CJS 2021

Online only.

Czech-Japanese Seminar in Applied Mathematics 2021

January 5 - January 7, 2021

Conference Information

The scientific colloquium organized together by the Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Shibaura Institute of Technology, Tokyo, Kanazawa University in Kanazawa and Meiji University Tokyo is devoted to the meeting of young Czech and Japanese applied mathematicians dealing with numerical solution of partial differential equations, mathematical modelling and numerical simulation of problems in technology, environment, biology and computer science. It is a continuation of the successful series of common conferences:
Czech-Japanese Seminar in Applied Mathematics 2004, Prague
Czech-Japanese Seminar in Applied Mathematics 2005, Kuju
Czech-Japanese Seminar in Applied Mathematics 2006, Prague
Czech-Japanese Seminar in Applied Mathematics 2008, Takachiho, Miyazaki
Czech-Japanese Seminar in Applied Mathematics 2010, Prague and Telč, Czech Republic
Czech-Japanese Seminar in Applied Mathematics 2013, Tokyo, Japan
Czech-Japanese-Polish Seminar in Applied Mathematics 2016, Krakow, Poland
Czech-Japanese Seminar in Applied Mathematics 2018, Noto and Kanazawa, Japan

Organizers

M. Beneš, Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague,
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Additional information

URL: `http://geraldine.fjfi.cvut.cz/cjs2021`
Venue: Online, MS Teams

List of Participants

The list of all participants in alphabetical order.

Name	University / Institute
Afifah, Maya Iknaningrum	Division of Mathematical and Physical Sciences, Graduate School of Natural Science and Technology, Kanazawa University
Akitoshi, Takayasu	University of Tsukuba
Alfat, Sayahdin	Kanazawa University, Division of Mathematical and Physical Sciences, Graduate School on Natural Science and Technology
Alifian, Mahardhika Maulana	Division of Mathematics and Physical Science, Kanazawa University
Anada, Koichi	Waseda University Senior High School
Beneš, Michal	Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering
Eichler, Pavel	Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering
Fejtek, Jan	Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering
Frolkovič, Peter	Slovak University of Technology, Bratislava
Fučík, Radek	Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering
Gális, Petr	Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering
Gašpar, František	Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering
Gusseva, Maria	Inria and LMS (Ecole Polytechnique), France and Inria, LMS (Ecole Polytechnique, France) and UT Southwestern Medical Center (Dallas, TX)
Holub, Robert F.	Clarkson University, Potsdam, N.Y., U.S.A.
Chabiniok, Radomír	University of Texas, Southwestern Medical Center Dallas, Texas, U.S.A.
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Ishiwata, Tetsuya	Shibaura Institute of Technology
Islam, Sahidul	Kanazawa University, Faculty of Mathematics and Physics
Jex, Martin	Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

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Keisuke, Abiko	Graduate school of Systems Engineering and Science, Shibaura Institute of Technology, Japan
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Minarčík, Jiří	Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering
Monobe, Harunori	Okayama University
Mori, Tatsuki	Musashino University, Graduate School of Engineering
Nagase, Jumpei	Shibaura Institute of Technology
Nakamoto, Kousuke	Shibaura Institute of Technology, Graduate school of Systems Engineering and Science
Nakata, Yukihiko	Aoyama Gakuin University, Department of Physics and Mathematics
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Pauš, Petr	Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

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Sasaki, Takiko	National Institute of Technology (KOSEN), Ibaraki College
Sekisaka, Ayuki	Meiji university (MIMS)
Shiga, Taichi	Shibaura Institute of Technology
Shimoji, Yusaku	Graduate School of Science and Technology, Meiji University
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Solovský, Jakub	Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering
Strachota, Pavel	Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering
Straka, Robert	AGH University of Science and Technology, Kraków, Faculty of Metals Engineering and Industrial Computer Science
Sunayama, Yosuke	Kanazawa University, Graduate school of Natural Science and Technology
Suzuki, Tasuku	Division of Mathematical and Physical Sciences, Graduate School of Natural Science and Technology, Kanazawa University
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Ševčovič, Daniel	Comenius University, Bratislava
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Tomoeda, Akiyasu	Musashino University

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Yazaki, Shigetoshi Meiji University

Scientific Programme

The scientific programme is scheduled for the days January 5 – 7, 2021, always in the morning of the Central European Time (approx. 8:15 – 13:00) = afternoon of the Japan Standard Time (approx. 16:15 – 21:00) = night of the U.S. Mountain Time (0:15 – 5:00).
Each talk will have the 20 minutes time slot including questions and discussion.
There are two parallel sessions every day, except for the opening and ending session. It is possible to switch between the sessions easily in MS Teams.

January 5, common session

The common session will be held in the channel **Session A**.

Chairman: Beneš, Michal

08:15 – 08:30	*Opening speech (M. Beneš, T. Ishiwata)*
08:30 – 08:50	**Frolkovič, Peter**: Recent results on semi-implicit methods for advection equations
08:50 – 09:10	**Tomoeda, Kyoko**: Mathematical analysis of suspension flowing down an inclined plane particle-rich ridge near the contact line
09:10 – 09:30	*The talk of Monobe Harunori was rescheduled to Jan 7, common session.*
09:30 – 09:45	*Short break*

January 5, parallel session A

Chairman: Frolkovič, Peter

09:45 – 10:05	**Straka, Robert**: Burning the lattice – LBM model of a campfire
10:05 – 10:25	**Anada, Koichi**: Asymptotic Expansions of Traveling Wave Solutions for a Quasi-linear Parabolic Equation
10:25 – 10:45	**Sasaki, Takiko** : Regularity of the blow-up curve at characteristic points for the nonlinear wave equation
10:45 – 11:00	*Short break*

Chairman: Strachota, Pavel

11:00 – 11:20	**Chabiniok, Radomír**: Characterization of early-stage heart failure assisted by biomechanical cardiac modeling
11:20 – 11:40	**Kovář, Jan**: Mathematical modeling of fluid flow and transport of contrast agent in vessels
11:40 – 12:00	**Škardová, Kateřina**: Bloch equations-based estimation of T1 relaxation time

January 5, parallel session B

Chairman: Mikyška, Jiří

09:45 – 10:05	**Sekisaka, Ayuki**: Topological mechanism of the accumulation of the eigenvalues in reaction-diffusion systems
10:05 – 10:25	**Strachota, Pavel**: Focusing the Latent Heat Release in 3D Phase Field Simulations of Dendritic Crystal Growth
10:25 – 10:45	**Yamamoto, Hiroko**: A reaction-diffusion approximation of a semilinear wave equation
10:45 – 11:00	*Short break*

Chairman: Ševčovič, Daniel

11:00 – 11:20	**Kalvoda, Ladislav**: Repeated freezing and melting of D20 / sand mixtures investigated by neutron diffraction method
11:20 – 11:40	**Alfat, Sayahdin**: A Mathematical Model of Crack Propagation Under Thermal Expansion by a Variational Approach
11:40 – 12:00	**Princ, Tomáš**: The Pore-network Modelling of the Infiltration Experiment with Unsaturated Coarse Sands

January 6, parallel session A

Chairman: Straka, Robert

08:30 – 08:50	**Gusseva, Maria**: Pre-interventional planning in patients with congenital heart disease by using biomechanical heart modeling
08:50 – 09:10	**Afifah, Maya Iknaningrum**: Three dimensional numerical simulation of the Navier–Stokes equations in straight and curved cylindrical domains
09:10 – 09:30	**Eichler, Pavel**: Turbulent fluid flow simulations above rough surface using cumulant lattice Boltzmann method
09:30 – 09:45	*Short break*

Chairman: Kimura, Masato

09:45 – 10:05	**Solovský, Jakub**: BDDC for MHFEM discretization of two-phase flow in porous media
10:05 – 10:25	**Nakata, Yukihiko**: On a blow-up phenomenon in scalar delay differential equations
10:25 – 10:45	**Fučík, Radek**: Equivalent Finite Difference and Equivalent Partial Differential Equations for the Lattice Boltzmann Method
10:45 – 11:00	*Short break*

Chairman: Sasaki, Takiko

11:00 – 11:20	**Mori, Tatsuki**: Global structure of stationary solutions of a cell polarization model with mass conservation
11:20 – 11:40	**Kolář, Miroslav**: Overview of Kuramoto-Sivashinsky model of flame/smoldering front
11:40 – 12:00	**Shimoji, Yusaku**: Mathematical modeling for magnetic fluid in Hele-Shaw cell

January 6, parallel session B

Chairman: Yazaki, Shigetoshi

08:30 – 08:50	**Nagase, Jumpei**: Mathematical Analysis on Skip Connections in Deep Neural Networks from the Viewpoint of Finite Sets
08:50 – 09:10	**Šembera, Jan**: The result of the Paretran project – a supercomputer modelling system for real-world reactive transport simulations
09:10 – 09:30	**Alifian, Mahardhika Maulana**: Numerical Analysis of Crack Path Selection Problem
09:30 – 09:45	*Short break*

Chairman: Notsu, Hirofumi

09:45 – 10:05	**Majerová, Dana**: Image Noise Reduction Using Min-Max Fuzzy Network
10:05 – 10:25	**Kolbe, Niklas**: An adaptive Lagrangian Finite-Volume method for convection-diffusion equations
10:25 – 10:45	**Gašpar, František**: Simulation study of Diffusion over Fractal Substrate
10:45 – 11:00	*Short break*

Chairman: Oberhuber, Tomáš

11:00 – 11:20	**Akitoshi, Takayasu**: Global existence and heteloclinics/homoclinics to a quadratic nonlinear Schrödinger equation
11:20 – 11:40	**Tran, Quang Van**: Smooth two-sided distribution created by regularization and symmetrization of a one-sided distribution
11:40 – 12:00	**Ichida, Yu**: Singular stationary solutions for a MEMS type reaction-diffusion equation with fringing field

January 7, parallel session A

Chairman: Fučík, Radek

08:30 – 08:50	**Smejkal, Tomáš**: New numerical solution of multi-phase compositional simulations with phase equilibrium computation
08:50 – 09:10	**Simon, John Sebastian**: Vorticity Maximization of a Linear Fluid Flow via Volume and Perimeter Constrained Shape Optimization
09:10 – 09:30	**Jex, Martin**: Phase stability testing of multi-component mixtures with application of Branch and bound algorithm
09:30 – 09:45	*Short break*

Chairman: Ushijima, Takeo

09:45 – 10:05	**Keisuke, Abiko**: Positivity-preserving numerical schemes for stochastic differential equations
10:05 – 10:25	**Fejtek, Jan**: Solving the Phase Stability Problem with Interval Arithmetic
10:25 – 10:45	**Sunayama, Yosuke**: Comoving mesh method for Hele-Shaw moving boundary problem
10:45 – 11:00	*Short break*

January 7, parallel session B

Chairman: Pauš, Petr

08:30 – 08:50	**Kukal, Jaromír**: Difference Schemes for Fractional Laplacian and Their Testing
08:50 – 09:10	**Tatsuoka, Fuminori**: The double exponential formula for the matrix fractional power
09:10 – 09:30	**Klinkovský, Jakub**: Efficient LBM simulator for vapor transport in air over a moist soil layer
09:30 – 09:45	*Short break*

Chairman: Kolář, Miroslav

09:45 – 10:05	**Minarčík, Jiří**: Minimal surface generating flow for space curves of non-vanishing torsion
10:05 – 10:25	**Suzuki, Tasuku** : A mass-conservative Lagrange-Galerkin scheme of second-order in time for convection-diffusion problems
10:25 – 10:45	**Pauš, Petr**: Numerical simulation of multiple dislocation cross-slip during dislocation-precipitate interaction
10:45 – 11:00	*Short break*

January 7, common session

The common session will be held in the channel **Session A**.

Chairman: Ishiwata, Tetsuya

11:00 – 11:20	**Udeani, Cyril Izuchukwu** : Application of maximal monotone operator method for solving Hamilton-Jacobi Bellman equation arising from optimal portfolio selection problem
11:20 – 11:40	**Tomoeda, Akiyasu**: Calculation of thickness of cylinder-type impossible solids using simple crystalline curvature flow
11:40 – 12:00	**Monobe, Harunori**: Fisher-Stefan problems and the singular limit of reaction-diffusion systems
12:00 – 12:20	**Beneš, Michal**: On Moving Interfaces in Two-Phase Flow
12:20 – 12:35	*Closing speech (M. Kimura, S. Yazaki)*

List of Abstracts

The list of abstracts of all talks and posters in alphabetical order.

Three dimensional numerical simulation of the Navier–Stokes equations in straight and curved cylindrical domains

Afifah, Maya Iknaningrum January 6, parallel session A, 08:50 – 09:10
Division of Mathematical and Physical Sciences, Graduate School of Natural Science and Technology, Kanazawa University

Research about natural violent flow phenomena like tornado has been done by researchers using Finite Element Method (FEM) to perform numerical computation of axisymmetric Navier-Stokes flows with no-slip flat boundary in a straight cylindrical domain which correspond to an ideal shaped tornado. But in natural phenomena, the central axis of tornado might have curvature. Using similar numerical approach, we make 3D simulations in curved cylindrical domain to simulate the tornado with curvature. It is observed that for the larger curvature, the distance from the position of maximum magnitude of the velocity to the central axis is getting larger. The phenomena observed for curved cylindrical domain that is not observed is straight cylindrical domain is the movement of low pressure region that correspond to high velocity region and center of vortex. Other than that, a new low pressure region appears in different direction and it indicates the rise of second vortex.
This is a join work with Hirofumi Notsu (Kanazawa University), Pen-Yuan Hsu (Kanagawa University), Tsuyoshi Yoneda (The University of Tokyo)
Keywords : Tornado, Navier-Stokes, FEM, Low pressure region

Global existence and heteloclinics/homoclinics to a quadratic nonlinear Schrödinger equation

Akitoshi, Takayasu January 6, parallel session B, 11:00 – 11:20
University of Tsukuba

In this talk, we present computer-assisted proofs of global existence of solutions to a quadratic nonlinear Schrödinger equation (NLS), which is non-conservative due to the lack of Gauge-invariance. Furthermore, we obtain the existence of heteloclinic/homoclinic trajectories to NLS by proving an enclosure of a local unstable manifold, a rigorous integration of the flow (starting from the unstable manifold) and a proof that the solution exists globally in forward time.

A Mathematical Model of Crack Propagation Under Thermal Expansion by a Variational Approach

Alfat, Sayahdin January 5, parallel session B, 11:20 – 11:40
Kanazawa University, Division of Mathematical and Physical Sciences, Graduate School on Natural Science and Technology

It is often observed that thermal stress enhances the crack propagation in a material, and conversely, the crack propagation can contribute to shifting the temperature of the material. In this study, we rst consider the thermoelasticity model by M. A. Biot (1956) and study its energy dissipation property. The Biot thermoelasticity model takes account of the following eects. The thermal expansion and contraction are caused by temper- ature changes, and conversely, the temperature is decreasing in the expanding area but increasing in the contracting area. Besides, we examine its thermomechanical property through several numerical examples. Then we observe that the thermal stress becomes more enhanced than the usual elastic stress near a singular point. In the second part, we propose a phase eld crack propagation model under thermal stress by coupling the crack propagation model by Takaishi-Kimura (2009) and the Biot thermoelasticity model. From our numerical experiments, we observe that the lowest temperature appears near the crack tip. The crack propagation is more enhanced by the thermoelastic coupling since the thermal stress near the crack tip is more singular than the usual elastic stress.
Keywords: Thermoelasticity, Crack Propagation, Phase Field Model, Finite Element Method

Numerical Analysis of Crack Path Selection Problem

Alifian, Mahardhika Maulana January 6, parallel session B, 09:10 – 09:30
Division of Mathematics and Physical Science, Kanazawa University

There is an infinite number of possibility of crack paths in a material. Moreover, a mathematical theory about finding the crack path is not so established at present. In this occasion, we would like to tackle such problem of finding crack path numerically in variational fracture framework. We consider crack path selection problem in a two-dimensional isotropic elastic domain. Using the variational crack propagation model by Francfort and Marigo, we investigate straight, kink, and circle crack paths then calculate it's energy by energy variation formula to find crack path numerically.
Keywords: crack path; finite element method; energy variation.

Asymptotic Expansions of Traveling Wave Solutions for a Quasilinear Parabolic Equation

Anada, Koichi January 5, parallel session A, 10:05 – 10:25
Waseda University Senior High School

We consider traveling wave solutions for a quasilinear parabolic equation which appers in curve shortening problems. In particular, it is important for investigations of singularities in curve shortening problems to provide asymptotic expansions of the traveling wave solutions. In this talk, we discuss asymptotic expansions in some cases. This is a joint work with T. Ishiwata (Shibaura Institute of Technology) and T. Ushijima (Tokyo University of Science).

On Moving Interfaces in Two-Phase Flow

Beneš, Michal January 7, common session, 12:00 – 12:20
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

The contribution comments on two particular phenomena occuring in the two-phase flow. First we discuss the one-dimensional model of fluidized bed formed by slowly moving dense fluid carrying solid-phase particles. This model originates in the conservation laws for the two-phase vertical flow simplified due to low values of the Reynolds number and leads to a free-boundary problem for bed height. Second we briefly show results of a simple model of closed vortex structures visualized by the second phase moving by the binormal curvature flow. Such motion is treated by the parametric method. In both cases, we show computational results motivating further investigation of such phenomena.
The ongoing research is partly supported by the project CZ.02.1.01/0.0/0.0/16 019/0000753 "Research centre for low-carbon energy technologies". Collaboration with the project team and with the students involved are gratefully acknowledged.

Turbulent fluid flow simulations above rough surface using cumulant lattice Boltzmann method

Eichler, Pavel January 6, parallel session A, 09:10 – 09:30
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

Dynamics of wall-bounded flow is an open problem in the theory of turbulence although it has been studied for decades. To investigate the complicate fluid flow in the boundary layer region, solution of numerical methods can be used. The main aim of this contribution is to present the investigation of the cumulant lattice Boltzmann method (CuLBM) simulations of the turbulent fluid flow in the boundary layer region above rough surfaces as the direct numerical simulator (DNS), i. e., with the numerical method without any turbulent models, etc. To investigate the CuLBM, two benchmark tests are selected. The first benchmark test deals with the turbulent fluid flow above a rough plate with regularly distributed protrusions. The second benchmark test is inspired by the street-canyon flow experiment. The CuLBM results are compared both with the standard finite difference method (FDM) and with experimental results. The CuLBM results were in a good agreement with both FDM and experimental results. Thanks to the good agreement, CuLBM can be considered as an appropriate for the turbulent fluid flow in the boundary layer above rough surfaces.

Solving the Phase Stability Problem with Interval Arithmetic

Fejtek, Jan January 7, parallel session A, 10:05 – 10:25
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

In this work, we study a method of testing the phase stability of multicomponent mixtures at a constant temperature, volume and moles. The phase stability criterion is formulated by the means

of the Tangent plane distance (TPD) function. To study the TPD function, we will use the methods of interval arithmetic. Finally, we will present our findings and the focus of current research.

Recent results on semi-implicit methods for advection equations

Frolkovič, Peter January 5, common session, 08:30 – 08:50
Slovak University of Technology, Bratislava

In this talk we present some recent results on numerical solutions of advection equations in conservative or non-conservative form. We present methods that are fully explicit in time (so computationally very cheap), but also semi-implicit methods. The latter methods are robust for problems with highly variable nodal Courant numbers where the explicit schemes are impractical due to the stability restriction on time steps requiring Courant number being less than one. We are motivated especially by a demand to simulate numerically some engineering applications that involve dynamic interfaces in a form of moving curves or surfaces. In particular we deal with level set methods for the numerical modelling of fire fronts in wildland fires and flow in porous media with evolving pores. In all these applications it is important to model precisely dynamic interfaces as they are integral part of the required results by users or as they determine some essential physical properties of simulated problems.

Equivalent Finite Difference and Equivalent Partial Differential Equations for the Lattice Boltzmann Method

Fučík, Radek, Straka, Robert January 6, parallel session A, 10:25 – 10:45
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

A general method for the derivation of equivalent finite difference equations (EFDEs) and subsequent equivalent partial differential equations (EPDEs)presented for a general matrix lattice Boltzmann method (LBM). The method can be used for both the advection diffusion equations and Navier-Stokes equations in all dimensions. In principle, the EFDEs are derived using a recurrence formula. A computational algorithm is proposed for generating sequences of matrices and vectors that are used to obtain EFDEs coefficients. The resulting EFDEs and EPDEs are derived for selected velocity models and include the single relaxation time, multiple relaxation time, and cascaded LBM collision operators. The algorithm for the derivation of EFDEs and EPDEs is implemented in C++ using the GiNaC library for symbolic algebraic computations. Its iplementation is available under the terms and conditions of the GNU general public license (GPL).

References:

R. Fučík and R. Straka: Equivalent Finite Difference and Partial Differential Equations for the Lattice Boltzmann Method, in review in Computers Mathematics with Applications

Simulation study of Diffusion over Fractal Substrate

Gašpar, František January 6, parallel session B, 10:25 – 10:45
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

The diffusion is studied in the spaces where dimension can also be of non-integer value. Applicability of the general findings is not assured due to the finite nature of the graph-based fractal models. Presented results of Monte Carlo simulations serve as an overview of possibilities of estimating the parameters of general models using discrete diffusion model on the regular grids and their subsets. The main focus of the talk is the study of the mass distribution parameters within the studied spaces.

Pre-interventional planning in patients with congenital heart disease by using biomechanical heart modeling

Gusseva, Maria, Chapelle, Dominique, Hussain, Tarique, Chabiniok, Radomír January 6, parallel session A, 08:30 – 08:50
Inria and LMS (Ecole Polytechnique), France and Inria, LMS (Ecole Polytechnique, France) and UT Southwestern Medical Center (Dallas, TX)

Coupling biomechanical model with clinical data has a potential to augment clinical markers derived by medical exams and contribute to optimize the therapy management. In this talk, we will exemplify it on congenital heart disease Tetralogy of Fallot, in whom the optimal timing of pulmonary valve replacement is crucial for long-term prognosis.

Characterization of early-stage heart failure assisted by biomechanical cardiac modeling

Chabiniok, Radomír January 5, parallel session A, 11:00 – 11:20
University of Texas, Southwestern Medical Center Dallas, Texas, U.S.A.

In this talk, an example application of selected cardiovascular models (such as models of ventricular mechanics or myocardial perfusion) will be presented aiming to characterize heart failure at its early stage.

Singular stationary solutions for a MEMS type reaction-diffusion equation with fringing field

Ichida, Yu January 6, parallel session B, 11:40 – 12:00
Graduate School of Science and Technology, Meiji University

We consider the singular stationary solutions for a MEMS type reaction-diffusion equation with fringing field. This equation arises in the study of the Micro-Electro Mechanical System (MEMS) devices. We purpose to prove the existence the (singular) stationary solutions of this equation and to give the asymptotic behavior. These are studied by applying the Poincare-Lyapunov compactification and basic theory of dynamical systems. This is a joint work with T.O. Sakamoto (Meiji University).

Phase stability testing of multi-component mixtures with application of Branch and bound algorithm

Jex, Martin January 7, parallel session A, 09:10 – 09:30
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

In this contribution we examine the phase equilibrium of mixtures in VTN variables. More precisely, the initial molar concentration c and the temperature of mixture is known and our task is to determine whether the mixture stays in one phase or splitting to more phases occurs. This physically motivated problem can be rendered to a mathematical problem of optimization of a non-convex function (TPD) on a convex set (interior of simplex). The optimization problem is solved by the branch and bound algorithm, in which the convex lower estimate of TPD function is used. This estimate is derived by using a convex-concave split and is optimized to be closest to original TPD function in certain sense. The algorithm is implemented in Mathematica and is illustrated on 3 examples with various level of diculty. Furthermore, the computational complexity is discussed. The implemented algorithm gives the consistent results with a recent paper, which are more precise than solutions obtained by previously used approaches.

Repeated freezing and melting of D20 / sand mixtures investigated by neutron diffraction method

Kalvoda, Ladislav, Vratislav, Stanislav, Kučeráková, Monika January 5, parallel session B, 11:00 – 11:20
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

Crystalline state of heavy water and its mixtures with quartz sand of three different grain coarseness (100 600, 300 800 and 600 1200 μm) is studied at different temperature regimes by neutron diffraction method. The contribution provides selected examples of observed effects and structural changes which might be useful in place of a reference to theoretical modelling of the systems.

Positivity-preserving numerical schemes for stochastic differential equations

Keisuke, Abiko January 7, parallel session A, 09:45 – 10:05
Graduate school of Systems Engineering and Science, Shibaura Institute of Technology, Japan

The solutions of mathematical models in biology, finance and so on often have positivity. However, numerical solutions don't satisfy this property. In this talk, we propose positivity-preserving numerical schemes for stochastic differential equations by virtue of Ito's formula. We also show the convergence result. Finally, we demonstrate numerical examples. This is a joint work Prof. Tetsuya Ishiwata.

Efficient LBM simulator for vapor transport in air over a moist soil layer

Klinkovský, Jakub January 7, parallel session B, 09:10 – 09:30
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

We present an efficient coupled computational approach for simulating component transport within single-phase free flow validated with controlled wind tunnel experiments. The developed approach is based on a combination of the lattice Boltzmann method (LBM) for weakly compressible fluid flow and the mixed-hybrid finite element method (MHFEM) for solving constituent transport. Both methods, as well as their collective coupling, are implemented entirely on a GPU accelerator in order to utilize its computational power and avoid the hardware limitations that slow communication between the GPU and CPU over the PCI-E bus. We describe the technical details behind the computational method, focusing primarily on the coupling mechanisms. The performance of the solver is demonstrated on modern high-performance supercomputers. Flow and transport simulation results are validated and compared herein with experimental velocity and relative humidity data measured above an evaporating soil surface under steady flow conditions in a climate-controlled low-speed wind tunnel operated by the US Army Corps of Engineers. Model robustness and flexibility is demonstrated by introducing rectangular bluff-bodies to the flow in several different experimental scenarios.

Overview of Kuramoto-Sivashinsky model of flame/smoldering front

Kolář, Miroslav January 6, parallel session A, 11:20 – 11:40
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

We summarize our recent results on the Kuramoto-Sivashinsky model, which describes the motion of flame/smoldering interface. We introduce the model within the context of fire science, including available experimental data, and propose the generalization of the model formulated in terms of theory of evolving parametric curves. We propose a numerical approximation scheme enhanced by the tangential erdistribution of discretization points and demonstrate the verification of our scheme by measurement of experimental order of convergence. We also summarize the latest findings of biffurcation analysis of the model and study of rotational wave solutions.
This is a joint work with Shunsuke Kobayashi (Kyoto Univ.), Yasuhide Uegata (Setagaya Gakuen Sch.) and Shigetoshi Yazaki (Meiji Univ.)

An adaptive Lagrangian Finite-Volume method for convection-diffusion equations

Kolbe, Niklas January 6, parallel session B, 10:05 – 10:25
Faculty of Mathematics and Physics, Kanazawa University, Kakuma, Kanazawa 920-1192, Japan

Spatial models of cell migration have become an important tool in the study of bio-medical problems. They often lead to simultaneous concentrated and diffusive regions that are challenging to resolve numerically in an efficient way. We present a new adaptive mesh scheme for convection-diffusion equations, which is well suited for these models and based on the Lagrange-Galerkin method. We demonstrate the efficiency of the scheme in 1D and 2D applications and present preliminary results with respect to the schemes stability and convergence.

Mathematical modeling of fluid flow and transport of contrast agent in vessels

Kovář, Jan January 5, parallel session A, 11:20 – 11:40
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

This contribution deals with mathematical modeling of problems associated with myocardial perfusion examination using a contrast agent. Initially, the problem of fluid flow and transport of contrast agent is divided into three benchmark problems, two of which will be analyzed within this contribution. The audience will be briefly introduced to a mathematical model of Newtonian incompressible fluid flow in an isothermal rigid porous medium and in an isothermal free flow system. The results of the benchmark problem of single-phase flow in a porous medium representing the myocardium and in a two-dimensional domain representing a blood vessel from the vascular bed using the lattice Boltzmann method will be shown. The results obtained by the lattice Boltzmann method will be further compared to the results acquired from the finite difference method or the mixed-hybrid finite element method.

Difference Schemes for Fractional Laplacian and Their Testing

Kukal, Jaromír, Michal Beneš January 7, parallel session B, 08:30 – 08:50
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

Onedimensional anomalous diffusion has been extensively studied in past decades. Various difference schemes for 1D fractional Laplacian are used for the simulation of mentioned process. The contribution is focused on a singularity elimination in adequate principal value integral. Resulting difference schemes are generalizations of traditional p.v. midpoint method and are comparable with spectral method. Their numerical properties are compared with the properties of classical difference schemes on examples with known analytical solution. This is a joint work with Michal Beneš (FNSPE, CTU in Prague).

Image Noise Reduction Using Min-Max Fuzzy Network

Majerová, Dana January 6, parallel session B, 09:45 – 10:05
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

This contribution focuses on removing Gaussian noise from a digital 2D signal (digital image processing in spatial domain). First, individual fuzzy filters that can be implemented in Lukasiewicz algebra with square root are described. Second, all individual fuzzy filters are applied to a set of artificial images with different level of Gaussian noise. Then the min-max fuzzy network (MMFN) is described. The MMFN consists of four layers. The number of nodes in the second layer of the MMFN is equal to the number of selected fuzzy filters applied to inputs. The third layer of the MMFN is a subject of optimization, specifically population-based heuristics are used. SNR is used as a quality of criterion. The MMFN output can be better than results of individual fuzzy filters that make up the MMFN if the number of fuzzy filters is at least four.

Minimal surface generating flow for space curves of non-vanishing torsion

Minarčík, Jiří January 7, parallel session B, 09:45 – 10:05
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

This contribution introduces geometric flow of space curves during which the curve traces out a zero mean curvature surface. Existence problems and properties of the flow as well as the generated minimal surface will be discussed.

Fisher-Stefan problems and the singular limit of reaction-diffusion systems

Monobe, Harunori January 7, common session, 11:40 – 12:00
Okayama University

In recent decades, it was reported that some mathematical models of population dynamics have an explicit form of the evolution equations for the spreading front, which is represented by free boundary problems, called Fisher-Stefan problems (See Mimura et al. (1985) and Du et al. (2010)). In this talk, we will show that the free boundary problems are regarded as the singular limit of some three-component (or two-component) reaction-diffusion systems. This is a joint work with H. Izuhara (Miyazaki Univ.) and C.-H. Wu (NCTU)

Global structure of stationary solutions of a cell polarization model with mass conservation

Mori, Tatsuki January 6, parallel session A, 11:00 – 11:20
Musashino University, Graduate School of Engineering

We are interested in a cell polarization model with mass conservation proposed by Y.Mori, A.Jilkine and L.Edelstein-Keshet. We obtained global bifurcation structure of stationary solutions for a stationary limiting problem of this model. However, global bifurcation structure of stationary problem is not clarified. In this talk, we give representation formula of a sheet consisted of all solutions to investigate global bifurcation structure of stationary problem and show numerical results by using it.

Mathematical Analysis on Skip Connections in Deep Neural Networks from the Viewpoint of Finite Sets

Nagase, Jumpei January 6, parallel session B, 08:30 – 08:50
Shibaura Institute of Technology

Deep Learning is a machine learning method that uses deep neural networks, and many derivatives of the network structure have been proposed. In this talk, we discuss skip connections in deep neural networks from the viewpoint of finite sets. Skip connection is proposed in Deep Residual Networks, and it is a powerful structure that is still often used today. On the other hand, even the differences between some basic skip connections are not clear. We consider this problem by using a finite set argument to clarify the correspondence between models with different skip connections. As a result, we present a transformation rule that allows more general class of skip connections to be attributed to the perceptron.

On a blow-up phenomenon in scalar delay differential equations

Nakata, Yukihiko January 6, parallel session A, 10:05 – 10:25
Aoyama Gakuin University, Department of Physics and Mathematics

A blow-up phenomenon called "delay-induced blow-up" is observed in a planar system of delay differential equations (Eremin et al., (submitted)). In the system, a blow-up solution exists, no matter how small the length of the delay is, while the corresponding non-delay system does not have such a blow-up solution. The blow-up mechanism formed by the time delay (nonlocality concerning time) has not been well understood, although there are some blow-up results on delay differential equations available. We present our recent studies concerning the existence of the blow-up solutions in scalar delay differential equations, which may partially characterize the role of the time delay in the blow-up phenomenon. The presentation is based on a collaboration work with Tetsuya Ishiwata (Shibaura Institute University).

Numerical simulation of multiple dislocation cross-slip during dislocation-precipitate interaction

Pauš, Petr January 7, parallel session B, 10:25 – 10:45
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

This contribution deals with the numerical simulation of dislocation-precipitate interaction in copper crystals by means of discrete dislocation dynamics. We consider a dislocation gliding in a slip plane under an external stress field and a precipitate located in the same slip plane also generating a stress field. The precipitate stress field forces the dislocation to perform a cross-slip mechanism (i.e., change the slip plane). We present an algorithm and a numerical study dealing with several sequential cross-slips of a single dislocation in this contribution. The glide dislocation is represented by a piece-wise planar parametrically described curve. The simulation model is based on the numerical solution of the dislocation motion law belonging to the class of curvature driven curve dynamics $velocity = curvature + force$.

The Pore-network Modelling of the Infiltration Experiment with Unsaturated Coarse Sands

Princ, Tomáš January 5, parallel session B, 11:40 – 12:00
Czech Technical University in Prague, Faculty of Civil Engineering

The relationship between entrapped air content (ω) and the corresponding hydraulic conductivity (K) was investigated experimentally for two coarse sands. Additionally the pore-network model based on OpenPNM platform was used to attempt simulation of a redistribution of the air bubbles after infiltration. Two packed samples of 5 cm height and 7.2 cm diameter were prepared for each sand. The cycles of infiltration and drainage led to entrapping of the air. The value of K was determined using Darcy's law by repetitive falling-head infiltration experiments. The entrapped air content was determined from gravimetrically after each infiltration run. The amount and distribution of air bubbles were quantified by X-ray computed tomography (CT) for selected runs. The obtained K(ω) relationship agreed well with Faybishenko's formula. CT imaging revealed that entrapped air contents and bubbles sizes were increasing with the height of the sample. Results from experiments were compared with the results from pore-network model.

Regularity of the blow-up curve at characteristic points for the nonlinear wave equation

Sasaki, Takiko January 5, parallel session A, 10:25 – 10:45
National Institute of Technology (KOSEN), Ibaraki College

We study a blow-up curve for the one dimensional wave equation $u_{tt} - u_{xx} = (u_t)^2 - (u_x)^2$. The purpose of this talk is to show that there exists x_0 such that the blow-up curve T satisfies that $T'(x_0) \to -1$ as $x \to x_0$ under suitable initial conditions.

Topological mechanism of the accumulation of the eigenvalues in reaction-diffusion systems

Sekisaka, Ayuki
Meiji university (MIMS)
January 5, parallel session B, 09:45 – 10:05

We consider the reaction-diffusion system on bounded domains, such as real line or multi-dimensional domain. It is known that the eigenvalues of linearized operator of steady solutions accumulate on the specific curves, called as the absolute spectrum, in the spectral plane. We will talk about the topological mechanism of the accumulation of the eigenvalues and its application of the stability problems.

Mathematical modeling for magnetic fluid in Hele-Shaw cell

Shimoji, Yusaku
Graduate School of Science and Technology, Meiji University
January 6, parallel session A, 11:40 – 12:00

Magnetic fluid creates intriguing patterns. One of the most famous pattern formation phenomena is called the Spike phenomenon. R. E. Rosensweig advocated a governing equation for magnetic fluid in three-dimension space. And the fluid also shows interesting pattern formation in a Hele-Shaw cell by which we make a quasi two-dimension space. Here, we try to develop the mathematical model for the magnetic Hele-Shaw problem by applying the governing equation for this problem.

Vorticity Maximization of a Linear Fluid Flow via Volume and Perimeter Constrained Shape Optimization

Simon, John Sebastian
Division of Mathematical and Physical Sciences, Graduate School of Natural Science and Technology, Kanazawa University
January 7, parallel session A, 08:50 – 09:10

In this work, we study an optimization problem that aims to determine the shape of an obstacle that is submerged in a fluid which is governed by the Stokes equations. The mentioned flow takes place in a channel which motivated the imposition of a Poiseuille-like input function on one end and a do-nothing boundary condition on the other.
The maximization of the vorticity is addressed by the L^2-norm of the curl and the det-grad measure of the fluid. Meanwhile, to ensure the existence of an optimal shape, a Tikhonov regularization in the form of a perimeter objective, and a volume constraint is imposed. Having been able to establish the existence of an optimal shape, the first-order necessary condition was formulated by utilizing the so-called rearrangement method (1). Finally, numerical examples are shown by utilizing a finite element method on the governing states, and a gradient descent method for the deformation of the domain. On the said gradient descent method, the task of conserving the volume is circumvented by using an augmented Lagrangian method (2).
This is a joint work with Professor Hirofumi Notsu.

References:
(1) Ito, Kazufumi, Kunisch, Karl, and Peichl, Gunther H., Variational approach to shape derivatives, ESAIM: COCV, 14 (2008), pp. 517–539.
(2) Charles Dapogny, Pascal Frey, Florian Omnès, and Yannick Privat, Geometrical shape optimization in fluid mechanics using freefem++, Structural and Multidisciplinary Optimization, 58 (2018), pp. 2761–2788.

New numerical solution of multi-phase compositional simulations with phase equilibrium computation

Smejkal, Tomáš January 7, parallel session A, 08:30 – 08:50
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

In this contribution, we deal with mathematical modeling of a multicomponent, multiphase compressible compositional flow. Our mathematical model consists of mass conservation for each component, extended Darcy's law for each phase, and an appropriate set of the initial and boundary conditions. The number of phases and the composition of each phase is computed using the phase stability testing and equilibrium computation in VTN-variables (known as VTN-stability and VTN-flash). The transport equations are numerically solved using the mixed-hybrid finite element method and the iterative IMPEC scheme. The phase equilibrium computation is solved via minimization of the Helmholtz free energy of the system. The Newton-Raphson method with line-search and with the modified Cholesky decomposition is used to find the global minimum. We provide 2D examples showing the performance of the numerical scheme.

BDDC for MHFEM discretization of two-phase flow in porous media

Solovský, Jakub January 6, parallel session A, 09:45 – 10:05
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

This work deals with the application of the Balancing Domain Decomposition based on Constrains (BDDC) method to two-phase flow problems in porous media. We briefly describe the spatial discretization of the problem which is based on the mixed-hybrid finite element method (MHFEM) and semi-implicit time discretization. Then in detail, we describe the BDDC method, discuss the differences between the 2D and 3D cases, and present necessary modifications of the algorithm to improve its efficiency for a more complicated 3D case. We describe the parallel implementation of the method and highlight the critical steps of the algorithm that affect the performance and scalability. The parallel implementation is then tested on benchmark problems in 2D and 3D and its efficiency is investigated on various meshes. The numerical results indicate that the method preserves high computational efficiency for increasing number of processes and, therefore, allows solving problems on very fine meshes.

Focusing the Latent Heat Release in 3D Phase Field Simulations of Dendritic Crystal Growth

Strachota, Pavel January 5, parallel session B, 10:05 – 10:25
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

We investigate a family of phase field models for simulating dendritic growth of a pure supercooled substance. Our aim is to remove limitations inherent to some existing models both in terms of the applicability to physically realistic situations and the feasibility of mathematical and numerical analysis. The central object of interest is the reaction term in the Allen-Cahn equation, which is responsible for spatial distribution of latent heat release during solidification. Several existing forms of the reaction term are analyzed and new variants are proposed, with consistent asymptotic behavior as the interface thickness tends to zero. The resulting models are tested in a number of numerical simulations focusing on mesh-dependence, model parameter settings, and the applicability to solidification under very large supercooling.

Burning the lattice - LBM model of a campfire

Straka, Robert January 5, parallel session A, 09:45 – 10:05
AGH University of Science and Technology, Kraków, Faculty of Metals Engineering and Industrial Computer Science

Lattice Boltzmann Method (LBM) is able to - more or less- efficiently solve Navier-Stokes equations (NSE) together with Advection-Diffusion-Reaction equations (ADRE) for scalars. Simplified models of combustion could be easily solved by LBM, especially when one neglects radiation, temperature dependency of material properties, and other stuff related to non-ideal gases. The application of LBM in 3D combustion will be presented, a cumulant based kernel is used to solve NSE, while a central moment based kernel is used for ADRE. This contribution is dedicated to JM who asked me to simulate a campfire for years!

Comoving mesh method for Hele-Shaw moving boundary problem

Sunayama, Yosuke January 7, parallel session A, 10:25 – 10:45
Kanazawa University, Graduate school of Natural Science and Technology

Hele-Shaw moving boundary problem or quasi-static Stefan Problem seeks a solution to a Laplace's equation in an unknown region whose boundary changes with time. In this talk, we propose a Lagrangian-type numerical scheme that we call Comoving Mesh Method (CMM) for solving such a class of moving boundary problems. The idea is to smoothly extend the deformation speed defined on the boundary to the entire domain using the Laplace operator. Then, the boundary and the finite element mesh on the domain can easily be updated by moving the nodal points along this velocity field. We illustrate the method through simple examples and calculate the experimental order of convergence between the numerical and manufactured solutions in order to examine the accuracy of the proposed scheme.

A mass-conservative Lagrange-Galerkin scheme of second-order in time for convection-diffusion problems

Suzuki, Tasuku January 7, parallel session B, 10:05 – 10:25
Division of Mathematical and Physical Sciences, Graduate School of Natural Science and Technology, Kanazawa University

A mass-conservative Lagrange-Galerkin scheme of second-order in time for convection-diffusion problems is presented, and stability and convergence are proved in the framework of L2-theory. It is noted that the scheme has common advantages of Lagrangian methods, i.e., robustness for convection-dominated problems, no requirement of CFL condition, and symmetry of coefficient matrix of resulting system of linear equations. Numerical results in one-, two-, and three-dimensions are shown to see the mass-conservation property and the second-order convergence in time.
This is a joint work with Kouta Futai (Panasonic System Networks R/D Lab. Co., Ltd.) and Hirofumi Notsu (Kanazawa University).

The result of the Paretran project - a supercomputer modelling system for real-world reactive transport simulations

Šembera, Jan January 6, parallel session B, 08:50 – 09:10
Technical University of Liberec, Faculty of Mechatronics and Interdisciplinary Studies

There is a lot of commercial and free software for transport problem simulations and also several good software tools for geochemistry modelling that are widely used. Most of the transport modelling software are able to include some special chemical models and most of the geochemistry modelling software have also a simple transport module in them. There are many problems that can be solved using such software. But there is no reactive transport simulating software that could simulate geometrically complex transport problems with geochemically complex reactions. It would be needed for simulations of long term complex problems such as safe deposit of radioactive waste, large mine flooding etc. In frames of the Paretran project, such a software was developed and it is now commercially available for public users. The talk will present basic tricks and ideas that allowed to put together such a system and some computational results will be shown.

Bloch equations-based estimation of T1 relaxation time

Škardová, Kateřina January 5, parallel session A, 11:40 – 12:00
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

In this contribution, we discuss how numerical simulations, machine learning, and experimental data can be combined in order to create a framework for physiological parameter estimation. Specifically, we deal with the estimation of T1 relaxation time based on image series acquired by the Modified Look-Locker Inversion Recovery (MOLLI) magnetic resonance imaging sequence. The estimation method combines machine learning and a mathematical model. The simplified mathematical model of the imaging sequence is used to generate a sufficiently large training dataset. The neural network prediction is further improved by a gradient-based optimization method. The proposed estimation method is evaluated on a phantom containing four samples with different values of T1.

The double exponential formula for the matrix fractional power

Tatsuoka, Fuminori January 7, parallel session B, 08:50 – 09:10
Nagoya University, Department of Applied Physics, Graduate School of Engineering

This talk considers numerical quadrature for computing the matrix fractional power, which arises in applications such as space-fractional partial differential equations. The matrix fractional power is represented by an integral whose integrand can be non-analytic at the endpoint. Taking the property of the integrand into account, we focus on the double exponential (DE) formula. The DE formula is one of the quadrature formulas, which is known for its effectiveness at treating nearly arbitrary endpoint singularities. Hence, it is more efficient than other quadrature formulas. In this talk, we present an algorithm based on the DE formula for the matrix fractional power. To guarantee the accuracy of the algorithm, we analyze the error of the DE formula. Subsequently, we analyze the convergence rate of the DE formula for Hermitian positive definite matrices. The convergence rate analysis and numerical results show the DE formula works well, especially in situations in which the Gaussian quadrature achieves slow convergence. This is a joint work with Tomohiro Sogabe (Nagoya University), Yuto Miyatake (Osaka University), Tomoya Kemmochi (Nagoya University), Shao-Liang Zhang (Nagoya university).

Calculation of thickness of cylinder-type impossible solids using simple crystalline curvature flow

Tomoeda, Akiyasu January 7, common session, 11:20 – 11:40
Musashino University

Some illusionary solids called "Impossible Solids" are cylinder type. When printing this type of solid with a 3D printer as an actual solid, it is necessary to add the thickness of the solid. Sugihara has already proposed several strategies for calculating the thickness of a solid, but the detailed calculation methods are unknown. Therefore, in this talk, we tried to calculate the thickness using a simple equation for crystalline curvature flow, and I will introduce its procedure.

Mathematical analysis of suspension flowing down an inclined plane particle-rich ridge near the contact line

Tomoeda, Kyoko January 5, common session, 08:50 – 09:10
Setsunan University

There are experimental results of suspension by Zhou et al. (2005): A suspension of polydisperse glass beads (diameter 250–425 mm) flows on an acrylic plate with an inclination angle between

0 and 90 degrees, then the surface of the suspension is characterized by three patterns. (a) At low inclination angles and the particle volume fraction, the particles settle to the substrate and the clear silicone oil flows over the particle bed. (b) At high inclination angles and the particle volume fraction, the particles accumulate at near the contact line forming a particle-rich ridge. (c) At intermediate inclination angles and the particle volume fraction, the particles remain well-mixed in the fluid. Zhou et al. (2005) and Cook et al. (2008) derived a system of conservation laws (lubrication model) to analyze the formation mechanism of a particle-rich ridge in pattern (b). Moreover Zhou et al. show by numerical simulations that the ridge formation is due to the double shock wave (1-shock wave and 2-shock wave). In this talk we deal with the Riemann problem of lubrication model. We show that the weak solution does not have 1-shock wave under certain conditions. Also we introduce a double shock wave with a profile different from the shock wave shown by Zhou et al. (2005). Our results suggest that the formation of a particle-rich ridge may be due to factors other than shock waves.This is a joint work with Kaname Matsue (Kyushu University).

Smooth two-sided distribution created by regularization and symmetrization of a one-sided distribution

Tran, Quang Van January 6, parallel session B, 11:20 – 11:40
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering

We propose a way to obtain a new smooth two-sided distribution by regularization and symmetrization of a one-sided distribution. A new distribution applicable for the whole real domain can retain all basic properties of the original distribution. Hence it can be used to model the returns of financial assets which is well-known for its heavy tail characteristic. The suitability of the prosed distribution is verified on returns of USD/EUR exchange rate.

Application of maximal monotone operator method for solving Hamilton-Jacobi Bellman equation arising from optimal portfolio selection problem

Udeani, Cyril Izuchukwu January 7, common session, 11:00 – 11:20
Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava

In this paper, we investigate a fully nonlinear evolutionary Hamilton-Jacobi-Bellman (HJB) parabolic equation utilizing the monotone operator technique. We consider the HJB equation arising from portfolio optimization selection, where the goal is to maximize the conditional expected value of the terminal utility of the portfolio. The fully nonlinear HJB equation is transformed into a quasilinear parabolic equation using the so-called Riccati transformation method. The transformed parabolic equation can be viewed as the porous media type of equation with source term. Under some assumptions, we obtain that the diffusion function to the quasilinear parabolic equation is globally Lipschitz continuous, which is a crucial requirement for solving the Cauchy problem. We employ Banach's fixed point theorem to obtain the existence and uniqueness of a solution to the general form of the transformed parabolic equation in a suitable Sobolev space in an abstract setting. Some financial applications of the proposed result are presented in one-dimensional space.

A reaction-diffusion approximation of a semilinear wave equation

Yamamoto, Hiroko January 5, parallel session B, 10:25 – 10:45
University of Tokyo, Graduate School of Mathematical Sciences

A reaction-diffusion approximation is a method that solutions of reaction-diffusion systems approximate those of differential equations. We introduce a reaction-diffusion system whose solutions approximate those of a semilinear wave equation under some assumptions of a reaction term. This is a joint work with Hirokazu Ninomiya (Meiji University).