Workshop on

Applied Mathematics and Scientific Computing

January 11, 2023 · 10:00 - 18:00 · Satellite Plaza, Kanazawa University

Schedule Overview

Morning Session

09:55 - 10:10	Opening	＊＊＊
Session 1	Speaker	Title of Talk
10:00 - 10:25	Michal Beneš	On Motion of Vortex Structures by Binormal Curvature
10:25 - 10:50	Miroslav Kolář	Qualitative and numerical aspects of dynamics of diffusion and transport mechanisms on evolving curves
10:50 - 11:15	Shigetoshi Yazaki	A new method for polygonal curvature flows
11:15 - 11:25	Break	＊＊＊
Session 2		
11:25 - 11:50	Koya Sakakibara	Numerical analysis of the minimal surface by the method of fundamental solutions
11:50 - 12:05	Yusaku Shimoji	Interfacial instability of Hele-Shaw flow due to periodic changes in gap
12:05 - 12:20	Takumi Mitooka	Convergence of numerical schemes for the mean curvature flow of graphs
12:20 - 12:35	Shun Ota	On the central configurations of the four-body problem
12:35 - 14:00	Lunch Break	＊＊＊

Afternoon Session

Session 3	Speaker	Title of Talk
14:00 - 14:25	Jakub Klinkovský	Simulating bubbling fluidization using Multiphase Particle-in-Cell method in OpenFOAM
14:25 - 14:50	Pavel Strachota	Challenges of simulating multiphase reacting flows in complex geometries
14:50 - 15:05	Aufa Numan Fadhilah Rudiawan	Energy estimates of a multi-phase flow model
15:05 - 15:20	Kharisma Surya Putri	A moving mesh method for a conservation law
15:20 - 15:35	Yuki Karasawa	A finite element scheme for the Oldroyd-B model with a second-order approximation of the upper-convected time derivative
15:35 - 15:50	Jingtong Li	Mathematical analysis of Zener-type viscoelastic wave equation
15:50 - 16:00	Break	* * *
Session 4		
16:00 - 16:25	Jakub Solovský	Investigation of potential brine leakage through caprock fracture zone
16:25 - 16:50	Takumi Seo	Deep reinforcement learning for traffic signal control optimization
16:50 - 17:05	Md. Sahidul Islam	Analysis for mass conservation of Smoluchowski coagulation equation
17:05 - 17:20	Shunsuke Kuzawa	Press machine control using delay differential equations
17:20 - 17:35	Kai Kitamura	An implicit linear scheme for nonlinear diffusion equations
17:35 - 18:00	Tetsuya Ishiwata	On blow-up of solutions to distributed delay differential equations
18:00 - 18:05	Closing	* * *

Abstracts

S. = Schedule · **P.** = Presenter · **T.** = Title · **A.** = Abstract

Session 1

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S. 10:00 - 10:25

P. Michal Beneš, *Czech Technical University in Prague, Prague, Czechia*

T. On Motion of Vortex Structures by Binormal Curvature

A. We discuss a model of vortex-ring dynamics based on motion of closed non-intersecting curves in space by curvature in the binormal direction and on their mutual interaction. Here, a vortex ring is represented as a closed curve in space by its core which represents concentrated vorticity and generates motion and force interaction in its vicinity. In the contribution, we formulate the general motion law and mention its analytical properties. The finite-volume scheme allows to solve the motion numerically. We demonstrate behavior of the solution on several computational studies of the flow combining the normal and binormal velocity and considering nonlocal interactions of moving vortex rings and discuss future generalizations.

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S. 10:25 - 10:50

P. Miroslav Kolář, *Czech Technical University in Prague, Prague, Czechia*

T. Qualitative and numerical aspects of dynamics of diffusion and transport mechanisms on evolving curves

A. In this talk we discuss our model of diffusion and transport acting on curved interfaces in the plane and with possible extension to 3D. The advection and transport model is coupled with the geometrical evolution equation for the interface in the schematical form “normal velocity = curvature + force”. This model is being developed within the context of study of the vortex dynamics. The moving interface is represented by a smooth parametrized curve. The technique of adding an artificial tangential velocity for stabilization of the numerical calculations is discussed and preliminary qualitative and quantitative results are shown.

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S. 10:50 - 11:15

P. Shigetoshi Yazaki, *Meiji University, Tokyo, Japan*

T. A new method for polygonal curvature flows

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Session 2

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S. **11:25 - 11:50**

P. Koya Sakakibara, *Okayama University of Science, Okayama, Japan and RIKEN, Japan*

T. Numerical analysis of the minimal surface by the method of fundamental solutions

A. The problem of finding minimal surfaces has been actively studied since Lagrange first proposed it in 1762. In this talk, we propose a numerical algorithm for finding minimal surfaces based on the method of fundamental solutions. The content of this talk is based on joint work with Dr. Yuuki Shimizu, and the preprint has been published on arXiv (arXiv:2212.06508).

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S. **17:35 - 18:00**

P. Yusaku Shimoji, *Meiji University, Tokyo, Japan*

T. Interfacial instability of Hele-Shaw flow due to periodic changes in gap

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S. **12:05 - 12:20**

P. Takumi Mitooka, *Meiji University, Tokyo, Japan*

T. Convergence of numerical schemes for the mean curvature flow of graphs

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S. **12:20 - 12:35**

P. Shun Ota, *Meiji University, Tokyo, Japan*

T. On the central configurations of the four-body problem

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Session 3

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S. **14:00 - 14:25**

P. Jakub Klinkovský, *Czech Technical University in Prague, Prague, Czechia*

T. Simulating bubbling fluidization using Multiphase Particle-in-Cell method in OpenFOAM

A. Our long-term goal is to develop a CFD software tool for simulating complex phenomena occurring in bubbling fluidized bed boilers operating in oxyfuel regime. We use the multiphase particle-in-cell (MP-PIC) method, which is a modern computational approach combining the advantages of both Eulerian and Lagrangian frameworks for modeling particle-fluid interactions. While the motion of particles is tracked using the Lagrangian framework, inter-particle interactions (i.e. collisions) are approximated using averaged quantities on the Eulerian grid where the fluid is simulated. Existing literature shows that the method is stable in dense particle flows, computationally efficient, and physically accurate, which makes it suitable for use in solvers targeting industrial-scale applications involving particle-fluid flows, including combustion in bubbling fluidized bed boilers.

We present ”kotelFoam”, a CFD simulator for bubbling fluidized bed boilers that is developed using the OpenFOAM framework. We describe the features of the solver and highlight our own modifications and improvements that are important for accurate and efficient simulations of the selected phenomena. Most importantly, we focus on the particle-stress model that approximates particle collisions in the MP-PIC method and ensures that the packing limit of a granular material is respected in the model. Finally, we present our simulations of fluidized sand particles in a laboratory-scale bubbling fluidization device.

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S. **14:25 - 14:50**

P. Pavel Strachota, *Czech Technical University in Prague, Prague, Czechia*

T. Challenges of simulating multiphase reacting flows in complex geometries

A. This contribution is an informal introduction to some of the challenges arising during the implementation of numerical solvers for multiphase reacting flows, in particular in the context of fluidized bed combustion. We will discuss the motivation for choosing particle-based approaches and the caveats of using the multiphase particle-in-cell (MP-PIC) method on unstructured meshes. Next, the multiscale nature of the simulated processes in both space and time will be explained. The many uncertainties arising in the study of the individual phenomena will be briefly laid out, including those in particle size distributions, non-sphericity of the particles, fuel particle devolatilization and burnout, convective and radiative heat transfer, and chemical reaction chain.

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S. **14:50 - 15:05**

P. Aufa Numan Fadhilah Rudiawan, *Kanazawa University, Ishikawa, Japan*

T. Energy estimates of a multi-phase flow model

A. The multiphase flow occurs regularly in many natural phenomena and is well-documented and crucial within various industries. In this talk, we present energy estimates of a multiphase flow model at the continuous and discrete levels. The content of this talk follows a private discussion by M. Beneš (Czech Technical University in Prague), M. Kimura (Kanazawa University), H. Notsu (Kanazawa University), and A. Žák (Czech Technical University in Prague).

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S. **15:05 - 15:20**

P. Kharisma Surya Putri, *Kanazawa University, Ishikawa, Japan*

T. A moving mesh method for a conservation law

A. In the solution of some biological models, the occurrence of a pattern with sharp spikes appears. In this talk, we present a Lagrangian moving mesh scheme for scalar conservation law problems in order to capture such a sharp pattern accurately and effectively. The content of this talk is based on joint work with N. Kolbe (RWTH Aachen University), T. Mizuochi (Kanazawa University), and H. Notsu (Kanazawa University).

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S. **15:20 - 15:35**

P. Yuki Karasawa, *Kanazawa University, Ishikawa, Japan*

T. A finite element scheme for the Oldroyd-B model with a second-order approximation of the upper-convected time derivative

A. An essential term in viscoelastic fluid flow models is the upper-convected time derivative (UCTD). Recently, a second-order approximation in time of the UCTD has been proposed and implemented in a finite difference framework in a paper (Medeiros et al., SIAM J. Numer. Anal., 2021). In this talk, we extend the idea and propose a finite element scheme. This is joint work with D.O. Medeiros (University of São Paulo), T. Nakazawa (Osaka University), H. Notsu (Kanazawa University), and C.M. Oishi (São Paulo State University).

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S. **15:35 - 15:50**

P. Jingtong Li, *Kanazawa University, Ishikawa, Japan*

T. Mathematical analysis of Zener-type viscoelastic wave equation

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Session 4

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S. 16:00 - 16:25

P. Jakub Solovský, *Czech Technical University in Prague, Prague, Czechia*

T. Investigation of potential brine leakage through caprock fracture zone

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S. 16:25 - 16:50

P. Takumi Seo, *Shibaura Institute of Technology, Tokyo, Japan*

T. Deep reinforcement learning for traffic signal control optimization

A. In this study, we suggest a way of designing intersection types whether scramble or simple intersection can provide better traffic scenarios through Traffic Signal Control optimization in mixed pedestrians and vehicle intersections using Reinforcement Learning method.

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S. 16:50 - 17:05

P. Md. Sahidul Islam, *Kanazawa University, Ishikawa, Japan*

T. Analysis for mass conservation of Smoluchowski coagulation equation

A. We have considered a generalized moment method for homogeneous Smoluchowski coagulation equation in continuous form and. We have provided a theoretical approach for a generalized M^b moment by choosing a function $b \in C\big([0,\infty)\big)$ with $b(x) \geq 0$ and defining m^b moment and its link with the usual moment. By means of the generalized moment method mass conservation property for a special class of kernel $K \in C^1([0,\infty)\times[0,\infty))$ under the assumptions $(x+y)K(x,y) \leq C_0\left(b(y)(x+1)+b(x)(y+1)\right)$ and $\big(b(x+y)-b(x)-b(y)\big)K(x,y) \leq C_1\left(\big(b(y)+y+1\big)(x+1)+\big(b(x)+x+1\big)(y+1)\right)$ are also studied here, for some constant $C_0, C_1 > 0$.

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S. 17:05 - 17:20

P. Shunsuke Kuzawa, *Kanazawa University, Ishikawa, Japan*

T. Press machine control using delay differential equations

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S. 17:20 - 17:35

P. Kai Kitamura, *Kanazawa University, Ishikawa, Japan*

T. An implicit linear scheme for nonlinear diffusion equations

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S. 17:35 - 18:00

P. Tetsuya Ishiwata, *Shibaura Institute of Technology, Tokyo, Japan*

T. On blow-up of solutions to distributed delay differential equations

A. It is well known that time lags or histories sometimes cause instability or oscillation. In this talk, we focus on distributed delay differential equations and discuss the effects of time delay for such instabilities from the viewpoint of a finite time blow-up of the solutions. We also show some numerical examples and give our observations. This is joint work with Y. Nakata.

*** **Nothing follows** ***