Hydrodynamic limits of interacting agent systems

Warwick Venice Conference Centre

June 9-13 2025

Conference schedule

	MONDAY
10:00–10:30	WELCOME/COFFEE
10:30–11:15	Paola Goatin: *Nonlocal macroscopic models of multi-population pedestrian flows for walking facilities optimization*
11:20–11:45	Changhui Tan: *On nonlocal traffic flow models*
11:50–12:15	Felisia A Chiarello: *Existence, uniqueness, stability and the singular limit for a nonlocal GARZ model*
12:15–14:15	LUNCH BREAK
14:15–15:00	Alexis Vasseur: *Non-uniqueness for continuous solutions to 1D conservation laws*
15:05–15:30	Andrea Tosin: *Kinetic Description and Macroscopic Limit of Swarming Dynamics with Continuous Leader-Follower Transitions*
15:30–16:00	COFFEE BREAK
16:00–16:45	Roman Shvydkoy: *Existence and long time behavior of weak solutions to the Fokker-Planck-Alignment models*
16:50–17:15	Benjamin Seeger: *Hamilton-Jacobi equations on Wasserstein spaces and applications*
17:20–17:45	Nilasis Chaudhuri: *Analysis of Generalized Aw-Rascle model*
18:00	WELCOME RECEPTION

	TUESDAY
9:30–10:15	Didier Bresch: *A duality method to justify mean field limits*
10:20–10:45	Maria Bruna: *Hydrodynamic limit of an active-passive lattice gas*
10:45–11:15	COFFEE BREAK
11:15–11:45	Jan Peszek: *Hydrodynamic limit of singular alignment*
11:50–12:15	Jinwook Jung: *Modulated energy estimates for singular kernels and their applications*
12:15–14:15	LUNCH BREAK
14:15–15:00	Benoit Perthame: *Monge-Kantorovich distance and PDEs*
15:05–15:30	Grzegorz Karch: *Solutions at vacuum and rarefaction waves in pressureless Euler alignment system*
15:30–16:00	COFFEE BREAK
16:00–17:30	Short Presentations: Maja Szlenk, Esther Bou Dagher, Jakub Woźnicki, Muhammed Ali Mehmood

	WEDNESDAY
9:30–10:15	Athanasios E. Tzavaras: *The Maxwell-Stefan system of multi-component diffusion*
10:20–10:45	Mattia Zanella: *Finite time blow-up for consensus dynamics and applications*
10:45–11:15	COFFEE BREAK
11:15–11:45	Trevor Leslie: *Sticky Particle Solutions of the Euler Alignment system*
11:50–12:15	Mohamad Ghattassi: *Boundary Layer Analysis in Diffusive Limits of Radiative Heat Transfer System*
	FREE AFTERNOON

	THURSDAY
9:30–10:15	Rinaldo Colombo: *Non Local Conservation Laws in Vehicular Traffic and Cryptography*
10:20–10:45	Piotr Gwiazda: *Bayesian Inference for PDE's problems*
10:45–11:15	COFFEE BREAK
11:15–11:45	Giacomo Albi: *Robust control of collisional plasma dynamics in presence of uncertainties*
11:50–12:15	Kevin Painter: *Chase-and-run interactions in heterogeneous populations*
12:15–14:15	LUNCH BREAK
14:15–15:00	Agnieszka Świerczewska-Gwiazda: *On the relative entropy method and unconditional stability of radially symmetric steady states of compressible viscous fluids*
15:05–15:30	Aneta Wróbleska-Kamińska: *Coupled Vlasov and non-Newtonian fluid dynamics*
15:30–16:00	COFFEE BREAK
16:00–17:30	Short Presentations: Katarzyna Ryszewska, Hanna Bartel, Samuel Charles, Jiakun Yang
19:00	CONFERENCE DINNER

	FRIDAY
9:30–10:15	Jose Antonio Carrillo: *Global minimizers of Interaction Energies*
10:20–10:45	Jakub Skrzeczkowski: *Optimal rate of convergence for a nonlocal-to-local limit in one dimension*
10:45–11:15	COFFEE BREAK
11:15–11:45	Markus Schmidtchen: *Localisation Limits and Degenerate Cross-Diffusion Systems*
11:50–12:15	Piotr Boguslaw Mucha: *The Compressible Euler System with Nonlocal Pressure*

TIMETABLE

	Monday		Tuesday	Wednesday	Thursday	Friday
9:30–10:15		9:30–10:15	Bresch	Tzavaras	Colombo	Carrillo
10:00–10:30	WELCOME	10:20–10:45	Bruna	Zanella	Gwiazda	Skrzeczkowski
10:30–11:15	Goatin	10:45–11:15	COFFEE	COFFEE	COFFEE	COFFEE
11:20–11:45	Tan	11:15–11:45	Peszek	Leslie	Albi	Schmidtchen
11:50–12:15	Chiarello	11:50–12:15	Jung	Ghattarsi	Painter	Mucha
12:15–14:15	LUNCH BREAK					
14:15–15:00	Vasseur	14:15–15:00	Perthame		Świerczewska	
15:05–15:30	Tosin	15:05–15:30	Karch		Wróblewska	
15:30–16:00	COFFEE	15:30–16:00	COFFEE		COFFEE	
16:00–16:45	Shvydkoy	16:00–17:30	Short Present 1		Short Present 2	
16:50–17:15	Seeger					
17:20–17:45	Chaudhuri					
18:00	RECEPTION				CONF DINNER	

Book of abstracts

Robust control of collisional plasma dynamics in presence of uncertainties

Giacomo Albi

University of Verona

Magnetic fusion aims to confine high-temperature plasma within a device, enabling the fusion of deuterium and tritium nuclei to release energy. Due to the very large temperatures involved, it is essential to isolate the plasma from the device walls to prevent structural damage and the external magnetic fields play a fundamental role in achieving this confinement. In realistic settings, the physical mechanisms governing plasma behavior are highly complex, involving numerous uncertain parameters and intricate particle interactions, such as collisions, that significantly affect both confinement efficiency and overall stability. In this work, we address particularly these challenges by proposing a robust feedback control strategy designed to steer the plasma towards a desired spatial region, despite the presence of uncertainties. From a modeling perspective, we consider a collisional plasma described by a Vlasov-Poisson-BGK system, which accounts for a self-consistent electric field and a strong external magnetic field, while incorporating uncertainty in the model. A key feature of the proposed control strategy is its independence from the random parameter, making it particularly suitable for practical applications. A series of numerical simulations confirms the effectiveness of our approach and demonstrates the ability of external magnetic fields to successfully confine plasma away from the device boundaries, even in the presence of uncertain conditions.

Multidimensional Opinion Formation

Hanna Bartel

University of Hamburg

Existing research on modelling opinion dynamics primarily examines scenarios in which individuals have opinions on only one topic. This talk presents a possibility of modelling opinion dynamics when individuals have opinions on multiple topics. I will introduce a kinetic model that describes the effect of interactions between people on their opinions, and discuss the corresponding partial differential equation, which describes that behaviour on a macroscopic level.

Interpolation inequalities on the sphere and phase transition: rigidity, symmetry and symmetry breaking

Esther Bou Dagher

Univeristé Paris Dauphine

We study phase transitions associated to a large family of Gagliardo-Nirenberg-Sobolev interpolation inequalities on the sphere. We characterize symmetry and symmetry breaking regimes, with a phase transition that can be of first or second order. We establish various new results and study the qualitative properties of the branches of solutions to the Euler-Lagrange equations.

This is a joint work with Jean Dolbeault.

A duality method to justify mean field limits

Didier Bresch

CNRS

We present a duality method (combined with the analysis of linearized dual correlations) to justify mean field limits that may be used for first and second order particle systems with singular interaction. It allows to cover for the first time arbitrary square-integrable interaction forces with a possibly vanishing temperature parameter. In case of first-order systems, it allows to recover in particular the mean-field limit to the 2d Euler and Navier–Stokes equations. The approach also provides convergence rates.

This is joint work with M. Duerinckx and P.E.Jabin.

Hydrodynamic limit of an active-passive lattice gas

Maria Bruna

University of Oxford

In this talk, I will discuss a model mixture of active (self-propelled) and passive (diffusive) particles with non-reciprocal effective interactions (or forces that violate Newton's third law). We derive the hydrodynamic PDE limit for the particle densities, which is not a Wasserstein gradient flow of any free energy, consistent with the microscopic model having non-equilibrium steady states. We study the emergence of collective behaviour, which includes phase separation and dynamical (travelling) steady states.

Joint work with Clément Erignoux, Rob Jack and James Mason.

Global minimizers of Interaction Energies

Jose Antonio Carrillo

University of Oxford

I will review the existence and uniqueness of global minimizers for interaction energy functionals. Euler-Lagrange equations in the infinity wasserstein distance will be discussed. Based on linear convexity/concavity arguments, qualitative properties of the global minimizers will also be treated. Anisotropic singular potentials appearing in dislocations will be shown to have rich qualitative properties with loss of dimension and ranges of explicit minimizers. They are steady states or moving flocks for hydrodynamic models.

This talk will be based on several works in collaboration with Ruiwen Shu (University of Georgia).

Global Existence of Finite-Energy Solutions of the Compressible Euler-Riesz Equations with Large Initial Data of Spherical Symmetry

Samuel Charles

University of Oxford

We are concerned with the global existence of spherically symmetric finite-energy solutions of the compressible Euler-Riesz equations (CEREs) for dimensions $n \geq 2$, considering both the attractive and repulsive case. Such an equation is incredibly useful in modelling compressible gaseous stars, plasmas, Riesz gases, swarming models and more. As such, the theory of existence is of particular importance. I will give an overview of the derivation and past work on the equation, in particular, considering the recent paper (G. Chen, L. He, Y. Wang, D. Yuan, CPAM, 2023), where solutions of the Euler-Poisson equations (a special case of the Euler-Riesz equations) are approximated by the solutions of the compressible Navier-Stokes-Poisson equations (CNSPEs) using a viscosity method. The difficulty with such a procedure is the possible concentration of the density at the origin. As such, a careful construction of the approximate solutions is required. Unlike the Poisson case where the potential can be represented locally, the singularity and regularity of the nonlocal radial Riesz potential near the origin require careful analysis, which is a crucial step. I will give an introduction and overview of our work to generalise the above paper to prove rigorously the existence of global weak solutions to the CEREs.

Analysis of Generalized Aw-Rascle model

Nilasis Chaudhuri

University of Warsaw

This talk explores the multidimensional generalization of the Aw-Rascle system, a well-established model for vehicular traffic and pedestrian dynamics. Both local and non-local formulations are examined, along with various notions of generalized solutions. In the one-dimensional setting, we further investigate the 'hard congestion limit' and demonstrate the convergence of solutions to a hybrid system that captures the transition between free-flow and congested regimes.

Existence, uniqueness, stability and the singular limit for a nonlocal GARZ model

Felisia A Chiarello

University of L'Aquila

We will analyse the nonlocal version of the so-called Generalized Aw-Rascle-Zhang model (GARZ), consisting of two conservation laws with nonlocality in the flux. The nonlocality is in convolution form. We will prove the existence, uniqueness and stability of weak solutions, and we will study the singular limit, i.e. the convergence of the solution of the nonlocal problem to that one of the corresponding 'local' problem, obtained as limit of the convolution kernel tending to a Dirac delta.

Non Local Conservation Laws in Vehicular Traffic and Cryptography

Rinaldo Colombo

University of Brescia

Non local conservation laws can be used to describe collective movements where individuals move with finite speed while the propagation of information is locally instantaneous. A typical situation is that of vehicular traffic. Recent results and open problems in this direction will be presented,

Besides, the analytical properties of non local balance laws suggest that they may serve also as an encryption tool. Examples will be presented, as well as the theorems on which they rely. Moreover, this point of view poses a variety of new analytical and numerical problems.

Boundary Layer Analysis in Diffusive Limits of Radiative Heat Transfer System

Mohamad Ghattassi

NYU Abu Dhabi

This work investigates the diffusive limit of nonlinear radiative heat transfer systems, focusing on boundary layers under various conditions, including reflective radiative, Dirichlet, Robin, and curved boundaries. The global existence of weak solutions is demonstrated using the Galerkin method, and the convergence of these solutions to a nonlinear diffusion model in the diffusive limit is established through compactness techniques, Young measure theory, and the Banach fixed-point theorem. This work also addresses the nonlinear Milne problem, where the nonlinearity of the Stefan-Boltzmann law introduces additional mathematical challenges. Existence, exponential decay, and uniqueness of solutions are proven using uniform estimates, monotonicity properties, and spectral assumptions. Furthermore, the coupling between elliptic and kinetic transport equations is resolved via combined $L^2 - L^\infty$ estimates. The extension to curved boundary domains includes a novel geometric correction for boundary layers, ensuring stability and convergence of solutions. These results significantly extend the existing mathematical framework for radiative heat transfer systems, providing a rigorous analysis of diffusive limits in complex geometries

Nonlocal macroscopic models of multi-population pedestrian flows for walking facilities optimization

Paola Goatin

Inria Centre of Université Côte d'Azur

We consider a class of nonlocal crowd dynamics models for N populations with different destinations trying to avoid each other in a confined walking domain. This can be formalized in a initial-boundary value problem for a system of nonlocal conservation laws, where the velocity vector field of each population depends on a nonlocal operator depending on the current density distribution. To account for the presence of obstacles, we proposed to evaluate the nonlocal operators on the convolution product of a kernel with the extended density including the presence of obstacles. Under suitable regularity assumptions, we prove a well-posedness result for the corresponding weak entropy solutions. The trick of incorporating the obstacles in the nonlocal operator allows to avoid including them in the vector field of preferred directions. In particular, we can address shape optimization problems aiming at finding the optimal position of the obstacles to minimize the total travel time, rewriting them as standard PDE-constrained optimization. In addition, to accelerate the numerical optimization procedure, we propose to address the computational bottleneck represented by the convolution products by a Finite Difference scheme that couples high-order WENO approximations for spatial discretization, a multi-step TVD method for temporal discretization, and a high-order numerical

derivative formula to approximate the derivatives of nonlocal terms, and in this way avoid excessive calculations.

Bayesian Inference for PDE's problems

Piotr Gwiazda

Polish Academy of Sciences

TBA

Modulated energy estimates for singular kernels and their applications

Jinwook Jung

Hanyang University

In this talk, we provide modulated interaction energy estimates for the kernel $K(x) = |x|^{-\alpha}$ with $\alpha \in (0, d)$, and their applications. The proof relies on a dimension extension argument for an elliptic operator and its commutator estimates. For the applications, we first discuss the quantified asymptotic limit of kinetic equations with singular nonlocal interactions. We show that the aggregation equations and the isothermal or pressureless Euler system with singular interaction kernels are rigorously derived. Second, we employ the estimates to establish the well-posedness theories in Hölder spaces for the kinetic and fluid equations involving singular interaction kernels, mainly about inviscid α-surface quasi-geostrophic (α-SQG) equations and kinetic Cucker-Smale model.

This talk is based on the collaboration with Y.-P. Choi (Yonsei Univ.) and J. Kim (Ajou Univ.).

Solutions at vacuum and rarefaction waves in pressureless Euler alignment system

Grzegorz Karch

University of Wroclaw

I shall present recent results, obtained jointly with Szymon Cygan, on an existence and large time behavior of solutions to the following Euler alignment system

$$
\begin{aligned}
&\rho_t + (\rho u)_x = 0, \\
&u_t + uu_x = \int_{\mathbf{R}} \frac{u(y,t) - u(x,t)}{|x-y|^{1+\alpha}} \rho(y,t)\, dy, \qquad x \in \mathbf{R}, \quad t > 0,
\end{aligned}
\tag{1}
$$

with $\alpha \in (0, 1)$. This model arises as the macroscopic realization of the Cucker and Smale agent model dynamics which describes the collective motion of N individuals in particular alignment and flocking.

We proved that, for a large class of initial conditions including bounded and compactly supported $\rho(x, 0)$ and suitably chosen $u(x, 0)$, the corresponding solutions of the initial value problem are global-in-time and behave for large values of time either as the Barenblatt profiles (*i.e* explicit self-similar solution) of the nonlocal porous medium equation or as a rarefaction wave (*i.e* the explicit self-similar solution of the inviscid Burgers equation.)

From kinetic Fokker—Planck to Isentropic Euler equations

Dowan Koo

Yonsei University

In this talk, I propose a kinetic Fokker–Planck equation with porous medium diffusion, which hydrodynamically relaxes to the isentropic Euler equations. This extends the well-known result of the nonlinear Fokker–Planck equation with linear diffusion, whose hydrodynamic limit corresponds to the isothermal Euler equations. We establish the asymptotic analysis by the relative entropy method, crucially employing the Log-Sobolev inequality for the porous medium diffusion.

This talk is based on a joint work with José A. Carrillo (University of Oxford).

Sticky Particle Solutions of the Euler Alignment system

Trevor Leslie

Illinois Institute of Technology

We discuss the theory of weak solutions for the Euler Alignment system with bounded or weakly singular communication protocol, in 1 spatial dimension (with remarks on ongoing work in the unidirectional case if time allows). The special structure in 1D allows one to reduce the two equations of the system to consideration of a single scalar balance law, the natural entropy conditions of which are compatible with a discretization of the system via "sticky particle" dynamics. This framework is inspired by work by Brenier and Grenier on the pressureless Euler Equations.

The main work discussed is joint with Changhui Tan (University of South Carolina).

The Compressible Euler System with Nonlocal Pressure

Piotr Boguslaw Mucha

University of Warsaw

In this talk, I will present a modified version of the compressible barotropic Euler system with friction, where a nonlocal, "fuzzy" pressure term replaces the traditional pressure. This nonlocal pressure is parameterized by $\epsilon > 0$, with the system formally converging to the classical pressure model as ϵ approaches zero. The main objective is to demonstrate that this modified system reliably approximates the classical compressible Euler system. Our findings are parameter-independent, allowing us to rigorously establish the convergence of solutions to those of the classical Euler system. An additional result is a rigorous derivation of the mass equation converging to various forms of the porous media equation as friction tends to infinity. This analysis is carried out in the whole space, which requires the use of an appropriate L1-in-time framework.

The talk is based on joint work with Raphael Danchin from Paris.

Chase-and-run interactions in heterogeneous populations

Kevin Painter

Politecnico di Torino

In a chase-and-run dynamic, members of one population chase members of another population. Interactions of this occur across systems from cellular (e.g. neural crest and placode cells), to animals (e.g. predators and prey), including humans (e.g. children in a playground). In this talk I will discuss the various forms of macroscopic behaviour that can be observed under such interactions, where phenomena range from stationary patterns to oscillating dynamics to a sustained chase-and-run at the population level (a group chasing another group). To explore the key drivers we focus on the interaction ranges – the distances over which populations interact with each other – showing that distinct interaction ranges strongly determine the type of macroscopic behaviour that emerges. We discuss the results in terms of robust collective migration of cellular populations during embryonic development.

Joint result with Sara Bernardi, Valeria Giunta, and Jonathan Potts.

Monge-Kantorovich distance and PDEs

Benoit Perthame

Sorbonne Université

The Monge transfer problem goes back to the end of the 18th century. It consists in minimizing the transport cost of a material from a mass distribution to another. Monge could not solve the problem and the next significant step was achieved 150 years later by Kantorovich who introduced the transport distance between two probability measures as well as the dual problem.

The Monge-Kantorovich distance is not easy to use for Partial Differential Equations and the method of a global doubling the variables is one of them. It is very intuitive in terms of stochastic processes and this provides us with a method for conservative PDEs as parabolic equations (possibly fractional), homogeneous Boltzman equation, scattering equation or porous medium equation...

Structured equations, as they appear in mathematical biology, are a particular class where the method can be used.

Hydrodynamic limit of singular alignment

Jan Peszek

University of Warsaw

One of the key goals in deriving hydrodynamic limits of multi-agent systems is to uncover interesting and useful macroscopic properties of their dynamics. In the case of classical hard-sphere interactions, the transition from a particle system to the Boltzmann equation, and eventually to the Navier-Stokes equations, leads to a significant simplification of the underlying chaotic dynamics. In this talk, I will present the natural hydrodynamic limit of the Cucker–Smale flocking model with a strongly singular communication weight - namely, the pressureless fractional Euler-alignment system - and address the question: what macroscopic properties emerge due to the singular nature of the interactions?

Stability of solutions to the filtration equation

Katarzyna Ryszewska

Polish Academy of Sciences

In the talk we consider a macroscopic model for the dynamics of living tissues incorporating pressure-driven dispersal and pressure-modulated proliferation. Given a power-law constitutive relation between the pressure and cell density, the model can be written as a porous medium equation with a growth term. We prove Lipschitz continuity of the mild solutions of the model with respect to the diffusion parameter (the exponent γ in the pressure-density law) in the L_1 norm. This result is a consequence of more general study conducted in [1], where the filtration equation is considered.

This is a joint work with T. Dębiec, P. Gwiazda, B. Miasojedow, Z. Szymańska, A. Wróblewska-Kamińska.

Localisation Limits and Degenerate Cross-Diffusion Systems

Markus Schmidtchen

TU Dresden

In recent years, there has been a spike in interest in multiphase tissue growth models. Depending on the type of tissue, the velocity is linked to the pressure through the nonlocal Brinkman law or the local Darcy law. While both velocity-pressure relations have been studied in the literature separately, only little emphasis has been placed on the relationship between them. In this talk, we report on several advances on localisation limits connecting both frameworks.

This is joint work with N. David, T. Dębiec, and M. Mandal.

Hamilton-Jacobi equations on Wasserstein spaces and applications

Benjamin Seeger

University of North Carolina at Chapel Hill

: In recent years, the study of differential equations on the space of probability measures has become increasingly active, in view of their many applications to mean field game theory, large deviations, and statistical physics. The analysis of such equations is difficult due to the nonlinear and infinite-dimensional nature of the underlying space. We discuss recent methods developed to address the well-posedness of such equations, as well as their applications as mean-field models for competition among a large number of interacting agents. Both qualitative and quantitative convergence results are presented for the finite agent models to the mean field ones.

This is joint work with Samuel Daudin (Université Paris-Cité) and Joseph Jackson (University of Chicago).

Existence and long time behavior of weak solutions to the Fokker-Planck-Alignment models

Roman Shvydkoy

University of Illinois at Chicago

In this talk we discuss the global existence of weak solutions, regularization, and global relaxation to Maxwellian for a broad class of Fokker-Planck-Alignment models which appear in collective dynamics. The main feature of these results, as opposed to previously known ones, is the lack of regularity or no-vacuum requirements on the initial data. With a particular application to the classical kinetic Cucker-Smale model, we demonstrate that any bounded data with finite energy, $(1 + |v|^2)f_0 \in L^1$, $f_0 \in L^\infty$, and finite higher moment $|v|^q f \in L^2$, $q \gg 2$, gives rise to a global instantly smooth solution, satisfying entropy equality and relaxing exponentially fast. The results are achieved through the use of a new thickness-based renormalization procedure, which circumvents the problem of degenerate diffusion in non-perturbative regime.

Optimal rate of convergence for a nonlocal-to-local limit in one dimension

Jakub Skrzeczkowski

University of Oxford

We consider a nonlocal approximation of the quadratic porous medium equation where the pressure is given by a convolution with a mollification kernel. It is known that when the kernel concentrates around the origin, the nonlocal equation converges to the local one. However, the question of how fast it converges is not well-explored in the literature. In one spatial dimension, for a particular choice of the kernel, and under mere assumptions on the initial condition, we quantify the rate of convergence in the 2-Wasserstein distance. First, we reprove the recent result of Amassad and Zhou (2025) yielding the rate of $\sqrt{\epsilon}$ using a simpler technique based on the Evolutionary Variational Inequality for both nonlocal and local equations. Next, using numerical simulations, we observe that the rate of $\sqrt{\epsilon}$ is not optimal. Therefore, we obtain a new formula for the Wasserstein distance between two abstract gradient flows which, when applied to the problem, together with Aronson-Benilian estimates, yields the rate of ϵ, suggested to be optimal by numerics.

This is joint work with J.A. Carrillo, S. Fronzoni (Oxford), C. Elbar (Lyon), P. Gwiazda (Warsaw).

Construction of weak solutions to a pressureless viscous model driven by nonlocal attraction–repulsion

Maja Szlenk

Université Savoie Mont Blanc

We analyze the pressureless Navier-Stokes system with nonlocal attraction–repulsion forces. Such systems appear in the context of models of collective behavior. We prove the existence of weak solutions on the whole space $\mathbb{R}^3$ in the case of density-dependent degenerate viscosity. For the nonlocal term, it is assumed that the interaction kernel has the quadratic growth at infinity and almost quadratic singularity at zero. Under these assumptions, we derive the analog of the Bresch–Desjardins and Mellet–Vasseur estimates for the nonlocal system, which, in particular, allow us to adapt the approach of Vasseur and Yu (2016) to construct a weak solution.

This is the joint work with Piotr Mucha and Ewelina Zatorska.

On the relative entropy method and unconditional stability of radially symmetric steady states of compressible viscous fluids.

Agnieszka Świerczewska-Gwiazda

University of Warsaw

I will discuss various applications of the relative entropy method in equations of fluid mechanics such as weak strong uniqueness results or asymptotic limits. I will mostly concentrate on recent result on unconditional stability of certain radially symmetric steady states of compressible viscous fluids in domains with inflow/outflow boundary conditions. This means that any not necessarily radially symmetric solution of the associated evolutionary problem converges to a single radially symmetric steady state.

On nonlocal traffic flow models

Changhui Tan

University of South Carolina

In this talk, I will present a family of traffic flow models that incorporate nonlocal, look-ahead interactions. While the classical Lighthill–Whitham–Richards (LWR) model is known to develop shock formations in finite time, corresponding to the onset of traffic jams, we explore how nonlocal extensions of the model can mitigate this behavior. These nonlocal models can be derived from discrete cellular automata frameworks. A key finding is that under appropriate conditions, the inclusion of nonlocal slowdown effects can prevent shock formation. This phenomenon also extends to the second-order Aw–Rascle–Zhang (ARZ) model with analogous nonlocal interactions.

Kinetic Description and Macroscopic Limit of Swarming Dynamics with Continuous Leader-Follower Transitions

Andrea Tosin

Politecnico di Torino

We present a kinetic description of swarming particle dynamics in an interacting multi-agent system featuring emerging leaders and followers. Agents are characterised by their position and velocity plus a continuous parameter quantifying their degree of leadership. From the kinetic description, we obtain a macroscopic model under a hydrodynamic limit reminiscent of that used to tackle the hydrodynamics of weakly dissipative granular gases, thus relying in particular on a regime of small non-conservative and short- range interactions.

Joint work with E. Cristiani (Rome), N. Loy (Torino), M. Menci (Rome).

The Maxwell-Stefan system of multi-component diffusion

Athanasios E. Tzavaras

King Abdullah University of Science and Technology (KAUST)

The Maxwell-Stefan System is a system of nonlinear equations commonly used in the description of diffusion processes in multi-component systems, like gases with many constituents. I will first discuss how the Maxwell-Stefan system emerges through a process of alignment in the high-friction limit of multi-component Euler flows. Then I focus to : (i) Analytical issues on existence and uniqueness of the Maxwell-Stefan system; (ii) The connection between minimization of the frictional dissipation and the Maxwell-Stefan system.

Non-uniqueness for continuous solutions to 1D conservation laws

Alexis Vasseur

The University of Texas at Austin

In this talk, we show that geometrical condition on 2×2 systems of conservation laws leads to non-uniqueness in the class of 1D continuous functions. This demonstrates that the Liu Entropy Condition alone is insufficient to guarantee uniqueness, even within the mono-dimensional setting. We provide examples of systems where this pathology holds, even if they verify stability and uniqueness for small BV solutions. Our proof is based on the convex integration process. Notably, this result represents the first application of convex integration to construct non-unique continuous solutions in one dimension.

This is a joint work with Robin Ming Chen, and Cheng Yu.

Coupled Vlasov and non-Newtonian fluid dynamics

Aneta Wróblewska-Kamińska

Polish Academy of Sciences

We study a coupled kinetic-non-Newtonian fluid system on the periodic domain, where particles evolve by a Vlasov equation and interact with an incompressible power-law fluid through a drag force. We prove the global existence of weak solutions for large enough power-law exponent of the fluid's stress-strain relation. Under an additional uniform boundedness assumption on the particle density, we also establish large-time decay of a modulated energy functional measuring deviation from velocity alignment which depends on the range of power-law exponent, reflecting the role of fluid dissipation in the large-time dynamics.

This is recent joint work with Young-Pil Choi and Jinwook Jung.

Global regularity and infinite Prandtl number limit of temperature patches for the Boussinesq system

Jiakun Yang

Beijing Normal University

The talk revolves the global regularity and infinite Prandtl number limit of temperature patches for the 2D non-diffusive Boussinesq system with dissipation in the full subcritical regime. Our first main result is a persistence of regularity of the patches globally in time. Importantly, our proof is robust enough to show uniform dependence on the Prandtl number in some cases. In addition, by studying the limit when the Prandtl number goes to infinity, we find that the patch solutions to the 2D Boussinesq system in the torus converge to the unique patch solutions of the (fractional) Stokes-transport equation and that the regularity of the patch boundary is globally preserved.

This is based on a joint work with Dr. Omar Lazar and Prof. Liutang Xue.

Finite time blow-up for consensus dynamics and applications

Mattia Zanella

University of Pavia

We introduce a new class of kinetic equations to explore mass-dependent effects in Fokker-Planck-type models originally developed for quantum indistinguishable particles in a spatially homogeneous setting. By analyzing the resulting PDE governing particle density evolution, we characterize the regimes in which a critical mass leads to finite-time blow-up of the solution. Finally, we discuss the implications of these findings for global optimization problems.

Index of speakers