Graduate Student Paper Presentation 2022

Date and Time:
Friday, April 29, starting at 2 p.m. CT

Venue: PGH 232 and virtually via Teams

Meeting details:

- Click here to join

Schedule

2:00–2:10	**Welcome remarks**		
2:10–2:30		**Gregory Hemenway**	Equilibrium States for Expanding Skew Products
2:30–2:50		**An Vu**	Numerical methods for incompressible multiphase flows applied to thermo-magnetohydrodynamics
2:50–3:10		**Nikolaos Panagopoulos**	Lattices in semisimple Lie groups and invariant subalgebras of group C^* and von Neumann algebras
3:10–3:30	**Break**		
3:30–3:50		**Thuyen Dang**	An invitation to mathematical homogenization
3:50–4:10		**Yerbol Palzhanov**	A decoupled, stable, and linear FEM for a phase-field model of variable density two-phase incompressible surface flow
4:10–4:30		**Mahmood Ghasemi**	Stochastic modeling of GREB1 gene transcription
4:45	**Winners Announced**		

List of Abstracts

Equilibrium States for Expanding Skew Products

Gregory Hemenway

Area of research: Dynamical Systems

We will discuss the thermodynamic properties of equilibrium states for expanding skew products. We show how a family of fiberwise transfer operators can be used to define the conditional measures along fibers of the product. We prove that the push forward of the equilibrium state onto the base of the product is itself an equilibrium state for a Hölder potential defined via this fiberwise transfer operator.

Numerical methods for incompressible multiphase flows applied to thermo-magnetohydrodynamics

An Vu

Area of research: Finite Element Methods

Magnetohydrodynamic (MHD) equations govern the evolution of electrically conducting fluids and their magnetic properties. The flow of fluid, along with magnetic fields, can conduct electricity and cause polarization in the fluid. The extension of MHD, thermo-MHD, also monitors the heat transfer using the heat equation. In this work, we study the thermal-MHD and the interactions of multiphase flows with the inspiration from liquid metal battery. We develop and analyze an incremental method to solve the system of temperature and MHD equations with variable density. This method uses the momentum and internal energy density as variables. We also validate this method numerically with manufactured tests on axisymmetric and nonaxisymmetric flows.

Lattices in semisimple Lie groups and invariant subalgebras of group C^* and von Neumann algebras

Nikolaos Panagopoulos

Area of research: Operator Algebras

In this talk, we will first discuss some old and recent generalizations of the Margulis' Normal Subgroup Theorem (for irreducible lattices in semisimple Lie groups) and then highlight the connection between the space of normal subgroups of such a lattice and the space of invariant subalgebras of the operator algebras generated by unitary representations.

An invitation to mathematical homogenization

Thuyen Dang

Area of research: Analysis of PDEs

Homogenization is finding the *effective* properties of a mixture of two or more different materials. In this short talk, I present the idea of mathematical homogenization through a case study. An intuitive method to derive the effective equation is discussed. If time permits, we will talk about some applications of the theory: What is the common thing between the *Sun*, the textitEarth's molten core, and a *magnetic suspension*? Are there any materials that *shrink* while being *heated*? Can the *Invisibility Cloak* of Harry Potter be made in real life?

A decoupled, stable, and linear FEM for a phase-field model of variable density two-phase incompressible surface flow

Yerbol Palzhanov

Area of research: Finite Element Methods

The paper considers a thermodynamically consistent phase-field model of a two-phase flow of in- compressible viscous fluids. The model allows for a non-linear dependence of fluid density on the phase-field order parameter. Driven by applications in biomembrane studies, the model is written for tangential flows of fluids constrained to a surface and consists of (surface) Navier–Stokes–Cahn–Hilliard type equations. We apply an unfitted finite element method to discretize the system and introduce a fully discrete time-stepping scheme with the following properties: (i) the scheme decouples the fluid and phase-field equation solvers at each time step, (ii) the resulting two algebraic systems are linear, and (iii) the numerical solution satisfies the same stability bound as the solution of the original system under some restrictions on the discretization parameters. Numerical examples are provided to demon- strate the stability, accuracy, and overall efficiency of the approach. Our computational study of several two-phase surface flows reveals some interesting dependencies of flow statistics on the geometry.

Stochastic modeling of GREB1 gene transcription

Mahmood Ghasemi

Area of research: Mathematical modeling in biology

Gene transcription is an essential step in the central dogma of biology. It is usually considered a highly regulated and ordered phenomenon, however, live imaging experiments often demonstrated an intrinsic stochasticity in mRNA production. Many mathematical models based upon different types of experiments have focused on messenger RNA (mRNA) production in single cells. This complex process is influenced by many factors and has often been analyzed through stochastic models with parameters that are strongly gene dependent. Our study is centered on the effects elicited by the steroid hormone 17β-Estradiol (E2), which binds to the estrogen receptor (ER) to regulate the expression of a large number of target genes, including GREB1, which is used in this study as a paradigm for a long ER target gene, in populations of MCF7 breast cancer cells. Our goal was to describe early responses to E2 by modeling dynamics from static time points. We monitored GREB1 gene transcription using high-resolution imaging and single-molecule Fluorescence In Situ Hybridization (sm-FISH) using spectrally separated probe sets for GREB1 introns and exons to perform both nascent and steady-state RNA analysis to investigate the effect of inhibitor, the level of its concentration, and some other factors.