Aspects locaux et non locaux en mécanique des fluides

Rapport sur les contributions

https://indico.math.cnrs.fr/e/alone

ID de Contribution: **1** Type: **Non spécifié**

Transport and mixing of phoretic or active particles

mercredi 15 mars 2023 14:00 (1h 45m)

Diffusiophoresis is a phenomenon which induces a transport of microparticles suspended in a solvent when salinity gradients are present. This effect, whose origin relies on charge effects at the surface of the particles, results in a tiny velocity drift with respect to the fluid flow which advect them. In this talk, I will discuss the physical origin of diffusiophoresis and its consequences when jointly mixing salt and colloids. I will explain how a one percent modification of the flow can radically modify this advection-diffusion problem, accelerating or delaying mixing, or leading to particle trapping in flows with closed streamlines. Depending on time, I will discuss the dynamics and modelization of an active system made of interacting camphor swimmers whose propulsion mechanism relies on the concentration inhomogeneities they create when releasing camphor at the surface of water.

Orateur: VOLK, Romain (Laboratoire de Physique, ÉNS Lyon)

ID de Contribution: **2** Type: **Non spécifié**

Hard congestion limit of the p-system in the BV setting

mercredi 15 mars 2023 16:00 (50 minutes)

In this talk, I will present a justi cation of the transition from a compressible (inviscid) system with singular pressure, modeling short range repulsive forces, towards a mixed compressible-incompressible system modeling partially congested dynamics. These systems may be used for the modeling of mixtures, of collective motions or partially free surface flows where a maximal constraint on the density or the height of the flow has to be taken into account. From the mathematical standpoint, I will develop an analysis for small perturbations of a reference profi le in the framework of BV solutions. This is a joint work with Fabio Ancona (Universit\‘a di Padova) and Roberta Bianchini (CNR, Roma).

Orateur: PERRIN, Charlotte (I2M, Aix-Marseille Université)

ID de Contribution: **3** Type: **Non spécifié**

Compressible flows with anisotropic diffusion in stationary regime

mercredi 15 mars 2023 16:50 (50 minutes)

The first result concerning the problem of the existence of weak solutions “à la Leray’“, in dimensions 2 or 3, for the stationary Navier-Stokes system governing the flow of compressible, viscous fluids was obtained in 1998 by P-L. Lions under the hypothesis of isotropic diffusion at constant shear and volume viscosities.
In this talk I will present a new proof of this result, witch will allow us to consider in the equation of momentum a diffusion operator that can be anisotropic or non-local. This is a physically relevant situation, for example for mixtures, which was outside the framework of the theory developed by Lions. This is joint work with Didier Bresch.

Orateur: BURTEA, Cosmin (IMJ-PRG, Université Paris-Cité)

ID de Contribution: **4** Type: **Non spécifié**

Derivation of a compressible flow model with bubbles

jeudi 16 mars 2023 09:00 (50 minutes)

We are interesting in modelling a flow with compressible bubbles by a homogeneisation method. At the microscopic scale, the fluid is described by the compressible Navier-Stokes system, while the bubbles behaviour is described individually. The novelty of the model relies in the fact that it takes into account the surface tension at the interfaces. Assuming that the number of bubbles diverges, we propose a construction of the macroscopic quantities.
We present the related system of macroscopic equations, which is composed by an evolution equation for the volume fraction and also by a kinetic equation for the distribution function of the bubbles. This is a joint work with M. Hillairet and N. Seguin.

Orateur: MATHIS, Hélène (IMAG, Université de Montpellier)

ID de Contribution: **5** Type: **Non spécifié**

Bounds on dissipation in compressible convection

jeudi 16 mars 2023 09:50 (50 minutes)

Concerning geophysical or astrophysical objects, we sometimes have measurements of the heat flux that escapes from them. For instance, the net heat flux leaving the Earth is approximately 47 TW (Davies and Davies, Solid Earth, 2010), while the luminosity ("heat flux" in astrophysics) of the Sun is $3.83 \sim 10^26$ W. Given that the heat flux is transported by convection, at least partly, one would like to know how much internal energy dissipation is associated with that heat flux. In mathematical terms, this question can be adressed in a simplified Rayleigh-Benard geometry. In the Boussinesq approximation, the answer is straightforward and the total (time-averaged) energy dissipated is equal to the product of the (time averaged) heat flux and the dimensionless dissipation number. In compressible convection, the answer depends on the flow configuration. We can then look for lower and upper bounds of the ratio of dissipation over heat flux. From numerical simulations, we obtain a small-scale flow configuration leading to a specific ratio when the Rayleigh number becomes sufficiently large. We will discuss whether that value can be used in general geo and astrophysical objects.

Orateur: ALBOUSSIÈRE, Thierry (LGL, ÉNS Lyon & Université Claude Bernard Lyon 1)

ID de Contribution: **6** Type: **Non spécifié**

Orientation mixing in active suspensions

jeudi 16 mars 2023 11:00 (50 minutes)

We consider a model introduced by Saintillan and Shelley to describe active suspensions of elongated particles. This model, which generalizes the classical Doi model for passive suspensions, couples a Stokes equation for the fluid substrate and a transport equation for the density distribution of particles in space and orientation. We investigate mixing properties of this model (damping and enhanced dissipation). The main new feature of the analysis is that the usual velocity variable of the euclidean space is replaced by an orientation variable on the sphere, which is responsible for strong qualitative changes and new mathematical difficulties. This is joint work with M. Coti Zelati and H. Dietert.

Orateur: GÉRARD-VARET, David (IMJ-PRG, Université Paris-Cité)

ID de Contribution: **7** Type: **Non spécifié**

Convergence of α-Euler to Euler for low regularity

jeudi 16 mars 2023 11:50 (50 minutes)

We consider the α-Euler equations on a bounded domain with Dirichlet boundary conditions in dimension two. We prove the convergence to the Euler equations when α goes to 0 when the potential vorticity belongs to L^p with $p \geq 1$ or is a bounded positive measure.

Orateur: BUSUIOC, Valentina (ICJ, Université Jean-Monnet Saint-Étienne)

ID de Contribution: **8** Type: **Non spécifié**

Non-homogeneous fluids with low regularity density and dynamical interpolation methods

jeudi 16 mars 2023 14:30 (1h 45m)

We are interested in the global existence and uniqueness issue for systems of PDEs describing the evolution of non-homogeneous viscous fluids.
In particular, we focus on the non-homogeneous incompressible Navier-Stokes system (INS) and on the system for pressureless gases (PNS). Despite their strong formal similarity – coupling between a mass conservation equation and a parabolic-type equation, same scaling invariance and same energy identity – those systems enjoy very different properties.

For (INS), we know from a short note of Kazhikov in 1974 that any initial datum consisting of a finite energy velocity field and a density bounded away from vacuum generates a global weak solution. However, apart from the case of constant density in dimension 2, the question of the uniqueness of such solution remains open. Moreover, we know many results on regular solutions in Sobolev and Besov spaces.
On the contrary, the number of results available for the (PNS) system is much lower, and establishing global results, even for small data, looks more delicate.

In this talk, we present global results with uniqueness for those two systems in some two-dimensional domains (under quite mild assumptions on the domain), which hold for densities having large variations but being bounded away from vacuum.
The initial velocity field belongs to a critical space, constructed by real interpolation, which is very close to the energy space. The velocity has to satisfy a smallness condition with respect to the viscosity coefficient for (PNS), whereas it can be arbitrarily large for (INS).

For the two systems, the constructed solution possesses a continuous differentiable flow, a fact which ensures the persistence of C^1 regularity of the discontinuity interfaces of the density and allows, via a lagrangian change of coordinates, to prove uniquess and stability of the solution with respect to perturbations of the initial datum.

The proof mainly relies on energy estimates with time-dependent weights, combined with a robust dynamical interpolation method. The choice of the functional spaces for the initial velocity is not the same for (PNS), which verifies a (almost) maximum principle, and for (INS), for which such property is false.

Orateur: DANCHIN, Raphaël (LAMA, Université Paris-Est Créteil)

ID de Contribution: **9** Type: **Non spécifié**

Numerical simulation of suspensions: taking close interactions into account

jeudi 16 mars 2023 16:30 (50 minutes)

We address the problem of numerical simulation of suspensions of rigid particles in a Stokes flow. We focus on the inclusion of the singular short range interaction effects (lubrication effects) in the simulations when the particles come close one to another. Taking into account these lubrication effects in numerical simulations is a difficult problem: capturing the singularity requires, for example, the use of very fine meshes in the gap between the particles.

We describe here two methods allowing to take into account lubrication without mesh refinement. The first one is based on an asymptotic development of the solution in the narrow gap between the particles. It allows to obtain accurate results with classical direct methods (finite elements,…) for coarse meshes, without adding new assumptions or new models. We will then describe a second method, based on a viscous contact model. This new contact model, coupled with a fluid solver, allows a good consideration of the effects of lubrication (which are not captured by the solver for coarse meshes).

Orateur: LEFEBVRE-LEPOT, Aline (CMAP, École Polytechnique)

ID de Contribution: **10** Type: **Non spécifié**

Nonlinear stability of 2D periodic waves of reaction-diffusion system

vendredi 17 mars 2023 09:00 (50 minutes)

In this talk we explain how to prove the nonlinear asymptotic stability of multiD periodic steady solutions that are diffusively spectrally stable, focusing our attention on the 2D case. Our goal is to extend the comprehensive theory now available for plane periodic waves to the multidimensional context. All this work is performed on reaction-diffusion systems but we expect it can be extended to viscous conservation laws. We show that two kind of asymptotic behavior can occur: a scalar-type and a dispersive type. This is a joint work with Miguel Rodrigues (IRMAR).

Orateur: MELINAND, Benjamin (CEREMADE, Université Paris Dauphine)

ID de Contribution: **11** Type: **Non spécifié**

Some recent trends for the regularity of the 3D Navier-Stokes equations

vendredi 17 mars 2023 09:50 (50 minutes)

In this talk we will review different recent aspects of the regularity for the 3D Navier-Stokes equations: (i) new versions of epsilon regularity, (ii) concentration near potential singularities, (iii) quantitative regularity, (iv) geometric aspects. The talk is based on works with Dallas Albritton, Tobias Barker, Pedro Fernandez-Dalgo and Jin Tan.

Orateur: PRANGE, Christophe (Laboratoire de Mathématiques AGL, Cergy Paris Université)

ID de Contribution: **12** Type: **Non spécifié**

Spontaneous oscillations and catastrophic events during fluid injection in water-saturated sands

vendredi 17 mars 2023 11:00 (50 minutes)

Although multiphase flows are ubiquitous in natural and industrial systems, the comprehension of the physical mechanisms at stake is still a challenge. In particular, the link between the processes at the microscale – grain size, shape, asperities – and the behavior at larger scale (particle suspension, transport, emergence of instabilities\ldots) remains unknown. Based on laboratory experiments, we investigate the dynamics of a confined granular layer submitted to a localized fluid injection. A suspension results from the competition between particle entrainment and sedimentation. In a given range of parameters and for different experimental configurations, the system exhibits puzzling self-induced oscillations and unexpected, violent particle resuspension. The importance of such phenomena will be discussed in regards to geophysical and environmental applications.

Orateur: VIDAL, Valérie (Laboratoire de Physique, ÉNS Lyon)

ID de Contribution: **13** Type: **Non spécifié**

First-order evolution PDEs under density constraints

vendredi 17 mars 2023 11:50 (50 minutes)

I will present a class of evolution equations which are characterized by the presence of an upper density constraint and of the gradient of an unknown, scalar, pressure affecting the drift in order to enforce such a density constraint. We studied these PDEs, in a series of papers in collaboration with Bertrand Maury and other co-authors, motivated by their applications to crowd motion models, but they have also been studied by other communities in connection with the Hele-Shaw flow and/or of the mesa problem for porous media or tumor growth models. These equations can be seen as a gradient flow of a very singular functional in the Wasserstein space, which is useful for some existence and for the easiest uniqueness results, but can also be seen as the limit of porous medium evolution when the exponent tends to infinity, which has been used by other authors (Noemi David and Markus Schmidtchen, in particular), to obtain new integrability estimates.
The goal of the talk will be to introduce the main questions and results, with a particular emphasis to the most recent ones, and the connections with other problems.

Orateur: SANTAMBROGIO, Filippo (ICJ, Université Claude Bernard Lyon 1)