2nd International Conference on Structural Nonlinear Dynamics and Diagnosis

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

University Hassan II – Casablanca

CSNDD 2014

Conference on Structural Nonlinear Dynamics and Diagnosis

May 19 - 21, 2014, Agadir

Booklet of Abstracts

Eds.: M. Belhaq, M. Houssni & I. Kirrou

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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 1^{st} International Conference on Structural Nonlinear Dynamics and Diagnosis (CSNDD 2012) was held in Marrakech, Morocco, April 30-May 2 and was organized by the Group of Nonlinear Dynamic, Hassan II University-Casablanca. The CSNDD 2012 has attracted a representative international scientific community in nonlinear dynamics, diagnosis and control. More than 160 papers from 26 countries were submitted and nearly 120 were accepted for presentation. 67 papers have been appeared in MATEC Web of Conferences Journal and 9 papers in ESAIM Proceeding. Thirteen mini-symposia were organized by leading experts in the field, who contributed to attract top-quality scientists.

Following the success of the 1^{st} version of the conference (CSNDD 12) and the positive feedback received from participants, the Nonlinear Dynamic Group of the Hassan II University-Casablanca is proud to organize the 2^{nd} version of the conference (CSNDD 14). The conference takes place in the nice city of Agadir (May 19-21, 2014) which is located south Morocco on the Atlantic Ocean.

The 2^{nd} International Conference on Structural Nonlinear Dynamics and Diagnosis intends to be a meeting place where scientists from different branches of applied mathematics, advanced physics and mechanics working in nonlinear dynamics and control can meet to discuss the latest of their achievements and to exchange ideas in theoretical, numerical and experimental techniques. Focuses are directed toward diverse topics, ranging from dynamical systems theory to different physical and engineering applications.

The CSNDD 2014 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, vibro-impact dynamic, nonlinear dynamics in MEMS/NEMS/AFM, energy harvesting materials and structures, active vibration control and smart structures, passive control of structures via nonlinear energy sinks, time-delayed feedback control, deterministic and stochastic dynamics, nonlinear thermal instability and complex phenomena in advanced physics.

It is a great privilege for the nonlinear dynamic Moroccan community to host the 2^{nd} CSNDD 2014 conference in Agadir, and we are proud to sustain such a high-level meeting in Morocco.

I am happy to report that the 2^{nd} CSNDD 2014 has already accomplished its goal. The meeting has attracted more than 200 papers from 30 countries and nearly 160 were accepted for presentation. It is scheduled that after peer review process, about 80 papers will be published in MATEC Web of Conferences Journal and 10 papers in ESAIM Proceeding. Fourteen mini-symposia are organized by leading experts in the field, who contributed to attract top-quality scientists.

I would like to thank all the Keynote lecturers, the invited speakers, the MS organizers, reviewers as well as the local and international organizing committee for their precious help in maintaining high standards of the Conference Technical Program.

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

M. Belhaq, M. Houssni & I. Kirrou, 2^{nd} *International Conference on Structural Nonlinear Dynamics and Diagnosis* (CSNDD 2014).

On behalf of the CSNDD 2014 Committees, welcome to Agadir, the city with a miraculous climate, and with its 10km-long beach providing more than 300 days of sunshine a year.

Enjoy a scientific stimulating and socially nice conference!

Mohamed Belhaq
CSNDD 2014 Chair
Agadir, May 2014

Contents

Committees

The 2nd *International Conference on Structural Nonlinear Dynamics and Diagnosis* takes place in Agadir, Morocco from **May 19 to 21, 2014**. The conference will provide a forum where researchers from different branches of applied mechanics, physics and mathematics working in nonlinear dynamics and structural systems can meet to share ideas and findings of their research. 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
- Minisymposia Sessions and Poster Sessions on pre-defined topics

The minisymposia are organized through parallel lecture sessions. As a rule, the available time slot per lecture presentation is 20 min, including discussion. According to specific lecture presentations, they can be longer (30 min).

Plenary Lectures

- Ali H. Nayfeh, Virginia Tech, USA
  Nonlinear dynamics: phenomena and applications
- Bernold Fiedler, Free University of Berlin, Germany
  Regulatory networks: faithful observation and open-loop Control
- Mohammad I. Younis, Binghamton University, USA
  Nonlinear dynamics of shallow arched micro and nanostructures
- Vladimir Babitsky, Loughborough University, UK
  Structural synthesis of vibro-safe hand-held percussion machines
- Peter Hagedorn, Technische Uniseritat Darmstadt, Germany
  Linear and nonlinear aspects of self-excited vibrations in circulatory systems
- Raouf A. Ibrahim, Wayne State University, USA
  Recent advances of structural life assessment and related problems
- Alain Holeyman, Université catholique de Louvain, Belgium
  Nonlinear soil-pile dynamic interaction
- Giuseppe Rega, Sapienza University of Rome, Italy
  Analysis, control and design from macro- to nano-mechanics: A global dynamics perspective
- Werner Schiehlen, University of Stuttgart, Germany
  Human walking dynamics: modelling, identification and control
- Aly El-Shafei, Cairo University, Egypt
  Diagnosis of installation faults in rotating machines
- Muhammad R. Hajj, Virginia Tech, USA
  Nonlinear dynamics of piezoaeroelastic energy harvesters
- Manuel G. Velarde, UC Madrid and Universidad Alfonso X el Sabio, Spain
  From macro-hydrodynamics to nano-electronics

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Minisymposia and chairs

- **MS1. New vibration absorbers and control devices: Piezo-electric systems, energy harvesting and nonlinear energy sinks**
  G. Kerschen (Belgium), C. H. Lamarque (France), A. Luongo (Italy)
- **MS2. Structural health monitoring**
  A. Deraemaeker (Belgium), S. F. Masri (USA)
- **MS3. Time-delayed feedback control: Theory and application**
  S. Gurevich (UK), S. Yanchuk (Germany)
- **MS4. Aerospace and naval structures: mathematical modeling, nonlinear dynamical behavior and control designs**
  J. M. Balthazar (Brazil), A. Fenili (Brazil)
- **MS5. Stability of rotating machines**
  A. El-Shafei (Egypt), J. Mahfoud (France)
- **MS6. Multiple time scale dynamical systems**
  J. Starke (Denmark), P. Szmolyan (Austria).
- **MS7. Nonlinear dynamics of MEMS/NEMS/AFM**
  N. Kacem (France), F. Najar (Tunisia), M. I. Younis (USA)
- **MS8. Deterministic and stochastic dynamics and control of nonlinear systems**
  J. M. Balthazar (Brazil), M. Hajj (USA), S. Lenci (Italy)
- **MS9: Nonlinear dynamics, bifurcations and analysis of chaos in electrical and electromechanical systems**
  A. El Aroudi (Spain), B.G.M. Robert (France)
- **MS10. Linear and nonlinear phenomena in advanced physics**
  M. Taki (France)
- **MS11. Analytical methods in nonlinear dynamics**
  M. Belhaq (Morocco), K. W. Chung (Hong Kong), I. Kovacic (Serbia)
- **MS12. Nonlinear thermal instability**
  B.S. Bhadauria (India), I. Hashim (Malaysia)
- **MS13. Optimization and reliability in structural vibrations**
  A. El Hami (France), B. Radi (Morocco)

Conference Synthetic Timetable

Registration (Palais des Roses Hotel, Agadir)

– Sunday, May 18, 16:00–22:00
– Monday, May 19, 8:00–9:00

Monday, May 19, 2014

8:00–9:00	***Registration***
9:00–9:20	Opening
9:20–10:00	Opening Plenary Lecture 1: Ali H. Nayfeh
10:00–10:15	***Conference Photo***
10:15–10:45	***Coffee Break***
10:45–11:25	Plenary Lecture 2: Bernold Fiedler
11:25–12:00	Plenary Lecture 3: Mohammad I. Younis
12:00–12:40	Plenary Lecture 4: Vladimir Babitsky
12:40–14:00	***Lunch***
14:00–16:30	Minisymposia (Parallel Sessions: S1, S2, S3, S4)
16:30–17:00	***Coffee Break and Poster Session***
17:00–19:20	Minisymposia (Parallel Sessions: S1, S5, S6, S7)

Tuesday, May 20, 2014

9:00–9:40	Plenary Lecture 5: Peter Hagedorn
9:40–10:20	Plenary Lecture 6: Raouf A. Ibrahim
10:20–11:00	***Coffee Break and Poster Session***
11:00–11:40	Plenary Lecture 7: Alain Holeyman
11:40–12:20	Plenary Lecture 8: Giuseppe Rega
12:20–14:00	***Lunch***
14:00–16:30	Minisymposia (Parallel Sessions: S8, S9, S10)
16:30–17:00	***Coffee Break***
17:00–19:30	Minisymposia (Parallel Sessions: S8, S11, S12, S13)
20:00	***Welcome Reception and Conference Dinner***

Wednesday, May 21, 2014

9:00–9:40	Plenary Lecture 9: Werner Schiehlen
9:40–10:20	Plenary Lecture 10: Aly El-Shafei
10:20–11:00	***Coffee Break and Poster Session***
11:00–11:40	Plenary Lecture 11: Muhammad R. Hajj
11:40–12:20	Closing Plenary Lecture 12: Manuel G. Velarde
12:20–12:45	***Closing***
12:45	***Lunch***
15:00	**Agadir City Tour**
20:30	**Steering Committee Meeting**

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Technical Program

	Monday, May 19		Tuesday, May 20		Wednesday, May 21
8:00 9:00	Registration Opening	9:00	Plenary Lecture 5 Peter Hagedorn	9:00	Plenary Lecture 9 Werner Schiehlen
9:20 10:00	Plenary Lecture 1 Ali H. Nayfeh Conference Photo	9:40	Plenary Lecture 6 Raouf A. Ibrahim	9:40	Plenary Lecture 10 Aly El-Shafei
10:15	Coffee Break	10:20	Coffee Break & Poster Session	10:20	Coffee Break & Poster Session
10:45	Plenary Lecture 2 B. Fiedler	11:00	Plenary Lecture 7 A. Holeyman	11:00	Plenary Lecture 11 M.R. Hajj
11:25 12:00	Plenary Lecture 3 M.I Younis Plenary Lecture 4 V. Babitsky	11:40	Plenary Lecture 8 G. Rega	11:40 12:20	Plenary Lecture 12 M.G. Velarde Closing
12:40	Lunch	12:20	Lunch	12:45	Lunch
14:00	S1 S2 S3 S4	14:00	S8 S9 S10	15:00	Agadir City Tour
16:30	Coffee Break	16:30	Coffee Break		
17:00	S1 S5 S6 S7	17:00	S8 S11 S12 S13		
		20:00	Welcome Reception Conference Dinner	20:30	Steering Committee Meeting

Abstracts

Plenary Lectures Abstracts

Scheduled:

Monday *9:20–12:35* Hotel Palais des Roses **Room Diwan I**

Nonlinear dynamics: phenomena and applications

Mon.
09:20–10:00
R Diwan I

Ali H. Nayfeh

Virginia Tech, USA and University of Jordan

There is a vast range of interesting, important, and potentially dangerous phenomena that are nonlinear. Nonlinearity brings a whole range of phenomena that are not found in linear systems. In single-degree-of-freedom systems, these include multiple solutions and jumps; limit cycles; frequency entrainment; natural-frequency shifts; subharmonic, superharmonic, combination, and ultrasubharmonic resonances; parametric instability; period-multiplying and demultiplying bifurcations; and chaos. In multidegree-of-freedom and continuous systems, interaction among different modes can be activated via internal resonance if the linear natural frequencies are commensurate or near commensurate or if the linear natural frequencies are widely separated, which can result in an energy exchange among them. What makes the exchange of energy among modes dangerous is that typically energy is transferred from the low-amplitude high-frequency components of the motion associated with the high modes to the high-amplitude low-frequency components of the motion associated with the low modes. Thus, the modal interaction makes it possible for a high-frequency low-amplitude excitation, which is capable of doing a lot of work on the system in a short period, to produce a large-amplitude low-frequency response. Modal interactions can lead to dangerously large responses in the very modes that are insignificant according to linear analysis.

Nonlinearities pose challenges and opportunities. The challenges include the design of systems that overcome the adverse effects of nonlinearities and the development of passive and active control strategies to expand the design space. The opportunities include the exploitation of nonlinearities for design.

Some of these phenomena, challenges, and opportunities are illustrated using examples drawn from ship motion, structures, cranes mounted on ships, identification, control, micro-air vehicles, energy harvesting, MEMS, and micro-gas sensors.

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Regulatory networks: faithful observation and open-loop control

Mon.
10:45–11:25
R Diwan I

B. Fiedler

Institute of Mathematics, Free university of Berlin, Germany

We consider systems of differential equations which model large regulatory networks. We show that the concepts of informative nodes (Mochizuki) and determining nodes (Foias, Temam) coincide with the notion of feedback vertex sets from graph theory.

As a result we can determine the long-time dynamics of the entire network from observations on the feedback vertex set, only. We present examples, including early Ascidian embryogenesis and genetic circadian clocks in mammals, where that required observation set is much smaller than the entire regulatory network. In simulations, the entire network can be forced to stably follow unstable trajectories by controlling the feedback vertex set.

All results are joint work with Atsushi Mochizuki (RIKEN, Tokyo).

Nonlinear dynamics of shallow arched micro and nanostructures

Mon.
11:25–12:00
R Diwan I

M.I. Younis

Binghamton University, USA and KAUST, Saudi Arabia

Micromachinedshallow arches have been under increasing focus in recent years in the MEMS community because of their unique attractive features. One major advantage is their bi-stability nature, which makes them suitable for switching and actuation applications. Particularly, these bi-stable structuresdo not require power to hold them down in either stable state (the on or off positions as switches); they need power only during the transition between the two states. Another advantage in actuation applications is that they can be displaced in large strokes compared to straight and mono-stable structures. Micromachinedshallow arches can also be unintentionally produced due to fabrication imperfections, such as stress gradient, residual stresses, and flexible anchors. This phenomenon is also common at the Nano scale. Particularly, fabricating perfectly straight Carbon Nano Tubes CNTs with controlled geometry and orientation is very difficult. Indeed, many studies have indicated that clamped-clamped CNTs are fabricated with some level of curvature (slack).

Whether it is intentional or not, the curvature of these structures can have pronounced impact on their static and dynamic behavior. When actuating a curved beam by a parallel-plate electrostatic force, its static and dynamic behavior becomes very complex. Curved beams may exhibit local motion, snap-through, pull-in instability, or combination among these depending on the interaction between mechanical and electrostatic forces.

In this talk, we will discuss some of the recent research advances relevant to the modeling and testing of arched Micro and Nano structures. Reduced-order modeling based on the Galrkin method will be presented. Shooting technique results showing various bifurcations will be shown. Analytical results based on perturbation analysis will be presented. Experimental data demonstrating some of the nonlinear phenomena will be shown.

Structural synthesis of vibro-safe hand-held percussion machines

Mon.
12:00–12:35
R Diwan I

V. Babitsky

Loughborough University, UK

Hand-held percussion machines are among the most popular machines throughout, however, their design and development have mainly heuristic character due to complexity of their dynamic behaviour. Vibration levels experienced by operators of hand-held percussion machines are high to cause injuries when operated for duration common in industry. That is why the design of low-vibration percussion machines is a problem of significant importance. It is intended to undertake the formulation of a general approach to analysis and synthesis of the vibro-safe hand-held percussion machines using methods of nonlinear dynamics, optimal control and modern simulation tools.
Synthesis of a new dynamical and engineering structure of a hand-held hydraulic breaker with a vibration-free handle/casing is presented. The dynamic structure of the percussion machine is considered as a multi-body, vibro-impact system and a solution with one body (handle/casing) being free of vibration is found and investigated. Computer simulations and experiments validate the new approach. The key element of the proposed engineering design which realises the synthesised structure is a mechanism with zero differential stiffness. A hydro-pneumatic unit with zero stiffness was developed and tested. Theoretical recommendations have been applied in development of a new JCB patented commercial hydraulic breaker. Modification of the design and effective use of existing hydraulic power source was shown to provide a significant improvement in performance.

Scheduled:

Tuesday	*9:00–12:20*	Hotel Palais des Roses	**Room Diwan I**

Linear and nonlinear aspects of self-excited vibrations in circulatory systems

Tue.
09:00–09:40
R Diwan I

P. Hagedorn

Technische Uniseritat Darmstadt, Germany

In mechanical engineering systems self-excited vibrations are in general unwanted and sometimes dangerous. There are many systems exhibiting self-excited vibrations which up to this day cannot be completely avoided, such as brake squeal, the galloping vibrations of overhead transmission lines, the ground resonance in helicopters and others. Most of these systems have in common that in the linearized equations of motion the self-excitation terms are given by non-conservative, circulatory forces. The presentation will discuss some recent results linear and nonlinear systems of this type. It has been well known for some time, that such systems are very sensitive to damping. Recently, several new theorems were proved concerning the effect of damping on the stability and on the self-excited vibrations of the linearized systems. The present paper discusses the importance of these results for practical mechanical engineering systems. It turns out that the structure of the damping matrix is of utmost importance, and the common assumption, namely representing the damping matrix as a linear combination of the mass and the damping matrices,may give completely misleading results for the problem of instability and the onset of self-excited vibrations. Also the nonlinear behavior of such systems can be quite interesting, in particular different types of Hopf bifurcations have recently been studied in the literature and will be discussed in the presentation.

Recent advances of structural life assessment and related problems

Tue.
09:40–10:20
R Diwan I

R.A. Ibrahim

Wayne State University, USA

Structural life assessment (SLA) is a diversified field and is based on the theories of fracture mechanics, fatigue damage process, probability of failure and reliability. SLA is not only governed by the theory of fracture mechanics and fatigue damage process, but by other factors such as corrosion, hydrogen embrittlement, impact loading, etc. The basic ingredients of the theory of fracture mechanics will be presented in terms of linear elastic fracture mechanics (LEFM) and elasto-plastic fracture mechanics (EPFM). The amount of energy available for fracture is usually governed by the stress field around the crack, which is measured by the stress intensity factor. SLA depends on the failure modes and the probabilistic description of failure. In view of structural parameter uncertainties, probabilistic analysis requires the use of reliability methods for assessing fatigue life by considering the crack propagation process, and the first passage problem, which measures the probability of the exit time from a safe operating regime. Different approaches of passive crack control in the form of crack arresters to stop crack propagation before it spreads over a structure component will be described for ship structures, aerospace structures and pipes. Crack arresters will be described for both metal and composite materials. This overview is by no means exhaustive and is based on over 1400 references. It does not address the structural health monitoring which constitutes a major task in the structural diagnostic process.

Nonlinear soil-pile dynamic interaction

Tue.
11:00–11:40
R Diwan I

A. Holeyman, M. Allani, V. Whenham

Université catholique de Louvain, Belgium

This invited lecture describes recent analytical and numerical advances in the modeling of the nonlinear dynamic interaction between a single pile and its embedding soil. On one hand, analytical solutions are developed for assessing the nonlinear axial dynamic response of the shaft of a pile subjected to dynamic loads, and in particular to vibratory loads. Radial inhomogeneity arising from shear modulus degradation is accounted for by assuming continuous variations of the medium properties. Recently developed analytical solutions are reviewed for two cases describing the radial decrease of the soil modulus according to two laws. The results are evaluated over a wide range of parameters and compared with those obtained by other authors and by a numerical radial discrete model simulating the pile and soil movements from integration of the laws of motion.

Axial and lateral dynamic pile analyses are then reviewed within a coupled framework since combined loading occurs in many situations (offshore piles, pile driving...). Effects of non linear lateral pile vibration on the non linear axial pile response are studied. New approximate non linear solutions for both axial and lateral pile behavior developed from general elastodynamic equations are presented. The solutions are obtained by extending the elastodynamic solution for the plane strain case to handle soil non linearity. Since axial soil resistance depends on the confining stress around the pile shaft, the effect of lateral soil behavior on the confining pressure around the pile circumference is investigated and axial soil reaction form coupled vibrations is derived. It is concluded that axial shear strength significantly increases when lateral soil vibration implies plasticity, which results in an increase of the axial dynamic bearing capacity of the pile.

Analysis, control and design from macro- to nano-mechanics: a global dynamics perspective

Tue.
11:40–12:20
R Diwan I

G. Rega

Sapienza University of Rome, Italy

The achievements occurred in nonlinear dynamics over the last thirty years entail a substantial change of perspective when dealing with vibration problems at whatever scale. The lecture will highlight the important, yet still overlooked, role that relevant concepts and tools may play in engineering applications. Upon dwelling on local and global dynamics, bifurcation, complexity, theoretical and practical stability, attractor robustness, basin erosion, dynamic integrity, recent results obtained for a variety of systems and models of interest in mechanics and structural dynamics are discussed in terms of analysis of nonlinear phenomena and their control. The global dynamics perspective permits to explain partial discrepancies between experimental and theoretical results based on merely local analyses, and to implement effective dedicated control procedures. This is addressed for discrete systems and reduced order models of continuous systems, and applications ranging from macro to nano mechanics. Fundamental understanding of nonlinear physical phenomena producing bifurcations and complex response has reached a critical mass and it is now time to exploit their potential to enhance performance and safety of technological systems, and to develop novel design criteria.

Scheduled:

Wednesday	*9:00-11:40*	Hotel Palais des Roses	**Room Diwan I**

Human walking dynamics: modelling, identification and control

Wed.
09:00–09:40
R Diwan I

W. Schiehlen

University of Stuttgart, Germany

Human gait simulation is a complex dynamical problem that requires in addition to the mechanical model accounting for muscle activations, neural excitations, and energetic and aesthetic considerations [1]. Two- and three-dimensional models using multibody system dynamics are presented [2]. The identification of the muscle actuation during human walking is based on data in literature [3, 4] comparing the resultant torques to each other. The control design uses inverse dynamics approaches and an optimization framework minimizing the metabolical energy consumption [5]. Numerical simulation results are shown for symmetrical as well as non-symmetrical models, and they are compared with experimental results.

Bibliography

[1] Mombaur, K.; Berns, K. (Eds.) Modeling, Simulation and Optimization of Bipedal Walking. Berlin, Springer 2013.
[2] Garcia-Vallejo, D.; Schiehlen, W. 3D-Simulation of Human Walking by Parameter Optimization. Archive Applied Mechanics, Vol. **82**, pp. 533-556, 2012.
[3] Anderson, F.; Pandy, M. A Dynamic Optimization Solution for Vertical Jumping in Three Dimensions. Computer Methods in Biomechanics and Biomedical Engineering, Vol. **2**, pp.201-231, 1999.
[4] Menegaldo, L.; Fleury, A.; Weber, H. Moment Arms and Musculotendon Lengths Estimation for a Three-dimensional Lower-limb Model. Journal of Biomechanics, Vol. **37**, pp. 1447-1453, 2004.
[5] Ackermann, M.; Schiehlen, W. Dynamic Analysis of Human Gait Disorder and Metabolical Cost Estimation. Archive of Applied Mechanics. Vol. **75**, pp. 569-594, 2006.

Diagnosis of installation faults in rotating machines

Wed.
09:40–10:20
R Diwan I

A. El-Shafei

Cairo University, Egypt

Many rotating machines perform well in factory testing, but experience difficulties in the field, mainly due to installation problems. The problems encountered range from misalignment and frame distortion to structural resonance and skid leveling. In this paper, a structured vibration analysis procedure is developed to identify installation problems in rotating machinery.
Spectral analysis is the main tool for vibration analysis of turbomachinery faults, however many problems appear at a single frequency. In this case phase analysis, time waveform, orbit and operating deflection shape (ODS) analysis become very important.

The paper presents a novel methodology for the diagnosis of installation problems in rotating machines and provides examples of cases with installation faults, and discusses methods of identification and solution.

Nonlinear dynamics of piezoaeroelastic energy harvesters

Wed.
11:00–11:40
R Diwan I

M.R. Hajj

Virginia Tech, USA

Aeroelastic vibrations are a common occurrence in aeronautical applications, civil structures and mechanical systems. In general, these vibrations are undesirable. On the other hand, they have been proposed as a means to harvest energy that can be used to operate low power consumption devices, such as microelectromechanical systems, health monitoring sensors, wireless sensors, actuators or replace small batteries that have a finite life span or would require hard and expensive maintenance. Of the different options, which include electromagnetic, electrostatic, and piezoelectric transduction, the piezoelectric one has received the widest consideration because of its capability to harvest energy over a wide range of frequencies, its ease of application, and required volume. We have considered different aeroelastic systems as possible candidates for energy harvesting. These include a wing undergoing limit cycle oscillations, vortex induced vibrations of a circular cylinder and galloping structures. Our approach is to experimentally demonstrate the capability of energy harvesting, use the experimental results to validate a model representing the piezoaeroelastic energy harvester and use modern methods of nonlinear dynamics to analyze the system. The results of our work have shown that the eccentricity and linear and nonlinear stiffness are important factors in determining the level of harvested power from wing based piezoaerelastic systems. The effects of variations in the electrical load resistance on the flutter speed and pitch and plunge motions are negligible. On the other hand, these variations affect the output voltage and power. When harvesting energy from vortex induced vibrations, the load resistance influences the onset of the synchronization region and its characteristics. The nonlinearity associated with the vortex induced oscillations results in a hardening behavior and hysteresis. The highest levels of harvested energy are associated with minimum displacement of the cylinder; a result that shows the need for the coupled analysis as performed in our investigations. The galloping phenomenon of prismatic structures offers the capability to harvest energy over a wide range of operating parameters (speed). The load resistance affects the onset speed of galloping. Also, analysis of the coupled electromechanical problem shows that the highest power levels are accompanied by minimal structural displacement. This is due to the fact that the kinetic energy of the structure is transferred to electrical power.

From macro-hydrodynamics to nano-electronics

Wed.
11:40–12:20
R Diwan I

M.G. Velarde

Universidad Complutense de Madrid and Universidad Alfonso X el Sabio, Spain

Soliton-mediated transport (with commercial purposes) was invented in "modern" times by the ship-building architect engineer J. S. Russell who in mid-XIXth Century made the discovery of the "solitary" wave at Union Canal near Edinburgh. Indeed, solitary waves, e.g., at the sea shore, and bores in rivers, permit matter transport and surfing (upstream!). Bores had been observed and used by peasants in China several centuries ago. They used them to transport goods surfing upstream, with small boats hence against the current, and getting back to origin with the downstream river flow. In the later quarter of the XIXth century, such waves received a good theoretical explanation by Boussinesq and Lord Rayleigh (who acknowledged Boussinesq's earlier achievements). Later on came Korteweg and de Vries who rediscovered the solitary wave evolution equation (fifteen years after Boussinesq). Their achievement was to also provide besides the solitary wave, another solution in the form of periodic cnoidal wave-train (their stability analysis was not correct). The former is the "homoclinic" solution of the (BKdV) (1+1)D evolution equation. It was not until mid-XXth Century that the curiosity of the "solitary" wave attracted the interest of Zabusky and Kruskal who numerically explored the solutions of the BKdV equation, and their (overtaking) collisions, and coined the soliton word and concept. Their research was motivated by earlier work of Fermi, Pasta and Ulam (FPU) on heat transfer and equipartition in (anharmonic) lattices. One of the lattice cases treated by FPU, i.e., with cubic potential interactions, was shown to have as continuum equivalent the BKdV equation. Eventually, subsequent mathematical work about BKdV and other soliton-bearing equations led to a new area in Applied Mathematics and General Physics (of conservative and, mostly, Hamiltonian integrable systems). The soliton concept has been a powerful paradigm to provide a unifying understanding of a disparate collection of phenomena found in several branches of Science and not just Physics (Fluid Physics, Nonlinear Optics and Lasers, Optical Fiber transmission, Acoustics, Plasmas, Neuro-dynamics, etc).

The BKdV equation is peculiar in the sense that it possesses a (local) balance between nonlinearity (velocity depends on amplitude) and dispersion (velocity depends on wavelength/color) that permits maintaining "alive" the "solitary" wave (or the cnoidal wave-train) as time proceeds. Dissipation or damping alone generally tends to destroy solitons, mostly through a leaking (linear) "radiation", a capillary-gravity wave-tail/head where viscosity eventually kills all wave motion. In the 20s of past century, Taylor and, subsequently, Burgers argued that waves could survive damping if an appropriate nonlinear-dissipation balance existed (another possibility is an input-output dynamic energy balance, much later studied). This led to the Taylor-Burgers equation which is a 1D caricature of the Navier-Stokes equations. The TB equation has "heteroclinic" solutions in the form of (supersonic) shocks in compressible gases (with local Mach number above unity) and bores (with corresponding Froude number above unity) in hydraulics. This (1D)-compressible gases-(2D)-hydraulics similarity had been known and exploited by Mach in the late XIXth century. The TB equation has also being used to model salient features of "turbulence" in (1D)-flows. Shocks, bores (mascarets, in French), hydraulic jumps, kinks, are also called "topological" solitons (to discriminate from non-topological e.g. Sech2-like solitons of the BKdV equation).

In the second half of the XXth century, room temperature soliton-mediated electric transport was experimentally observed and theoretical described in polymers like trans-polyacetylene (tPA). Their discovery led to the Nobel Prize for Chemistry awarded to A. J. Heeger, A. G. MacDiarmid and H. Shirakawa, in 2000. The supporting theory is based on a harmonic backbone Hamiltonian (as relative displacements are of the order of 0.04

Angstroms while the equilibrium inter-atomic lattice distance is about 1.22 Angstroms). As the ground state of tPA is degenerate, in the theory this is accounted by means of an additional double-well quadratic potential. This together with the nonlinear electron-lattice interaction brings the possibility of solitons in the form of kinks (so-called topological solitons) which are, generally, subsonic. Such soliton acts as the electron carrier which indeed constitutes a form of surfing at the nano-level. Most important feature of tPA and relatives is that they are easily doped thus offering very attractive features for electronic devices.

At about the same time, Davydov introduced the concept of electro-soliton to describe electron transfer (ET) along bio-(macro)-molecules. He also used a harmonic backbone Hamiltonian (though he studied, albeit fragmentarily, anharmonic cases) His clever use of the nonlinearity of the electron-phonon interaction together with suitable way of transition to the continuum description, permitted him to building a soliton-bearing system. Unfortunately, his predictions were shown not to survive above 10K and have not yet found support by experiment.

Recently, I have explored yet another possibility by starting with a soliton-bearing anharmonic lattice (using Morse interactions) and, as in the above mentioned theories, treating the electron in the standard quantum mechanical "tight-binding" approximation. The interaction between the electron and the lattice vibrations provides the dependence of the hoping electron transfer-matrix elements on the relative, time-dependent distance between neighboring lattice units (I am particularly interested in strong enough compressions, say, about half the equilibrium inter-atomic distance). It appears that when adding an excess electron there is electron trapping by the, generally supersonic moving, lattice solitons. This has been called a solectron which provides (sub- and supersonic) "electron surfing" at the nano-level. The solectron appears as a natural extension to anharmonic lattices of both the Landau-Pekar polaron (for harmonic lattices) and the Davydov's electro-soliton. It has also been shown that such lattice solitons (and solectrons) survive up to ambient temperatures (ca. 300K) for parameter values typical of bio-(macro)-molecules. A new form of electron pairing (satisfying Pauli's exclusion principle) mediated by lattice solitons has also been shown possible. The Hamiltonian system includes the non linear electron-lattice parts and the Coulomb repulsion using Hubbard's (local) approximation. Noteworthy is that such soliton-mediated pairing occurs in both momentum space and real space, i.e., there is at high temperatures a strong correlation between the electrons. This generalizes the low temperature Cooper pairing occurring only in momentum space, with complete delocalization in real space. The role of an external electric field has been studied thus showing features of a possible novel form of ET and electric conduction. The theory appears valid to support thirty-year old outstanding experimental results obtained by K. Donovan and E. G Wilson on polymers like polydiacetylene (PDA) crystals which behave quite differently from tPA (no doping allowed).

Finally, I shall also comment on recent related experimental work done, by several groups of scientists, on electron surfing on (Rayleigh) surface acoustic waves (SAW) in piezoelectric materials, like GaAs layers.

MS 1

New vibration absorbers and control devices: Piezo-electric systems, energy harvesting and nonlinear energy sinks

Organizers: *G. Kerschen* Belgium, *A. Luongo* Italy, *C.-H. Lamarque* France

Scheduled:				
	Monday	*14:00–16:30*	Hotel Palais des Roses	**Room Diwan I**
	Monday	*17:00–19:30*	Hotel Palais des Roses	**Room Diwan I**

Distributed passive vibration control via piezo-electromechanical structural members

Mon.
14:00–14:30
R Diwan I

F. Dell'Isola
Department of Structural and Geotechnical Engineering, Sapienza University of Rome, Italy

In this talk we show how to revive classical methods (i.e. those needed to synthesize analog circuits for designing direct computers) in order to conceive novel devices which we call piezo-electro-mechanical (PEM) structural members. By means of two independent synthesis procedures, new circuital analogs for the uniformly damped Elastica and Kirchhoff-Love plate can be found. These circuits are used as electrical wave guides gyroscopically coupled to the corresponding mechanical members to design electrically dissipative PEM systems. The concept on which these systems are based exploits piezoelectric transducers –uniformly distributed on the member– to transform strain energy into capacitive energy: this last will be subsequently dissipated using resistors, the optimal value of which is determined by a pole placement criterion. We underline that in PEM structures PZT transducers can be regarded, at the same time, as sensors and actuators. By means of analytical methods and numerical simulations, the electro-mechanical constitutive parameters of some PEM structures are determined and it is shown that they can be designed and may be technically feasible. Moreover it is shown that in PEM structures, also when mechanical dissipative phenomena are negligible, mechanical vibrations are efficiently damped by means of completely passive electrical circuits.

Perturbation method targeted to a bi-stable energy harvester

Mon.
14:30–14:50
R Diwan I

S. Casciati[1], D. Zulli[2], A. Luongo[2]

[1] *University of Catania, Struttura Didattica Speciale di Architettura, 96100 Siracusa, Italy*
[2] *University of L'Aquila, M&MOCS, Italy*

The possibility of converting vibrational energy into electrical power has been thoroughly investigated in recent years [1, 2]. Whereas linear oscillators resulted to be well suited for stationary and narrowband excitation near their resonant frequencies, they were shown to perform less efficiently for an ambient vibrational energy distributed over a wide spectrum, with time-varying spectral density, and dominant at very low frequencies. Hence, the need to resort to nonlinear energy harvesters [3] or frequency tuning techniques [4] in order to achieve a broadband performance was established in early studies. The bistable oscillators [3, 5] are uniquely characterized by a double-well restoring force potential. Since the dynamics of operation are more affected by the input excitation amplitude than by the frequency, the bistable oscillator can be excited at frequencies much less than the linear natural oneand the interwell escape can be exploited as a frequency up-conversion technique to achieve broadband energy harvesting. In Cohen et al. [6], a sharp potential barrier that converts slow motions into rapid oscillations is implemented via two repelling magnets which give rise to a slightly asymmetric double-well potential system. Whenever the average oscillations cross the potential barrier, the mass jumps to the opposing potential barrier and this jump produces a large velocity. The mass contains a magnetic field generator so that, when relative motion between the mass and the frame takes place, a voltage is induced on the coil which is attached to the frame. The harvested electrical power is commonly assumed to be proportional to the squared relative velocity of the mass with respect to the frame. Cohen et al. [6] used slow-fast decomposition to assess the dynamics of the system when a low-frequency base motion is used as excitation. However, the results in [6] are derived for a particular example where the response to specific amplitude, frequency and damping values is considered. The extendibility of these results to a wide range of parameters is herein investigated by adopting perturbation based methods to examine the repetitive transient dynamics of the oscillator near the potential barrier in cases of sub-resonance excitations. In particular, after a suitable rescaling of the parameters and variables of the system, the combined use of the Multiple Scalesand Harmonic Balance methods is pursued in order to derive the Amplitude Modulation Equations (AME). This reduced set of equations generally gives information on the asymptotic dynamics of the system. Such an approach has already been proposed for structures equipped with a Nonlinear Energy Sink [7, 8], and has proven adequate to analytically treat systems, as the one considered herein, where a small linear stiffness makes the equations of motion essentially non-linearizable, and small mass and damping induce singular perturbation. The slow-fast transitions characterizing the interwell escape of the bi-stable oscillator and appearing as relaxation oscillations are analysed in detail, with the aim of detecting their regions of existence in the parameters space. Results are compared to the ones obtained by numerical simulations.

Bibliography

[1] S. Priya, D.J. Inman, Energy Harvesting Technologies (Springer, 2008).
[2] F. Casciati, R. Rossi, Struct. Control Health Monit. **14**, 4 (2007).
[3] R. L. Harne and K. W. Wang, Smart Mater. Struct. **22** (2013).
[4] A. Abdelkefi, A. H. Nayfeh, M. R. Hajj, F. Najar, Smart Mater. Struct. **21** (2012).
[5] M. Karami, D. J. Inman, J. Sound. Vib. **330**, 23 (2011).
[6] N. Cohen, I. Bucher, M. Feldman, Mech. Syst. Sig. Process. **31** (2012).
[7] A. Luongo, D. Zulli, Nonlinear Dyn., **70**, 3 (2012).
[8] A. Luongo, D. Zulli, J. Vib. Control, DOI: 10.1177/1077546313480542, 2013.

Vibratory energy exchanges between a system with a chain of Saint-Venant elements and a nonlinear energy sink

Mon.
14:50–15:10
R Diwan I

C.-H. Lamarque, A.T. Savadkoohi

Université de Lyon, ENTPE, DGCB and LTDS, UMR CNRS 5513, France

We present time multi-scale energy exchanges between a system with chain of Saint-Venant elements and a nonlinear energy sink under periodic external forces. A general analytical methodology is presented to detect the invariant manifold of the system at fast time scale and then its equilibrium and fold singularities at slow time scale. The latter development will let us to predict attraction(s) of the dynamical system at slow time scale to be able to design proper nonlinear energy sink devices for the aim of control and/or energy harvesting.

Design and modelling of an energy harvester for tire pressure monitoring systems

Mon.
15:10–15:30
R Diwan I

E. Zaouali[1], F. Najar[1], N. Kacem[2], E. Foltete[2]

[1] *LASMAP, Tunisia Polytechnic School, University of Carthage, La Marsa, Tunisia*
[2] *FEMTO-ST, Université de Franche-Comté, Besançon, France*

The main objective of this work is to design a kinetic energy harvester for TPMS applications. The energy harvester presented in this work is a multi-pendulum fixed to a rolling wheel, which exploits nonlinear effects rendered by such a design.

Vibration absorption with a nonlinear absorder including time delay

Mon.
15:30–15:50
R Diwan I

S. Bellizzi[1], K.W. Chung[2], K. Hu[2,3]

[1] *LMA, CNRS, UPR 7051, Centrale Marseille, Aix-Marseille Univ, France*
[2] *Department of Mathematics, City University of Hong Kong Tat Chee Avenue, Kowloon, Hong Kong*
[3] *Sun Yat-sen University, Guangzhou, P. R., China*

In this paper, forced responses are investigated in a one degree-of-freedom linear system subjected to periodic excitation and coupled to a nonlinear energy sink including nonlinear damping with time delay.

Wave propagation in relaxed micromorphic continua: modelling metamaterials with frequency band-gaps

Mon.
15:50–16:10
R Diwan I

A. Madeo

Université de Lyon-INSA, LGCIE, France

We propose to use the relaxed micromorphic model previously developed by the authors to study wave propagation in unbounded continua with microstructure. By studying dispersion relations for the considered relaxed medium, we are able to disclose precise frequency ranges (band-gaps) for which propagation of waves cannot occur. These dispersion relations are strongly nonlinear so giving rise to a macroscopic dispersive be-

havior of the considered medium. We prove that the presence of band-gaps is related to a unique elastic coefficient, the so-called Cosserat couple modulus, which is also responsible for the loss of symmetry of the Cauchy force stress tensor. This parameter can be seen as the trigger of a bifurcation phenomenon since the fact of slightly changing its value around a given threshold drastically changes the observed response of the material with respect to wave propagation. We finally show that band-gaps cannot be accounted for by classical micromorphic models as well as by Cosserat and second gradient ones. The potential fields of application of the proposed relaxed model are manifold, above all for what concerns the conception of new engineering materials to be used for vibration control and stealth technology.

Passive control of the flutter instability on a two-degrees-of-freedom system with pseudoelastic shape-memory alloy springs

Mon.
16:10–16:30
R Diwan I

A. Malher, O. Doaré, C. Touzé

Unité de mécanique (UME), ENSTA-ParisTech, France

A passive control of aeroelastic instabilities on a two-degrees-of-freedom (dofs) system is considered here using shape memory alloys (SMA) springs in their pseudo-elastic regime. SMA present a solid-solid phase change that allow them to face strong deformations ($\sim 10\%$); in the pseudo-elastic regime, an hysteresis loop appears in the stress-strain relationship which in turn gives rise to an important amount of dissipated energy. This property makes the SMA a natural candidate for damping undesired vibrations in a passive manner. A 2-dofs system is here used to model the classical flutter instability of a wing section in an uniform flow. The SMA spring is selected on the pitch mode in order to dissipate energy of the predominant motion. A simple model for the SMA hysteresis loop is introduced, allowing for a quantitative study of the important parameters to optimize in view of an experimental design.

Nonlinear energy sink applied to an oscillator under principal and subharmonic external resonances

Mon.
17:00–17:30
R Diwan I

A. Luongo, D. Zulli

University of L'Aquila, M&MOCS, Italy

Nonlinear Energy Sinks (NES) are dumped oscillators with strongly nonlinear stiffness, used as passive control devices. The mass used in the oscillator is small compared to that of the main system to be controlled, and the essentially nonlinear stiffness causes irreversible energy absorption and dissipation through a physical phenomenon referred as Targeted Energy Transfer (TET, see [1] for an extensive overview). Moreover, as a major feature, NES have the capacity of getting resonant to the main structure in a wide frequency spectrum, as resonance capture occurs [2, 3]. Relaxation oscillations and strongly modulated responses, which are typical features of singular perturbation problems, occur as well, giving rise to transitions from slow to fast dynamics [4], and corresponding to high energy dissipation and significant performance of the NES.
The non-linearizable nature of the equations of NES causes that the standard perturbation techniques are not directly applicable. Accordingly, to analytically study the slow-flow

dynamics, the researchers very often make use of the complexification averaging (CX-A) proposed by Manevitch [5] and, as a further step, the Multiple Scale Method (MSM, [6]). In parallel, numerical approachs have been pursued and refined [7].
Recently, a new perturbation algorithm, based on a mix of Multiple Scale Method and Harmonic Balance (MSHBM), has been proposed to manage harmonically forced [8] as well as aero-elastic [9] multi-d.o.f. dynamical systems equipped with NES. The algorithm allows one to avoid the initial complexification averaging and, whatever is the number of d.o.f. of the main structure, it directly provides the normal form equations, in number equal to the co-dimension of the system. In this paper, a nonlinear 1 d.o.f. oscillator under external harmonic force is considered as main structure. The harmonic force is assumed as bi-frequent and in concurrent 1:1 and 1:3 resonance with the structure. A NES is applied in order to control the oscillation amplitude, which is affected by principal and sub-harmonic resonance [6]. The MSHBM is carried out, providing Amplitude Modulation Equations (AME) which rule both the invariant manifold corresponding to Nonlinear Normal Modes of the system, and slow-fast transitions corresponding to Strongly Modulated Responses, which are fundamental characteristic to optimize the constitutive parameters of the NES.

Bibliography

[1] Vakakis A.F., Gendelman O.V., Bergman L.A., McFarland D.M., Kerschen G., Lee Y.S., Nonlinear Targeted Energy Transfer in Mechanical and Structural Systems, Springer (2008).
[2] Vakakis A.F., Rand R.H., "Non-linear dynamics of a system of coupled oscillators with essential stiffness non-linearities", International Journal of Non-Linear Mechanics, **39**(7), 1079-1091 (2004).
[3] Vakakis, A.F., Gendelman, O., "Energy pumping in nonlinear mechanical oscillators" Journal of Applied Mechanics **68**(1), 42-48 (2001).
[4] Guckenheimer J., Wechselberger M., Young L.-S., "Chaotic attractors of relaxation oscillators", Nonlinearity, **19**: 701-720 (2006).
[5] Manevitch L., "The description of localized normal modes in a chain of nonlinear coupled oscillators using complex variables", Nonlinear Dyn., **25**: 95-109 (2001).
[6] Nayfeh A.H., Mook D.T., Nonlinear oscillations, John Wiley, New York (1979).
[7] Peeters A.M., Viguié, R., Sérandour G., Kerschen G., Golinval J.-C., "Nonlinear normal modes, Part II: Toward a practical computation using numerical continuation techniques", Mechanical Systems and Signal Processing, **23**, 195-216 (2009).
[8] Luongo A., Zulli D., "Dynamic analysis of externally excited NES-controlled systems via a mixed Multiple Scale/Harmonic Balance algorithm", Nonlinear Dynamics, vol. **70**, n. 3, 2049- 2061, (2012).
[9] Luongo A., Zulli D., "Aeroelastic instability analysis of NES-controlled systems via a mixed Multiple Scale/Harmonic Balance Method", Journal of Vibration and Control, DOI: 10.1177/1077546313480542, (2013).

Linear and nonlinear piezoelectric shunting strategies for vibration Mitigation

Mon.
17:30–17:50
R Diwan I

P. Soltani[1], G. Tondreau[2], A. Deraemaeker[2], G. Kerschen[1]

[1] *Space Structures and Systems Laboratory, University of Liège, Belgium*
[2] *Building Architecture and Town Planning (BATir), Belgium*

This paper studies linear and nonlinear piezoelectric vibration absorbers that are designed based on the equal-peak method. A comparison between the performance of linear mechanical and electrical tuned vibration absorbers coupled to a linear oscillator is first performed. Nonlinearity is then introduced in the primary oscillator to which a new nonlinear electrical tuned vibration absorber is attached. Despite the frequency-energy dependence of nonlinear oscillations, we show that the nonlinear absorber is capable of effectively mitigating the vibrations of the nonlinear primary system in a large range of forcing amplitudes.

Bifurcation analysis of nonlinear piezoelectric controlled systems under nonconservative loads

Mon.
17:50–18:10
R Diwan I

F. D'Annibale, G. Rosi, A. Luongo

M&MOCS, University of L'Aquila, Italy

Uncontrolled vibrations in mechanical structures can be source of many undesirables effects, as they can have an impact on their reliability and durability, and increase the risk of damage onset. In presence of nonconservative loads, e.g. follower forces [1–3], which can negatively affect the stability of the system, developing an effective control strategy for reducing risks of failure is crucial. Classical techniques adopted for controlling the mechanical vibrations in structures are essentially based on passive dissipative materials, as viscoelastic ones. While these techniques have the advantage of being easy to implement and optimize, their main drawback is that they usually make the structure heavier, especially when dealing with low frequency vibrations. When designing structures with strict weight constraints, especially in aeronautic or aerospace industry, adding mass is not desirable. In order to overcome these issues, the interest on active materials as piezoelectrics increased over the last twenty years. In particular, piezoelectric transducers are among the most common, for their versatility, reduced price and considerable force/volume ratio.
Piezoelectric based vibration controllers can be mainly divided into two main strategies, active or passive [4–6], depending on their ability to pump or not energy into the system they are controlling. These strategies have been object of several studies, and each of them has its advantages and drawbacks. One of the main issues, that is highlighted when dealing with active controllers, and as a consequence the main advantage of a passive one, is related to stability issues. In fact, even if active controllers are usually more effective, their intrinsic nonconservative behavior can be a source of instability, e.g. in case of the parameters mismatch, and they can drive to failure the system they are supposed to control. On the other hand, passive controllers, as they cannot pump energy into the mechanical system, experience a trade-off in performances, but are intrinsically stable.

Among all the techniques proposed for passive control, we will concentrate this study on distributed controllers which are the electrical analog of the mechanical structure to be controlled (i.e. they are governed by the same PDEs), as those presented in [7–9]. These systems exploit a network of uniformly distributed piezoelectric trans- ducers for coupling the electrical and mechanical system in a way which is optimized for maximizing the energy to flow from the mechanic to the electric form and to dissipate it by means of an optimized network of resistors. As they are based on a passive strategy, the stability of this kind of smart structures has never been fully investigated and the behavior in case of nonconservative loads have never been deeply studied.
The equations of motion for a discrete piezoelectric controlled system, in presence of nonconservative loads, can be derived via the Extended Hamilton's principle, namely:

$$\delta H = \delta H_m + \delta H_e + \delta H_{em} = 0 \tag{1.1}$$

in which, the subscripts "*m*", "*e*" and "*em*" refer to mechanical, electrical and electro-mechanical quantities, respectively. When a discretization of the mechanical system and of the network of transducers is carried out, the quantities appearing in Eq (1) read:

$$\begin{aligned} \delta H_m &= \int_{t_1}^{t_2} (\delta \dot{X}^T M_m \dot{X} - \delta X^T K_m X - \delta X^T C_m \dot{X} - \mu_m \delta X^T H_m X - \delta X^T f(X, X, X))dt \\ \delta H_e &= \int_{t_1}^{t_2} (\delta \dot{Y}^T M_e \dot{Y} - \delta Y^T K_e Y - \delta Y^T C_e \dot{Y} - \mu_e \delta Y^T H_e Y)dt \\ \delta H_{em} &= \int_{t_1}^{t_2} \gamma(\delta Y^T G \dot{X} - \delta X^T G^T \dot{Y})dt \end{aligned} \tag{1.2}$$

where X and Y are n-dimensional vectors of Lagrangian mechanical and electrical coordinates, respectively; M_i, K_i,C_i,H_i are the $(n \times n)$ mass, stiffness, damping and circulatory matrices for mechanical $(i = m)$ and electrical $(i = e)$ systems, respectively; G is the gyroscopic matrix; f is the vector of cubic-type nonlinearities; μ_i is the nonconservative load parameter for mechanical $(i = m)$ and electrical $(i = e)$ systems and γ is the coupling electromechanical parameter. While M_i, K_i , C_i are symmetric, the G and Hi matrices are not symmetric. By integrating by parts Eq (1), the following equations of motion are obtained:

$$\begin{aligned} M_m \ddot{X} + C_m \dot{X} + (K_m + \mu_m H_m)X + \gamma G^Y \dot{Y} = f \\ M_e \ddot{Y} + C_e \dot{Y} + (K_e + \mu_e H_e)X - \gamma G \dot{X} = 0 \end{aligned} \tag{1.3}$$

By using the Sensitivity Analysis and the Multiple Scale Method [10–13], we will show in this study that symmetric (or similar) passive controllers, which are the best choice for maximizing the energy exchange between mechanical and electrical parts, have instead a detrimental effect on the stability of discrete systems loaded by nonconservative forces. For this reason, a different choice in the design of the controller will be presented and, in particular three new control strategies will be defined. Results, concerning an improvement in the stability properties both in linear regime both in postcritical behavior, will be discussed at the conference's time.

Bibliography

[1] A. Luongo, A. Di Egidio, Bifurcation equations through multiple-scales analysis for a continuous model of a planar beam, Nonlinear Dynamics **41** (1-3) (2005) 171-190.
[2] A. Luongo, F. D'Annibale, Bifurcation analysis of damped visco-elastic planar beams under simultaneous grav- itational and follower forces, International Journal of Modern Physics B **26** (2012).
[3] A. Luongo, F. D'Annibale, Double zero bifurcation of non-linear viscoelastic beams under conservative and non-conservative loads, International Journal of Non-Linear Mechanics **55** (2013) 128-139.
[4] A. Baz, S. Poh, Performance of an active control system with piezoelectric actuators, Journal of Sound and Vibration **126** (2) (1988) 327-343.
[5] S. J. Elliott, P. Gardonio, T. C. Sors, M. J. Brennan, Active vibroacoustic control with multiple local feedback loops, The Journal of the Acoustical Society of America **111** (2) (2002) 908-915.
[6] N. W. Hagood, A. von Flotow, Damping of structural vibrations with piezoelectric materials and passive electrical networks, Journal of Sound and Vibrations **146** (1991) 243-268.
[7] S. Alessandroni, F. dell'Isola, M. Porri, A revival of electric analogs for vibrating mechanical systems aimed to their ecient control by pzt actuators, International Journal of Solids and Structures **39** (2002) 5295-5324.
[8] F. dell'Isola, C. Maurini, M. Porri, Passive damping of beam vibrations through distributed electric networks and piezoelectric transducers: prototype design and experimental validation, Smart Materials and Structures (2004).
[9] G. Rosi, J. Pouget, F. dell'Isola, Control of sound radiation and transmission by a piezoelectric plate with an optimized resistive electrode, European Journal Of Mechanics A-Solids (2010) 859-870.
[10] A. Nayfeh, Perturbation Methods, Wiley-VCH (2000).
[11] A. Luongo, Eigensolutions sensitivity for nonsymmetric matrices with repeated eigenvalues, AIAA journal **31** (7) (1993) 1321-1328.
[12] A. Luongo, Free vibrations and sensitivity analysis of a defective two degree-of-freedom system, AIAA journal **33** (1) (1995) 120-127.
[13] A. Luongo, A. Di Egidio, A. Paolone, Multiple scale bifurcation analysis for finite-dimensional autonomous systems, in: Recent Research Developments in Sound and Vibration, Transworld Research Network, Kerala, India (2002)161-201.

A new vibration absorber based on the hysteresis of multi-configuration NiTiNOL-steel wire ropes assemblies

Mon.
18:10–18:30
R Diwan I

B. Carboni, W. Lacarbonara

Dipartimento di Ingegneria Strutturale e Geotecnica, Sapienza University of Rome, Rome, Italy

A new vibration absorber based on the restoring forces of NiTiNOL and mixed NiTiNOL-steel wire ropes subject to flexural and coupled tensile-flexural states is presented. The peculiar hysteresis of the device is due to the simultaneous presence of interwire friction and phase transformations. An extension of the Bouc-Wen model is proposed to fit the experimental force-displacement cycles by employing the Differential Evolutionary optimization algorithm. The genetic-like optimization is carried out both for the constitutive identification and for the design of the vibration absorber. The effectiveness of the device is proved experimentally by a series of shaking table tests on a multi-story scale building.

Generalization of Den Hartog's equal-peak method for nonlinear primary systems

Mon.
18:30–18:50
R Diwan I

G. Habib, T. Detroux, G. Kerschen

Department of Aerospace and Mechanical Engineering University of Liège, Liège, Belgium

This study addresses the mitigation of one problem nonlinear resonance of a mechanical system. In view of the narrow bandwidth of the classical linear tuned vibration absorber, a new nonlinear absorber, termed the nonlinear tuned vibration absorber (NLTVA), is introduced in this paper. One unconventional aspect of the NLTVA is that the mathematical form of its restoring force is tailored according to the nonlinear restoring force of the primary system. The NLTVA parameters are then determined using a nonlinear generalization of Den Hartog's equal-peak method. The mitigation of the resonant vibrations of a Duffing oscillator is considered to illustrate the proposed developments.

Modeling and analysis of a horizontally-aligned energy harvester

Mon.
18:50–19:10
R Diwan I

M. Bendame[1], M. Soliman[2], E. Abdel-Rahman[1]

[1] *University of Waterloo, 200 University Avenue, Waterloo, Ontario, Canada*
[2] *Electronics Research Institute, Giza, Egypt*

In this paper we analyse an impact-type vibration energy harvester. In this study, the harvester is positioned so that the electromagnetic transducer moves along a horizontal linear guide when subjected to base excitations. The governing equation is a nonsmooth second order differential equation which cannot be solved analytically. Therefore, the averaging method is used to investigate its response. Experimental results are compared with the analytical solution to validate it. The results show that the existence of the nonlinearity in the system enables harvesting at low frequencies, increase the bandwidth, and enhances the output power significantly.

The three hinged arch as an example of piezomechanic passive controlled structure

Mon.
19:10–19:30
R Diwan I

L.C. Pagnini[1], G. Piccardo[1], F. Dell'Isola[2]

[1] *Dept of Civil, Chemical and Environmental Engineering, DICCA, University of Genoa, Italy*
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The present paper presents a preliminary step of a research plan dealing with the use of piezoelectric transducers acting as dampers on real-scale structural system. It considers a structural prototype constituted by a three hinged arch, that is chosen as a simple model

to represent the starting point for a generalization to the most common structural typologies of civil and industrial engineering structures. The optimal piezoelectric mechanical system is derived by a series of successive steps. The first step considers the original arch system and synthesizes its analog electric circuit that is constituted by inductors, capacitors and two-port transformers. It is conceived deducing the Lagrangian form of the evolutionary equation of the mechanical system and by paralleling the flux linkage to the Lagrangian coordinates of the three hinged arch, according to the so-called mass capacitance analogy. The second step institutes the piezomechanical truss distributing piezoelectric actuators over the mechanical system and interconnecting their electric terminals with the analog circuit, completed with resistors. The third step carries out the optimum design for vibration control by tuning the resonant frequencies of the electric circuit at the same resonant frequencies of the structural system to be damped.

MS 2
Structural health monitoring

Organizers: *A. Deraemaeker* Belgium, *S.F. Masri* USA

Scheduled:			
Monday	*14:00–16:30*	Hotel Palais des Roses	**Room Diwan II**

An overview of vision-based approaches for health monitoring and condition assessment of infrastructure systems

Mon. 14:00–14:30 R Diwan II

S.F. Masri
Viterbi School of Engineering, University of Southern California, Los Angeles, California, USA

Automated health monitoring and maintenance of civil infrastructure systems is an active yet challenging area of research. Nondestructive evaluation techniques, such as digital image processing and computer vision, are promising approaches for structural health monitoring to complement sensor-based approaches. For example, current infrastructure inspection standards require an inspector to travel to a target structure site and visually assess the structure’s condition. A less time-consuming and inexpensive alternative to current monitoring methods is to use a robotic system that could inspect structures more frequently, and perform autonomous damage detection. Among several possible techniques is the use of optical instrumentation (e.g., digital cameras). The feasibility of using image processing techniques to detect deterioration in structures has been widely investigated by many researchers in the field. This presentation will provide an overview of recent developments and applications of some promising approaches for a robust inspection tool based on the use of commercially available digital cameras. The proposed system can help an inspector to visually assess a target system remotely, without the need of having to travel to the structure’s site. Several illustrative examples using vision-based inspection procedures will be presented to cover a variety of applications dealing with civil and mechanical infrastructure systems.

On the use of the Mahalanobis squared-distance to filter out environmental effects in structural health monitoring

Mon. 14:30–14:50 R Diwan II

A. Deraemaeker[1], K. Worden[2]

[1] *Université Libre de Bruxelles - BATir 50 av F.D. Roosevelt, CP 194/02, B-1050 Brussels*
[2] *University of Sheffield -Department of Mechanical Engineering, United Kingdom*

This paper discusses the possibility of using the Mahalanobis squared-distance to perform robust novelty detection in the presence of important variability in a multivariate feature vector. The application of interest is vibration-based structural health monitoring with a focus on data-based damage detection. For this application, the Mahalanobis distance

M. Belhaq, M. Houssni & I. Kirrou, 2^{nd} *International Conference on Structural Nonlinear Dynamics and Diagnosis* (CSNDD 2014).

can be used to detect novelty using a multivariate feature vector extracted from vibration measurements from a structure at regular intervals during its lifetime. One of the major problems is that changing environmental conditions induce large variability in the feature vector under normal condition, which usually prevents detection of smaller variations due to damage. In this paper, it is shown that including the variability due to the environment in the training data used to define the Mahalanobis distance results in very efficient filtering of the environmental effects while keeping the sensitivity to structural changes.

Nonlinear features identified by Volterra series for damage detection in a buckled beam

Mon.
14:50–15:10
R Diwan II

S.B. Shiki, C. Hansen, S. Da Silva

UNESP-Univ Estadual Paulista, Brazil

The present paper proposes a new index for damage detection based on nonlinear features extracted from prediction errors computed by multiple convolutions using the discrete-time Volterra series. A reference Volterra model is identified with data in the healthy condition and used for monitoring the system operating with linear or nonlinear behavior. When the system has some structural change, possibly associated with damage, the index metrics computed could give an alert to separate the linear and nonlinear contributions, besides provide a diagnostic about the structural state. To show the applicability of the method, an experimental test is performed using nonlinear vibration signals measured in a clamped buckled beam subject to different levels of force applied and with simulated damages through discontinuities inserted in the beam surface.

Numerical and experimental assessment of the modal curvature method for damage detection in plate structures

Mon.
15:10–15:30
R Diwan II

F. Mosti, G. Quaranta, W. Lacarbonara

Department of Structural and Geotechnical Engineering, Sapienza University of Rome, Italy

This paper is concerned with the use of numerically-derived modal curvatures for damage detection in, both, homogeneous and composite laminated plates. Numerical simulations are carried out by using COMSOL Multiphysics, in which the plate is modeled as a Mindlin-Reissner plate and defects are introduced as localized smoothed variations of the baseline bending stiffness. Experiments are also performed on steel and aluminum plates using scanning laser vibrometry. Our study confirms that the central difference method greatly amplifies the measurement errors and its application basically leads to ineffective outcomes for damage detection, especially when a large set of measurement points is considered. Preliminary signal processing operations for noise reduction even if beneficial for high noise levels do not solve the problem in that neither the detection of damaged zones nor the reduction of false alarms exhibit significant improvements. As a consequence, more advanced numerical techniques are required to allow the effective use of numerically-obtained modal curvatures for structural health monitoring. Herein, the Savitzky-Golay filter (or least-square smoothing filter) is considered, a local method for numerical differentiation of noisy data. When applied to numerical or experimental

data with small levels of noise contamination, final results show that the Savitzky-Golay filter exhibits higher robustness against measurement errors, thus proving its superiority over the finite difference method for damage detection in plate structures.

In Situ testing and nonlinear modelling for a cable-stayed timber footbridge

Mon.
15:30–15:50
R Diwan II

D. Bortoluzzi[1], F. Casciati[1], S. Casciati [2], L. Faravelli[1]

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[2] *DICA, University of Catania, 96100 Siracusa, Italy*

The authors had the chance to collect structural response measurements of a cable-stayed gluedlaminated- timber (GLT) footbridge located in Farra d'Alpago (not far from the town of Belluno, in North- Eastern Italy). A consistent geometrically nonlinear finite element model was generated and its parameters were calibrated on the experimental data. Finally, a model validation was carried out.

Structural health and dynamic behavior of residential buildings field challenges in the rehab of damaged reinforced concrete

Mon.
15:50–16:10
R Diwan II

M.S. Chalhoub
Notre Dame University, Lebanon

Reinforced concrete buildings require special treatment compared to others due to their anisotropic and non-homogeneous material properties. Strain compatibility equations are used in analytical and code solutions with basic assumptions about the deformation field across the structural section and along the member. However, these assumptions fall short of describing real life structural behavior when such elements undergo dynamic loading including impulse, earthquake, or cyclical vibration.

This paper addresses first the structural health of reinforced concrete structures that have sustained dynamic loading, with emphasis on impulse or earthquake loading. It proposes a diagnosis method through analytical procedures and field measurement. Second, it discusses sustainability of the damaged structure to assist in a decision rule related to three levels of remedial action, namely (1) minor fixes, (2) major rehabilitation, and (3) disposal. The paper emphasizes the importance of drawing a distinction between reversible and irreversible effects of cyclic loading on the structure, and addresses bond and detailing for ductile behavior.

Given that building codes provide minimum requirements, whether on the loading side or on the strength availability side of the design equation, a theoretical model is presented to describe the behavior of aging or damaged structures. The model is then compared to empirical results from building data collected in the Middle East where reinforced concrete makes up the majority of residential buildings. The challenge becomes greater when environmental conditions around the building over-task the structure in a way that such basic design assumptions no longer hold. The analysis explores the effect of critical parameters on the dynamic properties of the building including steel-concrete bond, masonry in-fills, and extent to which the sections are cracked.

Results show a positive correlation between the theoretical model and the empirical results and confirm that the parameters identified above have a statistically significant correlation with the dynamic properties of the building. Those properties have a direct relationship with its response to potential dynamic excitations, including ground motion or impulse loading.

Diagnosis of autism child through mechanical analysis of marching in symbolic dynamics

Mon.
16:10–16:30
R Diwan II

L. Livi de Souza[1,2], S.S.R. Fleury Rosa [3,4], M.O. Magno de Carvalho[5]

[1] *University of Brasilia - UNB, PhD in Mechanical Sciences, Brazil*
[2] *Federal Institute of Goiás - Campus Uruaçu, Brazil*
[3] *Laboratory of Engineering and Biomaterial, Faculty Gama, Brazil*
[4] *MIT Media Lab, Camera Culture Group, Brazil*
[5] *University of Brasilia - UNB, Department of Mechanical Engineering, Brazil*

This article aims to demonstrate a new technique used to aid in the detection of children with autism symptoms. Given the complexity of the rapid identification of this disease is something that defies medicine in general, and propose a technique that would help doctors to observe patients with these symptoms have significant parameters that can accelerate the identification process. In this case we use the data from the pressure Autistic Walk (PCA), with these data we apply the technique of symbolic dynamics to observe the dynamics in these signs exist, and so we can capture important differences to aid in this differentiation. In preliminary results we can observe significant differences between the characteristics of the dynamic between male patients and female.

MS 3

Time-delayed feedback control: theory and application

Organizers: *S. Gurevich* Germany, *S. Yanchuk* Germany

Scheduled:			
Monday	*14:00–16:30*	Hotel Palais des Roses	**Room Diwan III**

Delayed feedback control of breathing localized structures in reaction-diffusion systems

Mon.
14:00–14:30
R Diwan III

S. Gurevich
Civil Institute for Theoretical Physics, University of Münster, Münster, Germany

We are interested in stability properties of a single breathing localized structure in a three-component reaction-diffusion system subjected to the time-delayed feedback. The presence of the time-delayed feedback enables a direct control of the amplitude and frequency of the oscillations. In particular, the variation in the delay time and the feedback strength can also lead to stabilization of the breathing solution. We also provide a bifurcation analysis of the delayed system and derive an order parameter equation, explicitly describing the temporal evolution of the localized structure in the vicinity of the bifurcation point.

Bifurcations in time-delay fully-connected networks with symmetry

Mon.
14:30–14:50
R Diwan III

D.P. Ferruzzo Correa, J.R.C. Piqueira

Universidade de Sao Paulo, Escola Politécnica, Sao Paulo-SP, Brazil

In this work a brief method for finding steady-state and Hopf bifurcations in a (R + 1)-th order N-node time-delay fully-connected network with symmetry is explored. The irreducible representations found due to the network symmetry are used to find regions of time-delay independent stability/instability in the parameter space. Symmetry-preserving and symmetry-breaking bifurcations can be computed numerically using the S_n map proposed in [1]. The analytic results show the existence of symmetry-breaking bifurcations with multiplicity N-1. A second-order N-node network is used as application example. This work is a generalization of some results presented in [2].

Bibliography

[1] Beretta Edoardo and Kuang Yang. Geometric stability switch criteria in delay differential systems with delay dependent parameters. SIAM Journal on Mathematical Analysis, **33**(5):1144-1165, 2002.
[2] Diego Paolo Ferruzzo Correa, Claudia Wulff, and Jose Roberto Castilho Piqueira. Symmetric bifurcation analysis of synchronous states of time-delayed coupled oscillators. October 2013.

Adaptive topology in the control of delay-coupled networks

Mon.
14:50–15:10
R Diwan III

A.J. Lehnert[1], Ph. Hövel [1,2], A. Fradkov[3,4], E. Schöll[1]

[1] *Institut für Theoretische Physik, TU Berlin, Berlin, Germany*
[2] *Bernstein Center for Computational Neuroscience, HU Berlin, Berlin, Germany*
[3] *SPb State University, Russia*
[4] *Russian Academy of Sciences, St. Petersburg, Russia*

Adaptive networks are characterized by a complicated interplay between the dynamics of the nodes and a changing topology: The topology evolves according to the state of the system, while at the same time the dynamics on the network and thus its state is influenced by that topology. Here, we present an algorithm for a changing topology that allows us to control the dynamics on the network. In particular, we control zero-lag and cluster synchronization in delay-coupled networks of Stuart-Landau oscillators. The emerging topology of the network is modulated by the delay. If the delay time is a multiple of the system's eigenperiod, the coupling within a cluster and to neighboring clusters is on average positive (excitatory), while the coupling to clusters with a phase lag close to π is negative (inhibitory). For delay times equal to odd multiples of half of the eigenperiod, we find the opposite: Nodes within one cluster and of neighboring clusters are coupled by inhibitory links, while the coupling to clusters distant in phase state is excitatory. We explain these delay modulations by considering conditions for the existence of a cluster solution

Optical feedback control of two-mode dynamics in semiconductor lasers

Mon.
15:10–15:30
R Diwan III

K. Panajotov[1,2], M. Virte[2,3], H. Thienpont[1], M. Sciamanna[3]

[1] *Brussels Photonics Team, Vrije Universiteit Brussels, Pleinlaan 2, 1050 Brussels, Belgium*
[2] *Institute of Solid State Physics, 1784 Sofia, Bulgaria*
[3] *Supelec, OPTEL Research Group, LMOPS EA-4423, Metz, France*

We first report on recently discovered polarization chaos in solitary Vertical-Cavity Surface-Emitting Lasers (VCSELs). Next, we review the features of the two-mode nonlinear dynamics induced by optical feedback in VCSELs and quantum dot semiconductor lasers.

Application of delay differential equations in modeling of multimode lasers

Mon.
15:30–15:50
R Diwan III

A.G. Vladimirov

Weierstrass Institute, Berlin, Germany

In this presentation we discuss an approach to the analysis of nonlinear dynamics in multimode semiconductor lasers based on a set of delay differential equations (DDE) for the electric field envelope and carrier density in nonlinear intracavity media. We consider DDE models of a passively mode-locked semiconductor laser generating short optical pulses and a frequency swept mode-laser used in optical coherence tomography. We present the results of numerical simulations of different dynamical regimes in these lasers and discuss asymptotic approaches for the stability analysis of these regimes. In particular, we derive a map describing the transformation of the characteristics of shot optical pulse after a round trip in the laser cavity and map determine the stability boundaries of different mode-locking regimes in the laser parameter space. Finally, using a DDE laser model we provide a theoretical interpretation of the dynamical regimes observed experimentally in a frequency swept laser operating in the Fourier domain mode-locked regime.

Coarsening and nucleation in bistable dynamical systems with long delay

Mon.
15:50–16:10
R Diwan III

S. Yanchuk, G. Giacomelli, F. Marino, M. Zaks

Humboldt University of Berlin, Germany

The correspondence between long-delayed systems and one-dimensional spatially extended media enables a direct interpretation of purely temporal phenomena in terms of spatio-temporal patterns. On the basis of this result, we provide the evidence of a characteristic spatio-temporal dynamics coarsening and nucleation in a long-delayed bistable system. Nucleation, propagation and annihilation of fronts, leading eventually to a single phase, are described in a general phenomenological model as well as in an experiment based on a laser with opto-electronic feedback.

Delayed feedback control of self-mobile localized structures in nonlinear optics

Mon.
16:10–16:30
R Diwan III

M. Tlidi

Université Libre de Bruxelles, B-1050 Bruxelles, Belgium

We report on the impact of the phase of the time-delayed optical feedback and carrier lifetime on the self-mobility of localized structures in nonlinear optics. Localized structures of light in nonlinear laser systems are among the most interesting spatiotemporal patterns occurring in extended nonlinear systems. They have attracted growing interest in optics due to potential applications for all-optical control of light, optical storage, and information processing. Since the experimental evidence of CSs in broad area semiconductor cavities, several possible applications of CSs such as all optical delay lines, logic gates, and microscope have been proposed. The fast response time of semiconductors makes them attractive devices for potential applications. Cavity solitons are not necessary stationary

objects: it has been shown that they exhibit a motion induced by a regular time-delayed feedback, which provides a robust and a controllable mechanism, responsible for the appearance of a spontaneous motion. Previous works revealed that when the product of the delay time and the rate of the feedback exceeds some threshold value, cavity solitons start to move in an arbitrary direction in the transverse plane [1–6]. In these studies, the analysis was restricted to the specific case of nascent optical bistability with a real feedback term.
We report on the impact of the phase of the time-delayed optical feedback and carrier lifetime on the self-mobility of localized structures of light in broad-area semiconductor cavities. We show both analytically and numerically that the feedback phase strongly affects the drift instability threshold as well as the velocity of cavity soliton motion above this threshold. In addition we demonstrate that the noninstantaneous carrier response of the semiconductor medium is responsible for the increase of the critical feedback rate corresponding to the drift instability.

Bibliography

[1] M. Tlidi, A.G. Vladimirov, D. Pieroux, and D. Turaev, Phys. Rev. Lett. **103**, 103904 (2009).
[2] S.V. Gurevich and R. Friedrich, Phys. Rev. Lett. **110**, 014101 (2013).
[3] K. Panajotov and M. Tlidi, Eur. Phys. J. D 59, 67 (2010).
[4] M. Tlidi, E. Averlant, A. Vladimirov, and K. Panajotov, Phys. Rev. A **86**, 033822 (2012).
[5] S.V. Gurevich and R. Friedrich, Phys. Rev. Lett. **110**, 014101 (2013).
[6] A. Pimenov, A.G. Vladimirov, S.V. Gurevich, K. Panajotov, G. Huyet, and M. Tlidi, Phys. Rev. A **88**, 053830 (2013).

MS 4

Aerospace and naval structures: mathematical modeling, nonlinear dynamical behavior and control designs

Organizers: *A. Fenili* Brazil, *J.M. Balthazar* Brazil

Scheduled:				
	Monday	*14:00–16:30*	Hotel Palais des Roses	**Room Diwan IV**

Quasi-coordinates based dynamics control design for constrained systems

Mon.
14:00-14:30
R Diwan IV

E. Jarzêbowska
Warsaw University of Technology, Warsaw, Poland

The paper presents model-based dynamics control design for constrained systems which exploits dynamics modeling in quasi-coordinates. These non-inertial coordinates are useful in motion description of constrained systems as well as in a controller design, since they offer many advantages in both areas. Specifically, dynamics model formulation results in a reduced-state form of the motion equations. The selection of quasi-coordinates is arbitrary so they may satisfy the constraint equations and be control inputs directly. The paper presents an approach to control oriented modeling and a controller design based on the generalized Boltzmann-Hamel equations where the generalization refers to constraint kinds which may be put upon systems, i.e. constraints may be material or artificial like control constraints. The control design framework applies to fully actuated and underactuated systems and it is computationally efficient. Examples of controller designs and their comparisons to a traditional, Lagrange model- based framework are presented.

Structural response of reduced scale naval structures under impact tests

Mon.
14:30–14:50
R Diwan IV

M.A.G. Calle, R.E. Oshiro, L.M. Mazzariol, M. Alves
Polytechnic School of the University of Sao Paulo, Sao Paulo, Brazil

Scaled models are important in naval engineering since actual ship size makes too expensive to test prototypes. However, the analysis of ship collision events employing naval structures in reduced scale is not an ordinary ship research area. The aim of this work is to create the basis for a posterior similarity study by analysing reduced scale ship structures submitted to impact loads. Two basic naval structures, commonly found in the construction of large ships, were considered for this study: a T cross-section beam submitted to a midspan impact test and a double plate panel with inner cross reinforcement

also submitted to a centre impact test. Both naval structures models were fabricated for experimental tests in a reduced scale of 1:100. The experimental material characterization was also carried out in this work which included the evaluation of the stress strain curve under quasi static conditions, the strain rate sensitivity and the structural failure using three criteria developed particularly for numerical modelling of ship collision by other authors.

Nonlinear modeling of slewing flexible structures: ideal and non ideal approaches

Mon.
14:50–15:10
R Diwan IV

A. Fenili, C.P. Fernandes Francisco, K.P. Burr, J.M. Balthazar, R.M.L.R. da Fonseca Brasil

Universidade Federal do ABC, Aerospace Engineering Santo André, SP - Brazil

The mathematical modelling of rotating nonlinear flexible beam-like wing, driven by a DC motor, with rectangular cross section is investigated here. The structure is mathematically modeled considering linear curvature and clamped-free boundary conditions. The flexible wing has an angle of attack which is considered constant. Nonlinearities resulting from the coupling between the angular velocity of the rotating axis and the transversal vibration of the beam are considered. A drag force and a lift force acting along the beam length are also included in the mathematical model. These forces are velocity dependent nonlinear excitations acting on the bean-like wing.

Buckling and postbuckling of nanobeams with nonlocal effect according to higher-order shear deformation theories

Mon.
15:10–15:30
R Diwan IV

S.A. Emam

United Arab Emirates University, Al Ain, United Arab Emirates

This study presents a unified model for the nonlocal response of nanobeams in buckling and postbuckling states. The formulation is suitable for the classical Euler-Bernoulli, first-order Timoshenko, and higher-order shear deformation beam theories. The small-scale effect is modeled according to the nonlocal elasticity theory of Eringen. The equations of equilibrium are obtained using the principle of virtual work. The stress resultants are developed taking into account the nonlocal effect. Analytical solutions for the critical buckling load and the amplitude of the static nonlinear response in the postbuckling state are obtained. It is found out that as the nonlocal parameter increases, the critical buckling load reduces and the amplitude of buckling increases. Numerical results showing variation of the critical buckling load and the amplitude of buckling with the nonlocal parameter and the length-to-height ratio for simply supported and clamped-clamped nanobeams are presented.

Effect of loading pulse duration on dynamic buckling of stiffened panels

Mon.
15:30–15:50
R Diwan IV

O. Mouhat, A. Khamlichi

Abdelmalek Essaadi University, Tetouan 93002, Morocco

Design of stiffened panels requires evaluating their stability under various loading combinations for all possible scenarios regarding material degradation or initial geometric imperfections that could affect them. Both static and dynamic loading conditions are to be investigated for assessing the buckling strength. In this work, dynamic buckling under in-plane uniform axial compression loading having the form of a transient pulse with finite duration is evaluated through nonlinear finite element modelling. A welding induced defect that consists of an initial geometric imperfection modifying the skin plate curvature in the longitudinal direction was incorporated. The Budiansky buckling criterion was employed to predict instability under this dynamic loading. The obtained results have shown that the pulse period yields a drastic effect on the buckling strength. For the considered boundary conditions, half-sine like pulses having periods that are comparable to two times the period of the first mode of natural vibrations of the stiffened plate were found to reduce hugely the buckling strength, with the dynamic buckling load representing almost only half its static value.

Control strategies for friction dampers: numerical assessment and experimental investigations

Mon.
15:50–16:10
R Diwan IV

H.T. Coelho[1], M.B. Santos[1], F.P. Lepore Neto[1], J. Mahfoud[2]

[1] *Mechanical Engineering School, Federal University of Uberlandia, Brazil*
[2] *LaMCoS, Insa Lyon, France*

The use of friction dampers has been proposed in a wide variety of mechanical systems for which it is not possible to apply viscoelastic materials, fluid based dampers or others viscous dampers. An important example is the application of friction dampers in aircraft engines to reduce the blades vibration amplitudes. In most cases, friction dampers have been studied in a passive way, however, a significant improvement can be achieved by controlling the normal force in the dampers. The aim of this paper is to study three control strategies for friction dampers based on the hysteresis cycle. The first control strategy maximizes the energy removal in each harmonic oscillation cycle, by calculating the optimum normal force based on the last displacement peak. The second control strategy combines the first one with the maximum energy removal strategy used in the smart spring devices. Finally, is presented the strategy which homogenously modulates the friction force. Numerical studies were performed with these three strategies defining the performance metrics. The best control strategy was applied experimentally. The experimental test rig was fully identified and its parameters were used for the numerical simulations. The obtained results show the good performance for the friction damper and the selected strategy.

Detecting structural change in an electromechanical system using embedding dimension

Mon.
16:10–16:30
R Diwan IV

C.A. Kitio Kwuimy, M. Samadani, C. Nataraj

Department of Mechanical Engineering, Villanova University, Villanova PA, USA

The embedding dimension of the reconstructed state space is considered in the paper as feature for preliminary diagnostics of nonlinear systems. We considered a well known model of nonlinear electromechanical system and simulated various structural defects. The results of the analysis were effective in detecting class of structural defects, including defects connected to coupling mechanism. There is clearly a huge potential of such approach for the diagnostic of complex machinery.

MS 5
Stability of rotating machines

Organizers: *J. Mahfoud* France, *A. El-Shafei* Egypt

Scheduled:

Monday *17:00–19:30* Hotel Palais des Roses **Room Diwan II**

Rotor-stator contact-overview of current research

Mon.
17:00–17:30
R Diwan II

O. Alber, R. Markert

Darmstadt University of Technology, Darmstadt, Germany

The aim of this paper is to provide a compact as well as comprehensive overview of Rotor-Stator Contact in rotordynamics. A general model is described, which accounts for most phenomena of Rotor-Stator Contact observed in literature. This model is compared to different modeling approaches used in the previous literature. A glance on the variety of motion patterns including analytical approaches to the synchronous motion and Backward Whirl motion is given. As an outlook a modal reduction technique is pointed out, which is capable of reducing systems with many degrees of freedom for rotor and/or stator to the described model.

Nonlinear responses of externally excited rotor bearing systems

Mon.
17:30–17:50
R Diwan II

B. Choudhary , B. Pratiher

Department of Mechanical Engineering, Indian Institute of Technology Jodhpur, India

The present work deals with the investigation of nonlinear responses of a flexible rotor bearing system subjected to harmonically varying support motion. A mathematical model of rotor bearing system consisting of flexible shaft and rigid disk is developed by incorporating higher rotary inertia, gyroscopic effect, higher order large deformations, rotor mass unbalance and periodically applied external support motion. Extended Hamilton’s principle is used to derive coupled nonlinear differential equations of motion. Perturbation technique is used to formulate a set of reduced order equations in order to obtain the approximate responses for various possible resonance conditions. The effect of nonlinearity due to higher order deformations and variations in the values of different parameters like mass unbalance and shaft diameter significantly on the dynamic behavior of the rotor system has been investigated. Subsequent investigation of existing bifurcations and their influences on the dynamics performance of rotor bearing system has been established. Finally, consequences from this manuscript can significantly employ towards design and development of moderately lightweight rotor bearing systems subjected to externally enforced support motion.

M. Belhaq, M. Houssni & I. Kirrou, 2nd *International Conference on Structural Nonlinear Dynamics and Diagnosis* (CSNDD 2014).

Experimental analysis of a rigid rotor supported on aerodynamic foil journal bearings

Mon.
17:50–18:10
R Diwan II

M. Arghir[1], F. Balducchi[1], A. Pilavoine[2]

[1] *Institut Pprime, UPR CNRS 3346, Université de Poitiers, France*
[2] *ENSMA ISAE Poitiers, France*

Aerodynamic foil bearings are highly non linear components used or intending to be used for supporting high speed rotors ($> 30krpm$) of low size rotating machines ($< 400kW$). The non linear character comes from the highly deformable structure of the bearing made of thin steel sheets and from the Coulomb friction forces arising during dynamic displacements. The present work shows the non linear response of a rigid rotor supported by a pair of such bearings and entrained at $82krpm$. The measurements performed during the coast down revealed sub synchronous and asynchronous vibrations of the rotor and their multiples. A simplified theoretical model reproduces qualitatively some of these non linear characteristics.

The Nonlinear dynamic response of a rotor system supported by hydrodynamic journal bearings

Mon.
18:10–18:30
R Diwan II

A. Amamou, M. Chouchane

National Engineering School of Monastir, Monastir, Tunisia

This paper investigates the bifurcation and nonlinear behaviour of a two degrees of freedom model of a symmetrical balanced rigid rotor supported by two identical journal bearings. The fluid film hydrodynamic reactions are modelled by applying both the short and the long bearing approximation and using half Sommerfeld solution. A numerical integration of the equations of motion of the journal centre is presented to predict the presence and the size of stable or unstable limit cycles in the neighbourhood of the stability threshold speed. For their stability margins, a continuation method based on the predictor-corrector mechanism is used. The numerical results of responses show that stability and bifurcation behaviours of periodic motions depend strongly on bearing parameters and its dynamic characteristics.

Method of the unbalanced rotor critical frequency overcoming by means of the operated magnetic spring

Mon.
18:30–18:50
R Diwan II

A. Lukin[1], I. Popov[1], D. Skubov [1,2], L. Shtukin[1,2]

[1] *St. Petersburg State Polytechnical University, Russia*
[2] *Institute of Problems of Mechanical Engineering RAS, Russia*

When passing critical rotational frequency of a rotor with significant imbalance there can be cross-oscillations with large amplitudes. The algorithm of critical rotational frequency overcoming which allows reducing these oscillations considerably is described.It is offered to use a differential magnetic spring as an elastic support with operated stiffness.

Dynamic behaviour of rotary lip seal

Mon.
18:50–19:10
R Diwan II

M. El Gadari[1], M. Belhaq[2]

[1] *ENSAM, University of Moulay Ismail, Meknès, Morocco*
[2] *Mechanics Laboratory, University of Hassan II, Casablanca, Morocco*

We report on the dynamic behavior of a rotary lip seal by considering the interaction between lip, film and shaft roughness assumed to have a periodic form. The nonlinearities of stiffness and viscosity of the film are taken into account in a mass-spring-dumper model. Using the harmonic balance method, analytical prediction of the lip displacement is obtained, the frequency response is provided and the effect of the shaft undulation on the amplitude jumps of the lip displacement and on the film thickness fluctuations are discussed. The results have direct applications in reducing leakage that may occur between a smooth lip seal and a rough shaft.

MS 6
Multiple time scale dynamical systems

Organizers: *J. Starke* Denmark, *P. Szmolyan* Austria

Scheduled:

Monday	*17:00–19:30*	Hotel Palais des Roses	**Room Diwan III**

Multiscale geometry of the Olsen model and non-classical relaxation oscillations

Mon.
17:00–17:30
R Diwan III

C. Kuehn , P. Szmolyan

Institut fur Analysis und Scientific Computing, Technische Universitat Wien, Wien

We study the Olsen model for the peroxidase-oxidase reaction [1]. This fourdimensional problem contains several small parameters and has complicated slowfast dynamics including mixed-mode and chaotic oscillations [6]. Despite many efforts, the Olsen model has resisted rigorous mathematical analysis for over thirty years. We provide a first detailed geometric singular perturbation analysis of the Olsen model to understand the dynamics. A scaling from [5] and the blow-up method [2–4] are used to identify several important subsystems which explain the dynamics in certain regimes. A rigorous analysis of the existence of non-classical relaxation oscillations is given in two cases. The analysis is based upon desingularization of lines of transcritical and submanifolds of fold singularities in combination with an integrable global return mechanism. The geometric decomposition we develop gives also insight into the mechanisms generating mixed-mode and chaotic oscillations.

Bibliography

[1] H. Degn, L.F. Olsen, and J.W. Perram. Bistability, oscillation, and chaos in an enzyme reaction. Annals of the New York Academy of Sciences, **316**(1):623-637, 1979.

[2] F. Dumortier and R. Roussarie. Canard Cycles and Center Manifolds, volume 121 of Memoirs Amer. Math. Soc. AMS, 1996.

[3] I. Kosiuk and P. Szmolyan. Scaling in singular perturbation problems: blowing-up a relaxation oscillator. SIAM J. Appl. Dyn. Syst., **10**(4):1307-1343, 2011.

[4] M. Krupa and P. Szmolyan. Extending slow manifolds near transcritical and pitchfork singularities. Nonlinearity, **14**:1473-1491, 2001.

[5] A. Milik. Mixed-mode oscillations in chemical systems. PhD thesis, Vienna University of Technology, Vienna, Austria, 1998.

[6] R. Larter, C.L. Bush, T.R. Lonis, and B.D. Aguda. Multiple steady states, complex oscillations, and the devil's staircase in the peroxidase-oxidase reaction. J. Chem. Phys., **87**(10):5765-5771, 1987.

M. Belhaq, M. Houssni & I. Kirrou, 2^{nd} *International Conference on Structural Nonlinear Dynamics and Diagnosis* (CSNDD 2014).

Epsilon-free methods for identifying canard explosions in slow-fast dynamical systems

Mon.
17:30–17:50
R Diwan III

M. Brøns[1], K. U. Kristiansen[1], M. Desroches[2] M. Krupa[1]

[1] *Technical University of Denmark 2800 Kongens Lyngby, Denmark*
[2] *INRIA Paris-Rocquencourt Research Centre Domaine de Voluceau, Le Chesnay, France*

The canard explosion is a bifurcation-like phenomenon occurring in nonlinear dynamical systems with several time scales: as a parameter varies across a narrow interval the amplitude and period of a limit cycle changes dramatically. Since the original discovery in the late 1970'ties it has been identified in a wide range of mathematical models arising in mechanics, chemistry and biology. For systems where a small parameter (usually denoted e) explicitly defines the time scale separation the canard explosion is well understood. However, many slow-fast systems arising in applications do not have an obvious small parameter; for such systems it clearly of interest to devise methods which can identify canards explosions by other means than the classical asymptotic expansions. In this talk we review some recent epsilon-free methods for finding the canard point, that is, the parameter value which is at the center of the canard explosion. The methods are adaptations of the Fraser-Roussel method and the zero derivative principle which yield approximations of invariant manifolds for slow-fast dynamical systems. We will show that the methods give asymptotically correct results for systems which do have an explicit small parameter and also demonstrate the strength of the methods for some examples of slow-fast systems without such a parameter.

Mathematical modeling and simulation of some renewable energy power plants

Mon.
17:50–18:10
R Diwan III

I. Gasser[1], M. Bauer[2], E. Felaco[1], M. Kamboh[2]

[1] *Universitat Hamburg, Germany*
[2] *TU Hamburg Harburg, Germany*

We present models to describe the power production of an Solar Updraft Tower [4] or an Energy Tower [5]. In both cases the energy source - the solar energy in the first case and the heat of evaporation in the second case - is used to induce an air flow in a tower which then powers a turbine and produces electrical energy. In both cases it is crucial to find a simple gas dynamic description of the air flow. In both cases the flow is buoyancy driven and therefore we have to start with a fully compressible (nonlinear PDE) model. Then we derive a small Mach number asymptotic (nonlinear mixed ODE-PDE) model which allows fast and robust numerical simulations [1–3]. Finally we present simulations and first optimization results for such power plants. In the case of a solar updraft tower with flat collectors we obtain good qualitative and quantitative agreement with the data of the prototype in Manzanares [4].

Bibliography

[1] M. Bauer, I. Gasser, Modeling, asymptotic analysis and simulation of an Energy Tower, SIAM J. Appl. Math. **72**(1), 362-381, (2012).

[2] I. Gasser, Modelling and Simulation of a Solar Updraft Tower, Kinetic and Related Models KRM, **2**(1), 191-204, (2009).
[3] I. Gasser, M Kamboh, Modeling, asymptotic analysis and simulation of a solar Updraft Tower for high latitude, in preparation, (2014).
[4] J. Schlaich, W. Schiel, Solar Chimneys, in RA Meyers (ed), Encyclopedia of Physical Science and Technology, 3rd Edition, Academic Press, London (2001).
[5] D. Zaslavsky, Energy Towers. PhysicaPlus-Online magazine of the Israel Physical Society (Israel Physical Society) 7, (2006).

Periodic orbits near a bifurcating slow manifold

Mon.
18:10–18:30
R Diwan III

K.U. Kristiansen

Technical University of Denmark, Department of Mathematics and Computer Science, Denmark

In this talk I will consider a class of one-degree-of-freedom Hamiltonian systems with a slowly varying phase. The slowly varying phase is assumed to unfold a Hamiltonian pitchfork bifurcation. The main result of the paper is that there exists an order of $\ln 2\epsilon^{-1}$-many periodic orbits that all stay within an $O(\epsilon^{1/3})$-distance from the union of the normally elliptic slow manifolds that occur as a result of the bifurcation. As they pass through the bifurcation the time scales are comparable. Here $\epsilon \ll 1$ measures the time scale separation. These periodic orbits are typically "moderately" unstable. This is in contrast with the periodic orbits that remain an $O(1)$-distance from the slow manifold. The effect of approaching the normally elliptic slow manifold is therefore to reduce the stability region. The smallest stable orbit *typically* remains further away from the slow manifold being distant by an order $O(\epsilon^{1/3} \ln^{1/2} \ln \epsilon^{-1})$. The proof is based on averaging of two blow-up systems, allowing one to estimate the effect of the singularity, combined with results on asymptotics of the second Painleve equation.

Analysis of implicit equation-free methods and applications

Mon.
18:30–18:50
R Diwan III

J. Starke[1], C. Marschler[1], J. Sieber[2]

[1] *Technical University of Denmark, Denmark*
[2] *University of Exeter, College of Exeter Engineering, Mathematics and Physical Sciences, UK*

An implicit method for equation-free analysis of slow-fast systems is presented and analyzed. Here, it is assumed that the behavior of a microscopic system converges quickly to a slow manifold representing the macroscopic behavior of the system. Equation-free analysis allows to investigate the behavior on this slow manifold without given explicit equations on a macroscopic level nor the microscopic system given in standard form with time-scale separation. This is done by extracting the necessary information on the macroscopic level from short simulation bursts of the microscopic model and repeated switching between the macroscopic and the microscopic level through so-called restriction and lifting operators. It is shown, that the implicitly defined coarse-level time stepper converges to the true dynamics on the slow manifold. In contrast to traditional explicit equation-free methods the implicit method avoids lifting-errors. The method is demonstrated by performing a coarse bifurcation analysis of macroscopic structures for different applications: Travelling wave solutions are investigated in a microscopic traffic model and the learning behavior of emerging periodic structures in the connectivity matrix of a neural network model are studied. A coarse integration is performed backward in time, stable and unstable branches of the coarse bifurcation diagram are continued, co-dimension one bifurcation points are detected on the coarse level and their continuation in two parameters is presented.

Existence of chapman-jouguet detonation and deflagration waves

Mon.
18:50–19:10
R Diwan III

J. Wächtler[1], I. Gasser[1], P. Szmolyan[2]

[1] *Universitat Hamburg, Germany*
[2] *Technische Universitat Wien, Wien*

We study the existence of profiles for Chapman-Jouguet detonation and deflagration waves in the Navier Stokes equations for a reacting gas. In the limit of small viscosity, diffusion and heat conductivity, the profiles correspond to heteroclinic orbits of a system of singularly perturbed ordinary differential equations. The existence of detonation and deflagration waves with non-sonic burned states has been established in [1] by using methods from geometric singular perturbation theory [2,4].
However, for Chapman-Jouguet processes the burned state of the waves is a non-hyperbolic equilibrium of the associated, purely gasdynamic layer problem. Hence standard methods from geometric singular perturbation theory fail. We show how to resolve this degeneracy by combining a center manifold reduction with the blow-up method [3]. The main result is the existence of viscous profiles for various types of Chapman-Jouguet processes. In addition we obtain results on the spatial decay rates of these waves which are expected to be relevant for the stability analysis of these waves.

MS 7
Nonlinear dynamics in MEMS/NEMS/AFM

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

Scheduled:

Monday	*17:00–19:30*	Hotel Palais des Roses	**Room Diwan IV**

Jump and pull-in dynamics of an electrically actuated bistable MEMS device

Mon.
17:00–17:30
R Diwan IV

L. Ruzziconi[1], S. Lenci[1], M.I. Younis[2,3]

[1] *Polytechnic University of Marche, Ancona, Italy*
[2] *King Abdullah University of Science and Technology (KAUST), Kingdom of Saudi Arabia*
[3] *State University of New York at Binghamton, Binghamton, 13902 NY, USA*

This study analyzes a theoretical bistable MEMS device, which exhibits a considerable versatility of behavior. After exploring the coexistence of attractors, we focus on each rest position, and investigate the final outcome, when the electrodynamic voltage is suddenly applied. Our aim is to describe the parameter range where each attractor may practically be observed under realistic conditions, when an electric load is suddenly applied. Since disturbances are inevitably encountered in experiments and practice, a dynamical integrity analysis is performed in order to take them into account. We build the integrity charts, which examine the practical vulnerability of each attractor. A small integrity enhances the sensitivity of the system to disturbances, leading in practice either to jump or to dynamic pull-in. Accordingly, the parameter range where the device, subjected to a suddenly applied load, can operate in safe conditions with a certain attractor is smaller, and sometimes considerably smaller, than in the theoretical predictions. While we refer to a particular case-study, the approach is very general.

Saddle-node bifurcation in a canonical electrostatic MEMS: a rigourous proof

Mon.
17:30–17:50
R Diwan IV

A. Gutiérrez[1], P.J. Torres[2]

[1] *Departamento de Matemáticas, Universidad Tecnológica de Pereira, Risaralda, Colombia*
[2] *Departamento de Matemática Aplicada, Universidad de Granada, Spain*

Our purpose is to prove analytically the existence of a saddle-node bifurcation of an idealized mass-spring model of electrostatically actuated micro-electro-mechanical system (MEMS) which has become canonical in the related literature. The system consists on two parallel capacitor plates separated by a distance d, one of them is fixed and the second one is movable and attached to a linear spring with stiffness coeffecient $k > 0$.

When an AC-DC voltage $V(t) = v_{dc} + v_{ac}\cos(wt)$ is applied, the Coulomb force between the plates makes the system highly nonlinear. Oscillations are ruled by the second order differential equation

$$my'' + cy' + ky = \frac{\varepsilon_0 A}{2} \frac{V^2(t)}{(d-y)^2} \tag{7.1}$$

where y is the vertical displacement of the moving plate (y is always assumed to be less than d), m is its mass, c is a viscous damping coeffecient, ε_0 is the absolute dielectric constant of vacuum and A is the area of the plates. This mode was introduced by Nathanson et al [1] in 1967 and extensively studied since then. In the recent paper [2], we give a rigorous proof of the known effect of pull-in instability and saddle-node bifurcation by using Leray-Schauder degree and the upper and lower solution method.

Bibliography

[1] H.C. Nathanson,W.E. Newell, R.A.Wickstrom, J.R. Davis, Jr., The resonant gate transistor, Electron Devices, IEEE Transactions on , vol.**14**, no.3, pp. 117-133, 1967.

[2] A. Gutiérrez, P.J. Torres, Non-autonomous saddle-node bifurcation in a canonical electrostatic MEMS, International Journal of Bifurcation and Chaos, Vol. **23**, No. 5 (2013) 1350088 (9 pages), DOI: 10.1142/S021812741350088.

On the control of bistability in non-contact mode AFM using modulated time delay

Mon.
17:50–18:10
R Diwan IV

I. Kirrou, M. Belhaq

Laboratory of Mechanics, University Hassan II-Casablanca, Morocco

We study the control of bistability in non-contact mode AFM using time delay with modulated feedback gain. We consider that the tip-sample interaction force is described by Lennard-Jones potential and the equation of motion is modeled by single degree of freedom system. Perturbation analysis is performed to obtain the modulation equations of the slow dynamic. The influence of the modulated time delay on the nonlinear characteristic of the frequency response is analyzed and the evolution of the bistability region in the modulated time delay parameter plan is examined. Results show that modulation of the feedback gain can be used to reduce the amplitude of the microcanteliver response and to suppress the bistability regime in large region of the modulated delay parameter space. The analytical predictions are compared to numerical simulations for validation.

Bifurcation topology transfer in nonlinear nanocantilever arrays subject to parametric and internal resonances

Mon.
18:10–18:30
R Diwan IV

S. Souayeh, N. Kacem

FEMTO-ST Institute - UMR CNRS 6174 24, chemin de l’Épitaphe, F-25000 Besançon, France

The collective nonlinear dynamics of a coupled array of nanocantilevers is investigated while taking into account the main sources of nonlinearities. The amplitude and phase equations of this device, subject to parametric and internal resonances, are analytically

derived by means of a multi-modal Galerkin discretization coupled with a multiscale analysis. Based on the steady-state solutions of these equations, the frequency response are numerically computed for a two-beam array. The effects of different parameters are investigated and several dynamical aspects are confirmed by numerical simulations. Particularly, we have demonstrated that the bifurcation topology transfer is imposed by the first nanocantilever and it can be general to the collective nonlinear dynamics of the NEMS array.

Investigation of an atomic force microscope system under the effects of Lennard-Jones forces and a slow harmonic base motion

Mon.
18:30–18:50
R Diwan IV

F. Lakrad, M. Khadraoui

Laboratory of Mechanics, University Hassan II-Casablanca, Morocco

We study nonlinear vibrations of an AFM system, modeled as a linear mass-spring-damper system, actuated by Lennard-Jones forces and an imposed harmonic base displacement. The frequency of this latter is very low with respect to the natural fundamental frequency of the system. The invariant slow manifolds of the system are approximated and their bifurcations are investigated. Chart of behaviors of different modes of the AFM are determined and the time contact is computed. It is shown that two dynamic saddle-node bifurcations, during one period of the base oscillation, of the contact and the non-contact invariant slow manifolds are responsible for triggering the tapping mode. It is also shown that these dynamic bifurcations govern the contact time between the probe and the sample.

On the use of dynamic pull-in for reducing the actuation voltage in microswitch applications

Mon.
18:50–19:10
R Diwan IV

M. Naoui, F. Najar, H. Samaali

LASMAP, Tunisia Polytechnic School, University of Carthage, La Marsa, Tunisia

In this paper, we study the use of dynamic pull-in instability to actuate a capacitive microswitch. Using a reduced-order model based on the Differential Quadrature Method, which fully incorporate the electrostatic force nonlinearities, we solve for static, transient and limit-cycle solutions. We show that using only nine grid points give relatively accurate results when compared to those obtained using ANSYS. Then we examine the dynamic behavior of the MEMS switch under different electrical actuation waveforms and obtain results indicating that subsequent reduction can be obtained in actuation voltage and switching time.

MS 8

Deterministic and stochastic dynamics and control of nonlinear systems

Organizers: *J.M. Balthazar* Brazil, *M.R. Hajj* USA, *S. Lenci* Italy

Scheduled:			
Tuesday	*14:00–16:30*	Hotel Palais des Roses	**Room Diwan I**
Tuesday	*17:00–19:10*	Hotel Palais des Roses	**Room Diwan I**

Uncertainty quantification in dynamical systems

Tue.
14:00–14:30
R Diwan I

J.E. Souza de Cursi

LOFIMS INSA de Rouen 685, Saint-Etienne du Rouvray, France

When considering mechanical systems, namely, structural dynamics, uncertainty arises from the variability or lack of information about parameters, materials, geometry and boundary or initial conditions. A typical example is furnished by a pendulum involving geometrical or physical parameters affected by uncertainty or variability: length, mass, rigidity or damping may be considered as random variables. Thus, uncertainty affects all the usual parameters involved in the analysis of the dynamical systems, such as natural frequencies, limit cycles, orbits etc.

When studying scalar parameters, such as natural frequencies, period, eigenvalues of the linearized system, etc... uncertainty quantification may be performed by using hilbertian techniques. A more complex situation arises when considering typical curves such as limit cycles, periodic orbits or Poincaré sections: the characterization of the probability distribution and the evaluation of statistics of these objects request the definition of probability distributions and statistical standard parameters in infinite dimensional spaces having functions as elements. For instance, the construction of mean limit cycle of a nonlinear oscillator needs the definition of probabilities in the space of all the possible limit cycles, which is an infinite dimensional functional space. In this case, the pointwise approach is not adapted, analogously to the formal one furnished by the use of cylindrical measures.

This work will present a method the analysis of these situations and presents numerical results. For the infinite dimensional situation, the approach involves a method for the construction of operational infinite dimensional probabilities.

On nonlinear dynamics and control of a robotic arm with chaos

Tue.
14:30–14:50
R Diwan I

J.L.P. Felix[1], E.L. Silva[1], J.M. Balthazar[2], A.M. Tusset[3], A.M. Bueno[4], R.M.L.R.F. Brasil[2]

[1] *UNIPAMPA, Bagé, RS, Brazil*
[2] *UFABC, Santo Andre, SP, Brazil*
[3] *UTFPR, Ponta Grossa, PR, Brazil*
[4] *UNESP, Sorocaba, SP, Brazil*

In this paper a robotic arm is modelled by a double pendulum excited in its base by a DC motor of limited power via crank mechanism and elastic connector. In the mathematical model, a chaotic motion was identified, for a wide range of parameters. Controlling of the chaotic behaviour of the system, were implemented using, two control techniques, the nonlinear saturation control (NSC) and the optimal linear feedback control (OLFC). The actuator and sensor of the device are allowed in the pivot and joints of the double pendulum. The nonlinear saturation control (NSC) is based in the order second differential equations and its action in the pivot/joint of the robotic arm is through of quadratic nonlinearities feedback signals. The optimal linear feedback control (OLFC) involves the application of two control signals, a nonlinear feedforward control to maintain the controlled system to a desired periodic orbit, and control a feedback control to bring the trajectory of the system to the desired orbit. Simulation results, including of uncertainties show the feasibility of the both methods, for chaos control of the considered system.

Fluid damping phenomena in a slender microbeam modelled on nonclassical theory

Tue.
14:50–15:10
R Diwan I

P. Belardinelli, S. Lenci, G. Cocchi

DICEA, Polytechnic University of Marche, 60131 Ancona, Italy

This work deals with the evaluation of the squeeze-film damping in an electrically-actuated microbeam considering the effects of an imposed static deflection. The model presents a reliable modelling of the mechanical behaviour by improving the classical approach with the features of the strain-gradient elasticity theory. Taking into account a correction of the electric actuation for the fringing field effects, a parametric analysis is performed. The work pays attention to evaluate the damping force on the beam surface both in small static deflection regime and near the static pull-in. The results show that the correction for the finiteness of beam edges and the high-order material parameters affect the response only at large deflections. A brief study on the static behaviour is carried out highlighting how the response is affected by the strain-gradient elasticity theory. A parametric analysis of the damping force is presented and the properties of the cut-off point are studied.

Study of the nonlinear longitudinal dynamics of a stochastic system

Tue.
15:10–15:30
R Diwan I

A. Cunha Jr, R. Sampaio

Pontifícia Universidade Católica do, Rio de Janeiro - RJ, Brazil

This paper deals with the theoretical study of how discrete elements attached to a continuous stochastic systems can affect their dynamical behavior. For this, it is studied the

nonlinear longitudinal dynamics of an elastic bar, attached to springs and a lumped mass, with a random elastic modulus and subjected to a Gaussian white-noise distributed external force. Numerical simulations are conducted and their results are analyzed in function of the ratio between the masses of the discrete and the continuous parts of the system. This analysis reveals that the dynamic behavior of the bar is significantly altered when the lumped mass is varied, being more influenced by the randomness for small values of the lumped mass.

Multimode interaction in axially excited cylindrical shells

Tue.
15:30–15:50
R Diwan I

F.M.A. Silva[2], L. Rodrigues[1], P.B. Gonçalves[1], Z.J.G.N. Del Prado[2]

[1] *Department of Civil Engineering, Pontifical Catholic University of Rio de Janeiro, Brazil*
[2] *School of Civil Engineering, Federal University of Goiás, Brazil*

Cylindrical shells exhibit a dense frequency spectrum, especially near the lowest frequency range. In addition, due to the circumferential symmetry, frequencies occur in pairs. So, in the vicinity of the lowest natural frequencies, several equal or nearly equal frequencies may occur, leading to a complex dynamic behavior. So, the aim of the present work is to investigate the dynamic behavior and stability of cylindrical shells under axial forcing with multiple equal or nearly equal natural frequencies. The shell is modelled using the Donnell nonlinear shallow shell theory and the discretized equations of motion are obtained by applying the Galerkin method. For this, a modal solution that takes into account the modal interaction among the relevant modes and the influence of their companion modes (modes with rotational symmetry), which satisfies the boundary and continuity conditions of the shell, is derived. Special attention is given to the $1:1:1:1$ internal resonance (four interacting modes). Solving numerically the governing equations of motion and using several tools of nonlinear dynamics, a detailed parametric analysis is conducted to clarify the influence of the internal resonances on the bifurcations, stability boundaries, nonlinear vibration modes and basins of attraction of the structure.

Nonlinear angle control of a sectioned airfoil by using shape memory alloys

Tue.
15:50–16:10
R Diwan I

G. Abreu[1], M. Maestá[1], C. Faria[2], V. Lopes Jr[1]

[1] *Department of Mechanical Eng., Universidade Estadual Paulista, Brazil*
[2] *Virginia Polytech Institute and State University, Blacksburg, USA*

The present work illustrates an application of shape memory alloys and nonlinear controller applied to the active angular control of a sectioned airfoil. The main objective of the proposed control system is to modify the shape of the profile based on a reference angle. The change of the sectioned airfoil angle is resultant by the effect of shape memory of the alloy due to heating of the wire caused by an electric current that changes its temperature by Joule effect. Considering the presence of plant's nonlinear effects, especially in the mathematical model of the alloy, this work proposes the application of an on-off control system.

Performance based analysis of hidden beams in reinforced concrete structures

Tue.
16:10–16:30
R Diwan I

S.H. Helou, P.E. Riyad Awad

Civil Engineering Department, An-Najah National University, Palestine

Local and perhaps regional vernacular reinforced concrete building construction leans heavily against designing slabs with imbedded hidden beams for flooring systems in most structures including major edifices. The practice is distinctive in both framed and in shear wall structures. Hidden beams are favored structural elements due to their many inherent features that characterize them; they save on floor height clearance; they also save on formwork, labor and material cost. Moreover, hidden beams form an acceptable esthetic appearance that does not hinder efficient interior space partitioning. Such beams have the added advantage of clearing the way for horizontal electromechanical ductwork. However, seismic considerations, in all likelihood, are seldom seriously addressed. The mentioned structural system of shallow beams is adopted in ribbed slabs, waffle slabs and at times with solid slabs. Ribbed slabs and waffle slabs are more prone to hidden beam inclusion due to the added effective height of the concrete section. Due to the presence of a relatively high reinforcement ratio at the joints the sections at such location tend to become less ductile with unreliable contribution to spandrel force resistance.
In the following study the structural influence of hidden beams within slabs is investigated. With the primary focus on a performance based analysis of such elements within a structure. This is investigated with due attention to shear wall contribution to the overall behavior of such structures.
Numerical results point in the direction that the function of hidden beams is not as adequate as desired. Therefore it is strongly believed that they are generally superfluous and maybe eliminated altogether. Conversely, shallow beams seem to render the overall seismic capacity of the structure unreliable. Since such an argument is rarely manifested within the linear analysis domain; a pushover analysis exercise is thus mandatory for behavior prediction under strong seismic events. In such events drop beams have the edge.

Identification of parameters in nonlinear geotechnical models using extenden kalman filter

Tue.
17:00–17:30
R Diwan I

T. Nestorovic, L.T. Nguyen, M. Trajkov

Ruhr-Universität Bochum, Mechanik adaptiver Systeme, Bochum, Germany

Direct measurement of relevant system parameters often represents a problem due to different limitations. In geomechanics, measurement of geotechnical material constants which constitute a material model is usually a very difficult task even with modern test equipment. Back-analysis has proved to be a more efficient and more economic method for identifying material constants because it needs measurement data such as settlements, pore pressures, etc., which are directly measurable, as inputs. Among many model parameter identification methods, the Kalman filter method has been applied very effectively in recent years. In this paper, the extended Kalman filter - local iteration procedure incorporated with finite element analysis (FEA) software has been implemented. In order to prove the efficiency of the method, parameter identification has been performed for a nonlinear geotechnical model.

Direct simulations of a bouncing ball system under randomly vibrating platform

Tue.
17:30–17:50
R Diwan I

C. Zouabi, J. Perret-Liaudet, J. Scheibert

LTDS - UMR 5513 CNRS - École Centrale de Lyon, 69134 Écully Cedex, France

This paper deals with the dynamics of a ball bouncing on a vibrating platform. Unlike some popular models, the vibration is random instead of a harmonic. We will describe the statistical properties of impact velocities and free flight duration as functions of the two control parameters, i.e the restitution coefficient and the gravitational acceleration. We will also show the dependence of these results with the statistical properties of the random motion of the platform, in particular its amplitude and velocity.

An energy harvester with a bistable dynamic magnifier

Tue.
17:50–18:10
R Diwan I

S.M. Sah, B.P. Mann

Department of Mechanical Engineering & Materials Science, Duke University, Durham, USA

This paper investigates the idea of using a secondary oscillator or dynamic magnifier to amplify the response of a bistable energy harvester. More specifically, the present study considers a nonlinear magnifier, in the form of a bistable oscillator, which is coupled to the original bistable harvester. Numerical and analytical investigations are used to compare the response behavior of the uncoupled harvester with the response behavior of the harvester coupled to the dynamic magnifier. Since the system can be arranged so the excitation is either applied to the magnifier or the harvester, both cases are studied to identify the most beneficial approach.

Mechanical modeling of human hearing

Tue.
18:10–18:30
R Diwan I

A. Eiber

Institute of Engineering and Computational Mechanics University of Stuttgart, Germany

The description of the human middle and inner ear with mechanical models facilitate the investigation of the hearing process itself, the improvement of diagnostic methods and in particular it facilitates the reconstruction of impaired hearing by means of passive or active implants. Classically, the physiological sound transfer can be described by linear models but in particular cases nonlinear considerations are necessary.
Based on Multi Body Systems (MBS) approach models containing elastic bodies (and mem-branes) (FMBS) are presented. Spatial motions of the ossicles in the middle ear and the travelling waves of the basilar membrane of the inner ear were simulated and the relations of the dynamical behavior depending on frequency, on different impairments as well as different reconstructions are shown. Measurements of static deformation and vibrational behavior on temporal bones or clinical observations are used to estimate ranges of the system parameters like stiffness, damping, hysteresis etc.. By means of Laser Doppler Vibrometry systems (LDV) very small static deflections and vibrations with high frequencies can be contactless measured without disturbing the measured objects and

significant nonlinearities were found in the soft tissues, e.g. ligaments and membranes. Experiments and investigations of the mechanical behavior and nonlinear properties of ligaments are shown in detail at the annular ring. Multi Frequency Tympanometry (MFT) considers changes in the vibrational behavior due to large pressure variations in the external ear canal, it is utilized to detect impairments and derive parameters. Passive implants and active implants driven by magnetic coils or piezo-electric devices are investigated and simulations of the sound transfer of such reconstructions are shown. Different techniques of coupling the implant to the natural structures e.g. as unilateral or bilateral constraints or different locations of coupling are possible, they determine essentially the quality and performance of reconstruction because a certain prestress may be necessary. Another example is the influence of the cochlear amplification in case of very low inner ear excitation by rocking motions of the stapes.
Nonlinear mechanical models of the human hearing allow realistic numerical simulations of the sound transfer. This is to understand the mechanisms of observed effects, the improvement of diagnostical procedures and essential for the development of passive and active implants for reconstruction of impaired hearing. It is also a valuable tool for the surgeon to improve the patient's safety and shorten the clinical trial and error series.

Synchronization dynamics in complex networks

Tue.
18:30–18:50
R Diwan I

R. Yalamova

University of Lethbridge, Canada

The goal of this paper is to create theoretical underpinning for the growing evidence of patterns before market crashes and to encourage development of dynamic models detecting emergence of self-organizing behavior. Increased information complexity leads to herding and rule based trading, where traders influence each others' decision. Log-periodic oscillations of index levels before crashes have been proved empirically, as well as the occurrence of bi-modal demand function above threshold noise level. I propose a model of the limit order book dynamics based on the logistic map. Changes in the reproduction rate of orders on either side of the limit order book is used as an indication of self-organization in the market, i.e. moving away from normally functioning efficient market that may produce bubbles in individual stock prices. Next level of analysis: stocks represent vertexes and cash flows connect them into a network. Network topology is encoded by the correlation structure of the price time series. Partition decoupling method reveals clusters of the network at different scales and allows observing changes and synchronization dynamics. Models of network dynamics with increasing coupling and loss of heterogeneity steer towards new attractors and crash. Non-linear dynamical representation points at effective intervention strategies to build resilience and prevent crashes.

Nonlinear dynamics and bifurcation behavior of a 2 DOF spring resonator with end topper for energy harvesting

Tue.
18:50–19:10
R Diwan I

D. O'Connell , A. El Aroudi

Universitat Rovira i Virgili, 43007, Tarragona, Spain

In this paper we will consider the nonlinear dynamics and bifurcation behavior of a 2-DOF spring resonator with end stopper for energy harvesting applications harmonic vibrations are considered as the main ambient energy source for the system and its performances, RMS value of the position, and the corresponding energy harvested are presented in the steady state non-equilibrium regime when the vibration intensity is considered as a control parameter. From this model, dynamical behavior is unveiled by computing state space trajectories, probability density and FFT spectra. Stability analysis of the periodic orbits is studied by Floquet theory in combination with the Fillipov method to compute the monodromy matrix.

MS 9

Nonlinear dynamics, bifurcations and analysis of chaos in electrical and electromechanical systems

Organizers: *A. El Aroudi* Spain, *B.G.M. Robert* France

Scheduled:			
Tuesday	*14:00–16:30*	Hotel Palais des Roses	**Room Diwan II**

Analyzing Complex dynamics and chaos in electrical energy conversion systems

Tue. 14:00–14:30 R Diwan II

B.G.M. Robert

University of Reims Champagne-Ardenne, France

This talk addresses a review of tools and methods to analyze experimental or computed chaotic data series in the context of electrical engineering. As an example, a prototype of linear switched reluctance motor which encounters chaotic behaviors under some specific feeding conditions is analyzed. At first, the nonlinear phenomena, as bifurcations and chaos, are observed by simulating a five dimensional simplified model. The main approach is to develop a methodology for evaluating the fractal dimension and validate it on simulated data before applying it to experimental data produced by the instrumented test bench. Note that very few experimental chaos in electrical machine have been reported in literature [1]. An other example concerns the analysis of bifurcation diagrams of a power electronics DC/AC converter under a current mode control.

Bibliography

[1] Robert, B.G.M., Alin, F., Goeldel, C., "Aperiodic and Chaotic Dynamics in Hybrid Step Motor-New Experimental Results". IEEE ISIE Conference, Pusan. pp. 2136-2141, 2001.

Synchronization of 4-D hyperchaotic system Qi by high gain observer

Tue. 14:30–14:50 R Diwan II

S.N. Lagmiri [1], E. El Mazoudi[2], N. Elalami[1]

[1] *Laboratoire d'Automatique et Informatique Industrielle, EMI, Agdal Rabat, Maroc*
[2] *Département d'Economie, University Caddy Ayyad, Marrakech, Morocco*

This paper investigates the master-slave synchronization of identical 4-D hyperchaotic Qi systems via a nonlinear high gain observer. Our aim is to implement the chaos synchronization via a nonlinear observer which synchronizes a slave hyperchaotic Qi system to a

master system. The synchronization via high gain observer consists of leading the slave trajectories to the master system trajectories. The purpose is to illustrate that the error between the real and the estimated system tend to zero when the observer gain growth. The verification is simulated with Matlab.

Backstepping controller of five-level three-phase inverter

Tue.
14:50–15:10
R Diwan II

R. Majdoul [1], A. Abouloifa[2], E. Abdelmounim[1], M. Aboulfatah[1], A. Touati[1], A. Moutabir[1]

[1] *L.A.S.T.I Lab, HASSAN 1_{er} University, Faculty of sciences and technology of Settat, Morocco*
[2] *L.T.I Lab, HASSAN II University Mohammedia, Faculty of Sciences Ben M'sik, Morocco*

Multilevel converters are becoming increasingly used in many industrial applications due to the many advantages that they offer. The improvements in the output signal quality, lower Total Harmonic Distortion (THD) and many other properties make multilevel converters very attractive for connecting photovoltaic generators to medium voltage grid directly or to be used in a local power supply. In this paper, we focus on the implementation of a three-phase five-level diode clamped inverter and design of a performing nonlinear controller using the Backstepping approach. The control objective is to generate, at the system output, sinusoidal three-phase voltages with amplitude and frequency fixed by the reference signal independently of load variations. The performance study of the multilevel inverter and the designed controller are made by simulations in Matlab/Simulink environment.

Stability analysis of a bidirectional high-step-up DC grid-connected two-stage boost DC-DC converter

Tue.
15:10-15:30
R Diwan II

A. El Aroudi[1], D. Giaouris[2], K. Mandal[3,4], S. Banerjee[3,4], A. Abu-Sorra[4], M. Hindawi[4], Y. Al Turki[4]

[1] *Universitat Rovira i Virgili, 43007, Tarragona, Spain*
[2] *Centre for Research and Technology Hellas, Thermi-Thessaloniki, Greece*
[3] *IISER-Kolkata, Mohanpur Campus, Nadia 741252, India*
[4] *King Abdulaziz University, Jeddah, Saudi Arabia*

High conversion ratio switching converters are used whenever there is a need to step-up dc source voltage level to a much higher output dc voltage level such as in photovoltaic systems, telecommunications and in some medical applications. A simple solution for achieving this high conversion ratio is by cascading different stages of dc-dc boost converters. The individual converters in such a cascaded system are usually designed separately. However, stage interaction can take place in the complete cascaded system. This paper first presents a glimpse on the bifurcation behavior that a cascade connection of two boost converters can exhibit. It is shown that the desired periodic orbit can undergo period doubling leading to subharmonic oscillations and chaotic regimes. Design-oriented analysis is carried out to obtain stability boundaries in the parameter space by taking into account slopes interactions between the state variables in the two-different stages.

Advanced nonlinear control of three phase series active power filter

Tue.
15:30–15:50
R Diwan II

Y. Abouelmahjoub [1], A. Abouloifa[2], F. Giri[3], F.Z. Chaoui[3], M. Kissaoui[1]

[1] *RCSLNL/LM2PI Lab, Mohammed V University Souissi, Rabat, Morocco*
[2] *L.T.I Lab, Hassan II-Casablanca-Mohammedia University, Morocco*
[3] *GREYC Lab, University of Caen Basse-Normandie, Caen, France*

The problem of controlling three-phase series active power filter (TPSAPF) is addressed in this paper in presence of the perturbations in the voltages of the electrical power supply. The control objective of the TPSAPF is twofold: (i) compensation of all voltages perturbations (voltage harmonics, voltage unbalance and voltage sags), (ii) regulation the DC bus voltage of the converter. A nonlinear controller formed by two non-linear regulators designed, using the Backstepping technique, is proposed to provide the above compensation. The regulation of the DC bus voltage of the converter is ensured by the use of a rectifier bridge which its output is in parallel with the DC bus capacitor. The Analysis of controller performances is illustrated by numerical simulation in Matlab/Simulink environment.

Suspended conductive plate oscillations in the magnetic field of the conductor with alternating current

Tue.
15:50–16:10
R Diwan II

I. Popov[1], A. Lukin[1], D. Skubov [1,2], L. Shtukin [1,2]

[1] *St. Petersburg State Polytechnical University, Mechanics and Control Processes Department*
[2] *Institute of Problems of Mechanical Engineering RAS*

The problem of cooling the conductor with an alternating high-ampere electric current is offered to be solved by using oscillations of suspended conductive plate. System basic parameters are estimated from analysing the system of differential equations describing the motions in coupled electrical-mechanical system. The parameters must satisfy the conditions of system's resonance. Examination of equilibrium position causes a researching of the differential equation with periodic coefficients.

Modeling and nonlinear responses of MEMS capacitive Accelerometer

Tue.
16:10–16:30
R Diwan II

C. Sri Harsha, C.S.R Prasanth, B. Pratiher

Center of Excellence in Energy, Indian Institute of Technology Jodhpur, India

A theoretical investigation of an electrically actuated micro-beam has been illustrated by considering different configuration of micro-size MEMS accelerometer separated by a distance from the electrode. Various electromechanical models have been proposed for narrow microbeam and parallel array of micro plates under the influence of electric field accounting for the nonlinearities of the system arising out of electric forces. Simple and accurate mathematical models have been developed using energy principle and the boundary conditions of the micro-beams are clamped-free, clamped-clamped and clamped-hinged. Pull-in voltage and pull-in deflection of wide micro-beams acted upon by DC electrostatic forces have been studied and behavioral simulations of electrostatic

MEMS, with respect to gap-length ratio of the devices have been illustrated in this study. For each configuration, static similar nonlinear responses have been determined using FEM tool, COMSOL and compared with the results obtained numerically. The resultant outcome enables a significant contribution towards the development and accurate design of MEMS devices.

MS 10

Linear and nonlinear phenomena in advanced physics

Organizers: *M. Taki* France, *M. Tlidi* Belgium

Scheduled:			
Tuesday	*14:00–16:30*	Hotel Palais des Roses	**Room Diwan III**

Nonlinear symmetry breaking in fiber cavities

Tue. 14:00–14:30 R Diwan III

M. Taki[1], A. Mussot[1], Z. Liu[1], S. Coulibaly[1], S. Coulibaly[2], F. Léo[2], P. Kockaert[2], Ph. Emplit[2], M. Haelterman[2]

[1] *Laboratoire PhLAM CNRS UMR 8523, Université de Lille, Villeneuve d'Ascq, 59655, France*
[2] *Service Opera-photonique, Université Libre, Bruxelles, CP 194/5, B-1050, Belgium*

We have demonstrated in previous works the important role of symmetry breaking in the generation of rogue waves in fiber systems [1]. A linear stability analysis has allowed the identification of this phenomenon but it is unable to describe the asymmetry observed in the frequency spectrum during the generation of supercontinuum [2]. We show here that this asymmetry originates from a nonlinear symmetry breaking in the modulation instability process by studying analytically, numerically and experimentally this process in an optical fiber resonator. Our analytical predictions are in excellent agreement with the experimental findings [3]. This work is not specific to optical fiber resonators and can be applied to a wide class of nonlinear dynamical systems that experience symmetry breaking. It may also shed light on the formation of rogue waves and experimental result of dissipative structures displaying strong asymmetries.

Bibliography

[1] Observation of extreme temporal events in CW-pumped supercontinuum, A. Mussot, A. Kudlinski, M. Kolobov, E. Louvergneaux, M. Douay and M. Taki; Opt. Express **17** (19), 17010 (2009).
[2] Third-order dispersion for generating optical rogue solitons, M. Taki, A. Mussot, A. Kudlinski, E. Louvergneaux, M. Kolobov, M. Douay; Phys. Lett. A **374**, 691-695 (2010).
[3] Nonlinear symmetry breaking induced by third-order dispersion in optical fiber cavities, F. Léo, A. Mussot, P. Kockaert, Ph. Emplit, M. Haelterman, and M. Taki; Phys. Rev. Lett. **110**, 104103 (2013).

Power law for front propagation in optical fiber resonators

Tue.
14:30–14:50
R Diwan III

S. Coulibaly [1], M. Taki[2]

[1] *Université des Sciences et Technologies de Lille, Villeneuve d'Ascq, France*
[2] *Faculté des Sciences, Université Libre de Bruxelles, Bruxelles, Belgium*

Like localized structures, fronts belong to the large variety of structures that can rise spontaneously in nonlinear dissipative systems. However, front dynamics has received only a scant attention. In this work, we consider dynamical behavior of front in a bistable system consisting of all fiber cavity driven by an external injected continuous wave. More specifically, we have focused on the asymptotic behavior of the front velocity. We show that the front velocity is affected by the distance from the critical point associated with bistability. We also provide a scaling low governing its evolution near the up-switching point of the bistable curve. Finally, we show that the velocity of front propagation obeys a generic power law when the front velocity approaches asymptotically its linear growing value.

Vegetation patterns in (semi)arid landscapes

Tue.
14:50–15:10
R Diwan III

M. Tlidi

Université Libre de Bruxelles, U.L.B., Bruxelles, Belgium

Patterns of vegetation biomass are typical of (semi-)arid regions where the potential evapotranspiration substantially exceeds the mean annual precipitation. This hydric deficit impedes the development of individual plants and, at the community level, promotes clustering behaviors which, via a modulational instability, take shape even if the topography is isotropic. The adaptation of root systems (rhizospheres) to water scarcity is a determinant factor of this dynamics. Confronted to drought, plants strive to maintain their water uptakes by seizing hold of more territory. To this end, they increase their roots spread which, amazingly, may overshoot the aerial structure (crown) by one order of magnitude. This adaptation however increases plant-to-plant competition and, correlatively, the importance of counterbalancing feedbacks, called facilitation, which the biomass exerts on its own growth. Understanding how such local adaptation and interactions allow for the formation of patterns at the landscape scale is a fundamental ecological question [1–4].

Bibliography

[1] Lejeune, O., Tlidi, M.; Couteron, P., 2002. "Localized vegetation patches: a self-organized response to resource scarcity", Phys. Rev. E, **66**, 010901.
[2] Lejeune, O., Tlidi, M., Lefever, R., 2004. "Vegetation spots and stripes: dissipative structures in arid landscapes". Int. J. Quantum Chemistry, **98**, 261-271.
[3] Tlidi, M., Lefever, R., Vladimirov, A. 2008, "On vegetation clustering, localized bare soil spots and fairy circles", Lecture Notes in Physics Volume **751**, 381.
[4] Fernandez-Oto C., Tlidi M., Escaff D., Clerc MG, "Strong interaction between plants induces circular barren patches: fairy circles" submitted.

Transcritical bifurcation and mixed mode oscillation in a two slow-two fast coupled system

Tue.
15:10–15:30
R Diwan III

M. Krupa[1], B. Ambrosio[2], M.A. Aziz Alaoui[2]

[1] *INRIA Paris-Rocquencourt Reasearch Center, Le Chesnay cedex, France*
[2] *Normandie University, CNRS 3335, Le Havre, France*

In this talk, we will present the appearance of Mixed Mode Oscillations (MMOs) in systems of two weakly coupled slow/fast oscillators.We focus on the existence and properties of a folded singularity called FSN II that allows the emergence of MMOs in the presence of a suitable global return mechanism. As FSN II corresponds to a transcritical bifurcation for a desingularized reduced system, we prove that, under certain non-degeneracy conditions, such a transcritical bifurcation exists. The proof relies on an hypothesis that allows to obtain a two dimensional reduced system. We will illustrate this result to the case of two coupled systems of FitzHugh-Nagumo type. This leads to a non trivial condition on the coupling that enables the existence of MMOs.

Modulational instability in high birefringent optical fibers

Tue.
15:30–15:50
R Diwan III

L. Drouzi [1], S. Coulibaly[1], M. Taki[1]

Université des Sciences et Technologies de Lille, Villeneuve d'Ascq, France

The nonlinear dynamics of copropagating polarized waves in a nonlinear birefringent fiber is a subject of considerable interest owing to their potential applications in communication technology. In a high nonlinear birefringent fiber, propagation of coupled polarized light waves is described by a set of two coupled nonlinear Schrodinger equations. Here, we study the impact of the walkoff (group velocity mismatch) on the linear stability of the CW-nonlinear stationary solutions. We show that, at the onset of the classical Modulational instability, the walkoff induced a splitting into convective and absolute instabilities. The characteristics in terms of frequency, group velocities and thresholds for their appearance are given in closed analytical forms. In the strongly nonlinear regime, the dynamics of the bifurcating modulated solutions is investigated by integrating numerically the governing equations.

Qualitative properties and hopf bifurcation in haematopoietic disease model with chemotherapy

Tue.
15:50–16:10
R Diwan III

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

[1] *Université Ibn Zohr, Faculté Polydisciplinaire de Ouarzazate, Ouarzazate, Morocco*
[2] *University Le Havre Cedex, France*

In this paper, we consider a model describing the dynamics of Hematopoietic Stem Cells (HSC) disease with chemotherapy. The model is given by a system of three ordinary differential equations with discrete delay. Its dynamics are studied in term of local stability of the possible steady states for the cases with/without drug intervention term. We prove the existence of periodic oscillations for each case when the delay passes trough a critical values. In the end, we illustrate our results by some numerical simulations.

Regularization method with parameter estimation for calibrated POD reduced-order models

Tue.
16:10–16:30
R Diwan III

B. Abou El Majd[1], L. Cordier[2]

[1] *Faculty of science Ain Chock, University Hassan II, Casablanca, Morocco*
[2] *Institut PPrime, Futuroscope Chasseneuil Cedex, France*

In this work we present a stabilization method based on the Tikhonov regularized technique to improve the accuracy of reduced-order models based on Proper Orthogonal Decomposition. The bench mark configuration retained corresponds to a case of relatively simple dynamics: a two-dimensional flow around a cylinder for a Reynolds number of 200. Finally, we show for this flow configuration that this procedure is the most effective in terms of reduction of errors.

MS 11

Analytical methods in nonlinear dynamics

Organizers: *K.W. Chung* Hong Kong, *I. Kovacic* Serbia

Scheduled:

Tuesday	*17:00–19:10*	Hotel Palais des Roses	**Room Diwan II**

Analytical methods for oscillators with single-term power-form nonlinearities: from Lyapunov's ideas to recent contributions

Tue.
17:00–17:30
R Diwan II

I. Kovacic
Faculty of Technical Sciences, University of Novi Sad, Serbia

This lecture is concerned with truly nonlinear oscillators: their restoring force is an odd, single-term power-form function of the displacement, when this power can be any non-negative real number. First, several mechanical and mathematical models of this type of force are presented and their characteristics with respect to a linear restoring force and a multi-term power-form restoring force that contains a linear term are emphasized. Among them are: a quasi-constant restoring force, which corresponds to the case when the power is zero, restoring force whose power is a fraction smaller or higher than unity, as well as a pure cubic restoring force. Then, the lecture focuses on free truly nonlinear conservative oscillators. An overview of a variety of special functions that one can use to define the period of their motion is given. This overview includes hyperbolic functions, gamma function, beta function, Pochhammer symbols, etc. Then, it is shown how one can use Lyapunov's functions, Rosenberg's Ateb functions and Jacobi elliptic functions to express the corresponding exact solution for motion. In addition, the approach for obtaining very accurate approximate solution for their motion by means of elliptic functions with a changeable elliptic parameter, which has recently been developed by the author and her colleague, is presented. Finally, some of the phenomena arising in autonomous and non-autonomous non-conservative truly nonlinear oscillators are shown and discussed.

A spectral theory of linear operators on a Gelfand triplet and its application to the dynamics of coupled oscillators

Tue.
17:30–17:50
R Diwan II

H. Chiba
Kyushu university, Japan

The Kuramoto model is a system of ordinary differential equations for describing synchronization phenomena defined as a coupled phase oscillators. In this talk, an infinite dimensional Kuramoto model is considered. Kuramoto's conjecture on a bifurcation diagram of the system will be proved with the aid of a new spectral theory of linear operators based on Gelfand triplets.

A Time-domain asymptotic approach to predict saddle-node and period doubling bifurcations in pulse width modulated piecewise linear systems

Tue.
17:50–18:10
R Diwan II

A. El Aroudi

GAEI research group, Universitat Rovira i Virgili, 43007, Tarragona, Spain

In this paper closed-form conditions for predicting the boundary of period doubling bifurcation or saddle-node bifurcation in a class of PWM piecewise linear systems are obtained. Examples of switched system considered in this study are a switching DCDC power electronics converters, temperature control systems, motor drives and hydraulic valve control systems among others. These conditions are obtained from the steady-state discrete-time model using an asymptotic approach without resorting to frequency-domain Fourier analysis and without using the monodromy or the Jacobian matrix of the discretetime model as it was recently reported in the existing literature on this topic. The availability of such design-oriented boundary expressions allows to understand the effect of the different parameters of the system upon its stability and its dynamical behavior.

On the state feedback control of inverted pendulum with hysteretic nonlinearity

Tue.
18:10–18:30
R Diwan II

M.E. Semenov[1,2], D.V. Grachikov[2], A.G. Rukavitsyn[2], P.A. Meleshenko[2,3]

[1] *Zhukovsky-Gagarin Air Force Academy, Voronezh, Russia*
[2] *Voronezh State University, Voronezh, Russia*
[3] *Zhukovsky-Gagarin Air Force Academy, Voronezh, Russia*

In this paper we consider the mathematical model of the inverted pendulum with the hysteretic nonlinearity (in the form of backlash) under state feedback control. The analytic results for the stability criteria as well as for the solution of the linearized equation are observed and analyzed. The theorems that determine the stabilization of the considered system are also formulated and discussed.

Effect of high-frequency AC electromagnetic actuation on the dynamic of an excited cantilever beam

Tue.
18:30–18:50
R Diwan II

A. Bichri[1], M. Belhaq[1] J. Mahfoud [2]

[1] *Laboratory of Mechanics, University Hassan II-Casablanca, Morocco*
[2] *LaMCoS, Insa Lyon, France*

The effects of high-frequency AC electromagnetic actuation (EMA) on the dynamic behavior of a harmonically excited cantilever beam is analyzed in this paper. Analytical treatment based on perturbation analysis is performed on a simplified one degree of freedom equation modelling the first bending mode of the cantilever beam. The results show that under a certain specific condition relating the intensity of the fast AC to the displacement, the nonlinear characteristic of the system can be controled.

Analytical approximation of heteroclinic bifurcation in 1:3 resonance using a nonlinear transformation method

Tue.
18:50–19:10
R Diwan II

B.W. Qin[1], K.W. Chung[1], A. Fahsi[2], M. Belhaq[3]

[1] *Department of Mathematics, City University of Hong Kong, Kowloon, Hong Kong*
[2] *FST, University Hassan II-Mohammadia, Mohammadia, Morocco*
[3] *Laboratory of Mechanics, University Hassan II-Casablanca, Casablanca, Morocco*

The method of nonlinear time transformation is applied to obtain analytical approximation of heteroclinic connections in a harmonically forced and self-excited nonlinear oscillator near 1:3 subharmonic resonance. The method uses the unperturbed heteroclinic connection in the slow flow to determine conditions on parameters under which the perturbed heteroclinic connection persist. The results show that the nonlinear time transformation method can predict well the triangle and clover heteroclinic connections near 1:3 resonance. The analytical finding are confirmed by comparisons to the results obtained by numerical simulations.

MS 12
Nonlinear thermal instability

Organizers: *B.S. Bhadauria* India, *I. Hashim* Malaysia

Scheduled:

Tuesday *17:00–19:10* Hotel Palais des Roses **Room Diwan III**

The Navier-Stokes equations -a never ending challenge?

Tue.
17:00–17:30
R Diwan III

W. Varnhorn

Institute of Mathematics, Kassel University, Germany

We consider the nonstationary nonlinear three-dimensional Navier-Stokes equations

$$\begin{aligned} v_t - \nu\Delta v + v\cdot\nabla v + \nabla p &= f, \\ \nabla\cdot v &= 0, \\ v|_{\partial\Omega} &= 0, \\ v|_{t=0} &= v_0. \end{aligned} \tag{N}$$

These equations describe the motion of a viscous incompressible fluid flow: The vector function $v = v(t,x) = (v_1(t,x), v_2(t,x), v_3(t,x))$ denotes the velocity and the scalar function $p = p(t,x)$ the pressure of the fluid at time $t > 0$ in $x = (x_1, x_2, x_3) \in \Omega$. Here the constant $\nu > 0$ represents the kinematic viscosity, the vector function $f = (f_1(t,x), f_2(t,x), f_3(t,x))$ is the given external force density, and the steady vector function $v_0 = (v_{0_1}(x), v_{0_2}(x), v_{0_3}(x))$ denotes the prescribed initial velocity at time $t = 0$. In the following we consider the fluid flow always in a bounded domain $\Omega \subset \mathbf{R}^3$ with smooth boundary $\partial\Omega$ of class $C^{2,\mu}$ $(0 < \mu \leq 1)$.

The system (N) occupies a central position in the study of nonlinear partial differential equations, dynamical systems, scientific computation, and classical fluid dynamics. Because of the complexity and variety of fluid dynamical phenomena on the one hand, and the simplicity and exactitude of the equations' shape on the other hand, a strong depth and beauty is expected in the mathematical theory. It is a source of pleasure and fascination that many of the most important questions in the theory remain yet to be answered. So the famous American Clay Mathematics Institute created the Navier-Stokes Millennium Price Problem and offered one Million Dollar for its solution, stating: Although the Navier-Stokes equations were written down in the 19th Century, our understanding of them remains minimal. The challenge is to make substantial progress toward a mathematical theory, which will unlock the secrets hidden in the Navier-Stokes equations.

The modern mathematical theory of the Navier-Stokes equations (N) started with the pioneering work of Jean Leray in 1933 - 34. Leray was the first to use methods of functional analysis for the treatment of partial differential equations. He developed the concept of weak solutions for the Navier-Stokes Cauchy problem and proved their existence globally

in time long before the theory of distributions was established by Schwartz and even before Sobolev systematically introduced the spaces which bear his name. Leray has laid the basis of the mathematical theory for (N) as we know it today, and he has introduced many tools and ideas used constantly since then.
The lecture introduces the Navier-Stokes equations from a historical and physical point of view, touches some fundamental mathematical problems of viscous incompressible fluid flow and ends up with recent regularity results on strong solutions.

Nonlinear thermal convection in a layer of nanofluid under G-jitter and internal heating effects

Tue.
17:30–17:50
R Diwan III

B.S. Bhadauria[1], P. Kiran[1], M. Belhaq[2]

[1] *School for Physical Sciences, Babasaheb Bhimrao Ambedkar University, Lucknow-226 025, India*
[2] *Faculty of Science Ain Chock, University Hassan II- Casablanca, Morocco*

This paper deals with a mathematical model of controlling heat transfer in nanofluids. The timeperiodic vertical vibrations of the system are considered to effect an external control of heat transport along with internal heating effects. A weakly non-linear stability analysis is based on the five-mode Lorenz model using which the Nusselt number is obtained as a function of the thermal Rayleigh number, nano-particle concentration based Rayleigh number, Prandtl number, Lewis number, modified diffusivity ratio, amplitude and frequency of modulation. It is shown that modulation can be effectively used to control convection and thereby heat transport. Further, it is found that the effect of internal Rayleigh number is to enhance the heat and nano-particles transport.

Soret effect on double-diffusive convection in a fluid saturated porous layer with local thermal non-equilibrium model

Tue.
17:50–18:10
R Diwan III

A.A. Altawalbehh[1], B.S. Bhadauria[2], I. Hashim [1,3]

[1] *Universiti Kabangsaan Malaysia, 43600 Bangi Selangor, Malaysia*
[2] *School for Physical Sciences, Babasaheb Bhimrao Ambedkar University, Lucknow, India*
[3] *Universiti Kabangsaan Malaysia, 43600 Bangi Selangor, Malaysia*

Soret effect on double-diffusive convection in a fluid saturated porous layer heated and salted from below with local thermal non-equilibrium is studied. It is found that the positive values of the Soret parameter S_r destabilize the system for stationary convection, while the negative stabilize it. The effect of S_r on oscillatory curves is negligible.

Interfacial instability in a time-periodic rotating Hele-Shaw Cell

Tue.
18:10–18:30
R Diwan III

J. Bouchgl[1], S. Aniss[1], M. Souhar[2], A. Hifdi[1]

[1] *University Hassan II-Casablanca, Morocco*
[2] *Lemta UMR CNRS 7563 Ensem, Vandoeuvre Lès-Nancy 54504, France*

The effect of time periodic angular velocity on the interfacial instability of two immiscible, viscous fluids of different densities and confined in an annular Hele-Shaw cell is investigated. An inviscid linear stability analysis of the viscous and time dependent basic flow

leads to a periodic Mathieu oscillator describing the evolution of the interfacial amplitude. We show that the relevant parameters that control the interface are the Bond number, viscosity ratio, Atwood number and the frequency number.

Fully-developed mixed convection of nanofluids in a porous vertical channel

Tue.
18:30–18:50
R Diwan III

N.A. Mohd Makhatar[1], H. Saleh[2], R. Roslan[3], I. Hashim[2,4]

[1] *Universiti Teknologi MARA, 40450 Shah Alam Selangor, Malaysia*
[2] *Universiti Kebangsaan Malaysia, 43600 Bangi Selangor,Malaysia*
[3] *Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, Malaysia*
[4] *Universiti Kebangsaan Malaysia, 43600 Bangi Selangor, Malaysia*

The present analysis is concerned with the effects of nanofluids on fully-developed mixed convection in a vertical channel filled with a porous medium. The flow velocity can be increased significantly by increasing the mixed convection parameter. Decreasing the nanoparticles mass flux parameter is found to enhance flow reversal.

Harmonic and subharmonic instabilities on modulated Taylor-Couette flow in the limit of low frequency

Tue.
18:50–19:10
R Diwan III

M. Riahi, S. Aniss, M.T. Ouazzani

Laboratory of Mechanics, University Hassan II-Casablanca, Morocco

The hydrodynamic instability of time-periodic flow in Taylor-Couette geometry, when the inner and outer cylinders are oscillating with the same amplitude and frequency, $\Omega_1(t) = \Omega_0 \cos(\omega t)$ and $\Omega_2(t) = \Omega_0 \cos(\omega t)$ is revisited. This topic was already studied analytically in the narrow gap approximation and experimentally by Aouidef et al. [Phys. Fluids 11 (1994)]. Numerical results in the low frequency limit as well as subharmonic responses were not reported. In this paper, we present numerical results covering the limit when the frequency number tends to zero. Moreover, the convergence is rapidly obtained when only few Fourrier modes are sufficient to get the desired accuracy, compared to those considered by Aouidef et al. Furthermore, the case of subharmonic responses is also presented.

MS 13
Optimization and reliability in structural vibrations

Organizers: *A. El Hami* France, *B. Radi* Morocco

Scheduled:			
Tuesday	*17:00-19:10*	Hotel Palais des Roses	**Room Diwan IV**

Reliability based design optimization framework for boat propeller

Tue.
17:00–17:30
R Diwan IV

M. Mansouri [1], A. Makhloufi[2], B. Radi[1], A. El Hami[2]

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[2] *INSA rouen, LOFIMS, France*

The need for improvements in engineering designs especially for coupled structures is becoming a major industry request. Actually, there is a need to perform optimizations in order to receive optimal system properties. However, for computationally expensive simulation models, an optimization may be too tedious to be motivated. Deterministic approaches are unable to take into account all the variations that characterize design input properties without leading to oversized structures. The aims of this work are to quantify the influence of material and operational uncertainties on the performance of marine structures, and to develop a reliability-based design optimization (RBDO) approach for boat propeller. Using a previously validated fluid-structure interaction model, performance functions are obtained and used to generate characteristic response surfaces. A first order reliability method is used to evaluate the reliability index and thus compute the failure probability. Furthermore, an outline of the methodology will be given that could serve as a guideline to develop a more efficient and optimized design process that takes into account the input parameters as random. For this purpose, a model of finite elements was created, for an industrial structure. Realistic variability has been assigned to material properties. This allows the assessment of the reported methods in terms of accuracy, computation time and applicability in conjunction with finite element models. The results demonstrate the efficiency of the proposed reliability-based design and optimization methodology, and demonstrate that a probabilistic approach is more appropriate than a deterministic approach for the design and optimization of adaptive marine structures that rely on fluid-structure interaction for performance improvement.

Active vibration control of piezoelectric plates

Tue.
17:30–17:50
R Diwan IV

M. Abukhaled

American University of Sharjah, Sharjah, United Arab Emirates

The control of thermally induced vibrations of a rectangular plate is investigated. An optimization problem is formulated to determine the control voltage needed to perform vibration suppression with least control effort. By eigenfunction expansion, the optimal control problem will be converted from a distributed to a lumped parameter system. By utilizing the variational theory, an explicit optimal control criterion will be derived.

Treatment of vibro-acoustic problem via sub-structuring and reliability

Tue.
17:50–18:10
R Diwan IV

M. Mansouri[1], B. Radi[1], A. El Hami[2]

[1] *FST Settat, Morocco*
[2] *INSA rouen, LOFIMS, France*

The comprehension of the mechanisms of interactions between a fluid and an elastic solid has a capital importance in several industrial applications. When a structure vibrates in the presence of a fluid, there is interaction between the natural waves of each media: the fluid flow generates a structural deformation and/or the movement of a solid causes the displacement of the fluid. These applications require an effective coupling. In addition, the dynamic analysis of the industrial systems is often expensive from the numerical point of view. For the coupling fluid structure finite elements models, the importance of the size reduction becomes obvious because the fluid freedom degrees will be added to those of the structure. The method developed couple Craig and Bampton type dynamic sub-structuring method and a method of acoustic subdomains based on an acoustic velocity potential formulation. This choice is guided by the shape and symmetry of the obtained coupled algebraic system property, on the other hand by enrichment facilitated local acoustic modal base. One of the principal hypotheses in the use of component mode synthesis method is that the model is deterministic; it is to say that parameters used in the model have a defined and fixed value. Furthermore, the knowledge of variation response of a structure involving uncertain materials, geometrical parameters, boundary conditions, tolerances of manufactures and loading conditions is essential in global process of conception. In order to do that, the modal condensation method is extended to reliability analysis for coupled fluid-structure finite element models. The two approaches FORM and SORM are used. A numerical vibratory study is leaded on a boat's propeller in the air and in immersion in water taking the acoustic aspect into account. The results of the reliability analysis tend to show the effectiveness of the step followed to condense the system and to take into account the uncertain parameters.

Blind source separation using sparse linear modeling for removing microphonic noise from nuclear spectrometry measurements

Tue.
18:10–18:30
R Diwan IV

D.D.L. Mascarenas [1], K.D. Ianakiev[2], M. Iliev[2], A. Cattaneo[1], C.R. Farrar[1]

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In this work we explore the use of a sparse linear modelling-based blind source separation technique for removing microphonic noise from nuclear spectrometry measurements. Microphonic induced by vibrations on certain types of nuclear detectors tends to degrade nuclear spectroscopy measurements by interfering with measured detector pulses. The result is that the measured energy spectrum peaks tend to widen, making it more difficult to identify the materials being measured. For many applications the use of a piston-driven mechanical cryocoolers is attractive to achieve the required cooling of the detector. Unfortunately, these cryocoolers contain a mechanical piston whose vibrations further introduce microphonic noise into the measurements. One important observation concerning this microphonic noise is that it tends to have a sparse representation in the Fourier basis. Conversely, the nuclear events themselves tend to have a sparse representation over a spike-like dictionary of signals. This characteristic of the measurements suggests that emerging sparse-linear modelling techniques based on L1-norm minimization techniques may hold promise for separating the microphonic noise in the measurement from the nuclear events themselves, thus leading to improved spectral resolution.

Mechanical reliability study of a coupled three-dimensional system with uncertain parameters

Tue.
18:30–18:50
R Diwan IV

M. Mansouri [1], R. El Maani[1], B. Radi[1], A. El Hami[2]

[1] *FST Settat, Morocco*
[2] *INSA rouen, LOFIMS, France*

The vibroa-coustique analysis of a structure whose complexity is that of a marine structure is a very difficult problem not only because of the complexity of the structure itself, due to its non- homogeneity and the very large number degrees of freedom, but also because of the uncertainty of the parameters of the problem. Results from numerical simulations are still far from reality and often have discrepancies with the experimental results. It is then legitimate to test the validity of the solution after such modeling. In this context, this work proposes a probabilistic simulation-based Monte Carlo, the response surface method and a reliability analysis based on FORM and SORM methods. The application of the proposed methods is illustrated by a boat propeller immersed in a 3D cavity. The numerical study is conducted using a MATLAB code coupled with finite element code MNSYS . To assess the effectiveness of the proposed method, comparison with experimental study was made.

Tue.
18:50–19:10
R Diwan IV

Development of Reliability and optimization methods to structural mechanics

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Uncertainty modelling with random variables motivates the adoption of advanced method for reliability analysis to solve problems of mechanical systems. This method is called the Probabilistic Transformation Method (PTM). It is readily applicable when the function between the input and the output of the system is explicit. However, the situation is much more involved when it is necessary to perform the evaluation of implicit function between the input and the output of the system through numerical models. In this work, we propose a new approach that combines Finite Element Analysis (FEA) and Probabilistic Transformation Method (PTM) to evaluate the Probability Density Function (PDF) of response where the function between the input and the output of the system is implicit. This technique is based on the numerical simulations of the Finite Element Analysis (FEA) and the Probabilistic Transformation Method (PTM) using an interface between Finite Element software and Matlab. In order to prove the applicability of the proposed technique, some problems of structures are treated. Moreover, the obtainedresults are compared to those obtained by the reference method of Monte Carlo. A second aim of this work is to develop an algorithm of global optimization using the local method SQP, because of its effectiveness and its rapidity of convergence. For this reason, we have combined the method SQP with the Multi start method. This developed algorithm is tested on test functions comparing with other methods such as the method of Particle Swarm Optimization (PSO). In order to test the applicability of the proposed approach, a structure is optimized under reliability constraints.

Posters Session

Scheduled:

Tuesday	*10:20–11:00*	Hotel Palais des Roses
Wednesday	*10:20–11:00*	Hotel Palais des Roses

Structural health monitoring

Seismic performance of existing buildings strengthened by reinforced concrete jackets and self-compacting concrete ones

K. Drouna[1], N. Djebbar [2]

[1] *University of Jijel, Architecture Department, Laboratory LMDC Constantine, Algeria*
[2] *LMDC, Department of Civil Engineering, University Constantine 1, Algeria*

Recent earthquakes over the world have shown that the main coherent strategy for seismic design of structures is the performance based design in which a structure is designed so that, under a specified level of ground motion, the performance is previously established. For existing buildings, the verification of seismic performances needs the application of a nonlinear analysis such the pushover to first estimate the capacity of the structure to compare with the demand and second, choose a methodology of rehabilitation. In this field, this study is the application of the pushover analysis to existing buildings braced by column-beam system where a low compressive strength of concrete is assigned to vertical components. Plastic hinges were characterized by a moment-curvature analysis considering mechanical properties of materials and geometrical characteristics of sections to introduce user defined plastic hinges .Various configurations were analyzed before and after applying reinforced concrete jacketing where two different jackets were tested using first an ordinary concrete and second a self compacting concrete with 15cm and 07cm, respectively. After rehabilitation the retrofit is determined for the two options and it is clearly recognized that the stiffness induced by the intervention may be the factor imposing the choice of a particular method of strengthening.

Detection of localized damage by eddy currents technique

A. Aoukili, A. Khamlichi

Abdelmalek Essaadi University, Tetouan 93002, Morocco

Non destructive evaluation techniques based on eddy currents (EC) are largely used for quality control of the castings in a lot of industries. The principle of detection by EC consists in using an adequate inductive coil to generate them by a variable magnetic field, and measuring their effects by using one or several sensors. These effects result from

the interaction between the induced magnetic field and the excited conductive material. A local variation of the physical properties or geometry of the tested sample, due to a singularity or a flaw, causes a modification of the EC distribution, enabling thus detection. In order to optimize the capacity of defect revealing by means of EC based probes, an accurate modelling of the problem is essential. This can be used to perform simulation of the EC distribution under different circumstances and to analyze the EC sensitivity to the various implicated parameters. In this work, the modelling of EC is made by using the finite element method. Using a B-scan strategy was used, detection of a small defect having the shape of an open cavity is shown to be correctly indicated via monitoring variations of the induced voltage in the receiver coil.

Influence of measurement noise on the PSO based localization of an impact occurring on elastic plates

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

[1] *Faculty of Sciences and Techniques, Tangier, Morocco*
[2] *Faculty of Sciences, Tetouan, Morocco*

This paper presents the application of particle swarm optimization algorithm to reconstruct the characteristics of impacts occurring on homogeneous and isotropic elastic plates and which cannot be reduced to a concentrated force. Solution of this inverse problem was achieved through minimizing a fitness function defined in terms of the root mean square error between the measured and the calculated responses. This included information provided by numerous sensors. The impacting force was assumed to result from uniformly distributed pressure acting over a rectangular patch. Use was made of the reciprocity theorem to decouple the localization problem from the deconvolution part intended to reconstruct the pressure time signal. The particle swarm optimization based model was found to be highly efficient in finding the impact zone location. Focus was done on the robustness aspect of force impact localization when an additive white noise is assumed to perturb response measurements.

Assessing impact force reconstruction via hierarchical Bayesian modelling in the time domain

S. Samagassi[1], A. Khamlichi[1], A. Driouach[1], E. Jacquelin[2]

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[2] *IFSTTAR, LBMC,* $UMR-T9406$*, Bron,* $F-69622$*, Lyon, France*

In this work, reconstruction of pressure time signal developed during an impact occurring on an elastic structure has been achieved through using Bayesian approach. The posterior probability density function integrating both the likelihood and prior random information was expressed in the particular case of a noisy measurement system admitting a linear representation, and for which the densities of probabilities associated the prior information and noise were assumed to be independent multivariate Gaussians. Bayesian hierarchical modelling conducted through Gibbs sampling has enabled to estimate the pressure signal in the case where the prior mean and covariance matrices are unknown.

The obtained results were remarkably good as the reconstructed pressure was really close to the original pressure applied at the system input. The hyper-parameters controlling the process of convergence of the hierarchical model have been studied parametrically in order to evaluate their influence on both accuracy and computational cost. It was found that large ranges of the hyper-parameters yield convergence of the Gibbs algorithm towards the exact solution. Finally, optimization of these parameters has been achieved with regards to the accuracy fitness function when fixing the total number of iteration to be performed by Gibbs sampler.

Identification of corrosion in reinforcement rebars by using the GPR

Z. Mechbal, A. Khamlichi

Abdelmalek Essaadi University, Tetouan 93002, Morocco

Considering the problem of corroded steel reinforcements buried in concrete members, a methodology based on ground penetrating radar was proposed for the identification of the corrosion affected zone. The method uses post-processing of radargram as obtained from a classic B-scan realized by the electromagnetic radar, when working with adequate high frequencies that are usually used for inspection of reinforced concrete structures. The radar displays are in general complex and not easy to interpret. However, significant information can be extracted from the obtained images to make a reliable report after the inspection. In this context, a correlation formula was proposed previously to estimate the perimeter of a reinforcement bar which is embedded in a concrete massif by using the radargram traces. This formula was employed in the present work in order to estimate the corroded zone perimeter. The obtained results have shown that it provides good prediction of the deterioration extent. Clear contrast of traces was noticed also while modifying the depth of the corrosion affected zone. However, to obtain the depth of the corroded segment of the rebar, further developments concerning image processing of a radargram are required.

Damage identification in beams by a response surface based technique

S. Teidj, A. Driouach, A. Khamlichi

Abdelmalek Essaâdi University, Tetouan 93002, Morocco

In this work, identification of damage in uniform homogeneous metallic beams was considered through the propagation of non dispersive elastic torsional waves. The proposed damage detection procedure consisted of the following sequence. Giving a localized torque excitation, having the form of a short half-sine pulse, the first step was calculating the transient solution of the resulting torsional wave. This torque could be generated in practice by means of asymmetric laser irradiation of the beam surface. Then, a localized defect assumed to be characterized by an abrupt reduction of beam section area with a given height and extent was placed at a known location of the beam. Next, the response in terms of transverse section rotation rate was obtained for a point situated afterwards the defect, where the sensor was positioned. This last could utilize in practice the concept

of laser vibrometry. A parametric study has been conducted after that by using a full factorial design of experiments table and numerical simulations based on a finite difference characteristic scheme. This has enabled the derivation of a response surface model that was shown to represent adequately the response of the system in terms of the following factors: defect extent and severity. The final step was performing the inverse problem solution in order to identify the defect characteristics by using measurement.

Non destructive characterization of trabecular bone: estimation of the velocity dispersion and attenuation

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The non destructive characterization of porous structures with ultrasonic wave's propagation allows determining the velocities and the attenuation for diagnosis of diseased bone (e.g., osteoporosis) by establishing correlations between ultrasonic parameters and mineral density of trabecular bone. Two compressional modes were identified independently in bovine trabecular bone, a fast wave and a slow wave. The principal objective of this paper is was to characterize the velocity dispersion and ultrasonic attenuation as functions of frequency and porosity of bovine cancellous bone. The porosity of the used samples varies between 40 % and 75 %. A transmission technique is used. This method only requires the measurement of the specimen's thickness and recording of two pulses: one without and one with the specimen inserted between the transmitting and receiving transducers. From the two pulses, the dispersion as well as the attenuation can be determined using spectral analysis. The attenuation coefficient increases approximately linear over the frequency 200 to 700 kHz and becomes nonuniform beyond. This results indicate that attenuation fits better to a polynomial function.(second order). The phase velocity exhibits a decrease with frequency. This behaviour contrasts with the Kramers-Kronig relations suggests that an increase of phase velocity with frequency. This is probably due to the highly attenuating nature of cancellous bone. The experimental results show a strong correlation between the bone density, the measured propagation velocity and the attenuation. The measurement of these velocities allows determining the bone elastic parameters. This study confirms the sensitivity of the ultrasonic propagation velocity to the change of bone porosity. The potential of ultrasound in bone tissue characterization seems to provide interesting results and would lead to predict bone pathology and particularly to permit better diagnosis of bone fragility.

Stability of rotating machines

Study of the effect of the speed of rotation and the radial load on the vibration behavior of the bearing

D. Zarour, S. Meziani

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This work aims to study the evolution of the RMS as a function of speed, and the radial force. To do this we used a test bench. The tests were carried out on a bearing type KB default scaling one of the tracks on the bearing components (inner ring and outer ring), under normal operating conditions (temperature and lubrication). Initially, we studied the effect of rotational speed on the vibration behavior of the bearing, with and without default, in a second stage, are considered the effect of the load. In the first, the load is fixed and varying the speed of rotation, and in the second, the reverse, we set the load, but, the speed is varied. The results showed that: factors load and speed play a significant role on the vibration behavior of the bearing. The vibration behavior of bearing increases according to the rotational speed, indeed, the influence of the centrifugal effect of the rolling elements, however the effect of the bearing vibration decreases as the load, and this result in the effect of contact pressure.

Fault detection and diagnosis in induction motor using artificial intelligence technique

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Induction machines play a vital role in industry and there is a strong demand for their reliable and safe operation. The online monitoring of induction motors is becoming increasingly important. The main difficulty in this task is the lack of an accurate analytical model to describe a faulty motor. Faults and failures of induction machines can lead to excessive downtimes and generate large losses in terms of maintenance and lost revenues, and this motivates the examination of on-line condition monitoring. The major difficulty is the lack of an accurate model that describes a fault motor. Moreover, experienced engineers are often required to interpret measurement data that are frequently inconclusive. A fuzzy logic approach may help to diagnose induction motor faults. In fact, fuzzy logic is reminiscent of human thinking processes and natural language enabling decisions to be made based on vague information.

Nonlinear dynamics, bifurcations and analysis of chaos in electrical and electromechanical systems

Adaptive nonlinear control of single-phase to three-phase UPS system

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This work deals with the problems of interruptible power supplies (UPS) based on the Single-Phase to Three-Phase converters built in two stages: an input bridge rectifier and a three phase output inverter. The two blocks are joined by a continuous intermediate bus. The objective of control is threefold: i) correcting the power factor "PFC", ii) regulating the DC bus voltage, iii) generation of a symmetrical three-phase system at the output even if the load is unknown. The synthesis of controllers has been reached by two nonlinear techniques that are the sliding mode and adaptive backstepping control. The performances of regulators have been validated by numerical simulation in MATLAB/SIMULINK.

Analysis and control design of two cascaded boost converter

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This work aims to study a cascade of two BOOST converters. First, a nonlinear model of the whole controlled system is developed. Then, a robust non-linear controller of currents is synthesized using a backstepping design technique. A formal analysis based on Lyapunov stability and average theory is developed to describe the control currents loops performances. A classical PI controller is used for the voltages loops. The study of the stability of the system will also be discussed. Simulated results are displayed to validate the feasibility and the effectiveness of the proposed strategy.

Nonlinear dynamics of an ambient noise driven array of coupled graphene nanostructured devices for energy harvesting

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Nonlinearities have been shown to play an important role in increasing the extracted energy of energy harvesting devices at the macro and micro scales. Vibration-based energy harvesting on the nano scale has also received attention. In this paper, we characterize

the nonlinear dynamical behavior of an array of three coupled strained nanostructured graphene for its potential use in energy harvesting applications. The array is formed by three compressed vibrating membrane graphene sheet subject to external vibrational noise excitation. We present the continuous time dynamical model of the system in the form of a double-well three degree of freedom system. Random vibrations are considered as the main ambient energy source for the system and its performances in terms of the probability density function, RMS or amplitude value of the position, FFT spectra and state plane trajectories are presented in the steady state non-equilibrium regime when the noise level is considered as a control parameter.

Numerical model of a Q-switched double-clad fiber laser

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The time-energy characteristics of a Q-switched neodymium-doped double-clad fiber laser are presented. Based on the proposed differential equations, a numerical model is developed to simulate this fiber laser. Using this model pulse duration and the energy of generated pulses can be predicted.

Topics on structural nonlinear dynamics

Larage vibration amplitude behaviour of c-c-c-ss symmetrically laminated rectangular composite plates

H. Bhar[1], B. Harras[2], R. Benamar[1]

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Laminated composite plates are frequently used in various engineering applications in the aerospace, mechanical, marine, and automotive industries. In the current investigation, the main objective is to find out the non-linear free vibration characteristics of the clamped-clamped-clamped simply supported (C-C-C-SS) composite plates at large vibration amplitudes. The theoretical model is based on the classical Plate theory and the Von Kármán geometrical nonlinearity assumptions. Assuming the out-of-plane displacement as a series of basic functions and expressing the mass tensor, the linear and the non-linear rigidity tensors, Hamilton’s principle is applied and a multimode approach is derived to calculate the fundamental nonlinear frequency parameters. The first non-linear mode shape is examined. The effect of non-linearity on the non-linear resonant frequencies and the non-linear fundamental mode shape and associated bending stress patterns at large vibration amplitudes is investigated. The validity of the present approach is established by comparing the results with those available in the literature.

Large amplitude free vibration analysis of functionally graded annular plates using an homogenization procedure

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The geometrically non-linear axisymmetric vibration of a simply supported FGM annular plate is analyzed in this paper, taking into account the membrane stresses induced by large transverse displacement amplitudes. The material properties of the constituents are assumed to be temperature-independent and the effective properties of FGM annular plates are graded in thickness direction according to a simple power law function in terms of the volume fractions. Based on the classical Plate theory and von Karman type nonlinear strain-displacement relationships, the nonlinear governing equations of motion are derived using Hamilton’s principle. The problem is solved by a numerical iterative procedure in order to obtain more accurate results for vibration amplitudes up to 1.5 times the plate thickness. An homogenization procedure has been used to reduce the problem under consideration to that of isotropic homogeneous annular plates. The numerical results are given for the first two axisymmetric non-linear mode shapes, for a wide range of vibration amplitudes and they are presented either in a tabular or in a graphical form, to show the significant effects that the large vibration amplitudes and the variation in material properties have on the nonlinear frequencies and the associated bending stresses of the FGM annular plates.

Non-linear vibration of a rectangular membrane subjected to axial tensions and shear stress resultant: Determination and analysis of the stress expressions

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Membranes are structures that are characterized by their lack of flexural rigidity, their lightness and thinness. In this paper, an analysis was carried out to determine the effects of these specifications on the response of a rectangular membrane to geometrically non-linear free vibrations, while subjected to axial tensions and shear stress resultant. The model used, is based on assuming a harmonic transverse displacement and expanding it in the form of a finite series of basic functions. Hamilton's Principle is then applied to obtain a set of non-linear algebraic equations, whose numerical solution leads to the displacement functions. A special attention was given here to study the induced non-linear stresses and emphasize their variations through the membrane via a simplified model in which the edges are supposed to be motionless and the in-plane displacements are assumed to be insignificant and therefore, neglected, and the strains along the lines parallel to the membrane's four edges are supposed to be constant. Thus, the obtained expressions for the stress involve only the transverse displacement. The results found, bring out higher stresses than those predicted by the linear theory, and show a good agreement with those obtained in previous studies.

Large free vibrations amplitude of thin isotropic plates on elastic foundations

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This paper deals with large vibration amplitudes of thin isotropic plates resting on elastic foundations. The transverse displacement is assumed to be harmonic in time; spectral analysis is used to obtain the discrete model. The motion equation of these plates is obtained via Hamilton's principle. That leads to a system of non-linear algebraic equations that involves a mass tensor and a linear and non-linear rigidity tensors. This system is solved numerically in the neighborhood of the first and the second modes in order to investigate the effect of the large vibration amplitudes on the basic function contribution coefficients. Three types of elastic foundation are examined: Winkler linear, Winkler with cubic nonlinearity and Pasternak two parameters foundations. Numerical results are presented showing the effects of geometrical non-linearity on the vibration parameters, and the comparison with previous results shows a good agreement.

Free vibration analysis of non-symmetric FGM sandwich square plate resting on elastic foundations

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Université de Sidi Bel Abbes, Département de Génie Civil, Faculté de Technologie, Algérie

In this study, free vibration analysis of simply supported sandwich plate resting on elastic foundation is examined. In this model, the displacements vary as a sinusoidal function across the plate thickness and satisfy zero shear stress condition at the top and bottom surfaces of the plate. The governing equations are derived by employing the principle of Hamilton. These equations are solved via Navier type and the dynamic results are presented by solving eigenvalue problems. The numerical results obtained through the present analysis for free vibration are presented and compared with those available in the literature.

Stabilization via energy-balancing of wind turbine with doubly fed induction generator by using Hamiltonian energy approach

Y. Adnani, N. El Alami

Mohammadia School Engineering Agdal, Rabat, Morocco

In this paper, the stabilization via energy-balancing controller is proposed for the wind turbine with doubly fed induction generator (DFIG), such that the closed-loop system achieves the asymptotically stability under the arbitrarily energy-balancing control. At first, the Hamiltonian energy function is constructed according to the system model. Then, the model of wind turbine is transformed into the port-controlled Hamiltonian (PCH) system. Next, the stabilization via energy-balancing is designed . Finally, in order to illustrate the effectiveness of the stabilization via energy-balancing control, the simulations are performed.

Mechanical and physical properties of normal-strength concrete and high-performance concrete subjected to elevated temperature

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This paper presents the results of an experimental study on the effects of elevated temperature on compressive and flexural strength of Normal Strength Concrete (NSC), High Strength Concrete (HSC) and High Performance Concrete (HPC). In addition, the specimen mass was measured before and after heating in order to determine the loss of mass during the test. In terms of non-destructive measurement, ultrasonic pulse velocity test was proposed as a promising initial inspection method for fire damaged concrete structure. 100 Cube specimens for three grades of concrete were prepared and heated at a rate of $3°C$/min up to different temperatures (150, 250, 400, 600 and $900°C$). The results show a loss of compressive and flexural strength for all the concretes heated to temperature exceeding $400°C$. The results also revealed that mass and density of the specimen significantly reduced with an increase in temperature.

Analytical methods in nonlinear dynamics

Galloping of wind-excited tower under external excitation and parametric damping

L. Mokni, I. Kirrou, M. Belhaq

Laboratory of Mechanics, University Hassan II-Casablanca, Morocco

This paper investigates the influence of combined fast external excitation and fast parametric damping on the amplitude and the onset of galloping of a tower submitted to steady and unsteady wind flow. A lumped single degree of freedom model is considered and the cases where the turbulent wind activates either external excitation, parametric one or both are studied. The methods of direct partition of motion and the multiple scales are used to drive a slow dynamic near primary resonance. The influence of the combined excitations on the galloping is examined showing the beneficial effect on the amplitude and the onset of galloping when the excitations are introduced together.

Nonlinear vibration of buckled von Karman plates by an asymptotic numerical method

L. Benchouaf, E.H. Boutyour

University Hassan 1st, Settat, Morocco

This work deals with the geometrically nonlinear vibration of buckled von Karman plates using an asymptotic numerical method and harmonic balance approach. The nonlinear governing equation is then transformed into a sequence of linear problems having the same stiffness matrix, which can be solved by a finite element method where the DKT 18 element is replaced by another triangular one having 24 d.o.f. The static behavior of the plates pre and post-buckled state is first computed. The nonlinear vibration of the plates is obtained in the vicinity of any deformated state. When the asymptotic expansions start from a bifurcation point, the tangent operator is singular, one uses a relaxation technique. Numerical tests and comparisons are given for nonlinear free vibrations of square and rectangular plates.

Stability analysis of periodic orbits in a class of duffing-like piecewise linear vibrators

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In this paper closed-form stability conditions are obtained for predicting the boundary of period doubling bifurcation or Saddle-Node bifurcation in a class of PWM piecewise linear systems with special emphasis on switching DC-DC power electronics converters. The boundary conditions are obtained by using an asymptotic model in the time domain

without resorting to frequency domain Fourier analysis as it was recently reported in the literature. This design-oriented condition is obtained from the discrete-time model and it is validated by means of numerical simulation under different cases. The availability of such design-oriented boundary expression allows to understand the effect of the different parameters of the system upon the stability boundary. PWL signum Sprot, symmetric nonsymmetric, thesis impreso capitulo.

Reduced-order model for non-linear dynamic analysis of viscoelastic sandwich structures in time domain

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The present paper deals with the analysis of the dynamic behavior of viscoelastic sandwich structures with localized nonlinearities. The Golla-Hughes Mac Tavish (GHM) viscoelastic model is used and the finite elements procedure is established to derive both linear and non-linear equations of motion. This model increase the order of the differential equations of motion through the addition of dissipative coordinates, which complicate further the numerical resolution with the addition of local nonlinearities in the junctions of the assembled structures. Hence, a reduced-order model is proposed to enhance the control of the dynamic behavior of such structures incorporating viscoelastic materials especially for structures with large finite element model.

Nonlinear thermal instability

Non similar solution and local similar solution of hydrodynamic slip flow boundary layer over a wedge

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This paper considers the problem of hydrodynamic boundary layer of gaseous slip flow over wedge. The non-similar and local similarity solutions of the boundary layer equations with velocity-slip boundary condition are obtained numerically. Results from non-similar solution and local similarity solution, are compared. We show that the local similarity approach used by several authors in the last decades produces substantial errors in the determination of hydrodynamic characteristics of the flow. This study confirms that for the accurate prediction of characteristics of slip flow, the slip parameter must be treated as a variable rather than a constant in the boundary layer.

Dynamic analysis of the thermal behavior of a novel composite phase change materials/concrete wall

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The main aim of the paper is to investigate the possibility of substituting the thick and heavy thermal mass external walls used in Mediterranean countries by thin and light thermal mass ones whilst maintaining similar comfort levels throughout the year. To make this substitution the use of PCM (phase change materials) panels incorporated into external wall structure are considered. The results show that external light mass wall should contain insulation in an external layer if it is combined with a PCM panel. Such lightweight external walls can substitute standard heavy mass walls comprised of insulation and concrete.

Forced convective heat transfer in a parallel plate microchannel with constant wall temperature including rarefaction and axial conduction effects

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University Hassan II-Casablanca, Morocco

Thermally developing laminar slip flow through a parallel plate microchannel, including both axial conduction and rarefaction effects with constant 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 conduction and rarefaction effects.

Choice of phase change materials involved in roofs of local conditioned versus comfort temperature

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Obviously, the outside annual climate change caused either by a major solar input during the hottest period or by a temperature drop during the coldest period leads to discomfort in inside buildings. This effect can be carry out by storing heat transmitted in phase change materials (PCM) as latent heat, in order to ensure a good situation of thermal comfort during all months of the year. In this work, thermal behavior of four roofing systems is studied at different temperatures comfort. Each roof is constituted by usual materials in building and two PCM inserted. One PCM is common for all roofs while the second depends on the comfort temperature. Study is interested to assess incorporation effect of two PCMs within the roof and to evaluate effect of PCM according to comfort temperature to reduce the energy consumption of air-conditioned room. Results show that insertion of two PCM in roof provides best energy consumption saving regardless annual climate change. It is possible to determine one combination of PCM suitable for different comfort temperatures.

Hydromagnetic stability of a plane Couette-Poiseuille with uniform cross flow

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The hydrodynamic stability of a plane Couette-Poiseuille flow of an electrically conducting fluid with uniform cross-flow (cross-flow Reynolds number, R_c) is investigated in the presence of an uniform extern transverse magnetic field (Hartmann number, M). A linear stability analysis leads to a modified classical Orr-Sommerfeld equation. This equation is solved numerically using the Chebyshev spectral collocation method to find the eigenvalues and the structure of the eigenspectrum as a function to various parameters of the problem. In this study, we find that the cross-flow Reynolds number, R_c, acts to stabilize and destabilize the flow depending on the range of values chosen. While the cross-flow sense causes modifications on the flow behavior mainly in the presence of magnetic field. It was observed that the Hartmann number, M, has both stabilizing and stabilizing / destabilizing effects.

Hydrodynamic stability of a periodic channel flow of viscoelastic fluid

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The local linear stability of periodic channel (PC) flow of second-order (SO) and second-grade (SG) fluids flow is investigated numerically. The fourth order modified Orr-Sommerfeld equation, governing the stability analysis, is solved using a spectral method with expansions in Lagrange polynomials based on collocation points of Gauss-Lobatto.

The combined effects of a periodic channel modulation (PCM) and fluid's elasticity on the stability chart are investigated. Based on the results obtained in this work, there is a difference between the stability of SO fluid flow and that of SG fluid flow. According to the channel section, we find that the channel amplitude has a stabilizing or destabilizing effect on the two fluids flow. The Y-shaped structure, such as a signature of the Orr-Sommerfeld spectrum of Newtonian plane Poiseuille flow is remarquabely modified by the elasticity of these fluids.

Method of finite volume for the resolution of heat transfer by natural convection in a cavity filled nanofluids

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Thermal instability in nanofluids is investigated in this work. 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 non dimensional analysis. Close form solutions for the Rayleigh number are derived from the method of finite volume.

Thermal instability of a nanofluid saturating an anisotropic porous medium layer under local thermal non-equilibrium condition

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The onset of convection in a horizontal nanofluid saturated anisotropic porous layer, heated from below and cooled from above, and salted from below, is examined analytically when the nano-particle, fluid, and the solid matrix, phases are not in local thermal equilibrium. Darcy model with anisotropic permeability is considered to describe the flow and a three-field model is used for energy equation each representing the nano-particle, fluid, and the solid matrix, phases separately. The linear stability theory is implemented to compute the Rayleigh number for non-oscillatory convection. The effect of thermal non- equilibrium and anisotropy on both mechanical and thermal properties of the porous medium on the onset of convection are discussed graphically.

On the quasi-periodic gravitational modulation on polymerization front with solid product

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We consider in this paper the propagation of polymerization front with solid product. We study the influence of quasi-periodic gravitational modulation on convective instability of polymerization front. The model includes the heat equation, the equation for the concentration and the Navies-Stokes equations under the Boussinesq approximation. Linear stability analysis of the problem is fulfilled, and the convective instability boundary is found depending on the amplitudes and on the ratio of the two incommensurate frequencies.

Study of heat transport in a temperature-dependent viscous liquid under temperature modulation

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The effect of time-periodic temperature modulation on thermal instability in a temperature dependent viscous fluid layer has been investigated by performing a weakly nonlinear stability analysis. The amplitude of temperature modulation is considered to be very small, and the disturbances are expanded in terms of power series of amplitude of convection. The Ginzburg-Landau equation for the stationary mode of convection is obtained and consequently the effect of temperature modulation on heat transport has been investigated. Effect of various parameters has been explained graphically. It has been found that, an increment in the values of thermo-rheological parameter and Prandtl number is to enhance the heat transport in the system. Further, temperature modulation can be used to control the heat transport effectively as an external mechanism to the system

Weakly nonlinear thermal instability under rotation speed modulation and internal heating effects

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In this paper, we carry out a theoretical investigation to study the combined effect of rotation speed modulation and internal heating on thermal instability in a horizontal fluid layer. Rayleigh..Bénard momentum equation with Coriolis term has been used to describe the convective flow. The system considered to be rotating about z..axis with non-uniform rotation speed. In particular, we assume that the rotation speed is varying sinusoidally with time. A weakly nonlinear stability analysis has been performed to find the effect of modulation on heat transport. Nusselt number is obtained in terms of amplitude of convection and internal Rayleigh number, and depicted graphically for showing the effects of various parameters of the system. The effect of modulated rotation speed is found to have a stabilizing effect for different values of modulation frequency. Further, internal heating is found to destabilize the system.

Convection in a binary nanofluid saturated rotating porous layer

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Double-diffusive convection in a horizontal rotating porous medium layer saturated by a nanofluid, for the case when the base fluid of the nanofluid is itself a binary fluid such as salty water, is studied. The model used for the nanofluid incorporates the effects of Brownian motion and thermophoresis, while the Darcy model is used for the porous medium. The Rayleigh numbers for stationary and oscillatory convection have been obtained in terms of various non- dimensional parameters. Several results are obtained as limiting cases of the present study.

Rheological behavior of a fresh geopolymer based on metakaolin effect of the introduction of calcium carbonate

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Geopolymers can be considered as inorganic polymers presenting good physicochemical properties. The principal advantage of these materials is their elaboration without a lot of energy spending compared to conventional materials. The choice of raw materials and the control of preparation conditions, represent important parameters controlling the rheological properties in the fresh state and physico-chemical properties of consolidated geopolymers. Calcium carbonate powder is incorporated in a geopolymer formulation based on metakaolin. The rheological tests elaborated in different conditions allowed us to model their rheological behavior and follow the effect of carbonate introduction. Two models are observed, the Bingham model and the Herschel-Bulkley model. The introduction of calcium carbonates seems to have no effect on the evolution of the viscosity, while this latter has a remarkable sensitivity to the geopolymerization temperature.

Comparison of OHAM and HPM methods for MHD flow of an upper-convected Maxwell fluid in a porous channel

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This paper presents comparison between optimal homotopy asymptotic method and homotopy perturbation method for the solution of two-dimensional steady flow of an incompressible Maxwell fluid over a transpiration channel within a porous medium due to a impulsively moving wall. The results obtained using HPM for injection case fails to be in accordance with the available analytical data.

Special Session

Multi-models approach to fault diagnosis for discrete event systems

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This paper introduces a framework to help the diagnosis of Discrete Event Systems (DES) based onoperating mode management. Studied systems present several operating modes thus causing complexity of statespace explosion. For this, we propose a multi-models approach and each model describes a system in a givenoperating mode. We assume that only one attempted operating mode is activated at a time, whilst other modesmust be inactivated. In order to ensure the switching between these operating modes in presence of failure events, we propose a multi-models approach to diagnosis. To cure the ambiguity problem between local diagnosis in each model, we propose an algorithm using a forced-event method.

Validation of Kaniennen's rule for fissured Co-Cr pieces used for adjoint prosthesis and calculation of their critical parameters

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We have proposed the calculation of the intensity of constraint factor (ICF) for the fissured isotropic material in Co-Cr used in adjoint prosthesis. The used piece is minimized by a minimizing coefficient with relation to a DCB piece; by the field displacement method which we compared to Kaneinnen's rule for different fissures lengths. The compared results between the two obtained methods show the targeted approach. Inspired by a program of finite elements of FORTRAN group, we have proposed a study on the isotropic Co-Cr material comportment while of overloading. At first, we have applied a criterion of preliminary fissures on the material above mentioned. This criterion consisted of taking the maximal charge just when the constraint of fissure breaches its ultimate value. Once we dispose of the critical charge, and the critical displacement, we carry out the calculation of the critical intensity of constraint factor, the rate of the critical restitution of energy and Rice's critical integral.

Numerical study of stress concentration in a doubly notched specimen in S355

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In the metal structures, the cracks generally start on the level of geometrical discontinuities of notches type or defects. The geometrical parameters of the structures and discontinuities control the starting or the propagation of the cracks and consequently the uniform or the resistance of the structure. In the industrial field, for economic reasons or safety we search to know the degree of harmfulness of the defects as well as the residual lifespan of the structures. This passes by the establishment of models based on the breaking mechanics or fatigue. On the level of the defects, the distribution of the constraints is relatively complex just as the parameters of the breaking mechanics. The numerical methods of finite elements type provide a robust solution to this problem. This solution must be validated, compared with the analytical solution when it exists and if possible confronted with the experiment. In this work we propose a step based on a numerical modeling by finite elements using computation software Castem 2009 and we compare with experimental results.

Optimize experimental conditions to obtain an ultra pure material

F. Lmai

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Vacuum distillation and zone melting purification processes of tellurium were studied. Results were obtained by atomic absorption spectroscopy with graphite furnace (AASGF). Concentrations of impurities such as Al, Ag, As, Ca, Cu Fe, In, Mg, Mn, Na, Pb, Se, Pd, and V were successfully decreased. We confirmed that the ultimate distribution of impurities was reached. A series of segregation coefficients was determined by fitting the experimental measurements of concentrations with Pfann's model plots. The majority of segregation coefficient values were less than 1. The segregation process and diffusion coefficients were affected by the atomic dimensions of impurities. Global characterization of the grown tellurium purity was achieved by electrical measurement on samples of tellurium at liquid helium temperature. We observed an increase of the electric mobility as well as a decrease in the number of carriers.

The preparation and characterization of phosphate material doped with chromium: $(26-y)Fe_2O_3-yCr_2O_3-19Na_2O-55P_2O_5$, with $(0 \leq y \leq 4)$

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In order to prepare a high quality glass with high water resistance, we investigated Chromium iron phosphate glass because of its improved chemical durability. The introduction of chromium in sodium-iron-phosphate glasses is used to compare its effect with iron in inhibition of corrosion. The sodium-chromium-iron phosphate glasses $(26-y)Fe_2O_3-yCr_2O_3-19Na_2O_3-55P_2O_5(\text{mol }\%)$, with $(0 \leq y \leq 4)$ were prepared by direct fusion of the mixture of the reactants followed by quenching in the air. The Sample was annealed at $650\,^{\circ}$C for 48 h. The glasses have been characterized by X-Ray diffraction, and the IR spectroscopy. Their dissolution rate at $90\,^{\circ}$C in distilled water showed a good chemical durability unlike borosilicate and window glasses. The chemical durability was then evaluated by weight losses of glass samples after immersion in hot distilled water for 30 days.Therefore it has been suggested that the chemical durability of these kinds of glasses is attributed to the replacement of P-O-P bonds by P-O-Cr and P-O-Fe bonds. The presence of P-O-Fe bands in higher concentrations makes the glass more hydration resistant. The P-O-Cr bands seem to play the same role than P-O-Fe bands.

The influence of the grain size during precipitation of GP zones in the hardening of the alloy Al-6% Zn 78 (atomic)

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The precipitation phenomena, occupy an important place in the various processes of preparing materials with high mechanical properties. Aluminum-Zinc alloy is the general interest because of the appearance, after quenching and tempering, thermodynamically metastable phases, responsible for structural hardening. The origin of this phenomenon is the interaction between the precipitates present in the solid solution and dislocations on the microscopic scale. Al-Zn alloy has a complication decomposition course in which included several stage in the supersaturated solid solution. The typical decomposition course is: The supersaturated solid solution (SSSS) $\longrightarrow$ GP zone $\longrightarrow$ the metastable phase $\longrightarrow$ the stable phase. In this work, we propose to determine the influence of the grain size of the alloy Al-6,78at.%Zn during the precipitation of GP zones, using a technique based on measurements of microhardness.

Mechanical, rheological and thermal properties of HDPE/ Nut-shells of Argan composites

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Mechanical, thermal and rheological properties of high-density polyethylene (HDPE)/ Nut-shells of Argan (NA) particles composites were investigated to see the effect of adding coupling agent and particles content on the composites properties. HDPE/NA particles composites formulations were melt-blended using a twin-screw mixer. Results of rheological properties show increase of storage (G') and loss (G'') modulus with the addition of $3wt.\%$ of agent coupling maleic anhydride grafted polyethylene (PE-g-MA) on the composite(with $15wt.\%$ of NA particles) and decrease in the absence of agent coupling. The thermal behavior of NA particles reinforced HDPE composites was studied by thermogravimetric. The effects of particles content on the thermal properties were evaluated. It was found that at high temperature NA particles degrades before the HDPE polymer. The experimental results of mechanical properties from this investigation indicate that the ductility and toughness decrease with increasing NA particles content, but increasing substantially its rigidity. The tensile properties were significantly improved with the addition of compatibilizing agent, being in accordance with the mechanical results.

Analysis of a chemostat model with variable yield coefficient and oxygen coefficient

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In this paper, the behaviour of a bioreactor unstructured model describing particularly the wastewater treatment processes is investigated in which the growth rate is given by a Contois expression. The steady states solutions and their stability in a bioreactor model with oxygen concentration are determined as a function of the residence time. An analytical conditions in which a different number of steady states and their stability are changed is provided. The effects of the model parameters on the region of periodic behaviour is also investigated.

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