

# Journal of Applied Nonlinear Dynamics

---

## Editors

### 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  
Fax: +351 22 8321159  
Email: [jtm@isep.ipp.pt](mailto:jtm@isep.ipp.pt)

### Albert C.J. Luo

Department of Mechanical and Industrial Engineering  
Southern Illinois University Edwardsville  
Edwardsville, IL 62026-1805  
USA  
Fax: +1 618 650 2555  
Email: [aluo@siue.edu](mailto:aluo@siue.edu)

## Associate Editors

### J. Awrejcewicz

Department of Automatics and  
Biomechanics K-16,  
The Technical University of Lodz, 1/15  
Stefanowski St., 90-924 Lodz, Poland  
Fax: +48 42 631 2225, Email:  
[awrejcew@p.lodz.pl](mailto:awrejcew@p.lodz.pl)

### Stefano Lenzi

Dipartimento di Ingegneria Civile  
Edile e Architettura, Universita'  
Politecnica delle Marche via Brecce  
Bianche, 60131 ANCONA, Italy  
Fax: +39 071 2204576  
Email: [lenci@univpm.it](mailto:lenci@univpm.it)

### Miguel A. F. Sanjuan

Department of Physics  
Universidad Rey Juan Carlos Tulipán s/n  
28933 Mostoles, Madrid, Spain  
Fax: +34 916647455  
Email: [miguel.sanjuan@urjc.es](mailto:miguel.sanjuan@urjc.es)

### Dumitru Baleanu

Department of Mathematics and  
Computer Sciences  
Cankaya University  
Balgat, 06530, Ankara, Turkey  
Fax: +90 312 2868962  
Email: [dumitru@cankaya.edu.tr](mailto:dumitru@cankaya.edu.tr)

### Shaofan Li

Department of Civil and  
Environmental Engineering  
University of California at Berkeley  
Berkeley, CA 94720-1710, USA  
Fax: +1 510 643 8928  
Email: [li@ce.berkeley.edu](mailto:li@ce.berkeley.edu)

### C. Steve Suh

Department of Mechanical Engineering  
Texas A&M University  
College Station, Texas 77843-3123  
USA  
Fax: +1 979 845 3081  
Email: [ssuh@tamu.edu](mailto:ssuh@tamu.edu)

### Nikolay V. Kuznetsov

Mathematics and Mechanics Faculty  
Saint-Petersburg State University  
Saint-Petersburg, 198504, Russia  
Fax: +7 812 4286998  
Email: [kuznetsov@math.spbu.ru](mailto:kuznetsov@math.spbu.ru)

### C. Nataraj

Department of Mechanical Engineering  
Villanova University, Villanova  
PA 19085, USA  
Fax: +1 610 519 7312  
Email: [c.nataraj@villanova.edu](mailto:c.nataraj@villanova.edu)

### Vasily E. Tarasov

Skobeltsyn Institute of Nuclear Physics  
Moscow State University  
119991 Moscow, Russia  
Fax: +7 495 939 0397  
Email: [tarasov@theory.sinp.msu.ru](mailto:tarasov@theory.sinp.msu.ru)

## Editorial Board

### Ahmed Al-Jumaily

Institute of Biomedical Technologies  
Auckland University of Technology  
Private Bag 92006 Wellesley Campus  
WD301B Auckland, New Zealand  
Fax: +64 9 921 9973  
Email: [ahmed.al-jumaily@aut.ac.nz](mailto:ahmed.al-jumaily@aut.ac.nz)

### Giuseppe Catania

Department of Mechanics  
University of Bologna  
viale Risorgimento, 2, I-40136  
Bologna, Italy  
Tel: +39 051 2093447  
Email: [giuseppe.catania@unibo.it](mailto:giuseppe.catania@unibo.it)

### Mark Edelman

Yeshiva University  
245 Lexington Avenue  
New York, NY 10016, USA  
Fax: +1 212 340 7788  
Email: [edelman@cims.nyu.edu](mailto:edelman@cims.nyu.edu)

### Alexey V. Borisov

Department of Computational  
Mechanics  
Udmurt State University, 1  
Universitetskaya str., Izhevsk 426034  
Russia  
Fax: +7 3412 500 295  
Email: [borisov@ics.org.ru](mailto:borisov@ics.org.ru)

### Liming Dai

Industrial Systems Engineering  
University of Regina  
Regina, Saskatchewan  
Canada, S4S 0A2  
Fax: +1 306 585 4855  
Email: [Liming.Dai@uregina.ca](mailto:Liming.Dai@uregina.ca)

### Xilin Fu

School of Mathematical Science  
Shandong Normal University  
Jinan 250014, China  
Email: [xilinfu@gmail.com](mailto:xilinfu@gmail.com)

# Journal of Applied Nonlinear Dynamics

Volume 4, Issue 3, September 2015

Editors

J. A. Tenreiro Machado

Albert Chao-Jun Luo



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, P.O. Box 99, 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, P.O. Box 99, 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.

## **© 2015 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 a 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 interdisciplinary journal publishes original and new research results on applied nonlinear dynamics in science and engineering. The aim of the journal is to stimulate more research interest and attention for nonlinear dynamics and application. The manuscripts in complicated dynamical systems with nonlinearity and chaos are solicited, which includes mathematical theories and methods, physical principles and laws, and computational techniques. The journal provides a place to researchers for the rapid exchange of ideas and techniques in nonlinear dynamics and engineering nonlinearity. Topics of interest include but not limited to

- Complex dynamics in engineering
- Nonlinear vibration and control
- Nonlinear dynamical systems and control
- Fractional dynamics and control
- Dynamical systems in chemical and bio-systems
- Economic dynamics and predictions
- Dynamical systems synchronization
- Bio-mechanical systems
- Nonlinear structural dynamics
- Nonlinear multi-body dynamics
- Multiscale wave propagation in materials
- Nonlinear rotor dynamics

No length limitations for contributions are set, but only concisely written manuscripts are published. Brief papers are published on the basis of Technical Notes. Discussions of previous published papers are welcome.

## **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**

For manuscript submission, 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 found from the website at <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**

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 with US\$30 per page. The copyright is still held by the Publisher. Without any request of the open access publication, the accepted manuscripts are assumed to be published traditionally.

*Continued from inside front cover*

**Juan Luis García Guirao**

Department of Applied Mathematics  
Technical University of Cartagena  
Hospital de Marina 30203, Cartagena,  
Spain  
Fax: +34 968 325694  
E-mail: juan.garcia@upct.es

**Hamid R. Hamidzadeh**

Department of Mechanical and  
Manufacturing Engineering  
Tennessee State University  
Nashville, TN37209-1561, USA  
Email: hhamidzadeh@tnstate.edu

**Clara Ionescu**

Department of Electrical Energy  
Systems and Automation  
Ghent University Technologiepark  
913, Gent-Zwijnaarde B9052  
Belgium  
Email: ClaraMihaela.Ionescu@UGent.be

**Reza N. Jazar**

School of Aerospace, Mechanical and  
Manufacturing  
RMIT University  
Bundoora VIC 3083, Australia  
Fax: +61 3 9925 6108  
Email: reza.jazar@rmit.edu.au

**Erno Keskinen**

Department of Mechanics and Design  
Tampere University of Technology  
33101 Tampere, Finland  
Fax +358 3 3115 2307  
Email: erno.keskinen@tut.fi

**Gennady A. Leonov**

Department of Mathematics and  
Mechanics  
St-Petersburg State University  
St-Petersburg, 198504, Russia  
Email: leonov@math.spbu.ru

**Shijun Liao**

Department of Naval Architecture  
and Ocean Engineering  
Shanghai Jiaotong University  
Shanghai 200030, China  
Fax: +86 21 6485 0629  
Email: sjliao@mail.sjtu.edu.cn

**Richard L. Magin**

Department of Bioengineering  
University of Illinois at Chicago  
Chicago, Illinois 60607-7052, USA  
Fax: +1 312 996 5921  
Email: rmagin@uic.edu

**Raoul R. Nigmatullin**

Department of Theoretical Physics  
Kremlevskaiya str.18  
Kazan State University, 420008  
KAZAN, Tatarstan Russia  
Email: nigmat@knet.ru

**Lev Ostrovsky**

Zel Technology/NOAA ETL  
Boulder CO, USA 80305  
Fax: +1 303 497 7384  
Email: Lev.A.Ostrovsky@noaa.gov

**Neil Popplewell**

Department of Mechanical and  
Manufacturing Engineering  
University of Manitoba  
Winnipeg, MB R3T 5V6, Canada  
Fax: +1 204 275 7507  
Email: npopple@cc.umanitoba.ca

**Richard H. Rand**

Department of Mathematics  
Cornell University  
Ithaca, NY 14853-1503, USA  
Fax: +1 607 255 7149  
Email: rand@math.cornell.edu

**S.C. Sinha**

Department of Mechanical  
Engineering  
Auburn University  
Auburn, Alabama 36849, USA  
Fax: +1 334 844 3307  
Email: ssinha@eng.auburn.edu

**Jian-Qiao Sun**

School of Engineering  
University of California  
Merced, 5200 N. Lake Road  
Merced, CA 95344, USA  
Fax: +1 209 228 4047  
Email: jqsun@ucmerced.edu

**József K. Tar**

Institute of Intelligent Engineering  
Systems  
Óbuda University  
Bécsi út 96/B, H-1034  
Budapest, Hungary  
Fax: +36 1 219 6495  
Email: tar.jozsef@nik.uni-obuda.hu

**Juan J. Trujillo**

Department de Análisis Matemático  
Universidad de La Laguna  
C/Astr. Fco. Sánchez s/n  
38271 La Laguna, Tenerife, Spain  
Fax: +34 922318195  
Email: jtrujill@ullmat.es

**Luis V. Vazquez**

Departamento de Matemática Aplicada  
Universidad Complutense de Madrid  
28040 Madrid, Spain  
Fax: +34 91 3947510  
Email: lvazquez@fdi.ucm.es

**Yuefang Wang**

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

**Mikhail V. Zakrzhevsky**

Institute of Mechanics  
Riga Technical University  
1 Kalku Str., Riga LV-1658 Latvia  
Email: mzakr@latnet.lv

**Jiazhong Zhang**

School of Energy and Power  
Engineering  
Xi'an Jiaotong University  
Shaanxi Province 710049, China  
Email: jzzhang@mail.xjtu.edu.cn

**Yufeng Zhang**

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