International Conference on Structural Nonlinear Dynamics and Diagnosis

A. Azouani, M. Belhaq, A. Fahsi & M. Houssni

Group of Nonlinear Dynamics
Department of Mechanics
Faculty of Sciences Aïn chock

Université Hassan II – Casablanca

CSNDD 2012

Conference on Structural Nonlinear Dynamics and Diagnosis

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Booklet of Abstracts

Eds.: A. Azouani, M. Belhaq, A. Fahsi & M. Houssni

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The abstracts of the paper in this Booklet were set individually by the authors. Only minor typographical changes have been made by the local organizing committee.

Booklet of Abstracts

Preface

The Conference on Structural Nonlinear Dynamics and Diagnosis (CSNDD 2012) is held in Marrakech, Morocco, and is organized by the Laboratory of Mechanics, Group of Nonlinear Dynamics of the Hassan II University of Casablanca, in the framework of the scientific activities of the Moroccan Association of Vibration and Acoustic (AMVA).

The International Conference on Structural Nonlinear Dynamics and Diagnosis intends to be a meeting place where scientists from different branches of applied mechanics and mathematics working in nonlinear dynamics, structural systems, diagnosis and control can meet to discuss the latest achievements and to exchange ideas in theoretical, numerical and experimental techniques for solving problems in nonlinear dynamics, diagnosis and control. Focuses are directed toward diverse topics, ranging from dynamical systems theory to different engineering applications.

The CSNDD 2012 aims at covering a large field of nonlinear dynamics, including structural health monitoring, diagnosis and damage detection, fast slow dynamics, multi-scale dynamics, advances on nonlinear PDEs and their dynamics, experimental methods, active vibration control and smart structures, identification of nonlinear systems, vibro-impact dynamic, and nonlinear dynamics in MEMS / NEMS and nanotechnology.

The Moroccan Association of Vibration and Acoustic would like to make this meeting a tradition and sets a goal of organizing the event every three years in Morocco or in the nearby countries.

It is a great privilege for the nonlinear dynamic Moroccan community, in general, and the Casablanca research group, in particular, to host the CSNDD 2012 Conference in Marrakech, as the first International Conference in Nonlinear Dynamics organized in Morocco.

I am happy to report that the first CSNDD 2012 has amply accomplished this goal. The event has attracted a representative international scientific community in nonlinear dynamics, diagnosis and control. More than 200 papers from 28 countries were submitted, most of them being invited, and nearly 180 were accepted. Thirteen Mini-symposia including fifteen oral and two poster sessions were organized by leading experts in the field, who contributed to attract top-quality scientists. All submissions were reviewed.

I would like to thank all MS Organizers, reviewers as well as the local and international organizing committees for their help in maintaining high standards of the Conference Technical Program.

A. Azouani, M. Belhaq, A. Fahsi & M. Houssni, *International Conference on Structural Nonlinear Dynamics and Diagnosis* (CSNDD 2012).

At the same time, I would like to thank all participants to the Conference, as well as PhD students, colleagues and friends who meaningfully helped with the organization.

On behalf of the CSNDD 2012 Committees, welcome to Marrakech, the "Captivating City", and enjoy a scientifically stimulating and socially nice conference!

Mohamed Belhaq
CSNDD 2012 Chair
Marrakech, May 2012

Contents

Committees

The *International Conference on Structural Nonlinear Dynamics and Diagnosis* takes place in Marrakech, Morocco from **April 30 to May 02, 2012**. The conference will provide a forum where researchers from different branches of applied mechanics and mathematics working in nonlinear dynamics, structural systems and diagnosis can meet to share ideas and findings of their research work on methods and applications. The meeting is also a forum to discuss the latest achievements, to exchange experience in theoretical, numerical and experimental techniques for solving problems in structural nonlinear dynamics, diagnosis and control.

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Scientific Program

The scientific program includes:

- Plenary Lectures
- Invited Lectures
- Minisymposia Sessions and Poster Sessions on pre-defined topics

The minisymposia are organized through 3 parallel lecture sessions. As a rule, the available time slot per lecture presentation is 20 min, including discussion. According to specific lecture presentation, they can be slightly longer (25 min).

Plenary Lectures

- Ali H. Nayfeh, Virginia Tech, USA
  Renewable Energy in Developing Countries
- Edriss S. Titi, University of California, Irvine, USA
  Navier-Stokes, Euler, and Other Relevant Equations
- Richard Rand, Cornell University, USA
  Parametric Excitation and Evolutionary Dynamics

Invited Lectures

- Chuck Farrar, Los Alamos Laboratory, USA
  Applications of Nonlinear Dynamics in Structural Health Monitoring
- Eckehard Schöll, TU Berlin, Germany
  Adaptive Time-Delayed Feedback Control of Complex Networks
- Joseph A. Turner, University of Nebraska-Lincoln, USA
  Recent Results on Diffuse Scattering in Materials under Applied Loads
- Bernold Fiedler, Free University of Berlin, Germany
  How Delayed Control Can Stabilize Delay Equations
- Jan Awrejcewicz, Technical University of Lodz, Poland
  On the Novel 3D Friction Model and Wobblestone Dynamics: Theory, Simulation and Experimental Results

A. Azouani, M. Belhaq, A. Fahsi & M. Houssni, *International Conference on Structural Nonlinear Dynamics and Diagnosis* (CSNDD 2012).

- Sami F. Masri, University of Southern California, USA
  Some Approaches for the Detection, Location, and Quantification of Changes in Nonlinear Structural Systems
- Vladimir Babitsky, Loughborough University, UK
  On Analysis of Vibro-impact Response of the Cracked Structures for non Destructive Health Monitoring
- Ricardo Perera, Polytechnic University of Madrid, Spain
  Multi Objective Damage Identification in Uncertain Environments

Minisymposia and chairs

- **MS1. Structural healt monitoring**
  M.N. Ichchou (France), C. Farrar (USA)
- **MS2. Time-delayed feedback control**
  B. Fieldler (Germany), E. Schöll (Germany)
- **MS3. Identification and vibro-impact of systems**
  A. Kareem (USA), M.R. Hajj (USA)
- **MS4. Recent advances on nonlinear PDEs and their dynamics**
  E.S. Titi (USA), A. Azouani (Germany)
- **MS5. Nonlinear dynamics of MEMS/NEMS/AFM**
  M. Younis (USA), F. Najjar (Tunisia)
- **MS6. Passive control of structures via nonlinear energy sinks**
  A. Luongo (Italy), C.-H. Lamarque (France)
- **MS7. Hydrodynamic instability and heat transfer**
  S. Saravanan (India), M. Hasnaoui (Morocco)
- **MS8. Complex systems, networks and synchronization**
  M. Aziz Alaoui (France), C. Bertelle (France)
- **MS9. Bifurcations and chaos in mechanical/mechatronical systems**
  J. Awrejcewicz (Poland), P. Hagedorn (Germany)
- **MS10. Asymptotic methods in nonlinear dynamics**
  K.W. Chung (Hong Kong), F. Lakrad (Morocco)
- **MS11. Active vibration control and smart structures**
  A. Benjeddou (France), L. Azrar (Morocco)
- **MS12. Nonlinear dynamics of systems**
  R. Benamar (Morocco), S. Glavatskih (Sweden)
- **MS13. Fast slow dynamics and applications**
  J. Starke (Denmark), P.G. Hjorth (Austria)

Conference Synthetic Timetable

Registration (Albatros Garden Hotel, Marrakech)

– Sunday, April 29, 14:00–24:00
– Monday, April 30, 8:00–9:00

Monday, April 30, 2012

8:00–9:00	***Registration***
9:00–9:30	Opening
9:30–10:15	Plenary Lecture 1: Ali H. Nayfeh
10:15–10:45	***Welcome Reception***
10:45–11:15	Invited Lecture 1: Chuck Farrar
11:15–11:45	Invited Lecture 2: Eckehard Schöll
11:45–12:15	Invited Lecture 3: Joseph A. Turner
12:30–14:00	***Lunch***
14:10–16:30	Minisymposia (Parallel Sessions: MS1, MS2, MS3)
16:30–17:00	***Coffee Break and Poster Session***
17:00–19:20	Minisymposia (Parallel Sessions: MS4, MS5, MS6)

Tueday, May 1, 2012

9:00–9:45	Plenary Lecture 2: Edriss S. Titi
9:45–10:15	Invited Lecture 4: Bernold Fiedler
10:15–10:45	***Coffee Break***
10:45–11:15	Invited Lecture 5: Jan Awrejcewicz
11:15–11:45	Invited Lecture 6: Sami Masri
11:45–12:15	Invited Lecture 7: Vladimir Babitsky
12:30–14:00	***Lunch***
14:10–16:10	Minisymposia (Parallel Sessions: MS4, MS7, MS8, MS9)
16:10–16:40	***Coffee Break and Poster Session***
16:40–19:20	Minisymposia (Parallel Sessions: MS10, MS11, MS12)

Wednesday, May 2, 2012

9:00–9:45	Plenary Lecture 3: Richard Rand
9:45–10:15	Invited Lecture 4: Ricardo Perera
10:15–10:45	***Coffee Break***
10:45–12:45	Minisymposia (Parallel Sessions: MS4, MS5, MS13)
12:45–13:15	***Closure***
13:15	***Lunch***
15:00	**Marrakech City Tour**

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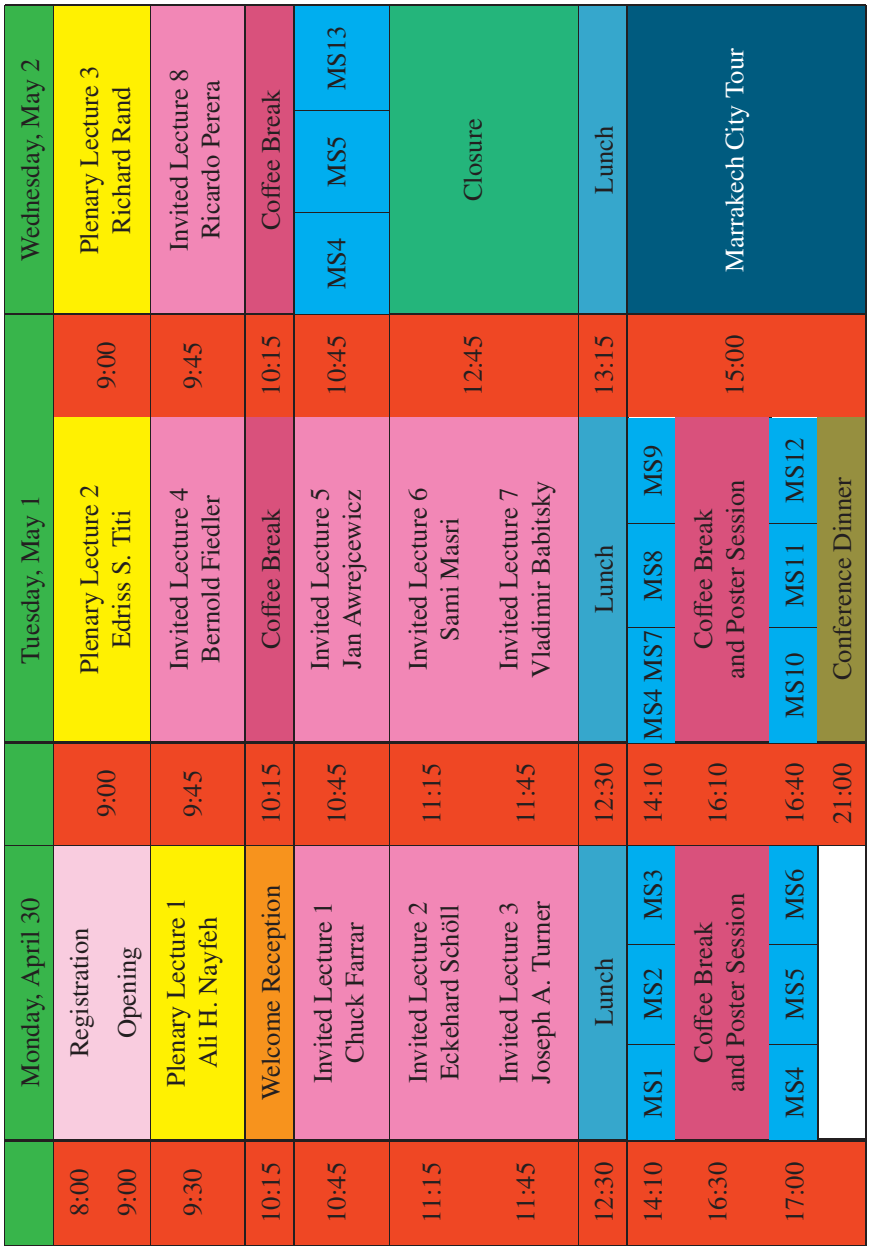
CSNDD'2012 Technical Program



Abstracts

MS 1
Structural health monitoring

Organizers: *C. Farrar* USA, *M.N. Ichchou* France

Scheduled:

Monday *14:10–16:30* Hotel Albatros **Room Toubkal**

Distributed Dynamic Effects in Composite T-Joints Due to Localized Damages

Mon. 14:10–14:30 R Toubkal

V. Pilipchuk, I. Grace, R. Ibrahim, E. Ayorinde

Mechanical Engineering, Wayne State University, Detroit, MI.

The purpose of the present work is to clarify how local damages of T-joints may affect global vibration modes of marine structures. Onsets of localized damages usually lead to barely detectable variations of stiffness and inertia involved into global vibration modes. Therefore, a methodology for observation of such effects must be examined in the first place. In particular, the purpose of the theoretical modelling and experimental investigation is to select such characteristics of the nonlinear modal and frequency responses that are most sensitive to the onset of cracks and other structural damages. Such methodologies can be used for on-line damage detection and health monitoring through real time signals from a limited number of sensors sufficient nevertheless for identification of mode shapes and spectra. In the present work, an analytical modelling is developed and then numerically simulated. Experimental results are found to exhibit some shifts in the global dynamic response of a T-joint structure due to its different damages. We propose a phenomenological approach to modelling sandwich beams, which are easy enough to adapt for nonlinear dynamic problems. The leading terms of the corresponding partial differential equation of motion are based on asymptotic estimates.

Acknowledgment: This work is supported by a grant from ONR under Award No: N00014-08-1-0647. Dr. Kelly B. Cooper is the Program Director.

Monitoring of the ultrasonic P-wave velocity in early-age concrete using Smart Aggregates

Mon. 14:30–14:50 R Toubkal

C. Dumoulin, G. Karaiskos, J. Carette, S. Staquet, A. Deraemaeker

Université Libre de Bruxelles - BATir 50 av F.D. Roosevelt, CP 194/02 B-1050 Brussels, Belgium

This paper deals with the use of embedded piezoelectric transducers to monitor the ultrasonic Pwave velocity evolution during the setting and hardening phases of concrete since casting time. The main advantage of the technique is the ability to overcome the limita-

tions of traditional methods which do not allow to apply specific mechanical boundary conditions during the measurement. The embedded transducers are based on the Smart Aggregates concept previously developed at the University of Houston, Texas. Two piezoelectric transducers are embedded in a prismatic mold and the evolution of the P-wave velocity is recorded for the first 24 hours in concrete after casting time. The results are very promising and show a good agreement with classical ultrasonic tests using external transducers.

On the reliability of a PCA-based method for structural diagnosis in bridge structures with environmental disturbances

Mon.
14:50–15:10
R Toubkal

G. Quaranta[1], B. Carboni[2], and W. Lacarbonara[2]

[1] *University of California at Davis, Davis CA 95616, USA.*
[2] *Sapienza University of Rome. Via Eudossiana 18, 00184 Rome, Italy.*

The basis for a vibration-based damage detection method is that changes in the physical properties of a structure will, in turn, modify its dynamic characteristics. Civil engineering structures are often subjected to varying environmental conditions. Thus the natural deviation of the identified structural features from the undamaged state may smear the changes caused by structural damages, thus causing non-issued alarms or false damage diagnoses. In order to assess their reliability for future field applications, damage detection methods can be preliminarily validated by means of mechanical models in which varying environmental conditions are appropriately simulated. Two issues must be considered: the first is about the adopted thermomechanical model, the second deals with damage scenarios modeling. To date, diagnostic tools are usually verified by means of oversimplified thermomechanical models, and the reliability of damage detection methods is demonstrated with reference to the damage severity only, whereas no effort has been directed toward the assessment of their effectiveness in identifying space- and time-varying damage scenarios. Based on a refined tridimensional thermomechanical model and a principal component analysisbased diagnostic tool, this study discusses the effectiveness of damage detection methods for health monitoring of reinforced concrete bridge structures.

Pipes inspection by torsional guided-waves generator, numerical and experimental analysis

Mon.
15:10–15:30
R Toubkal

M. Kharrata, M.N. Ichchou, O. Bareille and W. Zhou

Laboratoire de Tribologie et Dynamique des Systèmes, Ecole Centrale de Lyon, 36 avenue Guy de Collongue 69134 Ecully Cedex France.

Defect detection by guided waves is an effective technique in the structural health monitoring domain. Guided-waves propagation in pipes of great length allows the rapid inspection and identification of damages through pipelines. Hence, the interest of using guided waves that can control a relatively large structure from a single position. In this work, a prototype was developed for the generation of specific guided-waves for the defect detection in pipes. The designed generator aims at providing well referenced torsional

waves for structural health monitoring applications. A distributed network of piezoelectric patches network is considered. An experimental test bench is also provided in order to validate the concept. The ability of the distributed system in generating pure torsional waves is discussed. Numerical and experimental results confirm some specific features in the wave reflection coefficient based on the interaction between the damaged waveguide dynamics and torsional wave propagation.

On assessing the robustness of an input signal optimization algorithm for damage detection: the Info-Gap Decision Theory approach

Mon.
15:30–15:50
R Toubkal

M. Pasquali[1], W. Lacarbonara[1], G. Park[2], and C.R. Farrar[2]

[1] *Sapienza University of Rome, Via Eudossiana 18, 00184 Rome, Italy.*
[2] *Los Alamos National Laboratory, P.O. Box 1663, 87545 Los Alamos, NM, USA.*

The Info-Gap Decision Theory (IGDT) is here adopted to assess the robustness of a technique aimed at identifying the optimal excitation signal within a structural health monitoring (SHM) procedure. Given limited system response measurements and ever-present physical limits on the level of excitation, the ultimate goal of the mentioned technique is to improve the detectability of the damage increasing the difference between measurable outputs of the undamaged and damaged system. In particular, a 2 DOF mass- spring-damper system characterized by the presence of a nonlinear stiffness is considered. Uncertainty is introduced within the system under the form of deviations of its parameters (mass, stiffness, damping ratio...) from their nominal values. Variations in the performance of the mentioned technique are then evaluated both in terms of changes in the estimated difference between the responses of the damaged and undamaged system and in terms of deviations of the identified optimal input signal from its nominal estimation. Finally, plots of the performances of the analyzed algorithm for different levels of uncertainty are obtained, showing which parameters are more sensitive to the presence of uncertainty and thus enabling a clear evaluation of its robustness.

Nonlinear modeling and analysis of a vertical springless energy harvester

Mon.
15:50–15:10
R Toubkal

M. Bendame, E. Abdel-Rahman

University of Waterloo, 200 University Avenue, Waterloo, Ontario, Canada.

Harvesting energy from ambient sources has attracted the attention of researchers and scientists over the last few decades. While solar, thermal and wind energies have been exploited over the years, a new type of energy that has emerged in recent years, and is the subject of many research projects, is vibration energy harvesting. In this paper we will describe and analyze a recently proposed vibration energy harvester, namely the "Springless" vibration energy harvester. In this study, we will model and analyze the Springless vibration energy harvester in the vertical conguration. The vertically-aligned conguration is used when vibrations are predominantly in the vertical direction. Test results of a prototype model as well as results form a mathematical model describing the behavior of the harvester are presented. Test results show that the Springless energy vibration harvester

behaves as a softening nonlinear oscillator for excitations above 0:2g with its center frequency shifting to the right. Similar results were obtained using a mathematical model of the underlying impact oscillator.

Uncertainty analysis in the noise Parameters Estimation

Mon.
16:10–16:30
R Toubkal

W. Batko, P. Pawlik

AGH University of Science and Technology, Cracow, Poland

The new approach to the uncertainty estimation in modelling acoustic hazards by means of the interval arithmetic is presented in the paper. In the case of the noise parameters estimation the selection of parameters specifying the acoustic wave propagation in an open space as well as parameters which are required in a form of average values Ű often constitutes a difficult problem. In such case, it is necessary to determine the variance and then, related strictly to it, the uncertainty of model parameters. The application of the interval arithmetic formalism allows to estimate the input data uncertainties without the necessity of the determination their probability distribution, which is required by other methods of uncertainty assessment. A successive problem in the acoustic hazards estimation is a lack of the exact knowledge of the input parameters. In connection with the above, the analysis of the modelling uncertainty in dependence of inaccuracy of model parameters was performed. To achieve this aim the interval arithmetic formalism - representing the value and its uncertainty in a form of an interval Ű was applied. The proposed approach was illustrated by the example of the application the Dutch RMR SRM Method, recommended by the European Union Directive 2002/49/WE, in the railway noise modelling.

MS 2

Time-delayed feedback control: theory and application

Organizers: *B. Fiedler* Germany, *E. Schöll* Germany

Scheduled:

Monday *14:10–16:30* Hotel Albatros **Room Asni**

Chaos and synchronization in delayed system: Applications to laser networks

Mon. 14:10–14:30 R Asni

V. Flunkert[1], E. Schöll[2]

[1] *Instituto de Fisica Interdisciplinar y Sistemas Complejos, IFISC (UIB-CSIC), Campus Universitat de les Illes Balears, E-07122 Palma de Mallorca, Spain.*

[2] *Institut fur Theoretische Physik, Technische Universität Berlin, HardenbergstraSSe 36, 10623 Berlin, Germany.*

We discuss recent results on chaos synchronization of delayed systems. We investigate the limit of large coupling delays and discuss how in this limit the stability problem for the synchronized solution is drastically simplified. We use these results to derive rigorous conditions for chaos synchronization of all-optically coupled laser networks. In laser systems the optical coupling phases have to be taken into account and give rise to interference conditions. We show that the relative phases between lasers can be used to optimize the effective coupling matrix.

Destabilization of localized structures in Reaction-Diffusion systems induced by delayed feedback

Mon. 14:30–14:50 R Asni

S.V. Gurevich, R. Friedrich

Institut for Theoretical Physics, University of Münster, Wilhelm-Klemm-Str. 9, 48149 Münster, Germany.

We are interested in the stability of two-dimensional localized structures in reaction- diffusion systems subjected to a delayed feedback. We show that the presence of the delay can induce complex behavior of the localized structures, including, e.g., spontaneous motion or breathing of the localized objects. In the case of spontaneous motion, the corresponding order parameter equation for the position of the localized structure is derived. In addition, numerical simulations are carried out showing good agreement with the analytical predictions.

A. Azouani, M. Belhaq, A. Fahsi & M. Houssni, *International Conference on Structural Nonlinear Dynamics and Diagnosis* (CSNDD 2012).

The Effect of time-delay feedback controller on an electrically actuated resonator

Mon.
14:50–15:10
R Asni

S. Shao, K.M. Masri, M.I. Younis

Binghamton University, State University of New York PO BOX 6000 Binghamton, NY 13902-6000, USA.

This paper presents a study of the effect of a time-delay feedback controller on the dynamics of a Microelectromechanical systems (MEMS) capacitor actuated by DC and AC voltages. It is shown that negative time-delay feedback control gain can lead to an unstable system, even if AC voltage is relatively small compared to DC voltage. Perturbation method is utilized to present analytically the nonlinear dynamic characteristics of the MEMS capacitor. Agreements among the results of a shooting technique, long-time integration, basin of attraction analysis with the perturbation method are achieved.

Delay FitzHugh-Nagumo equations for modelling coupled neurons

Mon.
15:10–15:30
R Asni

A. Panchuk

Institute of Mathematics, NAS of Ukraine, Kyiv, Ukraine.

We consider a system of two interacting neurons, modeled by Fitzhugh-Nagumo type equations with delayed coupling and delayed feedback terms. The parameters are adjusted so that if coupling and feedback constants are zero, the considered system has the only stable fixed point, and thus, its dynamics is very simple and determinate. After switching on the coupling and the feedback, one can observe delay induced regular oscillations, as well as different bursting-type solutions. Furthermore, several stable solutions can coexist for the same parameter values entailing high level multi-stability. The appearance mechanisms and persistence conditions for these dynamical patterns are the main object of the current research.

Global analysis for a delay-distributed SIR epidemic model

Mon.
15:30–15:50
R Asni

A. Abta[1], M. El Fatini[2], A. Kaddar[3]

[1] *Université Chouaib Doukkali, FS, BP.20, El Jadida, Morocco*
[2] *Université Ibn Toufail, FS, LIRNE, EIM, BP. 133, Kénitra, Morocco.*
[3] *Université Mohammed V-Souissi, FSEJS, BP. 5285, Salé, Morocco.*

One of the most tools for describing the incubation period in the epidemiological dynamic models is the distributed delays. In this paper, we propose a distributed delayed SIR epidemic model with a nonlinear incidence rate. We show the global asymptotic stability of the disease-free and the endemic equilibria. This analysis extends and performs existing results.

Effect of time delay on vibroimpact dynamics in a forced Hertzian contact oscillator

Mon.
15:50–16:10
R Asni

L. Mokni, A. Bichri, M. Belhaq

Laboratory of Mechanics, University Hassan II-Casablanca, Morocco.

Vibroimpact dynamics of a forced single-sided Hertzian contact oscillator are typically initiated by jumps phenomena near resonances. It was shown that high-frequency excitations can be used to shift the threshold of such vibroimpacts toward higher or lower frequencies of the basic excitation depending on the type of the high-frequency excitation. These excitations not only produce a shift, but also soften the system behavior. The present paper investigates the effect of time delay state feedback on the threshold of vibroimpact dynamics of a forced Hertzian contact oscillator near the primary resonance. It is shown that for certain combinations of the gain parameters of delay state feedback, the jumps disappear leading the system to be maintained in contact when the excitation frequency sweeps through the resonance.

Qualitative Properties in a More General Delayed Hematopoietic Stem Cells Model

Mon.
16:10–16:30
R Asni

R. Yafia[1], M.A. Aziz-Alaoui[2]

[1] *Ibn Zohr University, Polydisciplinary Faculty of Ouarzazate, B.P: 638, Ouarzazate, Morocco.*
[2] *Laboratoire de Mathématiques Appliquées, 25 Rue Ph. Lebon, BP 540, 76058 Le Havre Cedex, France.*

In this paper, we consider a more general model describing the dynamics of Hematopoietic Stem Cells (HSC) model with one delay. Its dynamics are studied in terms of local stability and Hopf bifurcation. We prove the existence of the possible steady state and their stability with respect to the time delay and without delay. We show that a sequence of Hopf bifurcations occur at the positive steady state as the delay crosses some critical values. We illustrate our results by some numerical simulations.

MS 3

Identification and vibroimpact of systems

Organizers: *M. Hajj* USA, *A. Kareem* USA

Scheduled:

Monday *14:10–16:30* Hotel Albatros **Room Oukaimeden**

Experimental Identification of Concentrated Nonlinearity in Aeroelastic System

Mon.
14:10–14:30
R Oukaimeden

A. Abdelkefi[1], R. Vasconcellos[2], M. R. Hajj[1], A. H Nayfeh[1]

[1] *Department of Engineering Science and Mechanics, MC 0219, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061, USA.*
[2] *Laboratory of Aeroelasticity, University of São Paulo, São Carlos, Brazil.*

Identification of concentrated nonlinearity in the torsional spring of an aeroelastic system is performed. This system consists of a rigid airfoil that is supported by a linear spring in the plunge motion and a nonlinear spring in the pitch motion. A hardening cubic nonlinearity in the pitch moment is introduced to model the concentrated nonlinearity. The representation of the aerodynamic loads by the Duhamel formulation yielded accurate values for the flutter speed and frequency. For the identification of the cubic nonlinearity, numerical integrations are performed. The results show that the use of the Duhamel formulation to represent the aerodynamic loads yields excellent agreement between the experimental data and the numerical predictions.

Time History Forced Response in Nonlinear Mechanical Systems

Mon.
14:30–14:50
R Oukaimeden

K. Ahlin, A. Josefsson1, M. Magnevall

Blekinge Institute of Technology, Karlskrona, Sweden

A formulation of a digital filter method for computing the forced response of a linear MDOF mechanical system is proposed. It is shown how aliasing error effects can be avoided at the expense of a bias error. The bias error is however completely known and it is system independent, as it only depends on the sampling frequency used. The mechanical system is described by its modal parameters, poles and residues. The method is extended to include non-linear elements. A toolbox in MATLAB has been created where nonlinear elements with and without memory can be treated, as well as system described by coupled non-linear equations.

A. Azouani, M. Belhaq, A. Fahsi & M. Houssni, *International Conference on Structural Nonlinear Dynamics and Diagnosis* (CSNDD 2012).

Analysis of Passenger Ride Comfort

Mon.
14:50–15:10
R Oukaimeden

A. Sezgin, N. Yagiz

Mechanical Engineering Department, Istanbul University, Avcilar/Istanbul, Turkey.

In this study, the effect of vehicle vibrations on human beings is investigated. The computations were made with the help of a simulation program using a full vehicle model with driver and the results were evaluated using international ISO 2631 standard. The physical model of the investigated system is formed by a full-vehicle model and a driver. The road roughness is used as an input to the system and the responses are compared with the related standard. Finally, the results are discussed.

Modeling of nonlinear bridge aerodynamics and aeroelasticity: a convolution approach

Mon.
15:10–15:30
R Oukaimeden

T. Wu, A. Kareem

Nathaz Modeling Laboratory, University of Notre Dame, Notre Dame, IN 46556, USA.

Innovative bridge decks exhibit nonlinear behavior in wind tunnel studies which places increasing importance on the nonlinear bridge aerodynamics/aeroelasticity for long-span bridges. The convolution of firstorder kernels for linear analysis is first reviewed, based on which the convolution of higher-order kernels for nonlinear systems is introduced. A numerical example of a long-span suspension bridge demonstrates the accuracy and fidelity of the proposed scheme.

Use of stochastic optimization techniques for damage detection in complex nonlinear systems

Mon.
15:30–15:50
R Oukaimeden

R. Jafarkhani, S. F. Masri

Sonny Astani Department of Civil and Environmental Engineering, Viterbi School of Engineering, University of Southern California, Los Angeles, CA 90089-2531, USA.

In this study, the performance of stochastic optimization techniques in the finite element model updating approach was investigated for damage detection in a quarter-scale two-span reinforced concrete bridge system which was tested experimentally at the University of Nevada, Reno. The damage sequence in the structure was induced by a range of progressively increasing excitations in the transverse direction of the specimen. Intermediate non-destructive white noise excitations and response measurements were used for system identification and damage detection purposes. It is shown that, when evaluated together with the strain gauge measurements and visual inspection results, the applied finite element model updating algorithm on this complex nonlinear system could accurately detect, localize, and quantify the damage in the tested bridge columns throughout the different phases of the experiment.

Nonlinear responses of sloshing in square tanks subjected to horizontal random ground excitation

Mon.
15:50–16:10
R Oukaimeden

T. Ikeda[1], Y. Harata[1], R. A. Ibrahim[2]

[1] *Department of Mechanical Systems Engineering, Hiroshima University, 1-4-1 Kagamiyama, Higashi-Hiroshima, Japan, 739-8527*
[2] *Department of Mechanical Engineering, Wayne State University, Detroit, MI, USA, 48202*

Nonlinear responses of the predominant two sloshing modes in a square tank have been investigated when the tank is subjected to horizontal, narrow-band random ground excitation. Galerkin's method is applied to derive the modal equations of motion for nonlinear sloshing. Then the Monte Carlo simulation is used to calculate the mean square responses of these two modes. These to modes are nonlinearly coupled with each other, known as autoparametric interaction . The responses differ significantly from those of the corresponding linear model, depending on the characteristics of the narrow-band ground excitation such as the bandwidth, center frequency and the intensity. In addition, it is found that the direction of the excitation is a significant factor in predicting the mean square responses.

Intermittency in the case of a bouncing ball dynamic system induced by a Gaussian random restitution coefficient

Mon.
16:10–16:30
R Oukaimeden

J. Perret-Liaudet, Y. Kadmiri, E. Rigaud

Laboratoire de tribologie et dynamique des systèmes, UMR 5513, Ecole centrale de Lyon, membre de l'université de Lyon, Ecully, France.

A bouncing ball between two plates system with random restitution coefficients is analysed in this study. Some numerical results are reported, in particular focusing on the noise-induced intermittency phenomenon which is associated to the coexistence of a 1 T periodic response and a chaotic attractor observed for the deterministic case.

MS 4

Recent advances on nonlinear PDEs and their dynamics.

Organizers: *E.S. Titi* USA, *A. Azouani* Germany

Scheduled:

Monday	*17:00–19:20*	Hotel Albatros	**Room Toubkal**
Tuesday	*14:10–16:10*	Hotel Albatros	**Room Atlas**
Wedneday	*10:35–12:40*	Hotel Albatros	**Room Toubkal**

Feedback control of nonlinear dissaptive systems. A reaction-diffusion paradigm

Mon. 17:00–17:25 R Toubkal

A. Azouani[1], E.S. Titi[2,3]

[1] *Freie Universität Berlin, Institut für Mathematik I, Arnimallee 7, Berlin, Germany*
[2] *Department of Mathematics and Department of Mechanical and Aerospace Engineering, University of California, Irvine, CA 92697-3875, USA.*
[3] *TU Darmstadt, Germany*

The purpose of this talk is to present a general approach using all sorts of interpolant polynomials, and the notions finite numbers of of determining modes, nodes and volume elements to design finite-dimensional feedback control to stabilize the unstable solutions of a dissipative evolution nonlinear partial differential equations. We use the Chaffe-infante reaction-diffusion equation as a paradigm to fix ideas and to show that this abstract approach applies for the case of the Fourier modes, local volume element averages and nodal values to stabilize the zero steady state solution of this equation. Similar results are also valid for the Navier-Stokes equations. The same idea can be also extended to be implemented in data assimilation for weather prediction.

On a class of nonisothermal models for nematic liquid crystals

Mon. 17:25–17:50 R Toubkal

G. Schimperna[1], E. Feireis[2], A. Zarnescu[3], E. Rocca[4]

[1] *University of Pavia, Italy.*
[2] *Czech Academy of Sciences, Prague*
[3] *University of Sussex, UK.*
[4] *University of Milano, Italy.*

In this talk we will present a new class of models for nematic liquid crystal flows in the nonisothermal setting. The related equations describe the evolution of the vector variable u (macroscopic velocity of the flow, subject to the incompressibility constraint), of the absolute temperature ϑ, and of the variable $\mathbb{Q}$ representing the local orientation of the

liquid crystal. According to the so-called Q-tensor formulationproposed by de Gennes, $\mathbb{Q}$ is a 3×3 symmetric and traceless tensor. We will assume $\mathbb{Q}$ to be subject to a singular potential of Ball-Majumdar type, that forces the eigenvalues of Q to take values in the physical interval $(-1/3, 2/3)$.
In the first part of the talk we will introduce a general machinery, partly based on ideas due to M. Frémond, that permits to construct the models starting from the basic laws of Thermodynamics and Continuum Mechanics. Then, we will focus on mathematical results. In particular, we will prove existence of (at least) one weak solution for two different models (distinguished by the assumptions on the free energy and on the thermal conductivity). These results are valid in three dimensions of space and do not require any restriction on the magnitude on data and parameters. Due to the presence of quadratic terms in the right hand side, which cannot be controlled in the a-priori estimates, the heat equation has to be carefully managed. Actually, following an idea originally devised by Feireisl and Malek, this equation is replaced, in the weak formulation, by the total energy balance and by a differential inequality accounting for the entropy growth.

Existence and convergence of an MHD approximate deconvolution model

Mon.
17:50–18:10
R Toubkal

L.C. Berselli[1] , D. Catania[2] , R. Lewandowski[3]

[1] *Dipartimento di Matematica Applicata, Universita di Pisa, Via F. Buonarroti 1/c, I-56127 Pisa, ITALY*
[2] *Dipartimento di Matematica, Universitá di Brescia, Via Valotti 9, I-25133 Brescia, ITALY*
[3] *IRMAR, UMR 6625, Université Rennes 1, Campus Beaulieu, 35042 Rennes cedex FRANCE*

We consider a Large Eddy Simulation (LES) model for the equations of Magnetohydrodynamics (MHD). We study an $alpha$-model that is obtained by adapting to the MHD the approach by Stolz and Adams with van Cittert approximate deconvolution operators. We work with periodic boundary conditions and use the Helmholtz filter. We prove existence and uniqueness of a regular weak solution for a system with filtering and deconvolution in both equations. We show that when the deconvolution parameter goes to infinity, then the solution converges -in an appropriate sense- to the solution of the filtered MHD equations. These results can be extended to the problem with filtering acting only on the velocity.

All about blow-up for a semilinear wave equation in one space dimension

Mon.
18:50–19:15
R Toubkal

H. Zaag

CNRS, Université Paris 13, France.

We consider the semilinear wave equation with superlinear power nonlinearity in one space dimension, and prove all the blow-up features for this equation. In the first approach, we consider general blow-up solutions, and give their asymptotic behavior together with the regularity of their blow-up set. These two features are linked, and depend on the fact if we are near a characteristic or a non-characteristic point. In the second

approache, we give the first example of a blow-up solution having a characteristic point. This is a joint work with F. Merle. In a joint work with R. Côte, we further precise this construction. More precisely, given any integer $k \geq 2$, we construct a blow-up solution having a characteristic point, such that its asymptotic descripiton near blow-up shows a sum of k decoupled solitons with alternate signs.

On single mode forcing of the 2D Navier-Stokes equations

Mon.
19:15–19:40
R Toubkal

M. Jolly

Department of Mathematics, Indiana University, USA.

We examine how the global attractor of the 2-D periodic Navier- Stokes equations projects in the energy-enstrophy-plane when the force is an eigenvector of the Stokes operator. We find a sharper lower bound than that for a general force in [Dascaliuc et al., J. Dyn. Diff. Eq.,17, 2005], and derive semi-integral curves, which form the upper boundary in enstrophy. Along the way we find r egions of the plane in which the energy and enstrophy must decrease, and calculate the curvature of the projected solution at certain initial data. Finally, we obtain restrictions on solutions that project onto a single point in the plane. This is joint work with C. Foias and M. Yang.

On nonlinear dispersive equations in periodic structures: semiclassical limits and numerical schemes

Tue.
14:10–14:35
R Atlas

P. Markowich
Cambridge University, UK.

We discuss (nonlinear) dispersive equations, such as the Schrdinger equation, the Gross-Pitaevskii equation modeling Bose-Einstein condensation, the Maxwell-Dirac system and semilinear wave equations. Semiclassical limits are analysed using WKB and Wigner techniques, in particular for periodic structures, and connections to classical homogenisation problems for Hamilton-Jacobi equations and hyperbolic conservation laws are established. We present a new numerical technique for such PDE problems, based on Bloch decomposition, and show applications in semiconductor modelling, Bose-Einstein condensation and Anderson localisation for random wave equations.

Boundary layer analysis for certain classes of non-linear incompressible flows

Tue.
14:35–15:00
R Atlas

A. Mazzucato
Department of Mathematics, Penn State University McAllister Building University Park, PA 16802, U.S.A

We present recent results on the analysis of the vanishing viscosity limit and associated boundary layer in certain classes of non-linear 3D flows in pipes and channels.

A geometric classification of traveling front propagation in the Nagumo equation with cut-off

Tue.
15:00–15:25
R Atlas

Nicola Popovic

School of Mathematics, The University of Edinburgh Edinburgh, UK.

Reaction-diffusion systems are frequently employed in the continuum approximation of discrete (many-particle) models; however, the quality of this approximation deteriorates when the number of particles is not sufficiently large. The (stochastic) effects of this discreteness have been modeled via the introduction of (deterministic) "cut-offs" that deactivate the reaction terms whenever the particle concentration is below a certain threshold. We present an overview of the effects of such a cut-off on the front propagation dynamics in the classical Nagumo equation. Our analysis is based on the method of geometric desingularization ("blow-up"), in combination with dynamical systems techniques such as invariant manifolds and normal forms. In particular, our approach allows us to determine rigorously the asymptotics of the correction to the front propagation speed that is due to a cut-off. Moreover, it explains the structure of that asymptotics (logarithmic, superlinear, or sublinear) in dependence of the front propagation regime. Finally, it enables us to calculate the corresponding leading-order coefficients in the resulting expansions in closed form. The result is a joint work with Yuri Trakhinin (Novosibirsk).

About isentropic Euler equations with critical regularities

Tue.
15:25–15:50
R Atlas

T. Hmidi

Université de Rennes 1, Campus de Beaulieu, 35042 Rennes Cedex, France.

This paper is devoted to the study of the low Mach number limit for the isentropic Euler system with axisymmetric initial data without swirl. In the first part of the paper we analyze the problem correspond- ing to the subcritical regularities, that is H^s with $s > \frac{5}{2}$. Taking advantage of the Strichartz estimates and using the special structure of the vorticity we show that the lifespan T_ϵ of the solutions is bounded below by $\log\log\log\frac{1}{\epsilon}$, where ϵdenotes the Mach number. Moreover, we prove that the incompressible parts converge to the solution of the incompressible Euler system, when the parameter ϵ goes to zero. In the second part of the paper we address the same problem but for the Besov critical regularity $B^{\frac{5}{2}}_{2,1}$. This case turns out to be more subtle at least due to two facts. The first one is related to the Beale- Kato-Majda criterion which is not known to be valid for rough regularities. The second one concerns the critical aspect of the Strichartz estimate $L^1_T L^\infty$ for the acoustic parts : it scales in the space variables like the space of the initial data.

Stability of the Plasma-vaccum interface problem

Wend.
15:50–16:15
R Atlas

P. Secchi

Dipartimento di Matematica, Facoltà di Ingegneria, Università di Brescia Via Valotti, 9, 25133 Brescia, Italy.

In this talk we present a recent result about the free boundary problem for the plasma-vacuum interface in ideal compressible magnetohydrodynamics (MHD). In the plasma region the ow is governed by the usual compressible MHD equations, while in the vacuum region we consider the pre-Maxwell dynamics for the magnetic field. At the free-interface we assume that the total pressure is continuous and that the magnetic field is tangent to the boundary. The plasma density does not go to zero continuously at the interface, but has a jump, meaning that it is bounded away from zero in the plasma region and it is identically zero in the vacuum region. Under a suitable stability condition satisfied at each point of the plasma-vacuum interface, we prove the well-posedness of the linearized problem in conormal Sobolev spaces. The result is a joint work with Yuri Trakhinin (Novosibirsk).

Nonlinear a priori estimates for 3D incompressible current-vortex sheets

Wed.
10:35–11:00
R Toubkal

J.-F. Coulombel, A. Morando, P. Secchi, P. Trebeschi

Dipartimento di Matematica, Facoltà di Ingegneria, Università di Brescia Via Valotti, 9, 25133 Brescia, Italy.

We consider the free boundary problem for current-vortex sheets in ideal incompressible magneto-hydrodynamics. It is known that current-vortex sheets may be at most weakly (neutrally) stable due to the existence of surface waves solutions to the linearized equations. The existence of such waves may yield a loss of derivatives in the energy estimate of the solution with respect to the source terms. However, under a suitable stability condition satisfied at each point of the initial discontinuity and a flatness condition on the initial front, we prove an a priori estimate in Sobolev spaces for smooth solutions with no loss of derivatives. The result established gives some hope for proving the local existence of smooth current-vortex sheets without resorting to a Nash-Moser iteration. This would be a rigorous confirmation of the stabilizing effect of the magnetic field on Kelvin-Helmholtz instabilities, which is well known in astrophysics.

Existence of periodic solution for P-Laplacian neutral rayleigh equation with sign-variable coefficient of non linear term

Wed.
11:00–11:25
R Toubkal

A. Anane, O. Chakrone, L. Moutaouekki

Université Mohamed I, Faculté des Sciences, Département de Mathématiques et Informatique, Oujda, Maroc.

As p-Laplacian equations have been widely applied in field of the fluid mechanics and nonlinear elastic mechanics, it is necessary to investigate the periodic solutions of functional differential equations involving the scalar p-Laplacian. By using Mawhin's continuation theorem, we study the existence of periodic solutions for p-Laplacian neutral Rayleigh equation. It is meaningful that the functions c(t) and ?(t) are allowed to change signs in this paper, which are different from the corresponding ones of known literature.

Numerical ocean modelling: on structure-preserving discretizations and computational turbulence models

Wed.
11:25–11:50
R Toubkal

P. Korn

Max Planck Institute of Meteorology, Bundesstr. 55, 20146 Hamburg, Germany

One of the grand challenges in sciences is the understandig of the dynamics of the atmosphere/ocean/land system. In this talk we focus on the ocean component of the climate. Most of the numerical models of the global ocean rely on the so-called Primitive Equations , a set of equations consisting of the incompressible Navier-Stokes Equations with a free surface on a rotating sphere plus the hydrostatic and the Boussinesq approximation and coupled to PDE's that describe the evolution of the oceans temperature and salinity. In this talk we describe a numerical ocean model under development that discretizes the Primitive Equations on a so-called unstructured grid and, as such, is part of a new generation of numerical circulation models that operate on non-orthogonal grids. After having explained the challenges of abandoning orthogonality we describe our new structure-preserving discretization of the Primitive Equations. The grid is a Delaunay-Voronoi triangulation of the sphere which leads to a nearly uniform tesselation. The discretization is based on the method of mimetic-finite differences, it leads to a novel set of discrete equations. We describe the properties of our model, and illustrated it with results from global ocean simulations. Obtaining a specific discretization is not the end of the story. After having discretized the primitive equations of the ocean on a finite-resolution mesh we are facing the closure problem : how to include subgrid scale effects into the model ? In the second part of the talk we describe our experience with a nonstandard turbulence closure that is based on dispersive regularizations of the dynamical equations, the so-called α-model .

Sharp constants in the sobolev embedding theorem for the $L^\infty-$norm on the torus in one, two and three space dimensions

Wed.
11:50–12:15
R Toubkal

M.V. Bartuccelli[1], J.D. Gibbon[2]

[1] *Department of Mathematics, University of Surrey, Guildford, GU2 7XH, UK.*
[2] *Department of Mathematics, Imperial College, Queen's Gate, London SW7 2AZ, UK.*

Sharp estimates are obtained for the constants appearing in the Sobolev embedding theorem for the $L^\infty-$norm on the d?dimensional torus for d = 1, 2, 3. The sharp constants are expressed in terms of the Riemann zeta-function, the Dirichlet beta-series and various lattice sums. We then provide some applications including the two dimensional Navier-Stokes equations

MS 5
Nonlinear dynamics of MEMS-NEMS-AFM

Organizers: *M.I. Younis* USA, *F. Najar* Tunisia

Scheduled:

Monday	*17:00–19:20*	Hotel Albatros	**Room Asni**
Wednesday	*10:45–12:45*	Hotel Albatros	**Room Asni**

Subsurface imaging using atomic force acoustic microscopy at GHz frequencies

Mon. 17:00–17:20 R Asni

M. Büchsenschütz-Göbeler[1], Y. Luo[1], S. Hu[2], C. Su[1], W. Arnold[1,3], K. Samwer[1]

[1] *Physikalisches Institut, Universität Göttingen*
[2] *Nano Inc., Santa Barbara, CA, USA.*
[3] *Department of Materials, Saarland University.*

We describe a technique to image subsurface structures using Atomic Force Acoustic Microscopy operated at 1 GHz. The devices or samples to be imaged are insonified with 1 GHz ultrasonic waves which are amplitude modulated at a fraction or multiple frequency of cantilever contact-resonance [1]. The transmitted signals are demodulated by the nonlinear tip-surface interaction, enabling one to image defects in the device based on their ultrasonic scattering power which is determined by the ultrasonic frequency, the acoustic mismatch between the elastic properties of the host material and the defects, by their geometry, and by diffraction effects. We investigated defect structures in specially prepared samples, in silicon wafers as well as the cytoskeleton in living cells. Concerning the living cells we are interested to understand the contrast mechanism for imaging and the response to different substrate morphologies. Especially the interplay of cellular elasticity, adhesion and motility are brought into focus.

Financial support by the DFG SFB 937 is thankfully acknowledged.

Influence of tip-sample contact on vibration ring down of AFM cantilevers

Mon. 17:20–17:40 R Asni

J.A. Turner, E. Rezaei

Mechanical and Materials Engineering, University of Nebraska-Lincoln W342 Nebraska Hall, Lincoln, NE 68588-0526

Several material characterization techniques associated with the atomic force microscope (AFM) rely on the dynamics of the cantilever as it vibrates while in contact with the sample. In this talk, we focus on the ring down characteristics of an AFM cantilever that is excited with a short pulse while in contact with a sample. The equations of motion are first

derived and examined with respect to a linear viscoelastic contact. The response of the lowest several modes is illustrative of the linear contact. Next, the role of a nonlinear contact is examined with respect to the excitation amplitude, the temporal pulse width, and the applied static force. Finally, application of this analysis is discussed for a variety of materials including polymer blends and biological materials.

Effects of a high frequency harmonic voltage on the pull-in phenomenon in a capacitive MEMS

Mon.
17:40–18:00
R Asni

F. Lakrad, M. Belhaq

Laboratory of Mechanics, University Hassan II-Casablanca, Morocco

The pull-in instability is one of the main causes of capacitive MEMS failure. The main effects of a HF harmonic voltage on a 1 d.o.f. model of a movable electrode are: the shift of the resonance frequency and the delay of the pull-in instability. The effect of the HF voltage on the basin of attraction is also investigated.

Nonlinear dynamical analysis of an AFM tapping mode microcantilever beam

Mon.
18:00–18:20
R Asni

I. Manoubi[1], F. Najar[2], S. Choura[1], A.H. Nayfeh[3]

[1] *Micro Electro Thermal Systems Research Unit, National Engineering School of Sfax, University of Sfax, BP 3038, Sfax, Tunisia.*
[2] *Applied Mechanics and Systems Res. Lab, Tunisia Polytechnic School, University of Carthage, BP 743 La Marsa 2078, Tunisia.*
[3] *Dept. of Engineering Science and Mechanics, BMC 0219, Virginia Tech, Blacksburg, Virginia 24061, USA.*

We focus in this paper on the modeling and dynamical analysis of a tapping mode atomic force microscopy (AFM) microcantilever beam. This latter is subjected to a harmonic excitation of its base displacement and to Van der Waals and DMT contact forces at its free end. For AFM design purposes, we derive a mathematical model for accurate description of the AFM microbeam dynamics. We solve the resulting equations of motions and associated boundary conditions using the Galerkin method. We find that using one-mode approximation in tapping mode operating in the neighborhood of the contact region one-mode approximation may lead to erroneous results.

Frequency shift analysis and hysteresis suppression in contact-mode AFM using contact stiffness modulation

Mon.
18:20–18:40
R Asni

I. Kirrou, M. Belhaq

Laboratory of Mechanics, University Hassan II-Casablanca, Morocco

In this paper the frequency response shift and hysteresis suppression of contact-mode atomic forcemicroscopy is investigated using parametric modulation of the contact stiffness. Based on the Hertzian contact theory, a lumped single degree of freedom os-

cillator is considered for modeling the cantilever dynamics contact-mode atomic force microscopy. We use the technique of direct partition of motion and the method of multiple scales to obtain, respectively, the slow dynamic and the corresponding slow flow of the system. As results, this study shows that the amplitude of the contact stiffness modulation has a significant effect on the frequency response. Specifically, increasing the amplitude of the stiffness modulation suppresses hysteresis, decreases thepeak amplitude and produces shifts towards higher and lower frequencies.

Dynamics of a micro electrical mechanical system subject to thermoelastic and squeeze-Film damping

Mon.
18:40–19:00
R Asni

P. Belardinelli[1], M. Brocchini[1], L. Demeio[2], and S. Lenci[1]

[1] *DICEA, Polytechnic University of Marche, 60131 Ancona, Italy.*
[2] *DIISM, Polytechnic University of Marche, 60131 Ancona, Italy.*

The static and the dynamic behaviours of a MEMS subjected to thermoelastic and squeeze film effects have been investigated. Major attention is initially devoted to the modeling of this multi-physics system, including mechanical, electrical, thermoelastic and fluid dynamics behaviours, and their couplings. Then, static solutions have been obtained numerically by a finite-difference technique. Finally, an analysis of the vibrations is performed, and the complex natural frequencies are determined. The real part is related to the oscillatory behaviour, while the imaginary part provides the overall damping of the system.

Modeling and Design of an Electrically Actuated Resonant Switch

Wed.
10:45–11:05
R Asni

M. Jrad[1,3], M.I. Younis[2], and F. Najar[1]

[1] *Applied Mechanics and Systems Research Laboratory, Tunisia Polytechnic School, University of Carthage, BP 743, La Marsa 2078, Tunisia.*
[2] *Binghamton University, State University of New York PO BOX 6000 Binghamton, NY 13902-6000, USA.*
[3] *Department of Engineering Science and Mechanics, MC 0219, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061, USA.*

We present modeling and simulation of a new device concept of an electrically actuated resonant switch (EARS), which can be tuned to be triggered at low levels of acceleration, as low as those of earthquakes. The device is realized by mounting an electrostatically actuated cantilever microbeam with a mass at the tip on top of a compliant board or a printed circuit board PCB, which is modeled as a hinged-hinged beam. A distributed-parameter model of the device is derived for the microbeam and the PCB using Hamilton's principle based on the Euler-Bernoulli beam model. The equations are then discretized using the Galerkin procedure. A nonlinear numerical dynamic analysis is performed in order to characterize the behavior and performance of the device when subjected to acceleration pulses. We conduct a parametric study showing several curves of dynamic pull-in threshold for various values of electric voltage loads and frequency of excitations. We show that the device can be triggered at a wide range of acceleration ranging from 0.4g-200g for various values of the DC and AC voltages.

Theoretical and experimental investigation of the nonlinear response of an electrically actuated imperfect microbeam

Wed. 11:05–11:25 R Asni

L. Ruzziconi[1], A.M. Bataineh[2], M.I. Younis[2], S. Lenci[1]

[1] *Department of Civil and Building Engineering, and Architecture, Polytechnic University of Marche, 60131 Ancona, Italy.*

[2] *Department of Mechanical Engineering, State University of New York at Binghamton, Binghamton, 13902 NY, USA.*

In this study a theoretical and experimental investigation of the nonlinear response of an electrically actuated microbeam is performed. A mechanical model is proposed, which accounts for two common imperfections of microbeams, due to microfabrications, which are the compliant support conditions and the initially deformed profile. A computationally efficient single-mode reduced-order model is derived by combining the Ritz technique and the Padé approximation. Numerical simulations of the harmonic response of the device near primary resonance are shown illustrating nonlinear phenomena arising in the device response. Experimental investigation is conducted on a polysilicon imperfect microbeam confirming the simulation results. The concurrence between the theoretical results and the experimental data reveals that this model, while simple, is capable of properly capturing the response both at low and, especially, at higher electrodynamic voltages.

Bifurcations, basin erosion and dynamic integrity in a single-mode model of noncontact atomic force microscopy

Wed. 11:25–11:45 R Asni

V. Settimi, G. Rega

Dipartimento di Ingegneria Strutturale e Geotecnica, Università di Roma, La Sapienza, 00197 Rome, Italy

The nonlinear dynamical behavior of a single-mode model of noncontact AFM is analyzed in terms of attractors robustness and basin integrity. The model considered for the analyses, proposed by Hornstein and Gottlieb [7], consistently includes the nonlinear atomic interaction and the scan control, which appears as parametric excitation. Local bifurcation analyses are carried out to define the overall stability boundary in the excitation parameter space as the envelope of system local escapes, to be compared with the one obtained via numerical simulations. The dynamical integrity of the periodic bounded solutions is studied, and basin erosion is evaluated by means of IF and GIM integrity measures. The obtained erosion profiles allow us to dwell on the possible lack of homogeneous safeness of the stability boundary in terms of attractors robustness and to identify practical escape thresholds ensuring an a priori design safety target.

Nonlinear dynamics of nanoelectromechanical cantilevers based on nanowire piezoresistive detection

Wed.
11:45–12:05
R Asni

N. Kacem[1], S. Hentz[2], S. Baguet[3], R. Dufour[3]

[1] *FEMTO-ST Institute - UMR CNRS 6174, 24, chemin de l'Epitaphe, F-25000 Besancon, France.*
[2] *CEA/LETI - MINATEC, Grenoble, France.*
[3] *Université de Lyon, CNRS, INSA-Lyon, LaMCoS UMR5259, F-69621, Villeurbanne, France*

The nonlinear dynamics of in-plane nanoelectromechanical cantilevers based on silicon nanowire piezoresistive detection is investigated using a comprehensive analytical model that remains valid up to large displacements in the case of electrostatic actuation. This multiphysics model takes into account geometric, inertial and electrostatic nonlinearities as well as the fringing field effects which are significant for thin resonators. The bistability as well as multistability limits are considered in order to provide close-form expressions of the critical amplitudes. Third order nonlinearity cancellation is analytically inspected and set via an optimal DC drive voltage which permits the actuation of the NEMS beyond its critical amplitude. It may result on a large enhancement of the sensor performances by driving optimally the nanocantilever at very large amplitude, while suppressing the hysteresis.

Effects of a high-frequency harmonic voltage on the dynamic of MEMS and its basin of attraction

Wed.
12:05–12:25
R Asni

F. Lakrad, M. Belhaq

Laboratory of Mechanics, University Hassan II, Casablanca, Morocco.

The effects of a high-frequency harmonic voltage on a capacitive MEMS, initially actuated by a DC and a resonant AC voltages, are studied. We consider a single-degree-of-freedom equation modelling the movable electrode of the MEMS and we apply an averaging technique to derive the main equation describing the slow dynamic of the microstructure. It is shown that adding a high-frequency voltage can harden the system, shifts the main resonance and changes the global integrity measure of the basin of attraction. The effects on the pull-in instability are also discussed.

MS 6

Passive control of structures via nonlinear energy sinks

Organizers: *M. Luongo* Italy, *C.-H. Lamarque* France

Scheduled:

Monday *17:00–19:20* Hotel Albatros **Room Oukaimeden**

Aeroelastic instability analysis of NES-controlled systems via a mixed multiple scale/harmonic balance algorithm

Mon.
17:00–17:20
R Oukaimeden

A. Luongo, D. Zulli

DISAT - University of L'Aquila, Via Salaria Antica Ovest, 67100 L'Aquila (AQ) - Italy

The issue to passively control aeroelastic instability of general nonlinear multi-d.o.f. systems, suffering Hopf bifurcation, is addressed. The passive device consists of an essentially nonlinear oscillator (Nonlinear Energy Sink), having the task to transfer energy from the main to the secondary structure. The mathematical problem is attacked by a new algorithm, based on a suitable combination of the Multiple Scale and the Harmonic Balance Methods. The procedure is able to furnish the codimension-2 invariant manifold on which the motion occurs, thus revealing the passive character of the oscillations of the NES. The algorithm also provides the bifurcation equations, which govern the slow flow on the manifold, expressed in terms of the main structure amplitude and phase of motion. It is shown that NES, under suitable conditions, can shift forward the bifurcation point, and, moreover, it can reduce the amplitude of the limit cycles. Theory is applied to a sample structure already studied in literature, consisting of a two-d.o.f. rigid wing under steady wind. Relevant asymptotic results are compared, for validation purposes, with numerical simulations.

Analysis of a passive control of a chain under wide-band random excitation by nonlinear energy sinks using generalized orthogonal decompositions

Mon.
17:20–17:40
R Oukaimeden

S. Bellizzi[1], R. Sampaio[2]

[1] *Laboratoire de Mécanique et d'Acoustique, CNRS 31 chemin Joseph Aiguier, 13402 Marseille Cedex 20, France*

[2] *Departamento de Eng. Mecânica, PUC-Rio Rua Marquês de São Vicente, 225, 22453-900 Rio de Janeiro RJ*

The objective of this paper is to show how the generalized orthogonal decomposition named Smooth Decomposition (SD) can be used to analyze a passive control of structures under wideband random excitation by Nonlinear Energy Sinks (NES)[1]. Gener-

A. Azouani, M. Belhaq, A. Fahsi & M. Houssni, *International Conference on Structural Nonlinear Dynamics and Diagnosis* (CSNDD 2012).

alized orthogonal decompositions provide a powerful tool for random vibrations analysis. The most popular orthogonal decomposition is the Karhunen-Loève Decomposition (KLD). The KLD is a statistical analysis technique for finding the coherent structures in an ensemble of spatially distributed data. The set of structures (or KL modes) which are defined as the eigenvectors of the correlation matrix of the associated random field constitute an optimum basis in terms of energy. Recently, a modified decomposition, that is not orthogonal in the euclidean sense, named Smooth Decomposition (SD) has been proposed[2][3]. The SD can be view as a projection of an ensemble of spatially distributed data such that the vector directions of the projection not only keep the maximum possible variance but also the motions resulting along the vector directions are as smooth as possible in time. The vector directions (or structures or smooth modes) are defined as the eigenvectors of the eigenproblem defined from the correlation matrices of the random field and of the associated time derivative. It was shown that the SD is an interesting tool to random analysis. The parameters of the SD named the Smooth Modes, the Smooth Components and the Smooth Values can be interpreted in terms of normal modes and resonance frequencies given access to an modal analysis of the random problem. The control problem considered here consists of a chain of M strongly coupled linear oscillators (the primary system) with a strongly nonlinear end-attachment (the NES). This system was studied in [4] considering impulsive excitation. We propose here to analyze the targeted energy transfer from the linear chain to the NES when the excitation is random. This kind of excitation differs significantly from the deterministic case considered in [4] or [5]. We assume that a random force is applied to the primary system. This force is a gaussian white-noise scalar process with intensity s0. We have chosen a white-noise excitation because in terms of frequency contents, a white-noise excitation is similar to an impulsive excitation in the deterministic case, it permits to analyze the system without privileging a frequency band.

Delayed dynamical sytem strongly coupled to a nonlinear energy sink: application to machining chatter

Mon.
17:40–18:00
R Oukaimeden

E. Gourc[1], S. Seguy[1], G. Michon[2], A. Berlioz[3]

[1] *Université de Toulouse, INSA, ICA (Institut Clément Ader), F-31077, Toulouse, France.*
[2] *Université de Toulouse, ISAE, ICA (Institut Clément Ader), F-31055, Toulouse, France.*
[3] *Université de Toulouse, UPS, ICA (Institut Clément Ader), F-31062, Toulouse, France.*

This paper investigate the different response regimes of a cutting tool on a lathe strongly coupled to a nonlinear energy sink. The equations of motion are analysed via the method of multiple scales. Condition of elimination of secular terms permit to derive equation of the slow invariant manifold (SIM) and the behavior of the system has been explained by studying the location of the fixed points of the slow flow on the SIM. Different types of responses are revealed such as periodic response and also strongly modulated response (SMR) wich are not related to the fixed points of the slow flow. Analytic results are then compared to numerical simulations.

Energy partition oscillator and necessary and sufficient conditions of energy localization

Mon.
18:00–18:20
R Oukaimeden

V.N. Pilipchuk

Wayne State University, Detroit, Michigan, U.S.A.

A strongly nonlinear conservative oscillator describing the dynamics of energy partition between two linearly coupled Duffing oscillators is obtained. It behaves as a harmonic oscillator when the initial energy disbalance between the two interacting oscillators is small but it is gradually approaching the impact oscillator as the energy swing increases. The oscillator appeared to be exactly solvable in quadratures. As a result, the entire first order averaging system, describing the interaction of oscillators, admits exact analytical solution. Based on the first integral of the energy partition oscillator, explicit necessary and sufficient conditions of the energy localization are obtained.

Dynamics of a forced 2 dof piece-wise linear system by consideration of the weight

Mon.
18:20–18:40
R Oukaimeden

A.T. Savadkoohi[1], C.-H. Lamarque[1], Z. Dimitrijevic[2]

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[2] *PSA Peugeot Citroen Automobiles, DRIA/DSTF/MSMX, route de Gisy, F-78943 Vélizy-Villacoublay Cedex, France.*

Energy pumping phenomenon between a linear system and a non-smooth system by taking into account the weight of the system is studied. The system faces bifurcation when it reaches to its unstable border and then according to external forcing term it can follow lower stable branch or to face strongly modulated response by hysteresis jumps between its stable branches.

Passive control of resonances by nonlinear absorbers

Mon.
18:40–19:00
R Oukaimeden

J.W. Shao[1,2], B. Cochelin[1,2]

[1] *Laboratory of Mechanics and Acoustics (LMA), chemin Joseph-Aiguier, 13402, Marseille*
[2] *École Centrale Marseille (ECM), rue Frederic Joliot-Curie, 13451, Marseille*

A new passive technique of reducing vibration and noise using purely nonlinear absorbers is studied. Compared to classical passive systems (Frahmabsorbers, Helmholtz resonator), a single nonlinear absorber works in a limited range of forcing but in a wide band of frequency. In this paper, a simple system with two degrees of freedom is used to analyze the phenomenon of Targeted Energy Transfer (TET). We explain the beginning and ending of the TET phenomenon and define the zone of TET. Finally, an analytical formula of the level of forcing for the beginning of TET is established by a simplified approach.

The Nonlinear Tuned Vibration Absorber

Mon.
19:00–19:20
R Oukaimeden

R. Viguié, G. Kerschen

Space Structures and Systems Laboratory, Dept. of Aerospace and Mechanical Engineering, University of Liege, Belgium

The objective of this paper is to introduce a new nonlinear dynamical absorber, the nonlinear tuned vibration absorber, through a rigorous nonlinear extension of the tuning rule for the linear tuned vibration absorber. This nonlinear tuning methodology combined with the increased suppression bandwidth brought by the intentional use of nonlinearity leads to the development of an absorber that is effective in wide ranges of frequencies and motion amplitudes. The results are illustrated using a one-degree-of-freedom primary system.

MS 7
Hydrodynamic instability and Heat Transfer

Organizers: *S. Saravanan* France, *M. Hasnaoui* Morocco

Scheduled:

Tuesday *14:10–16:10* Hotel Albatros **Room Toubkal**

Nonlinear stability of a convective flow in an inclined channel

Tue.
14:10–14:30
R Toubkal

S. Saravanan, D. Brindha

Department of Mathematics, Bharathiar University, Coimbatore 641 046, Tamil Nadu, India

The energy method is employed to investigate the stability of a steady convective flow in a heat generating fluid arising due to the combined effect of buoyancy, shear and pressure gradient. By introducing a suitable generalized energy functional and using energy inequalities sufficient conditions for the existence of such a flow are found. An analysis through the variation principles is then made to find sharper limits for nonlinear stability. Comparisons are made with linear results in the literature.

Weak non-linear thermal instability under temperature modulation

Tue.
14:30–14:50
R Toubkal

B.S. Bhadauria

Department of Applied Maths and Statistics Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Rae Bareli Road, Lucknow-226025.

In this lecture I would like to talk about the weak non-linear thermal instability problem in a Newtonian fluid layer / porous layer saturated with fluid, confined between two horizontal surfaces, heated from below and cooled from above, and subjected to temperature modulation of the boundaries. Temperature modulation has been considered using sinusoidal function. Three types of time-periodic boundary conditions have been considered; the boundaries temperature is in phase, the boundaries temperature is out of phase or when only lower boundary temperature is modulated. The disturbance is expanded in terms of power series of amplitude of convection, which is assumed to be small. Using Ginzburg-Landau equation, the effect of modulation on heat and mass transport is analyzed. Effects of various constraints such as rotation, solute concentration, and magnetic field will also be discussed. Further effect of various parameters on the heat and mass transport will also be discussed and presented graphically.

A. Azouani, M. Belhaq, A. Fahsi & M. Houssni, *International Conference on Structural Nonlinear Dynamics and Diagnosis* (CSNDD 2012).

Effect of Horizontal Vibration on the Interfacial Instability in a Horizontal Hele-Shaw Cell

Thu.
14:50–15:10
R Toubkal

J. Bouchgl[1], S. Aniss[1], M. Souhar[2], O. Caballina[2]

[1] *University Hassan II Ain-Chock, Faculty of Sciences, Laboratory of Mechanics, Casablanca, Morocco.*
[2] *Lemta UMR CNRS 7563 Ensem, 2 avenue de la ForĹet de Haye, BP 160, Vandoeuvre L'es-Nancy 54504, France.*

The effect of periodic oscillations on the interfacial instability of two immiscible fluids, confined in a horizontal Hele-Shaw cell, is investigated. A linear stability analysis of the basic state leads to a periodic Mathieu oscillator corresponding to the amplitude of the interface. Then, the threshold of parametric instability of the interface is characterized by harmonic or subharmonic periodic solutions. We show that the relevant parameters that control the interface are the Bond number, density ratio, Weber number and amplitude and frequency of oscillations.

Hydromagnetic and Soret driving free convection in an inclined porous cavity saturated by a conducting binary mixture

Tue.
15:10–15:30
R Toubkal

A. Rtibi, M. Hasnaoui, A. Amahmmid

Cadi Ayyad University, Faculty of Sciences Semlalia, LMFE, Unit affiliated to CNRST (URAC 27) BP 2390, Marrakech, Morocco.

We consider the Soret convection in an inclined rectangular Darcy porous medium filled with an electrically conductive binary fluid. The long sidewalls of the porous cavity are subject to constant gradients of heat and submitted to a uniform and constant transversal magnetic field while its short sides are adiabatic and impermeable. An approximate analytical solution to the present problem, valid in the central part of the shallow cavity, is obtained on the basis of the parallel flow approximation and validated numerically using a finite-difference method. Results are presented in terms of streamlines, isotherms, iso-concentration lines, Nusselt and Sherwood numbers and separation of species for Hartmann number varying in the range [0, 20]. A good agreement is observed between the analytical predictions and numerical simulations.

Influence of the modulation of vibration amplitude on convective instability of reaction fronts in porous media

Tue.
15:30–15:50
R Toubkal

K. Allali[1], M. Belhaq[2]

[1] *Department of Mathematics, University Hassan II-Mohammedia Po. Box 146, FST-Mohammadia, Morocco.*
[2] *Department of physics, University Hassan II-Casablanca Po. Box 5366, Maarif, Casablanca, Morocco.*

This paper studies the influence of a periodic vibration with a frequency ν_1 on the convective instability of reaction fronts in porous media. Attention will be focused on the cases where the amplitude of this vibration is modulated either with a frequency 2 ν_1 or with

a frequency $\nu_{\frac{1}{2}}$. The model consists of the heat equation, the equation for the depth of conversion and the equations of motion under the Darcy law. The convective boundary is found to be depending on the frequency of the modulation. It is shown that a destabilizing effect of reaction fronts in a porous medium can be gained for a modulation frequency equal to half the frequency of the vibration, whereas a stabilizing effect is observed when the frequency of the modulation is double of that of the vibration.

Onset of vibrational convection in a binary fluid saturated non-darcy porous layer heated from above

Tue.
15:50–16:10
R Toubkal

T. Sivakumara, S. Saravanan

Department of Mathematics, Bharathiar University, Coimbatore 641 046, Tamil Nadu, India.

The study of thermal convection in a fluid layer with modulated gravitational field is an important class of problem in heat transfer. The effect of gravity modulation on a convectively stable configuration can significantly influence the stability of a system by increasing or decreasing its susceptibility to convection [1]. In our recent studies [2, 3], the stability of convection in a Brinkman porous layer in the presence of vibrations of arbitrary amplitude and frequency was considered. It was demonstrated that the vibration amplitude favors as well as suppresses the setting up of convection depending on the vibration frequency for the layer heated from below whereas it always favors convection irrespective of the frequency for the layer heated from above. Recently, Strong [4] investigated the vibrational thermosolutal convection in a horizontal Darcy porous layer and constructed the neutral curves for synchronous, subharmonic and quasiperiodic instability modes. More recently, Siddheshwar et al. [5] performed a weakly nonlinear analysis for this problem using Ginzburg-Landau equation in the presence of small amplitude oscillations. In the present study, our aim is to investigate the effect of vertical harmonic vibration on the onset of thermosolutal convection in a Brinkman porous medium heated from above for a wide range of modulation parameters.

MS 8

Complex Systems, Networks and Synchronization

Organizers: *M. A.. Aziz-Alaoui* France, *C. Bertelle* France

Scheduled:

Tuesday *14:10–16:10* Hotel Albatros **Room Asni**

Relation between synchronization of a ring of coupled Rössler systems and observability

Tue. 14:10–14:30 R Asni

A. Kerfourn[1], L. Laval[2], C. Letellier[1].

[1] *CORIA ŮUnviversité de Rouen, BP 12, F-76801 Saint-Etienne du Rouvray cedex, France.*
[2] *ENSEA, 6 avenue du Ponceau, 95014 Cergy-Pontoise cedex, France.*

It is shown how a lack of observability associated with the coupling variable can affect the resulting dynamics of a ring of Rössler systems, here investigated in a state sub-space of a local oscillator.

Synchronization and control of coupled reaction-diffusion systems of Fizhugh-Nagumo Type

Tue. 14:30–14:50 R Asni

B. Ambrosio, M. A. Aziz-Alaoui

Université du Havre, 25 Rue Philippe Lebon,76600 Le Havre

We consider a PDE FitzHugh-Nagumo Reaction-Diffusion type system (FHN). The dynamics of the reaction part induces a unique repulsive stationnary point (0; 0) and a unique attractive limit cycle for the trajectories of the ODE underlying system. After a description of the asymptotic behaviour of the PDE system (FHN) we deal with the synchronization and control analysis of two and three PDE systems of (FHN) type.

Complex Networks Dynamics

Tue. 14:50–15:10 R Asni

C. Bertelle[1,3], M.A. Aziz-Alaoui[2,3]

[1] *LITIS, University of Le Havre, 25 rue Ph. Lebon, B.P. 540, 76058 Le Havre cedex, France.*
[2] *LMAH, University of Le Havre, 25 rue Ph. Lebon, B.P. 540, 76058 Le Havre cedex, France.*
[3] *ISCN, University of Le Havre, 25 rue Ph. Lebon, B.P. 540, 76058 Le Havre cedex, France.*

This paper proposes a conceptual approach to study conceptual links in complex systems between dynamics, structure and control. Studies cases are presented and are developed, using a java library on dynamical graphs called GraphStream.

A. Azouani, M. Belhaq, A. Fahsi & M. Houssni, *International Conference on Structural Nonlinear Dynamics and Diagnosis* (CSNDD 2012).

Observers based digital synchronization for one sided Lipschitz non linear systems

Tue.
15:10–15:30
R Asni

M. Benallouch[1], M. Boutayeb[2]

[1] *CRP-HT, Luxembourg.*
[2] *Research Center of Automatic Control of Nancy UMR 7039, France.*

This note focuses on observers design for synchronization of one sided Lipschitz non linear systems. The later catch a large class of non linearities and may be seen as a general condition of the Lipschitz one. However, challenging problems arise such as relevant choice of the Lyapunov function or non convexity of the obtained stability conditions. In this work, the main contribution is to provide first some mathematical artifacts on the Lyapunov function to obtain simple and workable stability conditions; furthermore we show how to obtain Linear Matrix Inequalities (LMIs, convex conditions) to assure asymptotic convergence. High performances are shown through simulation results.

On the importance of Memristor Dynamics for the synchronization behavior of two HR Neutrons

Tue.
15:30–15:50
R Asni

F. Corinto[1], A. Ascoli[1], V. Lanza[2].

Institute of Engineering and Computational Machanics University of Stuttgart, Stuttgart, Germany

Networks made up of bio-inspired neuron oscillatory circuits connected through nanoscale memristors may achieve the highly parallel processing power of biological systems. Moreover, it has been shown that memristors also have potential to reproduce the behavior of a biological synapse. Our aim is to consider two Hindmarsh-Rose (HR) neurons, coupled via a memristor device, in order to mimic a biological synapse. We investigate how the dynamics of the memristor can in uence the syncronization properties of the network.

Topology identification and cluster synchronization in complex dynamical networks

Tue.
15:50–16:10
R Asni

J. Zhao[1], M. A. Aziz-Alaoui[2], C. Bertelle[3]

[1] *College of Mathematics and Computer Science, Wuhan Textile University, Wuhan, 430073, China.*
[2] *LMAH, FR-CNRS-3335 and ISCN, University of Le Havre, 76058, Le Havre Cedex, France.*
[3] *LITIS and ISCN, University of Le Havre, 76058, Le Havre Cedex, France.*

Topology identification of complex networks as well as cluster synchronization is an interesting issue in complex dynamical networks. In this paper, we study topology identification of complex networks and provided it for both complex networks with linear and nonlinear couplings. Adaptive laws are designed to achieve topology identification of complex networks. We found that topology identification is successful if persistently exciting condition is satisfied, and that the noise induces topology identification when this condition is not satisfied. We also study cluster synchronization of complex networks with nonidentical systems by input-to-state stability. Some sufficient conditions that en-

sure cluster synchronization of complex networks are provided. The increase of coupling strength inside clusters is very useful to achieve cluster synchronization; however, the coupling among clusters is an obstacle for cluster synchronization. Numerical simulations are given to validate our theoretical analysis.

MS 9

Bifurcations and chaos in mechanical-mechatronical systems

Organizers: *J. Awrejcewicz* Poland, *P. Hagedorn* Germany

Scheduled:

Tuesday *14:10–16:10* Hotel Albatros **Room Oukaimeden**

Bifurcation of contact between rotor and stator

Tue.
14:10–14:30
R Oukaimeden

O. Alber, R. Markert

Structural Dynamics, Darmstadt University of Technology, Petersenstr. 30, 64287 Darmstadt, Germany.

The paper discusses Bifurcation Diagrams of rotor stator contact problems and the transition from synchronous whirl towards different asynchronous movement patterns. Poincart'e Maps and Bifurcation Diagrams are presented for a Jeffcott rotor contacting a flexible mounted rigid stator ring to identify the type of motion as well as to describe the impact of changes of different parameters on the motion pattern and the transitions that result. These methods are applied systematically with respect to a plurality of motion patterns that have been observed in the past. From the studies a method for the unique identification of all motion patterns based on Bifurcation Diagrams and Poincart'eMaps is derived. Further insight on the conditions that lead to the change of motion patterns is given.

Analysis of regular and chaotic dynamics of multi-layered Timoshenko-type beams using wavelets

Tue.
14:30–14:50
R Oukaimeden

J. Awrejcewicz[1], O.A. Saltykova[2], M.V. Zhigalov[2], V.A. Krysko[2]

[1] *Department of Automation and Biomechanics, Technical University of Lodz, 1/15 Stefanowski Str, 90-924 Lodz, Poland.*

[2] *Department of Mathematics and Modeling, Saratov State Technical University, 410054 Saratov, Politehnicheskaya 77, Russian Federation*

In this work regular and chaotic dynamics of multi-layered Timoshenko-type-beams is studied putting emphasis on different boundary conditions [1-4]. The Timoshenko model allows us not only to describe various static and dynamic behaviors of beams/plates often exhibited by real construction members, but it is also governed by relatively simple differential equations. In what follows we construct a mathematical model of nonlinear dynamics of the multilayered beam using Timoshenko hypotheses. It should be emphasized that different layers may have various ratios of the shear modulus G and Young

A. Azouani, M. Belhaq, A. Fahsi & M. Houssni, *International Conference on Structural Nonlinear Dynamics and Diagnosis* (CSNDD 2012).

modulus E. For instance, for a boron-plastic material G / E =1/ 25, for a glass-plastic material G / E = 1/ 7 , for a graphite-plastic material G / E =1/ 40, and there are also materials having G / E =1/100 . Application of the Timoshenko model allows us to take into account a relatively low shear stiffness of beam layers. Investigation of the Timoshenko beams is carried out not only for different boundary conditions, but also it includes physical, geometric and design non-linearity. The reported approach and results extend earlier investigations of the authors [5,6], where the Euler-Bernoulli and Timoshenko one-layer beams have been investigated. Although in most cases one-layer beams have been investigated using FFT (Fast Fourier Transform), there are works putting emphasis on validity of the wavelet approaches [7]. In this report two main numerical approaches are applied to reduce an infinite problem to a finite one: FEM (Finite Element Method) and FDM (Finite Difference Method). Both validity and reliability of the obtained results are studied. For a proper detection of various transition scenarios from a regular to chaotic dynamics (and vice versa) of the studied Timoshenko multilayered beams, a rich tool of beams dynamic characteristics is applied including the FFT, wavelet-type analysis, Lyapunov exponents computation, the construction of Poincare maps and auto-correlation functions, and also the so called full vibration charts. A suitable wavelet choice among those of the Morlet and Gauss 1-8 wavelets is discussed and validated. Namely, it is shown that in the case of studied Timoshenko beams the Morlet wavelets are most useful. The Morlet wavelets allow for both detection and monitoring of various time evolutions of dynamic beam characteristics including frequency spectra, as it has been earlier proposed in reference [8]. A rich amount of the beam dynamical regimes (periodicity, sub- and super harmonic dynamics, quasi-periodicity, chaos and bifurcations) versus control parameters for the beam bending, beam displacements and its rotation angles have been reported. It allowed us to detect either classical or novel scenarios of transitions from the regular to chaotic dynamics. In particular, a typical vibration chart construction of beam vibration regimes using a plane of the excitation amplitude and frequency requires the analysis of 9000 various computational variants of solving ordinary differential equations for each pair of the two mentioned control parameters. Since the mentioned vibration charts are constructed for various sets of beams layers and their thicknesses, they enable controlling of the studied multi-layered beams in a parametric way.

Analysis of technical systems using Carleman linearization

Tu.
14:50–15:10
R Oukaimeden

E. Heffel, G. Spelsberg-Korspeter

TU Darmstadt, Germany.

According to an idea of Poincare nonlinear systems can be embedded in a higher dimensional linear space making available many nice features for the analysis. An overview about different mathematical aspects and several applications can be found in [1]. The method can be used to analyze autonomous and nonautonomous systems and can be used for free and forced vibrations within certain restrictions. The goal of this paper is to exploit the potential and limits of the method on concrete technical examples. In particular the method is useful to construct Liapounov functions for the accurate estimation of basins of attraction of solutions in nonlinear systems. Furthermore it allows studying classical problems such as the stability of systems with quasi periodic parametric excitation to arbitrary precision.

Using of a snap-through truss Absorber, in the attenuation of the Sommerfeld effect

Tue.
15:10–15:30
R Oukaimeden

W.R.A. de Godoy[1], J.M. Balthazar[2], B.R. Pontes Jr.[1], J.L.P. Felix[3]

[1] *UNESP, Department of Mechanics Engineering (FEB),Universidade Estadual Paulista, Brazil.*
[2] *UNESP, Department of Statistics, Applied Mathematics and Computation (DEMAC), Universidade Estadual Paulista, Brazil.*
[3] *UNIPAMPA, Federal University of Pampa, Brazil.*

This work, considers a vibrating system, which consists of a snap-through truss absorber (STTA) coupled to an oscillator, under excitation of an DC motor, with an eccentricity and limited power, characterizing a non-ideal oscillator (NIO). It is aimed to use the absorber STTA, to establish the conditions, that we have the maxim attenuation of the jump phenomenon (Sommerfeld Effect). Here, we are interested in determining the conditions of the vibrating system, in which there are reduced amplitudes of the oscillator, when it passes through the region of resonance.

Bifurcation analysis of nonlinear systems with periodic coefficients

Tue.
15:30–15:50
R Oukaimeden

D. Hochlenert

Chair of Mechatronics and Machine Dynamics, Technische Universität Berlin, Germany.

Self-excited vibrations arise in several technical systems. In many cases the self-excitation is due to a misrouting of energy actually supplied to maintain a steady operating state of the system. Examples are oscillations of rotors with inner damping and friction-induced vibrations of brakes or the directional stability of railway wheelsets. For numerous technical systems, the onset of the self-excited vibrations can usually be described by linear differential equations having constant or periodic coefficients. In these cases, the energy input is reflected in eigenvalues with a positive real part or in Floquet multipliers with modulus larger one. The linear analysis only indicates the onset of the self-excitation and predicts oscillations with exponentially growing amplitudes. The amplitudes are then limited by nonlinearities leading to limit cycles. However, in the case of subcritical Hopf or subcritical Neimark-Sacker bifurcations, the nonlinearities not only determine the amplitudes of the limit cycle but also result in multiple coexisting stable solutions. In fact, a stability analysis based on the linearized system can be misleading and should be completed by an investigation of the bifurcation. This paper is devoted to the analysis of the above mentioned nonlinear behavior of self-excited mechanical systems.

On a Control strategies to an energy harvester, using of a non-ideal and chaotic vibrating system, like device

Tue.
15:50–16:10
R Oukaimeden

I. Iliuk[1], J.M. Balthazar[2], A.M. Tusset[3], J.L.P. Felix[4], B.R. de Pontes Jr[1]

[1] *UNESP-São Paulo State University, Bauru, São Paulo, Brazil.*
[2] *UNESP-São Paulo State University, Rio Claro, São Paulo, Brazil.*
[3] *UTFPR- Paraná Federal Technological University, Ponta Grossa, Paraná, Brazil.*
[4] *UNIPAMPA-Pampa Federal University, Bagé, Rio Grande do Sul, Brazil*

In this paper, we deal with the research of a vibrating model of an energy harvester device, including of non-linearities, in the model of the piezoelectric coupling and the non-ideal excitation. We show, using numerical simulations, in the analysis of the dynamic responses, that the harvested power is influenced by non-linear vibrations of the structure. Chaotic behaviour was also observed, causing of the loss of energy throughout the simulation time. Using a perturbation technique, we find an approximate analytical solution for the non-ideal system. Then, we apply both two control techniques, to keep the considered system, into a stable condition. Both the State Dependet Ricatti Equation (SDRE) control as the feedback control by changing the energy of the oscillator, were efficient in controlling of the considered non-ideal system.

MS 10
Asymptotic methods in nonlinear dynamics

Organizers: *F. Lakrad* Morocco, *K.W. Chung* Hong Kong

Scheduled:

Thuesday *16:40–19:00* Hotel Albatros **Room Asni**

Asymptotic method for truely Non-Linear oscillator with time variable parameter

Tue. 16:40–17:00 R Asni

L. Cveticanin

Faculty of Technical Sciences, Trg D. Obradovica 6, 21000 Novi Sad, Serbia.

In this paper a new analytical method for solving the differential equation which describes the motion of an oscillator with polynomial or non-polinomial strong nonlinearity and slow-time variable parameter is introduced. The parameter variation is assumed to be a slow-time function, but not a periodical one. The analytical procedure suggested in the paper is based on the exact frequency of the oscillation for the corresponding oscillator with constant parameters. Using the first integral of motion for the oscillator with constant parameters the exact period of vibration in the form of the Euler beta function is obtained. Based on that value the solution of the strong nonlinear order differential equation with constant parameters is supposed in the form of a cosine trigonometric function. The approximate solution of the differential equation with time variable parameter is assumed in the aformentioned form, but with time variable amplitude and phase. Using the extended version of Krylov-Bogolubov the approximate solution is obtained. The suggested procedure is applicable for various polynomial and non-polynomial nonlinear terms, but also for the pure quadratic, cubic and quintic oscillators. The advantage of the suggested method is that is valid also for truely strong nonlinear oscillators of any order (the linear term does not exist) and with slow-time variable parameter and the accuracy of the approximate solution is very high as the period of vibration is very close to the exact one. The approximate solution of the differential equation which describes the vibration of such an oscillator is compared with exact numerical one and shows a good agreement.

Synthesis of multi-input Volterra systems by a topological assemblage scheme

Tue. 17:00–17:20 R Asni

L. Carassale[1], A. Kareem[2]

[1] *Dept. of Civil, Environmental and Architectural Engineering, University of Genova, Italy.*
[2] *NatHaz Modelling Laboratory, University of Notre Dame, IN, USA.*

The Volterra series expansion is widely employed to represent the input-output relationship of nonlinear dynamical systems. Such a representation is based on the Volterra

A. Azouani, M. Belhaq, A. Fahsi & M. Houssni, *International Conference on Structural Nonlinear Dynamics and Diagnosis* (CSNDD 2012).

frequency-response functions (VFRF), which can be calculated from the equation governing the system by the so-called harmonic probing method. This operation is straightforward for simple systems, may reach a prohibitive level of complexity for multiple-input systems when the calculation of a high-order VFRF is required. An alternative technique for the evaluation of the VFRFs of multiple-input systems is here presented generalizing an existing technique originally limited to the scalar case. A 2-dof mechanical example is used to illustrate the application of the technique.

On the Influence of the powers of a restoring and damping force on the response of a generalized Van der Pol oscillator

Tue.
17:20–17:40
R Asni

I. Kovacic

Department of Mechanics, Faculty of Technical Sciences, University of Novi Sad, 21215 Novi Sad, Serbia.

A generalized van der Pol type oscillator is considered in this work. Both the restoring force and the force related to a damping-like mechanism of a changeable sign have a nonlinear power form: the former with respect to the displacement, and the latter with respect to the displacement and velocity. First, it is investigated how the properties of a limit cycle depend on the values of the powers of nonlinearities for the case when the damping coefficient is small. Several different cases of the system parameters are considered and the corresponding limiting values of this amplitude are derived. Then, relaxation oscillations of the system with large values of the damping coefficient are analyzed. Depending on the values of the powers of the restoring and the damping force, three separate cases are distinguished related to the period of relaxation oscillations. The conditions under which this period decreases and increases are obtained, too.

Center manifold reduction of the Hopf-Hopf bifurcation in a time delay system

Tue.
17:40–18:00
R Asni

C. Heckman[1], J. Kotas[2], R. Rand[3]

[1] *Field of Theoretical and Applied Mechanics ; Cornell University ; Ithaca, NY USA.*
[2] *Department of Applied Mathematics ; University of Washington ; Seattle, WA USA.*
[3] *Department of Mathematics ; Cornell University ; Ithaca, NY USA.*
[4] *Department of Mechanical and Aerospace Engineering ; Cornell University ; Ithaca, NY USA.*

In this work, a differential delay equation with a cubic nonlinearity is analyzed as two parameters are varied by means of a center manifold reduction. This reduction is applied directly to the case where the system undergoes a Hopf-Hopf bifurcation, thereby giving rise to two separate modes of oscillation. In performing the reduction, the system is shown to exhibit quasiperiodic dynamics that are born out of the Hopf-Hopf bifurcation. This system has analogues in coupled microbubble oscillators.

A Novel construction of Homoclinic and Heteroclinic orbits in Nonlinear oscillators and a two-dimensional complex Ginzburg-Landau equation by a perturbation-incremental method

Tue.
18:00–18:20
R Asni

K-W. Chung[1], Y. Cao[1,2], J. Xu[3]

[1] *Department of Mathematics, City University of Hong Kong, Kowloon, Hong Kong.*
[2] *School of Mathematics and Computational Science, Sun Yat-sen University, Guangzhou 510275, P.R. China.*
[3] *School of Aerospace Engineering and Applied Mechanics, Tongji University, Shanghai 200092, P.R. China.*

Homoclinic and heteroclinic orbits (HOs) are of great importance in the study of chaotic behavior of dynamical systems and coherent structures in partial differential equations. The harmonic balance methods which are efficient in computing limit cycles of nonlinear oscillators have limitation in computing HOs since either it requires a large number of harmonic terms or the computation simply does not converge. In this talk, we introduce a novel construction of HOs using a perturbationincremental method. For small perturbation, accurate analytical solution of a HO can be obtained using a nonlinear time transformation. For arbitrary large value, an approximate solution expressed in terms of trigonometric functions can be obtained through an incremental process. As illustrative examples, we first consider planar oscillators with quadratic and cubic nonlinearities and show that only a few harmonic terms are enough to achieve high accuracy even for large parametric values. Next, we consider the coherent structures of a two-dimensional cubic Ginzburg-Landau equation. These coherent structures are relating to HOs in three-dimensional dynamical systems. Usually, the exact solutions are expressed in terms of Jacobi elliptic functions or hyperbolic functions. With our novel construction, such solutions are expressed in terms of trigonometric functions. This formulation not only reduces the computation effort but also can be extended to find solutions of the cubic-quintic Ginzburg-Landau equation.

Prediction of heteroclinic bifurcation in a Mathieu quadratic nonlinear oscillator near a 1:3 resonance

Tue,
18:20–18:40
R Asni

A. Fahsi[1], M. Belhaq[2]

[1] *University Hassan II-Mohammadia, FSTM, Mohammadia, Morocco.*
[2] *Laboratory of Mechanics, University Hassan II-Casablanca, Morocco.*

Analytical study of bifurcation of heteroclinic cycle in a Mathieu oscillator with quadratic nonlinearity is investigated near the $1:3$ resonance. This bifurcation mechanism, resulting from the disappearance of a stable slow flow limit cycle at the bifurcation point, gives rise to a frequency entrainment phenomenon. The analytical approach used to approximate this bifurcation is based on the collision criterion between the slow flow limit cycle and the three saddles involved in the bifurcation. The amplitudes of the subharmonic response and of the limit cycle are approximated and the collision criterion is applied leading to an explicit analytical condition of heteroclinic connection. Numerical simulations are performed and compared to the analytical finding for validation.

Dynamics of a rocking horizontal pendulum under high frequency excitation

Tue.
18:40–19:00
R Asni

S.M. Sah, B.P. Mann

Dept. of Mechanical Engineering and Material Science, Duke University, Durham, NC, 27708 USA.

In this work we investigate the dynamics of a pendulum positioned at a given distance from the platform. The effect of high frequency excitation on the pendulum is investigated. Two case were considered, one where the tilted angle of the platform is constant and the second case is when the angle varies periodically with time. In both cases the platform is subjected to high frequency excitation.

MS 11
Active vibration control and smart structures

Organizers: *L. Azrar* Morocco, *J.M. Bolthagas* Brasil

Scheduled:

Tuesday *16:40–19:00* Hotel Albatros **Room Asni**

Uncertainty quantification of piezoelectric energy harvesters from aeroelastic vibrations

Tue. 16:40–17:00 R Asni

A. Abdelkefi, M.R. Hajj, A. H Nayfeh

Department of Engineering Science and Mechanics, MC 0219, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061, USA.

A stochastic approach is presented to evaluate the uncertainties associated with variations in design parameters of a piezoaeroelastic energy harvester. The sensitivities of the harvested power to variations in the load resistance, the eccentricity (distance between the center of mass and the elastic axis), and the nonlinear coefficients are also determined. Moreover, the non-intrusive formulation of the polynomial chaos expansion in terms of the multivariate Hermite polynomials was employed to quantify the sensitivities in the harvested power and the plunge and pitch motions. The results show that the relationship between the input parameters and the harvested power is highly nonlinear. The results show also that the generated power is most sensitive to variations in the eccentricity and that the nonlinear coefficient of the plunge spring is less influential than the nonlinear coefficient of the torsional spring on the harvester's performance.

Quasi-static and static experimentations and their 3D finite element simulations of a piezoceramic d15 shear Ű induced direct torsion actuator

Tue. 17:00–17:20 R Asni

P. Berik[1], A. Benjeddou[2], M. Krommer[1]

[1] *Institute of Technical Mechanics, Johannes Kepler University Linz, Linz, Austria.*
[2] *LISMMA û Structures, Institut Supérieur de Mécanique de Paris, Saint Ouen, France.*

The objective of the present contribution is to perform static and quasi-static torsion actuation experimentations, using laser sensor and scanning laser vibrometer, of a cantilever smart beam with glass fiber-epoxy composite faces sandwiching a piezoceramic core d15 shear-induced torsion actuator composite of oppositely polarized two adjacent rows of eight patches assemblies. The quasi-static experiments are carried out on the experimental beam benchmark by applying different quasi-static AC voltages ranging from 35 to 195 V at 2 Hz for those using the laser scanning vibrometer and at 1Hz for the static torsion actuation ones using laser sensor. This benchmark test and corresponding 3D FE analysis results can serve for example for validating torsion actuation analytical solutions.

A. Azouani, M. Belhaq, A. Fahsi & M. Houssni, *International Conference on Structural Nonlinear Dynamics and Diagnosis* (CSNDD 2012).

Global semi-active vibration control: application to a piezostack-based active mount

Tue.
17:20–17:40
R Asni

T. Loukil, M. Ichchou, O. Bareille and M. Haddar

Ecole Centrale de Lyon, 36, avenue Guy de Collongue, France.

In this work, we address the vibration control of a suspended mass mounted on a piezostack-based active mount. An active controller with energy re-injection phases (by piezoelectric-based harvesters) called global semi-active controller is displayed. The principle of the control strategy is to extract the energy of the vibrations, convert it into electric energy and store it in accumulators. Based on the energy amount available in the accumulators, the controller switches between the active scheme (if the energy is sufficient) and the semi-active one (if not) and this by switching to the energy harvesting phase. The control performances of the suspended mass acceleration for the global semi-active control scheme show a switching between two vibration reduction levels: high performances when the active scheme is displayed and lower when only energy harvesting phase is addressed. But, globally, these performances are approaching those of the active ones. The stored energy evolution is also investigated and confirms the reduced power requirement of the controller since increasing with time.

Multi-coated magnetoelectroelastic composites with functionally graded interphases

Tu.
17:40–18:00
R Asni

A. Bakkali[1], L. Azrar[1,2], A. Al Junaidi[2]

[1] *Faculty of Sciences and Techniques of Tangier, University Abdelmalek Essaâdi; Tangier; Morocco.*
[2] *Faculty of Engineering, King Abdul Aziz University, Jeddah, Saudi Arabia.*

The aim of this work is to develop a micromechanical modeling to predict the effective properties of multi-coated magnetoelectroelastic composites with functionally graded interphases. The localization equations are derived based on the integral equation and on the interfacial operators. Magnetoelectroelastic composites with functionally graded interphases are analyzed and the effective properties are obtained. Based on different micromechanical models, the effects of the volume fractions, shapes of the multi-coated inclusions, thickness of the coatings and graded interphase on the effective properties are deeply analyzed.

Camber Effects on the Power Harvesting from Piezoaeroelastic Systems

Tue.
18:00–18:20
R Asni

A. Abdelkefi[1], A. Nuhait[2], A.H. Nayfeh[1], M.R. Hajj[1]

[1] *Department of Engineering Science and Mechanics, MC 0219, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061, USA.*
[2] *Mechanical Engineering Department, King Saud University, Riyadh 11421, Saudi Arabia.*

We investigate the effects of the aerodynamic loads on the performance of piezoaeroelastic energy harvesters. The harvester consists of a rigid airfoil having a pitch and plunge degrees of freedom with a piezoelectric coupling attached to the plunge degree of free-

dom. The Unsteady Vortex Lattice Method is used to model the unsteady flow and predict the loads. An iterative scheme based on HummingŠs fourth order predictor-corrector method is employed to solve simultaneously and interactively the governing equations. The effects of varying the airfoil camber coefficient are determined. We demonstrate that increasing the camber does not necessarily increase the level of the harvested power.

Fuzzy control of rotor system using an electromagnetic actuator

Tue.
18:20–18:40
R Asni

E.H. Koroishi[1], V. Steffen Jr[1], J. Mahfoud[2]

[1] *Federal University of Uberlândia (UFU) - School of Mechanical Engineering - Campus Santa Mônica, Av. João Naves de Àvila 2121, Bloco 1M, Uberlândia, MG, Brazil, ZIP CODE 38400-902.*
[2] *Lyon University, LAMCOS, INSA de Lyon, 20, Av. Albert Einstein, 69629 Villeurbanne, France.*

In recent years, a number of new methods dedicated to acoustic and vibration attenuation have been developed and proposed aiming at handling several types of engineering problems related to the dynamic behavior of the system. This is mainly due to the demand for better performance and safer operation of mechanical systems. There are various types of actuators available. The present contribution is dedicated to the electromagnetic actuator (EMA). EMA uses electromagnetic forces to support the rotor without mechanical contact. Due to the size of the system model, it was necessary to reduce the model of the rotating system. EMA is represented by a nonlinear model, which justifies the use of Fuzzy Logic Control. The results obtained with nonlinear model are compared with the linear model of the actuator. In the linear case, the controllers are designed for two situations, namely H^{∞}-norm and LQR, solved by LMIs in both cases. These techniques are able to take into account uncertainties in the system. In the control, the nonlinear electrodynamics forces of the actuators are considered as containing uncertainties. Simulation results demonstrate the effectiveness of the methodology conveyed.

Dynamic instability analysis of single walled Carbone nanotube conveying fluid with generalized boundary conditions

Tue.
18:40–19:00
R Asni

A. Azrar[1], L. Azrar[1,2], A.A. Aljinaidi[2]

[1] *MMC, FST of Tangier University Abdelmalek Essaadi, BP 416, Tangier, Morocco.*
[2] *Mechanical Engineering Department, King Abdulaziz University, Jeddah, Saudi Arabia.*

The dynamic instabilities of Carbon NanoTubes (CNTs) conveying fluid are modelled and numerically simulated based on the nonlocal elasticity theory. The small scale parameter and the fluid-tube interaction effects on the dynamic behaviors of the CNT-fluid system as well as the instabilities induced by the fluid-velocity are investigated. The critical fluid-velocity and frequency-amplitude relationships as well as the flutter and divergence instability types and the associated time responses can be obtained based on the presented methodological approach.

MS 12
Nonlinear dynamics of systems

Organizers: *R. Benamar* Morocco, *S. Glavatskih* Belgium

Scheduled:

Tuesday *16:40–19:20* Hotel Albatros **Room Oukaimeden**

Vibration response of a railway track obtained using numerical models based on FEM

Tue. 16:40–17:00 R Oukaimeden

A. Zougari, J.M. Miralles, S.C. Foix

Universitat Politècnica de Catalunya, Mechanical Engineering Department, Av. Diagonal 647, 08028 Barcelona, Spain

In the last forty years, researchers have developed models of wheel-rail contact force in order to study vibrations and rolling noise caused by railway traffic. These models range from analytical models, who consider a single rail of a railway track in contact with a rigid wheel attached to the bogie by means of the primary suspension, to numerical models based on finite element methods, boundary element, and mixed methods. Unlike analytical models, numerical models allow us to characterize more precisely the different components of railway track structure and consider the interaction between the entire track and a complete vehicle wheel-set. The study of the various elements constituting the set of the railway track, the wheel-set and the primary suspension, as well as the knowledge of their influence in vibration generation and transmission due to train passage is of great interest when evaluating the possible vibration effects in the railway surrounding areas. This paper presents a numerical model of the track structure based on the finite element method. It is devoted to the study of the vibration response caused by vertical forces applied at any location on the rails. The numerical results are compared with analytical results previously presented and developed in the bibliography.

A reduced order model for nonlinear vibroacoustic problems

Tue. 17:00–17:20 R Oukaimeden

Y. Gerges[1], M. Guedri[2], E. Sadoulet-Reboul[1], M. Ouisse[1], N. Bouhaddi[1]

[1] *Institut FEMTO-ST - Département de Mécanique Appliquée - 24 Chemin de l'Epitaphe - 25000 Besançon - France.*

[2] *Institut préparatoire aux études d'ingénieurs de Nabeul (IPEIN) - Groupe Dynamique des Structures - 8000 Mrezgua - Nabeul Tunisie.*

This work is related to geometrical nonlinearities applied to thin plates coupled with fluid-filled domain. Model reduction is performed to reduce the computation time. Reduced order model (ROM) is issued from the uncoupled linear problem and enriched with residues

to describe the nonlinear behavior and coupling effects. To show the efficiency of the proposed method, numerical simulations in the case of an elastic plate closing an acoustic cavity are presented.

Large amplitude free vibration analysis of functionally graded beams using an homogenisation procedure

Tue.
17:20–17:40
R Oukaimeden

K. EL Bikri[1], A. Zerkane[1], R. Benamar[2]

[1] *ENSET-Rabat, Mechanical Engineering Department, La MIPI, B.P. 6207, Rabat Instituts, Université Mohammed V, Souissi, Rabat, Morocco.*
[2] *EMI, EGT, LERSIM, Agdal Université Mohammed V-Souissi, Rabat, Morocco.*

The purpose of the present paper is to show that the problem of geometrically non linear free vibrations of functionally graded (FG) beams with immovable ends can be reduced to that of isotropic homogeneous beams with effective bending stiffness and axial stiffness parameters. The material properties of the functionally graded composites examined are assumed to be graded in the thickness direction and estimated through the rule of mixture. The theoretical model is based on the Euler-Bernouilli beam theory and the Von Kármán geometrical nonlinearity assumptions. An homogenization procedure is developed using the governing axial equation of the beam in which the axial inertia and damping are ignored. HamiltonŠs principle is applied and a multimode approach is derived to calculate the fundamental nonlinear frequency parameters, which are found to be in a good agreement with the published results. The non-dimensional curvatures associated to the nonlinear fundamental mode are also given in the case of clamped-clamped FG beams.

The effects of large vibration amplitudes on the mode shapes and natural frequencies of thin isotropic skew plates

Tue.
17:40–18:00
R Oukaimeden

H.M. Abdelali[1], K. El Bikri[2], R. Benamar[1]

[1] *EMI, Université Mohammed V-Agdal, Rabat, LERSIM, Morocco.*
[2] *ENSET, Université Mohammed V-Souissi Rabat, LaMIPI, Morocco.*

The present work concerns the nonlinear dynamic behavior of skew plates at large vibration amplitudes with fully clamped edges. The large amplitude free vibration problem is modeled by a set of non-linear algebraic equations using HamiltonŠs principle and spectral analysis. The natural frequencies and modes of vibration have been obtained for fully clamped edges for various values of the skew angle. The relationship between the amplitude and frequencies is studied for isotropic skew plates. It was found that the frequencies of non linear vibration increase with increasing amplitude. Numerical details are presented and results are given, corresponding in the linear case and to the non linear case for various values of θ and various amplitudes of vibration. The results, compared to the previous ones available, show a reasonably good agreement.

Nonlinear dynamic response of compliant journal bearings

Tue.
18:00–18:20
R Oukaimeden

M. Cha[1], S. Glavatskih[2]

[1] *The Royal Institute of Technology, Department of Machine Design, 100 44 Stockholm, Sweden.*
[2] *Ghent University, Department of Mechanical Construction and Production, 9000 Ghent, Belgium.*

This paper investigates the dynamic response of the compliant tilting pad journal bearings subjected to synchronous excitation. Bearing compliance is affected by the properties of pad liner and pad support geometry. Different unbalance eccentricities are considered. It is shown that bearing dynamic response is non-linear. Journal orbit complexity increases with pad compliance though the orbit amplitudes are marginally affected at low loads. At high loads, the journal is forced to operate outside the bearing clearance. The polymer liner reduces the maximum oil film pressure by a factor of 2 when compared to the white metal liner. The nonlinear dynamic response of compliant tilting pad journal bearings is thoroughly discussed.

Experimental validation of a new magnetic method applied to diagnose a low voltage breaker arc

Tue.
18:20–18:40
R Oukaimeden

N. Machkour[1], E. Kheddioui[2], A. Bourjillate[2]

[1] *Ecole National des Arts et Métiers de Casablanca, Université Hassan II - B.P. 150 - Mohammedia, Maroc.*
[2] *Laboratoire d'Opto-électronique, Analyse Optique et Simulation, Université Hassan II - B.P. 150 - Mohammedia, Maroc.*

In this paper, we present an original method, which allows reconstructing the current density in a low voltage breaker arc. This method is based on the deconvolution of magnetic induction measurements and a function depending on the experimental device geometry. For this study, we propose to use an iterative deconvolution method using minimisation by gradient.

Solution of internal erosion equations by asymptotic expansion

Tue.
18:40–19:00
R Oukaimeden

F. Yakhlef[1], A. Khamlichi, M. Bezzazi[1], M.A. Parron Vera[2], P. Dubujrt[3]

[1] *Laboratory MAS, Faculty of Sciences, Tetouan, Morocco.*
[2] *High Polytechnic School of Algeciras, University of Cadiz, Spain.*
[3] *Laboratory LTDS, University of Lyon, Saint-Etienne, France.*

One dimensional coupled soil internal erosion and consolidation equations are considered in this work for the special case of well determined sand and clay mixtures with a small proportion of clay phase. An enhanced modelling of the effect of erosion on elastic soil behavior was introduced through damage mechanics concepts. A modified erosion law was proposed. The erosion phenomenon taking place inside the soil was shown to act like a perturbation affecting the classical soil consolidation equation. This interpretation has enabled considering an asymptotic expansion of the coupled erosion

consolidation equations in terms of a perturbation parameter linked to the maximum expected internal erosion. A robust analytical solution was obtained via direct integration of equations at order zero and an adequate finite difference scheme that was applied at order one.

Liquefaction of tangier soils by using physically based reliability analysis modelling

Tue.
19:00–19:20
R Oukaimeden

N. Touil[1], A. Khamlichi[2], A. Jabbouri[1], P. Dubujrt[3]

[1] *Laboratoire MGC, FST Tanger, Morocco.*
[2] *Laboratoire MAS, FS Tétouan, Morocco.*
[3] *Université de Lyon, Lyon, France.*

Approaches that are widely used to characterize propensity of soils to liquefaction are mainly of empirical type. The potential of liquefaction is assessed by using correlation formulas that are based on field tests such as the standard and the cone penetration tests. These correlations depend however on the site where they were derived. In order to adapt them to other sites where seismic case histories are not available, further investigation is required. In this work, a rigorous one-dimensional modelling of the soil dynamics yielding liquefaction phenomenon is considered. Field tests consisting of core sampling and cone penetration testing were performed. They provided the necessary data for numerical simulations performed by using DeepSoil software package. Using reliability analysis, the probability of liquefaction was estimated and the obtained results were used to adapt Juang method to the particular case of sandy soils located in Tangier.

MS 13
Multiscale, fast slow dynamics and applications

Organizers: *J. Starke* Denmark, *P.G. Hjorth* Denmark

Scheduled:

Wednesday *10:45–12:45* Hotel Albatros Garden **Room Oukaimeden**

Geometric singular perturbation theory beyond the standard form

Wed. 10:45–11:05 R Oukaimeden

P. Szmolyan

Institut für Analysis und Scientific Computing, Technische Universität Wien, Wiedner Hauptstraße 8-10, 1040 Wien.

In many differential equation models multiple time scale dynamics occurs due to the presence of variables and parameters of very different orders of magnitudes. Situations with a clear "global" separation into fast and slow variables governed by singularly perturbed ordinary differential equations in standard form have been investigated in great detail during the last decades. However, many problems arising in applications are not of this standard form. For multi-scale problems depending on several parameters it can already be a nontrivial task to identify meaningful scalings. Typically these scalings and the corresponding asymptotic regimes are valid only in certain regions in phase-space or parameter-space. Another issue is how to match these asymptotic regimes to understand the global dynamics. In this talk I will show in the context of selected examples that geometric methods based on invariant manifold theory and in particular the blow-up method provide a powerful approach to problems of this type.

Continuation and bifurcation analysis in mechanical experiments

Wed. 11:05–11:25 R Oukaimeden

J. Starke, E. Bureau, I. Santos, F. Schilder, J. Thomsen.

Technical University of Denmark, Department of Mathematics.

Information about the bifurcation structure of experiments is very useful for many purposes. First, for the process of mathematical modelling and model verification a comparison of the bifurcations results in a much more demanding test than just comparing solutions of models with data from time-series for selected parameter values. Second, for cases where closed mathematical equations are not yet known, experimentally obtained bifurcation diagrams help to find parameter regions where a reliable operation mode with a specific qualitative behaviour is possible. A control based continuation method is used and further developed to perform a bifurcation analysis directly for a mechanical experiment. As example, we consider the vibration analysis of a nonlinear driven pendulum with impacts. The frequency responses are directly tracked in the experiments by apply-

ing a control force to the system under investigation, and using a predictor-corrector type path-following algorithm to systematically trace out branches of the bifurcation diagram. This allows to observe also unstable solution branches as the control locally stabilizes the system states.

Wave propogation in excitable media through randomly distributed heterogeneties; Stimulation and comparison to the effective medium theory

Wed.
11:25–11:45
R Oukaimeden

S. Alonso, M. Bär

Physikalisch-Technische Bundesanstalt, Abbestrasse 2-12, 10587 Berlin, Germany.

The propagation of traveling waves in excitable media with randomly distributed di?usion coefficient and excitation properties is studied. If the characteristic size of the waves is much larger than the heterogeneity size an effective medium theory based on a self-consistent homogenization approach can be applied. The random distribution of the medium properties is produced by domains of two phases. In each phase the values of the diffusion coefficient and reaction rate are different. The characteristic size of the domains of the two phases is varied in the numerical simulations. The resulting velocities of the traveling waves found by numerical simulations of the random media are compared with the predictions of the effective medium theory. For large size of the heterogeneities in comparison with the diffusion length of the reaction-diffusion system the numerical results show deviations with respect to the predictions.

A Closed Form Expression for Predicting Fast Scale Instability in Switching Buck Converters

Wed.
11:45–12:05
R Oukaimeden

A. El Aroudi.

GAEI research group, Dept. d'Enginyeria Electrònica, Elèctrica i Automàtica, Universitat Rovira i Virgili, 43007, Tarragona, Spain.

Fast scale instability is an undesired phenomenon in switching converters. In past studies, its prediction has been mainly carried out by deriving discrete time models and then linearizing the system in the vicinity of a fixed point. However, the results obtained from such an approach cannot be applied for design purpose except for simple cases of current mode control. Alternatively, in this paper, this phenomenon is analyzed by using a unified formal symbolic approach which can be applied for different control strategies. This approach is based on expressing the condition for fast scale instability occurrence using Fourier series and then converting the result into a matrix form expression which depends explicitly on the system parameters making the results directly applicable for design purpose. Under certain practical conditions concerning these parameters, the matrix form expression can be approximated by standard polynomial functions depending on the operating duty cycle. The approximating polynomial functions are widely related to the well known Clausen polynomial functions. The results presented in this work clearly generalize the well known stability condition of current mode control.

Control and synchronisation of chaotic oscillators with time-delayed couplings

Wed.
12:05–12:25
R Oukaimeden

H. Benner

TU Darmstadt, Germany.

Two identical chaotic oscillators that are mutually coupled via time delayed signals show very complex patterns of completely synchronized dynamics including stationary states and periodic as well as chaotic oscillations. We have experimentally observed these synchronized states in delay-coupled electronic circuits and have analyzed their stability by numerical simulations and analytical calculations. We found that the conditions for longitudinal and transversal stability largely exclude each other and prevent e.g. the synchronization of Pyragas-controlled orbits. Most striking is the observation of complete chaotic synchronization for large delay times, which should not be allowed in the given coupling scheme on the background of the actual paradigm.

Analysis of oscillations in pedestrian crowds

Wed.
12:25–12:45
R Oukaimeden

P.G. Hjorth

Technical University of Denmark, Department of Mathematics.

We model oscillations in a crowd of pedestrians as particles interacting through pairwise "social forces". The pedestrians move in a corridor where they are constrained by the walls of the corridor, and from both directions attempt to pass through a narrowing doorway perpendicular to the corridor. Several interesting types of collective behavior are observed, among them formation of lanes, and, as the width of the doorway is increased, a Hopf bifurcation into slow oscillations of net pedestrian flux through the doorway. Using an equation-free analysis approach we quantify through simulations the low dimensional (macroscopic) behavior of the system, the identification of the Hopf bifurcation, and we perform a numerical continuation of the bifurcation point to neighboring parameter values.

MS 14
Posters

Scheduled:

Monday	*16:30–17:00*	Hotel Albatros Garden
Tuesday	*16:10–16:40*	Hotel Albatros Garden

The effect of compression steel on ductility of unconfined reinforced concrete beams

Mon.
16:30–17:00
R Ourika

R. Abdel-Karim, I.M.A. Mahmoud

An-Najah National University Nablus-Palestine.

The primary objective of the following study is to numerically investigate and to report the effect of compression steel on ductility of unconfined reinforced concrete flexural elements. A computer program was written to calculate the curvature and to plot the relation between curvature and related yield and ultimate moments on reinforced concrete beams. Three identical beams are considered but with different reinforcement patterns; it is shown that the beam with compression steel showed considerable increase in its ductility. The three numerical examples are thus presented.

Thermal energy storage system with heat external source

Mon.
16:30–17:00
R Ourika

B. Abouelkhayrat, A. Oubarra, J. Lahjomr

Laboratory of Mechanic, Faculty of Sciences Aïn Chock, University Hassan II, B.P. 5366, Mâarif, Casablanca 20100 Morocco.

This work presents numerical study, of the heat storage of phase change material (PCM) encapsulated in rectangular shape. In order to improve the latent heat accumulator as a thermal energy storage system, the hotter fluid enters into the accumulator and heats the system, is associated with another heat transfer form as heat external source (HES) located at upper surface. The main objective is to determine the minimum time for complete melting of the PCM and to optimize the location of the source. It is then exploited to assess the effects of various values of we heat external flux and the size of opening on the performance of the system. On the other hand, compare the both accumulators, with and without heat external source (HES). The numerical results show that module improvement is crucial to the design of the same system, based on thermal energy storage.

Geometrically nonlinear free vibration of a beam carrying concentrated masses

Mon.
16:30–17:00
R Ourika

A. Adri[1], Z. Beidouri[1], M. EL kadiri[2], R. Benamar[2]

[1] *Université Hassan II Aîn Chock, Ecole Supérieure de Technologie, Laboratoire de Mécanique Productique et Génie Industriel, (LMPGI), Km 7 Route d'El Jadida BP 8012 OASIS, Casablanca, Maroc.*

[2] *Université Mohammed V, Ecole Mohammadia des Ingénieurs, Laboratoire des Etudes et Recherches en Simulation et Instrumentation, (LERSIM), Avenue Ibnsina, Agdal, Rabat, Maroc.*

The objective of this paper is to establish the formulation of the problem of nonlinear transverse vibration of a clamped-clamped (CC) Bernoulli-Euler beam carrying two concentrated masses and taking into account the associated rotatory inertia. The method used is based on the principle of Hamilton and spectral analysis for non-linear free vibration occurring at large displacement amplitudes. The problem is reduced to solution of a nonlinear algebraic system using the so-called second formulation applied previously to nonlinear transverse vibration of continuous structures, such as beams and plates, nonlinear longitudinal vibration of 2-dof and multi-dof systems and to nonlinear transverse vibration of 2-dof systems. The backbone curves, corresponding to the nonlinear fundamental mode of a CC beam carrying one concentrated mass is presented to determine the error in the measurement of the nonlinear frequency.

Radon transport through porous media

Mon.
16:30–17:00
R Ourika

A. Azouani[1], F.Z. Boujrhal[2,4], R. Cherkaoui El Moursli, H. Sabbani[3,4]

[1] *Freie Universität Berlin, Institut für Mathematik I, Arnimallee 7, Berlin, Germany.*
[2] *Laboratory of Management and valorization of natural resources.*
[3] *University Sultane MY Slimane, FST Béni Mellal, B.P. 523, , Morocco.*
[4] *ISTA NTIC, Béni Mellal, Morocco.*
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Radon atoms are emanated from solid grains of the material into the pore space predominantly by recoil in the $\alpha-$decay of Radium and by diffusion through the solid matrix. Moreover, radon atoms being radioactive may disappear from the system by nuclear decay. Indeed, Radon gas usually exists at very low levels, but it can accumulate to levels that substantially increase the risk of lung cancer, in confined areas without adequate ventilation, such as underground mines.
The aim of this work is to suggest an appropriate mathematical model of the diffusion transport of radon in porous media simulating the whole measuring process.

Reliability assessment of stress concentration performance state for a perforated composite plate under traction

Mon. 16:30–17:00 R Ourika

S. Attajkani[1], A. Khamlichi[1], A. Jabbouri[2]

[1] *Department of Physics, FS Tetouan, Morocco.*
[2] *MGC Laboratory, FST Tangier, Morocco.*

Considering a perforated sandwich plate made from two elastic homogenous and isotropic layers, and having a square hole, reliability assessment of stress concentration limit state for which the stress should not exceed a given threshold is performed in this work. Assuming that the plate dimensions and the applied loading are deterministic, focus is done on the square hole center position and edge length considered to be random variables. The means and the standard deviations of these variables are assumed to be known, but no information is so far available about their densities of probabilities. To assess reliability of the performance state, reliability analysis known methods are applied to a response surface representation of the stress concentration factor of the perforated plate which is obtained through quadratic polynomial regression of finite element results. A parametric study is performed regarding the influence of the distributions of probabilities chosen to model the hole dimensions uncertainties. It is shown that the probability of failure depends largely on the selected densities of probabilities.

Thermal instability of nanofluids in natural convection

Mon. 16:30–17:00 R Ourika

A. Badrezzamane, N. Yadil, R.Sehaqui

Université Hassan II, Faculté des Sciences Ain Chock, Laboratoire de Mécanique, Km 8 route d'El Jadida BP 5366 Maarif, Casablanca, Maroc.

Thermal instability in nanofluids is investigated in this work. Emphasizing the combined behaviors of Brownian motion and thermophoresis of nanoparticles, the critical Rayleigh number is shown to be lower by one to two orders of magnitude than that for regular fluids. The highly promoted turbulence increases the energy bearing capacity of nanofluids, which could result in higher overall heat transfer coefficient than the increase of the effective thermal conductivity alone. The dominating groups are extracted from the nondimensional analysis. Close form solutions for the Rayleigh number are derived from the method of eigenfunction expansions and the weighted residual method.

Reflection and transmission of a Lamb waves at a bevelled bimetallic junction

Mon. 16:30–17:00 R Ourika

T. Belhoussine Drissi[1,2], B. Morvan[2], J.L. Izbicki[2], P. Pareige[2], M.V. Predoi[3]

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This work deals with the evaluation of bevelled junction of two plates by means of ultrasonic guided waves. Two plates, made of different materials, are edge to edge welded. The reflection and transmission of guided Lamb wave on this junction is studied. The theoretical coefficients of reflection and transmission are obtained by a multi-modal approach based on the orthogonality relation between the Lamb modes. The Finite Element Method (FEM) is used and allows determining the limits of the theoretical model. Finally, an experimental study is performed. Converted waves are observed. From the measured normal surface displacements, reflection and transmission energy coefficients of the incident S0 wave through the junction are calculated. It highlights the effects of diffraction that have not been taken into account in the two dimensional theoretical and numerical models.

The Tumbling Universe: Dynamics of Bianchi Models in the Big-Bang Limit

Mon.
16:30–17:00
R Ourika

Stefan Liebscher
Free University Berlin, Germany.

We consider cosmological models of Bianchi type. They yield spatially homogeneous, anisotropic solutions of the Einstein field equations. In particular, we are interested in the alpha-limit dynamics of the Bianchi model corresponding to the big-bang singular limit of the Einstein equations.
Emphasis is on transient behavior of solutions near the (backward) Bianchi attractor composed of the Kasner circle of equilibria and attached heteroclinic connections. The heteroclinic orbits in the Bianchi attractor form formal sequences of shift type.
We prove the existence of unstable manifolds to heteroclinic sequences. This relates alpha-limit transients of cosmologies of Bianchi type to formal sequences of Kasner heteroclinics.

Variability of dynamic behavior of finite coupled structure with uncertainties.

Mon.
16:30–17:00
R Ourika

M.A. Ben Soufi[1], M. Ichchou[1], O. Barbareille[1], M. Haddar[2]

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[2] *Ecole nationale d'Ingénieurs de Sfax, Unité de Mécanique, Modélisation et Productique, Tunisie.*

The effect of uncertainties on the dynamic behavior of coupled elements is investigated. This paper treated the case of two deterministic waveguides connected through a stochastic structure. The local variability(mechanical or geometrical variability) of the coupling element affects the dynamics of the whole structure. In order to predict the vibration behavior of the coupled media, which is described through wave propagation, the first step consists of elaboration of a hybrid method to evaluate the statistics (mean and standard deviation) of reflected and transmitted wave through the coupling element for semi-infinite waveguides. This hybrid method is based on a spectral formulation called the wave finite element (WFE) and the stochastic finite element method . The second step consists of the evaluation of the statistics of kinematic variables for finite wave guides. This presented methodology is applied and validated by Monte Carlo simulations.

Nonlinear dynamic response of compliant journal bearings

Mon.
16:30–17:00
R Ourika

M. Cha, S. Glavatskih

The Royal Institute of Technology Stockholm, Sweden.

Large amplitude shaft motion is not desirable since it can lead to a machine failure. Furthermore, performance limitations of conventional white metal bearings call for the development of new bearing designs. An outstanding steady state and tribological performance can be achieved by introducing compliant polymer liners. Polymer composites can provide much lower breakaway friction. At the same time, bearings with compliant liners may alter rotor-bearing system dynamic behavior compared to the systems with conventional white metal bearings. This paper investigates the nonlinear dynamic response of compliant journal bearings: plain cylindrical and tilting pad. Different unbalance eccentricities and compliant liner thicknesses have been considered. It is shown that non-linearity in compliant bearing response significantly increases in some operating conditions. Practical means to reduce non-linearity are discussed.

Design of a low cost planar antenna AIAC Ultra high frequencies laboratory

Mon.
16:30–17:00
R Ourika

J. El aoufi, N. ALaoui, T. Bercha.

Mohammed VI International Academy of Civil Aviation Mohammed V Airport, Casablanca, Morocco.

After it has understood the extent of the RFID technology, and its promising future, the AIAC decided to set up a sorting luggage system with RFID technology. To be done, Mohammed VI International Academy of Civil Aviation proposed to design an RFID antenna tag .This paper presents the design of a low cost antenna, in the shame of a rectangular patch operating in the 2.4 Ghz band, with a radiation pattern higher than 100ř.The designed antenna uses a plastic material as a substrate, and is soldered to a microstrip line (feeder) adapted by notches. The patch and the feeder Dimensions, as well as the notches dimensions of adaptations are calculated according to the line of transmission model. The Simulation and the optimization of this antenna were carried out under Microwave Studio of CST by using the planar electromagnetic simulation module. Specifics results are obtained with different sizes of the antenna in order to increase the opening angle of the Tag, these results can been used in the air handed treatment of the airports to put on the serving quality of the passengers.

Reconstruction of distributed force characteristics in case of non punctual objects impacting beams

Mon.
16:30–17:00
R Ourika

A. El-Bakari[1], A. Khamlichi[2], R. Dkiouak[1], A. Limam[3]

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The inverse formulation considered to reconstruct the characteristics of an impact uses in general a technique of minimizing the root mean square error between the measured and

the calculated responses. The problem takes like this the form of parametric identification. To perform this in practice, a large number of sensors or an excessive computing time is required. In this work, the characteristics of impact in case of an elastic beam with the impacting object not necessarily punctual are reconstructed. We use first the reciprocity theorem in order to decouple the localization problem from the identification problem. We solve then the localization problem by means of a particle swarm algorithm.

Adding a new faulty mode to the multi-model system for switching management

Mon.
16:30–17:00
R Ourika

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Since the discrete event systems can generate unwanted sequences, several authors focused on the problem of diagnosis. However, few who have considered the operating mode management in an uncertain environment. In this context, we propose an approach that allows the minimizing the problem of the diagnosability of a complex system, we propose to add a detection mode of failed states considering the different modes of operation possible a physical system. This approach is based upon an approach multi-model; each model describes a system in a given operating mode. We present algorithms for solving the problem of ensuring switching between modes.

Reconstruction of a distributed force impacting an elastic plate

Mon.
16:30–17:00
R Ourika

F. El Khannoussi, A. Hajraoui, A. Khamlichi

Modeling and Analysis of Systems Laboratory, Faculty of Sciences, 93002 Tetouan, Morocco.

This work deals with reconstruction of distributed force signal resulting from a non punctual object impacting perpendicularly an elastic homogeneous and isotropic rectangular plate. The impacting force is assumed to be uniformly distributed over a rectangular patch of the plate. The direct problem was solved by using modal decomposition method with explicit analytical modes. An associated discrete problem was obtained by sampling the continuous convolution integral. To extract the pressure signal by deconvolution of the dynamic response measured at a given point of the plate, solution of an inverse problem had been achieved. Since this type of problem is known to be ill-posed due to bad conditioning of the involved Toeplitz like matrix, regularization is needed to obtain a physically meaningful solution. A new regularization technique based on truncation filtering was introduced. This technique uses as a first step the generalized decomposition of Toeplitz matrix on singular values. Then, regularization of the decomposed form through a truncation filter is performed. The truncation consists in eliminating the first low index terms up to an optimal rank representing the contribution of low amplitude generalized singular values. If the impact force signal has a half sine like standard form, the index corresponding to time instant where the maximum displacement response is obtained was found to be a good order of truncation. This technique has proved to be effective in reconstructing impact pressures through various cases of study and the computational cost was found to be much lower than that of the classical truncation method based on L-curve criterion.

Stress intensity factor KI of isotropic materials used in dentistry

Tue. 16:10–16:40 R Ourika

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The stress intensity factor KI (parameter often used on the fracture mechanic) has been calculated numerically by finite element method. Different methods based on numerical method have been developed as stress field method and compliance method: displacement field method. For different crack's length of structure, comparison between the values calculated by analytical method and numerical method are in good agreement. The aim of this work is the application of the analytical expression validated numerically of stress intensity factor KI on the isotropic materials used in medical dentistry (TMA, pure titan, Co-Cr and Ni-Cr).

Latent heat storange in building for year round Casablanca climate thermal management

Tue. 16:10–16:40 R Ourika

M. Faraji

Laboratoire de Physique des Matériaux, Microélectronique, Automatique et Thermique, Département de Physiques, Faculté des Sciences Ain Chock, Université Hassan II, Casablanca, Morocco.

Efficient and economical technology that can be used to store large amounts of heat or cold in a definite volume is the subject of research for a long time. Latent heat storage in a phase change material (PCM) is very attractive because of its high-energy storage density and its isothermal behavior during the phase change process. Thermal storage plays a major role in building energy conservation, which is greatly assisted by the incorporation of latent heat storage in building products. Increasing the thermal storage capacity of a building can enhance human comfort by decreasing the frequency of internal air temperature swings so that the indoor air temperature is closer to the desired temperature for a longer period of time. However, it is impossible to select a phase change material to suit all the weather condition in a given location. The PCM that reduces the internal air temperature swing during the winter season is not suitable for the summer season as the PCM remains in the liquid state at all the times during these months and hence the system cannot exploit the latent heat effect. This study attempts to study the thermal performance of an inorganic eutectic PCM based thermal storage system for thermal management in a residential building. The system has been analyzed by theoretical investigation. A layer PCM concept is studied in detail to achieve year round thermal management in a passive manner.

Optimal Control of compressible flows through porous media with hysteresis

Tue. 16:10–16:40 R Ourika

E. Gornostaeva

Technical University of Munich, Department of Mathematics, Boltzmannstr. 3, 85748 Garching. b., Muenchen, Germany.

Hysteresis is a phenomenon that occurs in several and rather different situations, for instance in physics we find it in plasticity, ferromagnetism, flows through porous media, in phase transitions. Hysteresis encounters also in engeneering, chemistry, biology and multiple other settings According to [2, 7] we can distinguish two main features of hysteresis phenomena: *the memory effect* and the *rate independence*. The evolution can be formalized by the introduction of the concept of a hysteresis operator [2, 5, 7]. At any instant t the output will depend on the evolution of the input until that time t and also on the initial state of the system. So the initial ; or some equivalent information must be specified.

Numerical Study of a tensile specimen doubly Notched Steel E36

Tue.
16:10–16:40
R Ourika

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The crack initiation in a mechanical structure is most often due to the presence of a notch. The harmfulness of notches generally depends on their dimensions and their geometrical parameters such as radius and angle of cut. It is within this context that the present study. The studied material is steel A36 (E36) used as a matching plate for boilers and pressure vessels. The objective of our work is to establish a finite element numerical modeling of a tensile specimen with double notches using the computer code CAST3M. This method finds its importance in the study and design of mechanical structures. The obtained results allow to conclude that the nominal stress is calculated numerically equal to the applied stress during the fatigue test. More stress is maximum at the bottom of the notch. The coefficient of stress concentration Kt obtained numerically coincides with the experimentally determined Kt. The numerical study also reveals that the maximum stress decreases gradually along the axis of the specimen over the range 0 to 2mm. Then it stabilizes at the nominal value which corresponds to the applied stress.

Forced convection by slip-flow in a micro-pipe with the effects of axial conduction and viscous dissipation

Tue.
16:10–16:40
R Ourika

Y. Haddout, A. Oubarra, J. Lahjomri

Laboratory of Mechanics, Faculty of Science Ain Chock, University Hassan II, B.P. 5366, Maarif, Casablanca 20100 Morocco.

Thermally developing laminar slip flow through a micro-pipe, including both axial heat conduction, viscous dissipation and rarefaction effects with uniform wall temperature boundary condition is analytically investigated. The solution is based on the self-adjoint formalism resulting from a decomposition of the energy equation into a system of first-

order partial differential equations. The analytical results obtained are compared for simplified cases to available numerical calculations and good agreement is found. Results show that the heat transfer characteristics of flow in the thermal entrance region are strongly affected by axial heat conduction, viscous dissipation and rarefaction effects.

Influence of a phase change materials on the inertia of buildings

Tue.
16:10–16:40
R Ourika

H. Hamza, A. Oubarra, J. Lahjomri

Laboratory of Mechanic, Faculty of Sciences Aïn Chock, University Hassan II, B.P. 5366, Mâarif, Casablanca 20100 Morocco.

Low thermal inertia of walls and facades for any building generates in-situ the fluctuations of the outside temperature and the effect of the solar energy. Save thermal comfort inside that type of building requires the use of an air conditioning in an overheating situation, while, the heating is used in the opposite case. Hence, a Phase Change Materials (PCM) can be used in order to avoid this kind of problem. The principles characteristic of these materials is isothermal change of state solid-liquid associate absorption or delivery of heat phase change. A large variety of PCM is available versus desired applications and specially its specific temperature. Several PCM can be used for applications in thermal building. They have phase change temperature between extremely temperatures for which building is submitted. Our goal is to study the influence of the presence of such a material in a conventional wall construction and in particular the comparison of heat flux transmitted through the wall with and without the PCM. Two points are studied: What is the best PCM between all available for thermal building and what is the relative position of these PCM in the wall.

Defect detection in stiffened panels through guided structural waves

Tue.
16:10–16:40
R Ourika

T.L. Huang, M.N. Ichchou, O.A. Bareille

Laboratoire de Tribologie et de Dynamique des Systèmes. Ecole Centrale de Lyon, 36 Avenue Guy de Collongue, 69134 Ecully Cedex, France.

The issue of defect signature in stiffened panels at medium frequencies is addressed in this work. The Inhomogeneous Wave Correlation, a tool for analyzing the wave propagation characteristics of two-dimensional structures by k-space analysis, enables the estimation of wave numbers for waves propagating in stiffened panels. Here, the method is employed with the sparse simulated normal displacements of a set of stiffened panels. New insights into the use of their k-space behavior are hence highlighted. The guided wave behavior, which starts to appear at medium frequencies, can be extracted and treated in order to detect the presence of damage through a multi-modal wave propagation analysis in stiffened panels.

Asymptotic numerical method for stationary non-newtonian fluid

Tue.
16:10–16:40
R Ourika

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The aim of this work consists in computing solution branches of a stationary viscous non-Newtonian fluid using an Asymptotic Numerical Method. The adopted behaviour law is described by Power low model. To employ a polynomial representation of the solution, the regularisation technique is used.

Fault detection in robotic systems using artificial neural networks

Tue.
16:10–16:40
R Ourika

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The Robots need the ability to independently as well as effectively detect and tolerate internal failures in order to continue performing their tasks without the need for immediate human intervention. In this paper the artificial neural networks are used for both residual generation and residual analysis. A multilayer perceptron (MLP) is employed to reproduce the dynamics of the robotic manipulator. Its outputs are compared with actual position and velocity measurements, generating the so-called residual vector. Simulations employing a Scara robot three links robotic manipulator are showed demonstrating that the system can detect correctly faults.

Effect of fast frequency excitation on tower oscillations under turbulent wind flow

Tue.
16:10–16:40
R Ourika

I. Kirrou, L. Mokni, M. Belhaq

Laboratory of Mechanics, University Hassan II-Casablanca, Morocco

In this paper, vibrations of a self-excited tower under turbulent wind flow, in the presence of a fast frequency excitation, are investigated. The nonlinear governing equation including self, parametric and external excitation, are considered and the effect of fast external excitation on the tower oscillations is studied. It is showthat fast excitations may shift the frequency response toward higher frequency, thus delaying Hopf bifurcation of the tower motion. For validation of analytical results, comparisons with numerical simulations are given for different types of excitations.

Modeling the fluid/soil interface erosion in the Hole Erosion Test

Tue.
16:10–16:40
R Ourika

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Soil erosion is a complex phenomenon which yields at its final stage to insidious fluid leakages under the hydraulic infrastructures known as piping and which are the main cause of their rupture. The Hole Erosion Test is commonly used to quantify the rate of piping erosion. In this work, The Hole Erosion Test is modelled by using Fluent software package. The aim is to predict the erosion rate of soil during the hole erosion test. Therenormalization group theory - based turbulence model equations are used. This modelling makes it possible describing the effect of the clay concentration in flowing water on erosion. Unlike the usual one dimensional models, the proposed modelling shows that erosion is not uniform erosion along the hole length. In particular, the concentration of clay is found to increase noticeably the erosion rate.

Crack's bifurcation in an anisotropic material

Tue.
16:10–16:40
R Ourika

F. Lahna, N. Belrhazi, A. El Kaaba

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The orthotropic of a solid is characterized by the material directions and corresponds to six main directions of the crack' distribution 21, 31, 32, 12, 13 and 23 (the first number corresponds to the normal of the crack's plan, the second in the crack's front). In this work, it was suggested studying the crack's bifurcation solicited in the mixed mode of an anisotropic fracture's specimen by varying several geometrical parameters. The study showed that the critical angle of bifurcation depends on the crack's length, the specimen's height, the angle of load as well as on the chosen configuration.

Geometrically Nonlinear Transverse Vibrations of n^2-plan-DOF Systems

Tue.
16:10–16:40
R Ourika

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The purpose of this paper is to give the solution of the problem of transverse nonlinear vibration of nš-plan-dof systems, with localised non-linearity. It is to recall that this method is based on the principle of Lagrange and spectral analysis. The method has been successfully used previously to solve the problem of nonlinear vibrations of beams, rectangular and circular plates and shells. The mass tensor, the linear and nonlinear

rigidity tensors are expressed in both the displacement basis, denoted in what follows as DB, and the modal basis, denoted as MB. The application of the method to 3š-plan-dof systems is then developed in the MB.

Physical properties of a semi-conductor p-Cd0.96Zn0.04Te related to dislocations

Tue.
16:10–16:40
R Ourika

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Comparative studies between deformed and undeformed semi-conductor p-Cd0.96Zn0.04Te samples are conducted to investigate the effect of introduced dislocations on their electrical and optical properties. To generate dislocations, a plastic deformation by means of Vickers's microhardness on several Cd (111) and Te faces was carried out. Experimental observations, carried out by the help of electrical and photoluminescence measurements confirm that the plastic deformation results in: i) a decrease of Zn concentration in the deformed region, which is higher on the Cd face, ii) an increase of the acceptor concentration, and iii) a leakage current and a density of surface states, which are higher on the Te face. The calculation of the barrier height leads to identify the dominant defect, which is the complex [VCd, ACd] on the Cd face and VTeon the Te side respectively, and we found that the deformation produced an excess of acceptors in the p-CdZnTe. Finally we confirm that the atoms decrease the movement of dislocations.

Combined scales effects for effective brazing at low temperature

Tue.
16:10–16:40
R Ourika

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[2] *Faculty of Mechanical and Process Engineering, University Of Applied Science Niederrhein, Krefeld, Germany.*

In modern joining technology the focus is on effective brazing and soldering of temperature sensitive materials such as electronic components or materials with special microstructural design. In brazing and soldering as well as in diffusion welding processes the needed thermal energy is externally realized in the joint zone. This produces a heating of the whole joining parts, since in laminar joining the thermal energy is transported in interior by thermal conduction. An excess of critical temperatures or tolerable impact periods in wide parts of materials and respectively components is often not avoidable. This can lead to thermal damages. In this point of view nanotechnology shows promising possibilities as scale effects and their resulting thermophysical effects such as meltin g tem-

perature reduction and high diffusion rates can be used for providing a Self-Propagating High-Temperature Synthesis at room temperature. After ignition by an external energy source such as spark, flame etc. a self propagating exothermic reaction is started. By producing a multilayer system with alternately arranged nanoscaled layers of Al and Ni, for example, the resulting thin foil can be used as heat source for melting the braze or solder material within the joining zone without any external preheating. Due to the high process velocities up to 30 m/s and the local heat input significant thermal influences on the joined parts are not detectable. Within the investigations a deep view into the reaction behavior and the bonding mechanisms of the used foils is investigated by SEM and TEM analysis as well as high speed camera recording. Moreover, tensile strength had been tested to define influencing parameters on the joining process.

Non-linear forced vibration analysis of rectangular plates including the coupling between transverse and in-plane displacements

Tue.
16:10–16:40
R Ourika

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The objective of this work is to study the geometrically non-linear steady state periodic forced response of fully clamped rectangular plates (FCRP) with immovable in-plane conditions, taking into account the effect of the in-plane displacements. A complete formulation has been proposed first, reducing the equations of motion to a system of coupled non-linear algebraic equations, which are decoupled once the in-plane inertia is omitted. An averaging technique has then been developed, in order to simplify the first method and to develop an engineering complete theory. The forced response is given in the case of a concentrated harmonic excitation force with various intensities. The numerical results obtained here with the two formulations, using an explicit analytical solution, were compared with those obtained previously using a formulation in which the in-plane displacements have been neglected, showing an "over-stiff" effect.

Finite element modeling of the aluminothermic welding with internal defects and experimental analysis

Tue.
16:10–16:40
R Ourika

I. Mouallif[1], Z. Mouallif2, A. Benali[1], F. Sidki[1]

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There are several hundred saluminothermic welds and tenth of new welds being made daily on the Moroccan rail network. Although the aluminothermic welding technique is well proven, it is a critical safety component of the rail infrastructure. The consequences of a single failure could result in the derailment. The observations suggest that these defects are mainly of two types: defects of adhesion (or bonding defects) and porosity defects (or multiple blisters defects). Each of these defects may constitute a privileged

site of stress concentration. Depending on the level of these stresses, potential damage process may be developed and put off the rail. It therefore seems necessary to model the mechanical behavior of these welds with these defects in order to classify them by their criticality. In this study, we therefore modelled with the same load and with the same boundary conditions, the weld seam for each type of defect. The numerical and experimental results show that the defects of adhesion tend to concentrate the most constraints.

Reliability and optimization of mechanical structures using probabilistic transformation

Tue.
16:10–16:40
R Ourika

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In this work we propose a technique that combines Finite Element Analysis (FEA) and Probabilistic Transformation Method (PTM) to evaluate the Probability DensityFunction (PDF) of response where the function between the input and the output ofthe system is implicit. This technique is based on the numerical simulations of theFinite Element Analysis (FEA) and the Probabilistic Transformation Method (PTM) using an interface between Finite Element software and Matlab. Some problems ofstructures are treated in order to prove the applicability of the proposed technique.Moreover, the obtained results are compared to those obtained by the reference methodof Monte Carlo. A second aim of this work is to develop an algorithm of global optimization using thelocal method SQP, because of its effectiveness and its rapidity of convergence. Forthis reason purpose; we combine the method SQP with the Multi start method. Thisdeveloped algorithm is tested on test functions comparing with other methods suchas the method of Particle Swarm Optimization (PSO). In order to test the applicability of the proposed approache, a structure is optimizedunder reliability constraints.

A Discrete model for the natural frequencies and mode shapes of constrained vibrations of beams with various boundary conditions

Tue.
16:10–16:40
R Ourika

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The purpose of the present paper is the development of a physically discretemodel for free transverseconstrained vibrations of beams. The discrete model consists on an N-degree of freedom system made of massesplaced at the end of solid bars connected

with spiral springs. The calculations made involve two tensors, namelythe mass tensor and the linear rigidity tensor. The results obtained by the physically discrete modelshow a good agreement and a quick convergence to the equivalent continuous beam for various end conditionsfor both the natural frequencies and the corresponding mode shapes. The model proposed in the present paper,which has been validated here using classical cases, may be easily applied to the flexural vibration of beams withvarious types of discontinuities, and to beams carrying concentrated masses.

Stability of plane poiseuille flow of viscoelastic fluids in the presence of a transverse magnetic field

Tue.
16:10–16:40
R Ourika

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The linear stability of plan Poiseuille flow of an electrically conducting viscoelastic fluid in thepresence of a transverse magnetic field is investigated numerically. The fourth-order Sommerfeld equation governing the stability analysis is solved by spectral method with expansions in lagrange's polynomials, based oncollocation points of Gauss-Lobatto. The critical values of Reynolds number, wave number and wave speed arecomputed. The results are shown through the neutral curve. The main purpose of this work is to check the combined effect of magnetic field and fluid's elasticity on the stability of the plane Poiseuille flow. Based on theresults obtained in this work, the magnetic field is predicted to have a stabilizing effect on the Poiseuille flow of viscoelastic fluids. Hence, it will be shown that for second-order fluids ($K < 0$), the critical Reynolds numbers Rec increase when the Hartman number M increases for different values of elasticity number K, which isa known result. The more important result we have found, concerning second-grade fluids ($K > 0$) is that thecritical Reynolds numbers Rec increase when the Hartman number M increases for certain value of elasticitynumber K and decrease for others. The latter result is in contrast to previous studies.

Rayleigh and Prandtl number dependence of heat transport in nonlinear magnetoconvection

Tue.
16:10–16:40
R Ourika

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The effect of vertical magnetic field on heat transfer of Rayleigh-Benard convection at the onset for an electrical conducting fluid is studied theoretically. The numerical technique is based on expansion of nonlinear equation describing the fields of motion, temperature and magnetic fields using solutions of linear stability problem into series of inhomogeneous linear equations. We find finite number of steady state finite amplitude solutions which formally satisfy these equations. We report an explicit expression at the onset of

convection in terms of parameter of the system in the case of idealized boundary condition. The dependence of Nusselt number on Rayleigh number and Prandtl number is extensively examined up to sixth order using an expansion for Rayleigh number proposed by Kuo (1961) for nonlinear magneto convection under vertical magnetic field. It is shown that rate of heat transfer increases as Rayleigh number increases in the absence of magnetic field, but this rate of heat transfer decreases as thermal Prandtl number (Pr1) increases. It is also shown that heat flow increases by increasing Pr1 and heat flow decreases by increasing magnetic Prandtl number (Pr2) under a uniform magnetic field at the onset.

Linear stability of time-periodic flow between two oscillating concentric cylinders

Tue.
16:10–16:40
R Ourika

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We present a linear stability analysis of a pulsed flow in Taylor-Couette geometry when the inner and the outer cylinders oscillate, respectively, with angular velocities $\Omega_0 \cos(\omega t)$ and $\epsilon\,\Omega_0 \cos(\omega t)$. In the case of the different values of $\epsilon = -1, 0, 1$, we have determined the basic flow. We have solved numerically, using the Floquet theory, the governing differential equations corresponding to a linear perturbation of the basic state by the numerical method transforming a boundary conditions eigen value system to an initial conditions eigen value system. The results are consistent with theoretical and experimental results discussed by Tennakon, Aouidef et al [Eur. J. Mech. B-Fluid. 16 (1997) 227, 248]. This work constitutes a preliminary study to address the case of viscoelastic fluid and to analyze the effect of elasticity on the instability of the pulsed flow.

Effects of in-plane inertia on natural frequency and stresses of long circular cylindrical shell

Tue.
16:10–16:40
R Ourika

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In this paper an analytical procedure is given to study the free-vibration characteristics of thin long circular cylindrical shells with simply supported boundary conditions. An approach based on Sander's nonlinear theory and Lagrange equations is employed. Influence of in-plane inertia on natural frequencies and stress for several modes shape is discussed. Natural frequencies for a number of particular cases are evaluated and compared with some available experimental and other analytical results in the literature. The distributions of the bending and axial stresses associated with the nonlinear modes shape are given and compared with those obtained via the linear theory.

The inclusion of warping in free vibration of structure

Tue. 16:10–16:40 R Ourika

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Thin walled cellular structures are widely used in many civil, mechanical and aerospace engineering applications: these applications have increased with the economic necessity of providing high strength with low weight and cost. In the present study the effect of cross sectional warping on the dynamic behavior of box girder deck is investigated using discrete element approach in idealizing the structure and incorporating the warping as a seventh degree of freedom in a space frame element. Shear deformation due to uniform torsion in addition to transverse shear deformation are taken into account in the problem formulation. The analysis is performed using the computer program DNG6 and DNG7.It can be seen that the transverse shear contributes considerably to lowering the natural frequencies of the flexural vibration modes, and the inclusion of warping considerably increased the natural frequencies of the torsional-dominant vibration modes.

Soret-driven double diffusive magneto-convection in couple stress liquid

Tue. 16:10–16:40 R Ourika

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The stability analysis of Soret driven double diffusive convection for electrically conducting couple stress liquid is investigated theoretically. The couple stress liquid is confined between two horizontal surfaces and a constant vertical magnetic field is applied across the surfaces. Linear stability analysis is used to investigate the effect of various parameters on the onset of convection. Effect of magnetic field on the onset of convection is presented by means of Chandrasekhar number. The problem is analyzed asa function of Chandrasekhar number (Q), positive and negative Soret parameter (Sr) and couple stress parameter (C), mainly. The results show that the Q, both positive and negative Sr and C delay the onset of convection. The effect of other parameters is also discussed in paper and shown by graphs.

Effect of vertical quasiperiodic vibrations on the stability of the free surface of an inviscid liquid layer

Tue. 16:10–16:40 R Ourika

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The aim of the present paper is to examine the effect of the vertical quasiperiodic oscillations on the stability of the free surface of an ideal horizontal liquid layer. The quasiperiodic motion considered here is characterized by two incommensurate frequencies and . The governing system of equations is reduced to a quasi periodic Mathieu equation. In

this situation, using the harmonic balance method developed by Rand et al [10, 11] and Hill's determinants, we determine the marginal stability curves. We show that the quasi periodic excitation produces a stabilizing or a destabilizing effect strongly depending on the ratio of the frequencies

Numerical simulation of natural convection of nanofluid in a square enclosure heated from below

Tue.
16:10–16:40
R Ourika

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In the present work, we numerically study the laminar natural convection of a nanofluid confined in a square cavity. The main goal of our work is to understand the nanofluid effect on the mechanism of natural convection in enclosures. In this context, we developed a dedicated code where a finite difference formulation of the 4th order is used to discretize the equations of the problem. The numerical simulations are performed for Prandtl number , the Rayleigh number varying between and for different volume fractions for the pure fluid and for nanofluid .

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