science and Numerical Simulation. Topics of interest includes but not limited to

- Deterministic chaos,
- Nonlinear dynamical systems and control,
- Fractional dynamics and applications,
- Synchronization phenomena,
- Fractal structures in nonlinear dynamics,
- Fluctuations and noise effects on dynamical systems
- Chaos in Hamiltonian systems,
- Nonlinearity and chaos in quantum mechanics,
- Chaos in Astrophysics and Celestial Dynamics,
- Integrable systems and solitons,
- Collective behaviors in many-body systems,
- Biological physics and networks,
- Nonlinear mechanical systems,
- Nonlinear phenomena and chaos in Physics
- Complex systems and complexity.

## Peer Review

*Journal of Applied Nonlinear Dynamics* adopts the traditional blind-review policy in which the reviewers' names are concealed for submission author(s) for free submission. Each submitted manuscript is reviewed at least two referees in appropriate fields. In addition, the editorial board members' recommendation or established experts' recommendation publication are welcome.

## Manuscript Submission Guidelines

Author(s) should submit manuscripts via the website: <https://www.editorialmanager.com/JAND/Default.aspx>. For any questions, authors can directly contact Editors-in-Chief. Manuscript preparation can follow the sample papers and journal manuscript templates (word file and Latex files), which can be downloaded from the website: <https://lhscientificpublishing.com/Journals/JAND-Default.aspx>.

## Proofs and Electronic Offprints

Authors will receive a PDF proof of their articles and, on publication, electronic offprints of the article.

## Open Access Options

After manuscripts were accepted, author(s) have a right to request the accepted manuscripts published by L&H Scientific publishing with open access, and the author(s) have a responsibility to paying the open access publication fee. The copyright is still held by the Publisher, but the open access permission is given to the author(s) as follows. Without any request of the open access publication, the accepted manuscripts are assumed to be published traditionally. This journal offers authors two choices to publish their research.

- *Open access:* Articles are freely available to both subscribers and the wider public with permitted reuse. An open access publication fee is payable by authors or their research funder.
- *Subscription:* Articles are made available to subscribers through our access programs. No open access publication fee.

L&H scientific does offer alternative open access publishing options in accordance with funding body requirements. Your publication choice will have no effect on the peer review process or acceptance of your submission.

## Open Access Articles

- User rights

All articles published gold open access will be immediately and permanently free for everyone to read and download. We offer authors a choice of user licenses, which define the permitted reuse of articles. We are continuously working with our author communities to select the best choice of license options, currently being defined for this journal as follows:

*Creative Commons Attribution (CC BY)*: lets others distribute and copy the article, to create extracts, abstracts, and other revised versions, adaptations or derivative works of or from an article (such as a translation), to include in a collective work (such as an anthology), to text or data mine the article, even for commercial purposes, as long as they credit the author(s), do not represent the author as endorsing their adaptation of the article, and do not modify the article in such a way as to damage the author's honor or reputation.

*Creative Commons Attribution-NonCommercial-NoDerivs (CC BY-NC-ND)*: for non-commercial purposes, lets others distribute and copy the article, and to include in a collective work (such as an anthology), as long as they credit the author(s) and provided they do not alter or modify the article.

- Open access publication fee

To provide open access, this journal has a publication fee which needs to be met by the authors or their research funders for each article published open access. The open access publication fee for this journal is USD 100 per page, excluding taxes.

## Self-archiving Policy

Authors can share their research in a variety of different ways. The author(s) can also self-archive their author manuscript immediately and enable public access from their institution's repository after an embargo period. This is the version that has been accepted for publication and which typically includes author-incorporated changes suggested during submission, peer review and in editor-author communications.

An author is entitled to post the accepted manuscript in their institution's repository and make this public after an embargo period (known as self-archiving). The embargo period for this journal can be found below.

Without the L&H permission, the published journal article cannot be shared publicly, such as, on ResearchGate or Academia.edu, to ensure the sustainability of peer-reviewed research in journal publications.

*Embargo period*: For subscription articles, an appropriate amount of time is needed for journals to deliver value to subscribing customers before a manuscript becomes available for free to the public. This is called an embargo period and it begins from the date the article is formally published online in its final and fully citable form.

This journal has an embargo period of 24 months and the embargo period for the USA is 12 months.

*Continued from inside front cover*

**Michael Small**

Department of Mathematics and  
Statistics  
The University of Western Australia  
35 Stirling Highway, 6009 Perth  
Australia  
Email: michael.small@uwa.edu.au

**Juan J. Trujillo**

Department de Análisis Matemático  
Universidad de La Laguna  
C/Astr. Fco. Sánchez s/n  
38271 La Laguna, Tenerife  
Spain  
Email: jtrujill@ullmat.es

**Jianhua Yang**

School of Mechatronic Engineering,  
China University of Mining and  
Technology,  
Xuzhou, Jiangsu, 221116  
China  
Email: jianhuayang@cumt.edu.cn

**Charalampos (Haris) Skokos**

Department of Mathematics and Applied  
Mathematics, Faculty of Science  
Mathematics Building, Upper Campus  
University of Cape Town  
Rondebosch, 7701, South Africa  
Email: haris.skokos@uct.ac.za,  
[haris.skokos@gmail.com](mailto:haris.skokos@gmail.com)

**Juan Alejandro Valdivia**

Departamento de Física  
Facultad de Ciencias  
Universidad de Chile  
Las Palmeras 3425, Nunoa  
Santiago, Chile  
Email: [alejo@macul.ciencias.uchile.cl](mailto:alejo@macul.ciencias.uchile.cl)

**Yufeng Zhang**

College of Sciences  
China University of Mining and  
Technology  
Xuzhou, Jiangsu 221116  
China  
Email: mathzhang@126.com

**Vasily E. Tarasov**

Skobeltsyn Institute of Nuclear Physics  
Moscow State University  
119991 Moscow, Russia  
Email: tarasov@theory.sinp.msu.ru

**Yuefang Wang**

Department of Engineering Mechanics  
Dalian University of Technology  
Dalian, Liaoning, 116024, China  
Email: yfwang@dlut.edu.cn

**Zhigang Zheng**

Institute of Systems Science,  
Huaqiao University,  
No.668 Jimei Avenue,  
Xiamen, Fujian 361021  
China  
Email: zgzheng@hqu.edu.cn