University Center for Mathematical Modeling, Applied Analysis and Computational Mathematics

Semester Seminar, 20th May 2014, 12:20–17:10, Room K1

Schedule

Time	Speaker	Title
12:20		Opening
12:25	Václav Vlasák	Monotone metric spaces
12:40	Miloslav Vlasák	A posteriori error estimates for evolution problems with conforming discretizations
12:55	Iveta Hnětynková	Wedge-shaped generalization of Jacobi matrices
13:10	Martin Lanzendörfer	On full CFD and Reynolds approaches in hydrodynamic lubrication
13:25		Discussion
13:35		Coffee break
13:55	Václav Kučera	What does the finite element method really approximate?
14:10	Ondřej Kurka	Exceptional points for the Lebesgue density theorem
14:25	Dušan Pokorný	Curvatures of singular sets - how to count Euler characteristic?
14:40	Vít Průša	Tensorial implicit constitutive relations in mechanics of incompressible non-newtonian fluids
14:55		Discussion
15:05		Coffee break
15:25	Miroslav Bulíček	Darcy-Forchheimer equation involving an implicit, pressure-dependent relation between the drag force and the velocity
15:40	Ondřej Souček	On derivation of thermodynamically consistent boundary conditions for Korteweg type fluids
15:55	Benjamin Vejnar	Covering an uncountable square by graphs of countably many continuous functions
16:10		Discussion
16:25		Concluding remarks

Abstracts

Miroslav Bulíček, Darcy-Forchheimer equation involving an implicit, pressure-dependent relation between the drag force and the velocity. We study mathematical properties of steady flows described by the system of equations generalizing the classical porous media models of Darcy's and Forchheimer's. The considered generalizations are outlined by implicit relations between the drag force and the velocity, that are in addition parameterized by the pressure. We analyze such drag force–velocity relations which are described through a maximal monotone graph varying continuously with the pressure. Large-data existence of a solution to this system is established, whereupon we show that under certain assumptions on data, the pressure satisfies a maximum or minimum principle, even if the drag coefficient depends on the pressure exponentially.

Iveta Hnětynková, Wedge-shaped generalization of Jacobi matrices. Jacobi matrices, i.e. symmetric tridiagonal matrices with positive sub- and superdiagonal entries, represent thoroughly studied objects appearing in many mathematical problems. Properties of Jacobi matrices have been widely analyzed. In this talk, we introduce the so called wedge-shaped matrices and explain why they can be seen as a generalization of Jacobi matrices. We concentrate especially on analysis of their spectral properties.

Václav Kučera, What does the finite element method really approximate? Classically, the convergence of the finite element method (FEM) is investigated with respect to the exact solution of the problem. We propose a new alternative point of view, where the FEM solution on a given mesh approximates a whole set of functions, which degenerates to the exact solution in the limit. We show how this concept could possibly be used to explain the Gibbs phenomenon in the FEM, construct useful apriori error estimates and overcome problems with insufficient regularity of the exact solution.

Ondřej Kurka, Exceptional points for the Lebesgue density theorem. In spite of the Lebesgue density theorem, every non-trivial measurable set of real numbers has a point at which both the lower densities of the set and of its complement are positive. The problem of finding an optimal quantitave version of this statement was studied in a paper of V. I. Kolyada, as well as in some recent papers. In the talk, a solution of this problem will be presented.

Martin Lanzendörfer, On full CFD and Reynolds approaches in hydrodynamic lubrication. Recent results comparing the two main approaches in (elasto-)hydrodynamic lubrication - the Reynolds approximation or the solution of full system of equations - will be discussed shortly.

Dušan Pokorný, Curvatures of singular sets - how to count Euler characteristic? In the talk I will give a brief overview of the curvature theory for singular sets and also present some recent results in this area obtained in cooperation with J. Rataj.

Vít Průša, Tensorial implicit constitutive relations in mechanics of incompressible non-newtonian fluids. Properties of a particular fluid are, in the framework of classical continuum mechanics, described by so-called constitutive relation. In the purely mechanical setting, the constitutive relation determines the response of the fluid to the stimuli such as the deformation or the stress. The dominant approach to the development of constitutive relations for non-newtonian fluids is to express the stress (Cauchy stress tensor) as a function of the deformation (symmetric part of the velocity gradient). We investigate a generalization of the standard approach. The generalization is based on the simple idea that the constitutive relation is indeed only a relation between the stress and deformation, and that the stress is not necessarily given as an explicit function of the deformation. Interestingly, this apparently insignificant change has substantial impact on the mathematical modeling of the response of non-newtonian fluids.

For a class of implicit constitutive relations we discuss their thermodynamical admissibility and the dynamical admissibility of the simple shear flow. We show that using the new approach one can develop thermodynamically and dynamically admissible models for various non-newtonian effects—in particular for the normal stress differences effect—that overcome some of the limitations of the classical models.

Ondřej Souček, On derivation of thermodynamically consistent boundary conditions for Korteweg type fluids. We present derivation of thermodynamically consistent boundary conditions for a fluid model of Korteweg type. The derivation benefits from exploiting the local form of balance laws at singular surfaces which naturally provides coupling of surface terms with the corresponding bulk fluxes. By establishing a suitable constitutive ansatz for surface free energy, the local form of the second law of thermodynamics then allows a thermodynamically consistent closure of the remaining constitutive functionals.

Benjamin Vejnar, Covering an uncountable square by graphs of countably many continuous functions. A classical result of Sierpinski from 1919 is saying that there is an uncountable set whose cartesian product with itself can be covered by countably many graphs of functions and inverses of these functions. We were able to enhance this set theoretical result by proving a topological counterpart, i.e. the existence of a countable family of continuous real functions whose graphs together with their inverses cover an uncountable square in the plane. We will discuss an application in the Borel graph theory and further strengthening to smooth functions.

Miloslav Vlasák, A posteriori error estimates for evolution problems with conforming discretizations. We will consider a simple heat equation as a well understood object from theory of PDEs. We will assume conforming Galerkin (Petrov–Galerkin) discretizations in space as well as in time. On such a numerical problem residual based a posteriori technique will be applied. As a side motive it shall be partially shown that the analysis of a posteriori error estimates naturally arise from the fact that the discretization of the problem is in a good agreement with the known properties of the problem itself.

Václav Vlasák, Monotone metric spaces. We present the notion of monotone metric spaces and show some results about this topic. We will also talk about the upper bounds on the Hausdorff dimension of monotone metric spaces.