Preface: IUTAM Symposium Analytical Methods in Nonlinear Dynamics

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Nonlinear dynamics encompasses a fascinating and continually enlarging body of research which includes both theory and applications. Its importance grows with each decade as researchers, from diverse scientific and engineering fields, appreciate its impressive range of technical and applied mathematical tools to tackle problems and give new insights into their respective subjects. With careful observation, almost everywhere in nature, in physical experiments or numerical simulations, one encounters beautiful dynamical phenomena. Knowledge of these, in turn, enrich non-linear dynamic theory by directing research into non-obvious areas. Engineering systems currently being investigated are, for example, self-excited vibrations of rotor systems, dynamics of wind turbines, granular dynamics, fluid-structure interaction, vibro-impacts, elastic waves in non-linear media, and many other fields. Numerics and algorithmic tools can however only be effective when joined with qualitative insight to understand the underlying generic mechanisms. A wealth of analytical and semi-analytical methods and techniques is available for the investigation of non-linear systems. Many of them are classical, such as perturbation theory, others are contemporary. Examples of analytical methods for the investigation of ordinary and partial differential equations, which commonly arise in the context of non-linear oscillations, are centre manifold theory, normal form theory, non-linear normal mode analysis, and embedding techniques, such as Carleman linearisation, among others. The major applied challenges are, for example, a mapping of the bifurcations affecting stable states (including bifurcations of tori and of high co-dimension), the estimation of basins of attraction, and the detection of the onset of chaotic behavior. The methods have to be adapted to different systems which may have slow and fast dynamics, as well as discontinuities yielding stiff differential equations.

Against this background, the IUTAM Symposium on "Analytical Methods in Nonlinear Dynamics" planned to further develop the subject by bringing together leading scientists in applied mathematics and engineering science. The focus was to be on systems described by ordinary and partial differential equations with the expectation that in the future, the analytical and semi-analytical methods of non-linear dynamics will be more commonly applied across engineering fields, providing more robust solutions and useful new insights to current and future problems. For this reason, understanding the potentials and limitations of each techniques is of a particular necessity.

The symposium took place in the Spenerhaus Hotel and Conference Center Frankfurt from July 6^{th} through 9^{th}, 2015 and was hosted by the Dynamics and Vibration Group of Technische Universität Darmstadt, Germany. For planning and preparation of the event, a local organisation committee was formed consisting of Prof. Peter Hagedorn, Dr. Aydin Boyaci, Dr. Melanie Gattermayer, Mr. Matthias Heymanns, Prof. Richard Markert, Ms. Maria Rauck, Prof. Bernhard Schweizer and Dr. Henning Spiegelberg. This was overseen by an international scientific committee with members:

- Prof. Peter Hagedorn (Germany - Chairman)
- Dr. Gottfried Spelsberg-Korspeter (Germany)
- Prof. Jan Awrejcewicz (Poland)
- Prof. Giuseppe Rega (Italy)
- Prof. Jon Juel Thomsen (Denmark)
- Prof. Richard Rand (USA)
- Prof. Alois Steindl (Austria)
- Prof. Ferdinand Verhulst (The Netherlands)

During the symposium, Ms. Maria Rauck, Mr. Jan-Hendrik Wehner and Ms. Melina Vruna manned the registration desk and helped delegates with general questions and queries. Two international academics visiting the Dynamics and Vibrations groups at the time, Prof. Diego Francisco Ledezma Ramírez, acted as official cameraman, and Humboldt fellow Dr. Masaki Nakamiya, offered useful advise and engagement. Interest in the symposium was higher than initially anticipated with 68 participants from the following 20 countries: Austria, Belgium, Brazil, China, Denmark, France, Germany, Great Britain, India, Ireland, Israel, Italy, Japan, Mexico, Morocco, New Zealand, Poland, Russia, The Netherlands, and USA. From the abstracts submitted for the symposium, 46 were selected for an oral presentation. Due to uncontrollable circumstances, one scientist was unable to present his work. In addition, 10 papers were selected for the poster session, but only 3 were presented in the end. Below, the official schedule for presentations and events is reproduced.

Sunday July 5th 2015

18:00-19:00 Early Registration at Hotel and Conference Center Spenerhaus

Monday July 6th 2016

08:00-09:00 Registration
09:00-09:30 Welcome Address and Opening Session

Session Chair: Jan Awrejcewicz, Jon Juel Thomsen

09:30-09:50 Ferdinand Verhulst: "Torus break-down and bifurcations in coupled oscillators"
09:50-10:10 Elisabeth Wesson, Richard Rand: "A model of evolutionary dynamics with quasiperiodic forcing"
10:10-10:30 Firdaus E. Udwadia, Harshavardhan Mylapilli: "An Analytical Dynamics Approach to the Energy Control of General Nonlinear Lattices"
11:00-11:20 Valeria Settimi, Giuseppe Rega, Stefano Lenci: "Analytical and numerical control of global bifurcations in a noncontact atomic force microcantilever"
11:20-11:40 Valery N. Pilipchuk: "Effective Hamiltonians for resonance interaction dynamics and interdisciplinary analogies"
11:40-12:00 Miguel R. Hernandez-Garcia, Sami F. Masri, Roger Ghanem: "Characterization of dynamic properties of a nonlinear mechanical joint from experimental data"

Session Chair: Giuseppe Rega, Ferdinand Verhulst

14:00-14:20 Johannes Störkle, Nicolai Wengert, Peter Eberhard: "Simulation and Optimization of the Dynamical-Optical Behavior of Mirror Systems"
14:20-14:40 Wim T. van Horssen: "On the mathematical analysis of vibrations of axially moving strings"
14:40-15:00 Stefano Lenci, Giuseppe Rega: "Nonlinear free vibrations of planar elastic beams: A unified treatment of geometrical and mechanical effect"
15:00-15:20 Alexander Fidlin, Olga Drozdetskaya: "On the averaging in strongly damped systems: The general approach and its application to asymptotic analysis of the Sommerfeld effect"
16:00-16:20 Hartmut Hetzler: "Attractivity and bifurcations of stationary solutions in systems with non-smooth frictional damping"
16:20-16:40 Giuseppe Habib, Gaetan Kerschen: "Enforcing force-displacement proportionality in nonlinear systems through the addition of nonlinearity"
16:40-17:00 Oleg Gendelman, Aviv Alloni: "Dynamics of forced system with vibroimpact energy sink"

17:00 Closing first day

18:00-20:00 Symposium Reception and Get Together at restaurant MainNizza, Frankfurt am Main

Tuesday July 7th 2015

Session Chair: Peter Eberhard, Alexander Fidlin

09:00-09:20	Arnaldo Casalotti, Walter Lacarbonara: "Nonlinear Vibration Absorber Optimal Design via Asymptotic Approach"
09:20-09:40	Iliya I. Blekhman, Vladislav S. Sorokin: "Extension of the Method of Direct Separation of Motions for Problems of Oscillating Action on Dynamical Systems"
09:40-10:00	Angelo Luongo, Sara Casciati, Daniele Zulli: "A perturbation scheme to solve a bi-stable energy harvester"
10:00-10:20	Alexander F. Vakakis, Leonid I. Manevitch: "Nonlinear Oscillatory Sonic Vacua"
10:20-11:00	Poster Session - Posters by: Tugce Akkaya, Wim T. van Horssen: "On the Effectiveness of Boundary Dampers for Strings or Beams" Eugen Kremer: "Coupled Oscillators: Harmonical Balance as an Optimization" J. P. Meijaard: "The Motion of a Railway Wheelset on a Track or a Roller Rig" Konrad Weisheit, Steffen Marburg: "Calculation of the response of a periodically excited beam with frictional contact using the harmonic balance method"
11:00-11:20	Alois Steindl: "Detecting the Shilnikov scenario in a Hopf-Hopf bifurcation with 1 : 3 resonance"
11:20-11:40	Alexei A. Mailybaev, Gottfried Spelsberg-Korspeter: "Resonant effects in stability of a rotor due to time-periodic terms"
11:40-12:00	Nishanth Lingala, N. Sri Namachchivaya, Ilya Pavlyukevich: "Random Perturbations of Periodically Driven Nonlinear Oscillators"

Session Chair: Richard Rand, Alois Steindl

14:00-14:20	Ivana Kovacic: "Strongly Nonlinear Oscillators with a Zero, Negative and Positive Linear Stiffness Term: Generalised Perturbation Techniques for Free and Forced Systems"
14:20-14:40	Mikael A. Langthjem, Tomomichi Nakamura: "Highly nonlinear liquid surface waves in the dynamics of the fluid balancer"
14:40-15:00	Daniel Hochlenert: "Analysis of Engineering Systems by Normal Form Theory"
15:00-15:20	E. Hacker, S. Pandey, Oded Gottlieb: "Nonlinear Dynamics Orbital Instabilities and Transient Chaos in Magnetic Resonance Force Microscopy"
15:20-16:00	Continuation of Poster Session
16:00-16:20	Paulo B. Gonçalves, Frederico M. A. da Silva, Zenón Del Prado: "Reduced Order Models for the Nonlinear Dynamic Analysis of Shells"
16:20-16:40	Olga Drozdetskaya, Alexander Fidlin: "On the dynamic balancing of a planetary moving rotor using a passive pendulum type device"

Wednesday July 8th 2015

Session Chair: Ivana Kovacic, Richard Markert

08:40-09:00	Vladislav S. Sorokin, Jon J. Thomsen: "The Method of Varying Amplitudes for Solving (Non)linear Problems Involving Strong Parametric Excitation"
09:00-09:20	Carlos E. N. Mazzilli, Fabio Rizza, Thiago Dias: "Heave-imposed motion in vertical risers: a reduced-order modelling based onBessel-like modes"
09:20-09:40	Leonid I. Manevitch: "Limiting Phase Trajectories as an Alternative to Nonlinear Normal Modes"
09:40-10:00	Lauren Lazarus, Matthew Davidow, Richard Rand: "Dynamics of a delay limit cycle oscillator with self-feedback"
10:00-10:20	Dmitry S. Dobrynin, Alexander S. Kuleshov: "Solvable cases in the problem of motion of a heavy rotationally symmetric ellipsoid on a perfectly rough plane"
10:50-11:10	Agnessa Kovaleva: "Asymptotic Analysis of Autoresonant Oscillatory Chains"
11:10-11.30	Leo Dostal, Edwin J. Kreuzer: "Analytical and Semi-Analytical Solutions of Some Fundamental Nonlinear Stochastic Differential Equations"
12:15-23:00	Symposium Excursion: Boat Tour on River Rhine and Symposium Dinner at Kloster Eberbach

Thursday July 9th 2015

Session Chair: Bernhard Schweizer, Daniel Hochlenert

09:00-09:20	C.-H. Lamarque, S. Charlemagne, M. Weiss, B. Vaurigaud, A. Ture Savadkoohi: "Analysis of the 1:1 resonant energy exchanges between two coupled nonlinear oscillators"
09:20-09:40	Henrik Westermann, Jörg Wallaschek: "Evaluation of a Kinematic Approach for Backward Whirl with an Application to Drillstring Dynamics"
09:40-10:00	Márcio José Horta Dantas, Rubens Sampaio, Roberta Lima: "Phase Bifurcations in an electromechanical system"
10:00-10:20	Jun Jiang, Ling Hong, Yanhua Chen: "Knowledge-based Analytical Aproaches to Characterization of Self-excited Oscillations in Rotor-Stator Rubbing Systems"
11:00-11:20	Jan Awrejcewicz, Roman Starosta, Grażyna Sypniewska-Kamińska: "Stationary and transient resonant response of spring pendulum"
11:20-11:40	Walter V. Wedig: "New Resonances and Velocity Jumps in Nonlinear Road-Vehicle Dynamics"
11:40-12:00	Balakrishnan Santhosh, Sadagopan Narayanan, Padmanabhan Chandramouli: "Discontinuity Induced Bifurcations in Nonlinear Systems"

Session Chair: Oded Gottlieb, Rubens Sampaio

14:00-14:20	Elżbieta M. Jarzębowska: "Analytical Dynamics Based Strategy for Acceleration Control of a Car-Like Vehicle Motion"
14:20-14:40	Konstantin E. Starkov, Alexander P. Krishchenko: "Global Dynamics of Raychaudhuri Equations"
14:40-15:00	Francesco Romeo, Oleg Gendelman: "Discrete breathers in forced chains of oscillators with cubic nonlinearities"
15:40-16:00	Vladimir I. Babitsky, Vikrant R. Hiwarkar: "Nonlinear Dynamic Structures with Developing Discontinuity"
16:00-16:20	Faouzi Lakrad, Mourad Khadraoui, Mohamed Belhaq: "Effects of a Slow Harmonic Excitation on an Atomic Force Microscope System"
16:20-16:40	Aydin Boyaci: "Numerical Continuation Applied to Nonlinear Rotor Dynamics"
16:40	Closing Session Fourth and Last Day

All oral and poster contributors at the symposium were invited to submit their work in the form of a manuscript to be considered for the official proceedings. The review process and the publication of the scientific papers were organised and edited by Prof. Peter Hagedorn and Dr. Eoin J. Clerkin with the assistance of Mr. Jan-Hendrik Wehner and Ms. Melina Vruna. In total, 35 manuscripts were submitted for review with 33 accepted after subsequent revision. Considerable gratitude must go the reviewers, nominated from the attendees of the symposium, who donated their time, expertise and effort to conduct a thorough refereeing process. Although some notable presentation were not included, for reasons given above, the scientific papers presented in this volume reflect the range of topics addressed at the symposium.

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of the University of Canterbury, Christchurch (New Zealand), of the Institute of Numerical Methods in Mechanical Engineering of TU Darmstadt, and of the Graduate School of Computational Engineering of TU Darmstadt is gratefully acknowledged. The Symposium could not have been realised without the constant help of all the members of the scientific committee and of the local organising committee. In particular, my secretary, Maria Rauck, has been an essential driving force in all organisational matters of the symposium. Finally, we thank all participants, contributors, staff, and attendees for allowing a successful conference and for fostering a fruitful intellectual atmosphere, which we hope will be continued for future IUTAM symposia.

Peter Hagedorn
Symposium Chair