BMS workshop

mercredi 22 mai 2024 - vendredi 24 mai 2024

INRIA

Recueil des résumés

Contents

1

David Gérard-Varet - Analyse mathématique des couches limites

Nous tenterons dans cet exposé de faire une synthèse de résultats mathématiques obtenus ces dernières années autour du phénomène de couche limite en hydrodynamique.

2

Giacomo Dimarco - Control and uncertainty quantification through deep neural networks for plasma simulation

We will consider the development of numerical methods for simulating plasmas in magnetic confinement nuclear fusion reactors. In particular, we focus on the Vlasov-Maxwell equations describing out of equilibrium plasmas influenced by an external magnetic field and we approximate this model through the use of particle methods. We will additionally set an optimal control problem aiming at minimizing the temperature at the boundaries of the fusion device or alter- natively the number of particles hitting the boundary. Our goal consists then in confining the plasma in the center of the physical domain. In this framework, we consider the construction of multifidelity methods based on neural network architectures for estimating the uncertainties due to the lack of knowledge of all the physical aspects arising in the modeling of plasma.

3

Urbain Vaes - Derivative-free Bayesian Inversion Using Multiscale Dynamics

Inverse problems are ubiquitous because they formalize the integration of data with mathematical models. In many scientific applications the forward model is expensive to evaluate, and adjoint computations are difficult to employ; in this setting derivative-free methods which involve a small number of forward model evaluations are an attractive proposition. Ensemble Kalman based interacting particle systems (and variants such as consensus based and unscented Kalman approaches) have proven empirically successful in this context, but suffer from the limitation that they cannot be systematically refined to return the true solution, except in the setting of linear forward models. In this talk, we present a new derivative-free approach to Bayesian inversion, which may be employed for posterior sampling or for maximum a posteriori (MAP) estimation, and can be systematically refined. The method relies on a fast/slow system of stochastic differential equations (SDEs) for the local approximation of the gradient of the log-likelihood appearing in a Langevin diffusion.

4

Frédéric Lagoutière - Convergence of a semi-discrete mesoscopic

multi-fluid model toward the Baer-Nunziato equations

We consider a bi-fluid Navier-Stokes semi-discrete model with two fluids with different pressure laws, at a scale where they are unmixed. We let this scale converge to 0 and we prove that the solution converges to the solution to the continuous Baer-Nunziato model in which all the coefficients are known (including the relaxation coefficient). The interest of this semi-dicrete approach is that it is easily discretized, what allows to illustrate the theoretical results.
The results have been obtained in collaboration with Didier Bresch, Cosmin Burtea and Pierre Gonin–Joubert.

5

Analysis seminar - Daniel Han-Kwan

Thématiques:

6

Nina Aguillon - Barotropic/baroclinic splitting in ocean models

This numerical strategy is commonly used in the ocean model community to reduce the computationnal cost. This model are 3 dimensional and frequently run with over 40 layers along the vertical. In a monolothic code the timestep is constrained by the speed of the gravity waves. In the barotropic/baroclinic splitting, the surface waves and the mean horizontal velocities are treated in a 2D manner, which makes this severe CFL acceptable. This barotropic part very much looks like a classical one layer shallow water model. The remaining adjustements contain exchanges between the vertical layers and the 3D advection of the tracers. It is much more costly but has a large material time step. In this talk we present this strategy in the framework of multilayer shallow water model with terrain following coordinates and detail the operator splitting. We present several nice properties of both the barotropic and the baroclinic parts. Numerical results based on a 3D code on Cartesian grid will illustrate how state-to-art strategies can be re-employed in the barotropic part, such as the perservation of the geostrophic equilibrium. This is a joint work with Sophie Hörnschemeyer (RWTH Aachen) and Jacques Sainte-Marie (INRIA/LJLL).

7

Georg Maierhofer - Structure-preserving low-regularity integrators for dispersive nonlinear equations

Dispersive nonlinear partial differential equations can be used to describe a range of physical systems, from water waves to spin states in ferromagnetism. The numerical approximation of solutions

with limited differentiability (low regularity) is crucial for simulating fascinating phenomena arising in these systems including emerging structures in random wave fields and dynamics of domain wall states, but it poses a significant challenge to classical algorithms. Recent years have seen the development of tailored low-regularity integrators to address this challenge.
Inherited from their description of physical systems many such dispersive nonlinear equations possess a rich geometric structure, such as a Hamiltonian formulation and conservation laws. To ensure that numerical schemes lead to meaningful results, it is vital to preserve this structure in numerical approximations. This, however, results in an interesting dichotomy: the rich theory of existent structure-preserving algorithms is typically limited to classical integrators that cannot reliably treat low-regularity phenomena, while most prior designs of low-regularity integrators break geometric structure in the equation. In this talk, we will outline recent advances incorporating structure-preserving properties into low-regularity integrators. Starting from simple discussions on the nonlinear Schrödinger and the Korteweg–de Vries equation we will discuss the construction of such schemes for a general class of dispersive equations before demonstrating applications of these algorithms including to nonlinear Schrödinger equations with random dispersion, and to the simulation of low-regularity vortex filaments. This is joint work with Yvonne Alama Bronsard, Jianbo Cui, Valeria Banica, Yvain Bruned, and Katharina Schratz.

8

Pauline Lafitte - Towards a scheme of uniform order in time for the Fokker-Planck equation

The sensitive issue of the discretisation of Neumann's boundary condition for a Fokker-Planck equation while preserving self-adjointness led us to the study of an inconsistent scheme for the evolutionary or stationary heat equation. Together with Guillaume Dujardin, we showed the *uniform convergence in time* at order 1/2 for this last scheme, under a classical stability condition, and pursue this study for the Fokker-Planck equation.
This order of convergence is also the one obtained numerically.

9

Annika Lang - Computing solutions to stochastic partial differential equations on surfaces

Looking around us, many surfaces including the Earth are no plain Euclidean domains but special cases of Riemannian manifolds. One way of describing uncertain physical phenomena on these surfaces is via stochastic partial differential equations. In this talk, I will introduce how to compute approximations of solutions to such equations and give convergence results to characterize the quality of the approximations. Furthermore, I will show how these solutions on surfaces are a first step towards the computation of time-evolving stochastic manifolds.

10

Christophe Berthon - Artificial numerical viscosity to get discrete entropy inequalities

When considering the numerical approximation of weak solutions of systems of conservation laws, the satisfaction of discrete entropy inequalities is, in general, very difficult to be obtained. In the present talk, we present a suitable control of the artificial numerical viscosity in order to recover the expected discrete entropy inequalities. Moreover, the artificial viscosity control turns out to be very easy and it can be applied to any first-order finite volume scheme in a very convenient way.

11

Mireille Bossy - Long-range correlation modeling for Lagrangian transport in turbulence and application to reduced wind gust model

The ability to model, simulate, and predict dispersed turbulent two-phase flows is crucial for various industrial and environmental applications. In this context, the development of stochastic Lagrangian models for particle phase tracking is closely linked with the development of reduced PDE models, such as URANS or LES methods used in various applications. These models, which neglect small scales, cannot account for the temporal and spatial correlations inherent to the structured motions present in turbulent flow.

An exemplary manifestation of such structured motions are wind gusts. Using this unsteady, near-wall phenomenon as a starting point, I will introduce stochastic reduced Lagrangian transport models, discuss their application to wind time series, and outline the approaches we are developing to better account for the correlations induced by turbulent structures in these reduced models.

12

Philippe Helluy - High order entropy dissipative lattice-Boltzmann method

The Lattice-Boltzmann Method (LBM) is a highly efficient technique for simulating fluid flows. It is traditionally reserved to low-Mach viscous flows. In this talk we show how to extend it to compressible flows, thanks to the vectorial kinetic approach of Bouchut, how to achieve high-order accuracy with entropy dissipation and how to handle boundary conditions.