MASCOT Mathematical Meeting

UiT campus Narvik

April 3rd, 2023

Program

13.15	Brahim Amaziane (University of Pau, France)	High Performance Numerical Simulation of Fully Coupled Processes of Reactive Multiphase Flow in Porous Media
14.05	Trygve Johnsen (UiT Tromsø)	Codes, graphs and derived combinatorial objects
14.55	Boris Kruglikov (UiT Tromsø)	On variationality of Differential Equations
15.40	Coffee break	
16.10	Igor Velčić (Zagreb University, Croatia)	Stochastic homogenization of high-contrast medium
17.00	Elena Zhizhina (UiT Narvik & IITP Moscow)	Water purification model based on high-contrast media approach
17.50	Eivind Schneider (UiT Tromsø)	Recurrent Weyl structures

Organized by **Andrei Piatnitski** (UiT Narvik)
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Abstracts.

Brahim Amaziane (University of Pau, France)

High Performance Numerical Simulation of Fully Coupled Processes of Reactive Multiphase Flow in Porous Media

Abstract: Reactive multiphase multicomponent flows in porous media are involved in many applications related to subsurface environment and energy issues. We can mention non exhaustively production of geothermal energy, geological sequestration of CO2 and nuclear waste, underground H2 storage or polluted soil remediation. Such flows are governed by a set of highly nonlinear system of degenerate partial differential equations (describing a multiphase compositional flow) coupled with algebraic and/or ordinary differential equations (related to geochemical model) requiring special numerical treatment. The numerical strategies for solving this system are divided into two main categories: the global implicit and the sequential approaches. The global implicit approach solves one global nonlinear system gathering all equations at each time step while for the sequential approach, flow and reactive transport (or possibly flow, transport and chemistry) are solved sequentially at each time step.

In the framework of the parallel platform DuMu, we have developed and implemented several finite volume schemes to tackle such problems. Firstly, we developed a sequential approach solving a two-phase compositional flow problem followed by a reactive transport problem using a direct substitution approach. Both subsystems have been discretized in a fully implicit manner.

Nonetheless, sequential approaches can introduce operator splitting errors. By consequence, we developed and implemented a fully-coupled, fully implicit method to solve reactive two-phase flows to achieve improved stability. Both strategies were validated by numerous 2D and 3D test cases including High Performance Computing. Numerical results including an advanced comparison between both strategies for a three-dimensional scenario of geological storage of CO2 will be presented.

I will present a part of the work done by the LMAP porous media team in the context of the development of Reactive-DuMu: a collaborative parallel platform for numerical simulation of multiphase multicomponent flow with reactive transport in porous media.

Trygve Johnsen (UiT, Tromsø)

Codes, graphs and derived combinatorial objects.

Abstract: In this talk we will look at how error-correcting codes and graphs have a common combinatorial structure whose generalizations may lead one into different areas of mathematics (study of compact surfaces, matrix spaces).

Boris Kruglikov (UiT, Tromsø)

On variationality of Differential Equations.

Abstract: I will give a short introduction to the calculus of variations and demonstrate some variational and non-variational differential equations, including those from physical applications (with the principle of minimal action being a cornerstone). Then I concentrate on a particular problem of variationality of paths, having its origin in the works of Darboux and Douglas. I will discuss the results from a short note, I wrote jointly with Vladimir Matveev (Jena), which, in particular, shows that the submaximally symmetric Egorov connection is neither pseudo-Riemannian nor Finsler metrizable but its geodesic paths are variational.

Eivind Schneider (UiT, Tromsø)

Recurrent Weyl structures.

Abstract: A Weyl structure on a manifold is a conformal structure together with a compatible connection. It was introduced by Weyl in 1918 as an alternative structure on space-time, generalizing the pseudo-Riemannian geometry in General Relativity which was proposed by Einstein. In this talk I will focus on a special type of Weyl structures, called recurrent Weyl structures, and give a classification of these. On the way I will introduce the main geometric concepts involved and explain their role in the definitions and theorems presented. The talk is based on joint work with Andrei Dikarev and Anton Galaev.

Igor Velčić (University of Zagreb, Croatia)

Stochastic homogenization of high-contrast medium.

Abstract: We study the homogenisation problem for elliptic high-contrast operators whose coefficients degenerate as homogenization parameter tends to zero, on a set of randomly distributed inclusions. We discuss the limit operator (in the sense of the resolvent convergence) and the convergence of spectrum.

On the bounded domain the limiting spectrum is equal to the spectrum of the limit operator, while in the whole space setting the spectrum of the limit operator is the subset of the limiting spectrum. Additionally, we characterize the limiting spectrum in the case of finite correlation.

This is a joint work with Matteo Capoferri (Herriot-Watt University, Edinburgh), Mikhail Cherdantsev (University of Cardiff) and Kirill Cherednichenko (University of Bath).

Elena Zhizhina (UiT, Narvik and IITP, Moscow)

Water purification model based on high-contrast media approach.

Abstract: The talk will focus on a mathematical model of the water treatment process. We start with a model at the microscopic scale which is a lattice random walk in high-contrast periodic media with absorption. Then using the upscaling procedure, we obtain the macroscopic model for total mass evolution.

We will discuss both the dynamic and the stationary regimes and show how the effective characteristics affect the speed of the purification process.