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Program of Mechanics Colloquium –MARCH 2011

Sreda (Wednesday), 2 mart (March 2) 2011 u 18 sati (18h) **Lecture No. 1144**

Dr Branko Sarić, Visoka školi tehničkih strukovnih studija u Čačku.

One solution of singularity problem and perihelion problem

Abstract: Newton's gravity concept, which describes with sufficiently exactness, in spite of some acutely vexed questions within it, Sun's planetary system, via Kepler's laws of planetary motion, is one of the fundamental laws of the classical mechanics. The first vexed question, based on the purely theoretical basis, is the so-called singularity problem. Namely, on the basis of the mathematical model of two material points motion of the same mass in the field of action of the central Newton's gravity force, when the direction of material points motion coincides with the assaulted direction of the force, it is easy to see that absolute values of all relevant physical variables, such as velocity, force, kinetic and potential energy, in the limit as mutual distance of the material points tends to zero, tend to infinity. The second one, which is cleanly empirical nature, is the perihelion problem. Namely, it has been experimentally stated that the perihelion of Mercury's orbits moves into the plane of its planetary motion around the Sun. In other words, all planetary motions of Sun's planetary system depart from elliptical orbits obtained from Newton's mathematical gravity model. Accordingly, to solve simultaneously these two acutely vexed questions within Newton's gravity concept, the goal of the manuscript is a modification of Newton's gravity concept itself.

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Sreda (Wednesday), 9 mart (March 9) 2011 u 18 sati (18h) **Lecture No. 1145**

Perof. dr Vladimir D. Stevanović, University of Belgrade, Faculty of Mechanical Engineering

DEVELOPMENT AND APPLICATION OF COMPUTATIONAL MULTI-FLUID DYNAMICS

Abstract: Computational Multi-Fluid Dynamics (CMFD) for multidimensional gas-liquid flows is an emerging field. Due to the complexity and diversity of two-phase gas-liquid flow conditions, further development of two-phase flow modelling, closure laws and numerical methods is needed in order to achieve the general purpose and efficient CMFD methods, which will be applicable to a wide variety of technical and technological conditions.

An original approach to the various aspects of CMFD modelling is presented. It is based on the multi-fluid modelling approach, development of necessary closure laws and derivation of appropriate numerical methods for efficient governing equations solution. Mass, momentum and energy conservation equations are written for several fluid streams, depending on the investigated flow conditions. Great differences of phase densities and other thermo-physical properties in two-phase flows impose strict requirements to the stability and accuracy of applied numerical method of solution. The numerical method should be applicable to interpenetrating multiphase

flows, as well as to separated structures with interface movement. Velocity and pressure fields are solved with the SIMPLE type pressure-corrector method developed for the multiphase flow conditions. For the solution of scalar parameters transport equations both implicit and explicit methods are presented. The implicit method is suitable for steady state, slow transients and problems without the sharp front propagation. The explicit method, based on the fluid particle tracking, is a third order accurate numerical scheme. It is developed in order to predict scalar parameters front propagations, as well as phase interface tracking problems.

The developed method possibilities are demonstrated by solving standard benchmark tests, as well as real engineering problems. The solving of the benchmark problems includes the transient boiling boundary prediction, interface tracking problems such as the broken dam problem and the initially homogeneous two-phase mixture separation in the vessel, the dispersed gas phase-droplets and liquid film flows around spacers, and the burn-out in pool boiling. Solved macro domain engineering problems are steady-state and transient two-phase flows in steam generators and kettle reboilers, headers of heat exchangers for refrigerant evaporation and the steam condensation in non-vented pipes in the presence of non-condensables. Obtained numerical results are compared and verified with experimental data or available analytical solutions. The presented numerical results show that the developed CMFD method for multiphase flow is a useful and robust tool for the simulation and analyses of fluid flow in equipment of different geometry and in different thermal-hydraulic processes. Obtained results are a support to equipment design, plant operational diagnostics and safety analyses in energy, chemical and process industry.

Sreda (Wednesday), 16 mart (March 16) 2011 u 18 sati (18h) **Lecture No. 1146**

Prof. dr Zivorad Tomovski, St.Cyril and Methodius University of Skopje , Faculty of Mathematics and Natural Sciences, Institute of Mathematics, Macedonia

Fractional and Operational Calculus with generalized Mittag Leffler functions and Applications

Abstract. The subject of fractional calculus has gained importance and popularity during the past three decades or so, due mainly to its demonstrated applicability in numerous seemingly diverse fields, namely in the areas of electromagnetism, control engineering , fractional viscoelastic models, diffusion theory, continuum mechanics, signal processing, etc. Indeed, it provides several useful tools for solving differential, integral, and integro-differential equations and various other problems involving special functions of mathematical physics as well as their extensions and generalizations in one and more variables. The objective of this talk is to consider some fractional differential equations of modern physical interest.

There are several definitions that lead to different results, making difficult the establishment of a theory of fractional calculus in agreement with current practice. Those of Riemann-Liouville (R-L), Caputo, Grünwald-Letnikov, Weyl, Hadamard, Osler, Marchaud are some of the known definitions. We'll consider a certain family of generalized (R-L) fractional derivative operators of order μ and type ν which were introduced by R. Hilfer (2000) and investigated by R. Gorenflo/F. Mainardi (2007); H.M.Srivastava/Z. Tomovski (2009); R. Hilfer/Yu. Luchko/Z. Tomovski (2009), Tomovski/Hilfer/Srivastava (2010), e.t.c. in several earlier works. Many solutions of the fractional differential equations can be expressed via Mittag-Leffler (M-L) functions, Wright functions, Fox H-function, e.t.c. (M-L) functions are natural extensions of the exponential and trigonometric functions. As mentioned in the survey (Gorenflo and Mainardi), even the classical (M-L) functions, for a long time, have been almost totally ignored in the common handbooks on special functions and tables of transforms, although a description of their properties has appeared already in the third volume of the Bateman Project (Erdelyi, et.al.,) in a chapter devoted to "miscellaneous functions".

The basic processes of relaxation, diffusion, oscillations, and wave propagation have been generalized by several authors by introducing fractional derivatives in the governing (ordinary or partial) differential equations. This leads to superslow or intermediate processes that, in mathematical physics, we may refer to as fractional phenomena. We will derive various compositional properties, which are associated with (M-L) functions and Hardy-type inequalities for the generalized (R-L) fractional derivative operators. Furthermore, by using the Laplace transformation methods and operational method of Mikusinski, we will provide solutions of many different classes of fractional differential equations with constant and variable coefficients and some general Volterra-type differintegral equations in the space of Lebesgue integrable functions and certain spaces of generalized functions. Particular cases of these general solutions and a brief discussion about some recently investigated fractional kinetic equations by Saxena-Kalla will be also considered. The proposed fractional models are solved by analytical methods, such us the Laplace, Melline, and Fourie transform methods, method of separation of variables, Sturm-Liouville problem, Operational method of Mikusinski, Tauberian Theorems and some numerical methods.

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Sreda (Wednesday), 23 mart (March 23) 2011 u 18 sati (18h) **Lecture No. 1147**

Prof. dr Mihailo P. Lazarević,' Department of Mechanics, Faculty of Mechanical Engineering, University of Belgrade

Applications of Fractional Calculus in Mechatronics and Control Theory: New Results

Abstract: In recent years**,** there have been extensive research activities related to applications of fractional calculus (FC) in mechatronics and control theory. In this presentation a quite new stability test procedure is proposed for perturbed (non)linear (non) homogeneous fractional order systems with/without time delay. Results from the area of finite time and practical stability extends to (non)linear, continuous, fractional order (time-delay) systems given in state space form. Sufficient conditions of finite time stability and practical stability for this class of fractional systems are derived using generalized Gronwall inequalities. Specially, previous results can be applied for stabilization of mechatronic system where it appears a time delay in PD^{α} fractional control system. Besides that, a PD^{α} type of iterative learning feedback control (ILFC) is proposed for class -fractional linear time invariant system. When the structure is not known or when many parameters cannot be determined, ILC may be considered. The learning control scheme comprises two types of control laws: a PD^{α} feedback law and a PD^{α} feed-forward control law.A sufficient condition for convergence of a proposed ILC will be given by the theorem and proved. Using feedback loop, the PD^{α} controller provides better stability of the system and keeps its state errors within uniform bounds. Next, it will be presented here a new algorithms of PID control based on applying FC in control of given mechatronic system for the producing of technical gases, i.e air production cryogenic. Objective is to find out optimum settings for a fractional $PI^{\alpha}D^{\beta}$ controller in order to fulfill different design specifications for the closed-loop system, taking advantage of the fractional orders and

properties of liquid. Moreover, it will be shown that active control of nonlinear vibration of simply supported smart composite beam can be obtained using suitable fractional $PI^{\alpha}D^{\beta}$ controller where sensing and actuating are achieved using piezoelectric sensors and actuators. At last, the generalization of the splines (fractional B-splines), and other fractional wavelet constructions will be disscused,where we can build the wavelet bases parameterized by the continuously-varying regularity parameter α. In that way, the fractional WT technique offers very handy tool to perform the signal analysis for pattern specially welcomed in real-life non-destructing testing, which enhance already existing testing equipment with advanced signal processing - denoising, magnifying and clustering the original signal.

Sreda (Wednesday), 30 mart (March 30) 2011 u 18 sati (18h) Lecture No. 1148

Prof. dr Stevan Maksimović, dipl- ing., Militarz Scientific Technical Institute, Department for Aeroronautics Serbian Armz

SOME ASPECTS TO STRENGTH ANALYSIS OF AIRCRAFT STRUCTURES WITH RESPECTS TO FATIGUE AND FRACTURE MECHANICS

Abstract: The fatigue life of structural components is generally divided into crack initiation and crack growth. Where plastic strain predominates, at short lives, crack growth accounts for the major part of cyclic to failure. At long lives, elastic strain is dominant, as are the cycles occupied by crack initiation. Even in the case of nominal elastic loading, some zones have stress concentrations leading to plastic fatigue. In summary, fatigue analysis may be thought of as a process of initiating and then growing a crack, which finally causes the structure to break into two or more pieces. The mathematical models used to simulate the initiation and propagation processes are quite different. The initiation phase is usually modelled using strain-life and cyclic stress-strain curves while the propagation phase uses crack growth rate versus stress intensity curves.

Attention in this consideration is focused on developing computation methods of damaged structural components with respect fatigue and fracture mechanics. Considered computation methods are based on combining singular finite elements to determine stress intensity factors for cracked structural components with corresponding crack growth lows that include effect of load spectra on number of cycles or blocks up to failure. Crack growth analyses are considered using two aproaches: conventional and strain energy density (SED) approach.

For the lifetime evaluation of structural elements until the occurrence of initial damage in the low-cycle fatigue domain the relations for which the magnitudes of low-cycle material behaviour properties have to be obtained experimentally are being used. For the crack propagation analysis and evaluation of residual lifetime of structures two approaches can be used. First approach is based on conventional crack propagation laws such as Paris` crack propagation law, for which it is necessary to experimentally obtain dynamic properties of the material. The second approach for crack propagation analysis is based on the use of Strain Energy Density Method. This approach uses the low-cycle properties of the material, which are also being used for the lifetime evaluation until the occurrence of initial damage. Therefore experimentally obtained dynamic properties of the material such as Paris` constants are not required when this approch is concerned.

To demonstrate efficient computation procedure in fatigue life estimation here numerical examples are included. Attention in this work is focused on design of aircraft wing-fuselage joints. Computation procedure to strength analize with respects fatigue and fracture mechanic is applied to cracked aircraft structural components. Computation results are compared with correspond experiments.

Key words: *Fatigue, Fracture mechanics, Aircraft structures, Cracked stuctural components, Finite Elements, Strain energy density method, Residual life estimation*

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Предавања ће се одржавати средом са почетком у 18.00 часова, у сали 301 F на трећем спрату зграде Математичког института САНУ, Кнез Михаилова 36/III, (зграда преко пута главне зграде САНУ).

Позив научницима и истраживачима да пријаве сцоја предавања
Пријава потенцијалног предавача треба да садржи апстракт предавања до једне странице на српско језику ћирилицом и превод на енглески јesик, као и ЦВ обима до две странице. Пријаву послати на адресу управника одељења за механику у виду Word DOC на адресу: khedrih@eunet.rs

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Announcement and Invitation

Start of each lecture is at each Wednesday at 18,00 h in room 301 F at Mathematical Institute SANU, street Knez Mihailova 36/III.

All scientists and researchers in area of Mechanics are invited to contribute to the Program of Mechanics Colloquium of Mathematical Institute of Serbian Academy of Sciences and Arts. One page Abstract of proposed Lecture with short CV is necessary to submit in world doc to Head of Department of Mechanics (address: **khedrih@eunet.rs**), one month before first day in the next moth.

Катица (Стевановић) Хедрих

Katica R. (Stevanovic) Hedrih
Head of Department of Mechanics