Директору Математичког института САНУ
Проф. др Зорану Огњановићу
Научном већу Математичког института САНУ
академику Драгошу Цветковићу

Извештај о одржаном
Мини-симпозијуму „Механика контакта: Теорија и примене“

Београд, 14. март 2017, од 10:30-19:00h у Математичком институту САНУ

у организацији

Пројекта ОИ174001 ''Динамика хибридних система сложених структура. Механика материјала.''

координираног у Математичком институту САНУ

Поштовани директоре, Професоре Огњановићу,
Поштовани председниче, Професоре Цветковићу,
Цењени чланови Научног Већа МИ САНУ,

У оквиру активности промоције научних резултата пројекта ОИ174001 "Динамика хибридних система сложених структура. Механика материјала,'' координираног у Математичком институту САНУ, као и сарадње са другим пројекима и/или појединим истраживачима са других пројеката из земље и иностранства, у Београду, 14. марта 2017, у Математичком институту САНУ успешно је организован још један једнодневни мини-симпозијум:

„Механика контакта: Теорија и примене“

Организатори: *др* ***Ивана Д. Атанасовска,*** Математички институт САНУ, Београд
Проф. др ***Катица Р. (Стевановић) Хедрих***, Математички институт САНУ, Београд и Машински факултет Универзитета у Нишу
Ко-организатор: *Проф. др* ***Радивоје М. Митровић,*** Машински факултет – Универзитет у Београду

У радном делу Мини-симпозијума „Механика контакта: Теорија и примене“ одржано је **10 предавања** по позиву. Предавања су била подељена у три тематске секције, две преподневне и једна поподневна.

Да одрже предавања у оквиру овог Минисимпозијума позвани су истраживачи који су својим вишегодишњим истраживачким радом афирмисани у различитим областима истраживања у оквиру механике контакта, од аналитичких, нумеричких, преко експерименталних истраживања и конкретних случајева примене. Поред аутора из **Србије**, учествовали су и аутори из иностранства – из **Шпаније**, **Грчке**, **Италије**, **Малезије** и **Индије**. Иностраним предавачима по позиву било је обезбеђено по два преноћишта са доручком у хотелу Славија.

Сва предавања су била оригинална и веома инспиративна, те су наишла на велико интересовање учесника Мини-симпозијума, којих је укупно било око педесет. Сваком од предавача је након успешног излагања и дискусије, уручен Сертификат о одржаном предавању.

Поред радног дела програма, Мини-симпозијум је садржао и прилике за неформалне разговоре, успостављање нових контаката и идеја за будућа заједничка истраживања и међународну сарадњу.

Апстракти изложених предавања, у двојезичном приказу на српском и енглеском језику, објављени су у **Књизи апстраката (Booklet of Abstracts) са каталогизацијом НБ Србије**.

У Прилогу 1 дат је списак одржаних предавања.

Гост на Мини-симпозијуму је био и **Prof. Yuri Vladimirovich MIKHLIN, Dept.of Applied Mathematics, National Technical University "Kharkov Polytechnical Institute", Ukraine**.

Prof. Yuri Vladimirovich MIKHLIN је наредног дана, 15.03.2017., успешно одржао предавање на Семинару за механику Одељења за механику Математичког института САНУ:

Prof. Yuri Vladimirovich MIKHLIN, Dept.of Applied Mathematics, National Technical University "Kharkov Polytechnical Institute", Ukraine.

SREDA, 15.03.2017. u 18:00, Sala 301f, MI SANU, Kneza Mihaila 36

NONLINEAR NORMAL MODES OF VIBRATING MECHANICAL SYSTEMS AND THEIR APPLICATIONS

Abstract: Nonlinear normal modes (NNMs) are periodic motions of specific type, which can be observed in different nonlinear mechanical systems. In the normal vibration mode a finite degree-of-freedom system vibrates like a single-degree-of-freedom conservative one. The significance of NNMs for mechanical engineering is determined by the important properties of these motions. In particular forced resonances motions of nonlinear systems occur close to NNMs. Nonlinear localization and transfer of energy can be analyzed using NNMs.

У Прилогу 2 дат је астракт одржаног предавања Проф. Yuri Vladimirovich MIKHLIN-а, а у Прилогу 3 његова биографија.

С поштовањем и захвалношћу за подршку пројектним активностима,

У Београду, 22.03.2017.

Катица (Стевановић) Хедрих

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Проф. др Катица (Стевановић) Хедрих
Руководилац Пројекта ОИ174001

Ивана [illegible]

____

др Ивана Атанасовска, виши научни сарадник

Прилог 1. Списак одржаних предавања на

Мини-симпозијуму
„Механика контакта: Теорија и примене“
Математички институт САНУ и Пројекат ОИ174001,
Београд, 14. март 2017, од 10:30-19:00h, сала II, први спрат, Кнеза Михаила 36

I Session.

I-1. Contact problems in airframe structures on elastic supports (Проблеми контакта код ваздухопловних структура на еластичним ослонцима)
Prof. dr ***Mirko Dinulović,*** University of Belgrade-Faculty of Mechanical Engineering, Serbia, mdinulovic@mas.bg.ac.rs

I-2. Some aspects of 3D finite element modeling of contact effects in wire rope strands (Неки аспекти 3D моделовања утицаја контаката између жица у плетеним ужадима методом коначних елемената)
Prof. dr ***Gordana Kastratović,*** University of Belgrade, Faculty of Transport and Traffic Engineering, Serbia, g.kastratovic@sf.bg.ac.rs

I-3. Numerical simulation for investigating the contact problems in industrial life (Нумеричке симулације у истраживањима контактних проблема у индустријском животу)
dr ***Ana Pavlović***, Alma Mater Studiorum- University of Bologna, Italy, ana.pavlovic@unibo.it
dr ***Cristiano Fragassa***, Alma Mater Studiorum- University of Bologna, Italy, cristiano.fragassa@unibo.it
dr ***Snežana Vulović***, Faculty of Engineering, University of Kragujevac, Serbia, vsneza@kg.ac.rs

II Session.

II-1. A quaternion-based analytical solution for the generalised 3-D non-conjugate gear contact analysis problem (Аналитичко решење за генерализовану 3-D анализу некоњугованог контактног проблема код зупчаника, базирано на кватернионима)
Prof. dr ***Vasilios Spitas***, National Technical University of Athens, School of Mechanical Engineering , Athens, Greece, vspitas@central.ntua.gr

II-2. Contact analysis applied to gear design (Анализа контакта у конструисању зупчаника)

dr ***Victor Roda-Casanova***, Jaume I University, Castellón, Spain, vroda@uji.es
Prof. dr ***Francisco Sanchez-Marin***, Jaume I University, Castellón, Spain, ftsan@uji.es

II-3. Effect of friction inclusion on gear contact stresses (Утицај трења на контактне напоне код зупчаника)
dr ***Santosh Patil,*** Department of Mechanical Engineering, Manipal University Jaipur, Jaipur, Rajasthan, India, santosh.patil@jaipur.manipal.edu
Prof. dr ***Saravanan Karuppanan***, Department of Mechanical Engineering, Universiti Teknologi PETRONAS, Perak, Malaysia, e-mail: saravanan_karuppanan@utp.edu.my
dr ***Ivana D. Atanasovska***, Mathematical institute of SASA, Belgrade, Serbia, iviatanasov@yahoo.com

III Session. Chairman:

III-1. Contact between abrasive particles and worn surfaces within rolling bearing (Контакт између абразивних честица и похабаних површина код котрљајних лежаја)
Prof. dr ***Tatjana Lazović****, Prof. dr* ***Radivoje M. Mitrović****,* ***Žarko Mišković,***
University of Belgrade-Faculty of Mechanical Engineering, Serbia
tlazovic@mas.bg.ac.rs, rmitrovic@mas.bg.ac.rs, zmiskovic@mas.bg.ac.rs

III-2. A review of as-cast and austempered ductile iron behaviour under cavitation conditions (Преглед понашања ливеног гвожђа и аустемперованог нодуларног лива у условима кавитације)
dr ***Olivera Erić Cekić***, Innovation center, Faculty of Mechanical Engineering, University of Belgrade, Belgrade, Serbia,olivera66eric@gmail.com
dr ***Dragan Rajnović****, Prof. dr* ***Leposava Sidjanin****, dr* ***Sebastian Baloš***
Department of Production Engineering, Faculty of Technical Sciences, University of Novi Sad, Serbia, draganr@uns.ac.rs, lepas@uns.ac.rs, sebab@uns.ac.rs

III-3. Wheel-rail contact forces – experimental and computational approach (Силе у додиру точак–шина – експериментални и прорачунски приступ)

*dr **Dragan Milković***, University of Belgrade-Faculty of Mechanical Engineering, Serbia, dmilkovic@mas.bg.ac.rs
*Prof. dr **Goran Simić***, University of Belgrade-Faculty of Mechanical Engineering, Serbia, gsimic@mas.bg.ac.rs

III-4. Contact mechanics of wheel/brake block on railway vehicles (Контактна механика склопа точак/кочница код железничких возила)

*mr sci. **Marija Vukšić Popović*** , College of Professional Railway Studies, Belgrade, Serbia, vuksicpopovic@bvcom.net
*mr sci. **Saša Radulović,*** University of Belgrade-Faculty of Mechanical Engineering, Serbia, sasa.radulovic76@gmail.com

ПРИЛОГ 2.

NONLINEAR NORMAL MODES OF VIBRATING MECHANICAL SYSTEMS AND THEIR APPLICATIONS

Yuri V. Mikhlin
National Technical University "KhPI", Kharkov, Ukraine,

Nonlinear normal modes (NNMs) are periodic motions of specific type, which can be observed in different nonlinear mechanical systems [1-3]. In the normal vibration mode a finite degree-of-freedom system vibrates like a single-degree-of-freedom conservative one. The significance of NNMs for mechanical engineering is determined by the important properties of these motions. In particular forced resonances motions of nonlinear systems occur close to NNMs. Nonlinear localization and transfer of energy can be analyzed using NNMs.

Kauderer [4] was the first who developed quantitative methods for the NNM analysis in two-DOF conservative nonlinear systems. Rosenberg considered ***n***-DOF conservative systems and deduced the first definition of NNMs as "vibrations in unison", i.e., synchronous periodic motions, where all material points of the system reach their maximum and minimum values at the same instant of time [5,6]. He considered wide classes of essentially nonlinear systems, which have nonlinear vibrations modes with straight modal lines. The NNMs based on the determination of modal lines in configuration space, can be called **the Kauderer-Rosenberg nonlinear normal modes**. In general, the NNM modal lines in a configuration space are curvilinear. The power series method to construct the curvilinear trajectories in conservative systems was proposed in [1,7-9]. The non-localized and localized NNMs, bifurcations of the NNMs and global dynamics of the nonlinear systems near NNMs are analyzed in different papers [1-3,10-15]. Pade´ approximations are used to derive the NNMs with arbitrary amplitudes [16].

Shaw and Pierre developed an alternative concept of NNMs for nonlinear dissipative finite-DOF systems [17,18]. Their research was based on the computation of invariant manifolds of motion in phase space. This second type of the NNMs is called **the Shaw-Pierre nonlinear normal modes**.

Generalization of the NNMs concepts to forced, self-exited and parametric vibrations is possible [1,11,19-24]. In particular the Rauscher method and the power-series method for the modal line construction can be used to analyze the NNMs of non-autonomous systems. NNMs in systems with non-smooth characteristics are considered [25-28]. Generalization of the NNMs to continuous systems is made in several publications [29-31].

NNMs have been used to solve applied problems of mechanical and aerospace engineering [32]. Such vibrations take place in different structures and machines.

The Kauderer- Rosenberg NNMs are applied for the analysis of large amplitude dynamics of finite-DOF nonlinear mechanical systems. In particular, free and forced NNMs are considered in systems with nonlinear absorbers [33-35]. Localized and non-localized NNMs are analyzed in such systems. Applications of the Kauderer-Rosenberg NNMs for discretized systems are also discussed. These systems can be obtained by use of the Galerkin procedure to initial continuous structures. The Kauderer-Rosenberg NNMs are successfully used to analyze large amplitude free and forced vibrations of the cylindrical shells with geometrical nonlinearity [36,37]; cylindrical shells interacting with a fluid [38]; parametric vibrations of cylindrical shells under the action of longitudinal force [39]; shallow arch snap-through motions [40]; vibrations of beams interacting with essential nonlinear absorbers [41].

The Shaw-Pierre NNMs are applied to analyze the dynamics of nonlinear mechanical systems. In particular NNMs are used to analyze dynamics of pre-twisted beams with geometrical nonlinearity [42]; beam parametric vibrations [22]; nonlinear free vibrations of shallow shells with complex base [43]; nonlinear vibrations of the vehicle suspensions [44]. Nonlinear dynamics of an one-disk rotor in two bearings is studied using the Shaw-Pierre NNMs [45-47]. Gyroscopic effects, nonlinear flexible base, inertial forces in supports and internal resonances are taken into account.

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ПРИЛОГ 3.

Yuri Vladimirovich MIKHLIN, Professor

CURRICULUM VITAE

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EDUCATIONAL BACKGROUND:

1988 Doctor of Science (Physics & Mathematics), Moscow Institute for Problems in Mechanics (Russian Academy of Sciences).
1974 Ph.D. (Physics & Mathematics), Dnepropetrovsk State University.
1970 Graduated from the Dneptopetrovsk State University summa cum laude in Mechanics.

INDUSTRIAL AND FACULTY APPOINTMENTS:

1995 - at present: National Technical University “Kharkov Polytechnic Institute” (Professor).
1989-1995 Dnepropetrovsk State University (Professor).
1976-1989 Dnepropetrovsk Civil Engineering Institute (Docent in Mathematics, Researcher in Mechanics).
1970-1976 Dnepropetrovsk Automation in Metallurgy Institute (Researcher in Mechanics and Control).

QUALIFICATION and AREA OF EXPERTISE:

More than 45 years of experience in Nonlinear Dynamics and Applied Mathematics.

The main scientific results in: Theory of nonlinear normal vibration modes; Analysis of the nonlinear vibrations stability; Theory of perturbation; Applications of the nonlinear dynamics.

Current research focuses on: Nonlinear normal mode theory, Nonlinear rotor dynamics; Nonlinear dynamics of elastic systems, Vibro-absorption problems; Transient and localization problems et al.

INTERNATIONAL SCIENTIFIC ACTIVITY:

Organizer and Chair of the Mini-Symposium on Nonlinear Dynamics in Engineering Systems at the European Nonlinear Oscillations Conference, June 25-30, 2017, Budapest, Hungary

Organizer and Chair of the Mini-Symposium on Nonlinear Dynamics of Structures and Machines at the European Nonlinear Oscillations Conference, July 6-11, 2014, Vienna, Austria

Organizer and Chair of the Mini-Symposium on Nonlinear Dynamics of Structures and Machines at the European Nonlinear Oscillations Conference, July 24-29, 2011, Rome, Italy

Organizer and Chairman of the Sci. Committee of the Fifth International Conference on Nonlinear Dynamics which will be held at the National Technical University "Kharkov Polytechnic Institute", Kharkov, September, 27-30, 2016.

Organizer and Chairman of the Sci. Committee of the Fourth International Conference on Nonlinear Dynamics which will be held in Sevastopol, June, 19-22, 2013.

Organizer and Chairman of the Sci. Committee of the Third International Conference on Nonlinear Dynamics which will be held at the National Technical University "Kharkov Polytechnic Institute", Kharkov, September, 21-24, 2010.

Organizer and Chairman of the Sci. Committee of the Second International Conference on Nonlinear Dynamics at the National Technical University "Kharkov Polytechnic Institute", Kharkov, September, 25-28, 2007.

Organizer and Chairman of the Sci. Committee of the International Conference on Nonlinear Dynamics at the National Technical University "Kharkov Polytechnic Institute", Kharkov, September, 14-16, 2004.

Memberships in Editorial Board of the journals: Nonlinear Dynamics, Mathematical Problems in Engineering and Journal of Mechanical Engineering Science.

Memberships in Scientific Committees of Int. Conferences in Belgium, France, Greece, Italy, Poland, Ukraine, UK et al.

Memberships in AMS, GAMM.

Visits to: Technion (Haifa), Israel, 2014, Lublin Technical University, Poland, 2013, University UNESP, Rio-Claro-San-Paulo, Brasil, 2012, Glasgow University, UK, 2008; Aberdeen University, UK, 2008; Michigan University, Ann Arbor, USA, 2005; ENTPE, Lion, France, 2003; Modena University, Italy, 2001; Technical University, Vienna, Austria, 2000 et al.

SUPPORTING AGENCIES: Grants by Ukrainian Academy of Science and the Russian Academy of Science (2009-2013); NATO Scientific Affairs Division (2001-2003), USA Air Force Office of Scientific Research (2001-2003); Grants from the Ministry of Science and Education of Ukraine (1997-at present).

PUBLICATIONS: - Number of papers in refereed journals: 125
- Number of communications to scientific meetings: 125
- Number of books: 7

SOME SELECTED PUBLICATIONS:

Normal Modes and Localization in Nonlinear Systems. NY: Wiley, 1996, 552 p. (A.F.Vakakis, L.I.Manevich, Yu.V.Mikhlin, V.N. Pilipchuk, A.A.Zevin), ISBN 0-471-13319-1.

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Прилог 4. Фото галерија

ФОТО ГАЛЕРИЈА

Мини-симпозијум „Механика контакта: Теорија и примене“

Пројекат ОИ174001, Београд, 14 март 2017






ФОТО ГАЛЕРИЈА

Семинар за механику Одељења за механику

SREDA, 15.03.2017. u 18:00, Sala 301f, MI SANU, Kneza Mihaila 36

Prof. Yuri Vladimirovich MIKHLIN, Dept.of Applied Mathematics, National Technical University “Kharkov Polytechnical Institute”, Ukraine.

NONLINEAR NORMAL MODES OF VIBRATING MECHANICAL SYSTEMS AND THEIR APPLICATIONS