Activity Report 2016

Project-Team COFFEE

COmplex Flows For Energy and Environment

IN COLLABORATION WITH: Laboratoire Jean-Alexandre Dieudonné (JAD)

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Project-Team COFFEE

Creation of the Team: 2011 July 01, updated into Project-Team: 2013 January 01

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 6.2.1. - Numerical analysis of PDE and ODE
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 4.2. - Nuclear Energy
 7.1. - Traffic management

1. Members

Research Scientist
 Thierry Goudon [Senior Researcher, Team leader, Inria, Research Scientist, HDR]

Faculty Members
 Florent Berthelin [Associate Professor, Univ. Nice, Faculty Member, HDR]
 Konstantin Brenner [Associate Professor, Univ. Nice, Faculty Member]
 Stéphane Junca [Associate Professor, Univ. Nice, Faculty Member, HDR]
 Stella Krell [Associate Professor, Univ. Nice, Faculty Member]
 Roland Masson [Professor, Univ. Nice, Faculty Member, HDR]
 Magali Ribot [Professor, Univ. Orléans, Faculty member, HDR]

PhD Students
 Laurence Beaude [Univ. Nice Région PACA]
 Mayya Groza [Univ. Nice, until Dec. 2016]
 Julian Hennicker [Univ. Nice & Total]
 Thi Huong Le [Univ. Nice-Erasmus]
 Giulia Lissoni [Univ. Nice]
 Julie Llobell [Univ. Nice]
 Bastien Polizzi [Univ. Nice, until Oct. 2016]
 Nathalie Ayi [Univ. Nice, until Oct. 2016]
 Pierre Castelli [Univ. Nice]

Post-Doctoral Fellows
 Arthur Vavasseur [Univ. Nice & ATER]
 Nabil Birgle [Inria-ANDRA]
 Feng Xing [Inria-BRGM]

Administrative Assistant
 Marie-Cécile Lafont [Inria]

2. Overall Objectives

2.1. Overall Objectives

The project aims at studying mathematical models issued from environmental and energy management questions. We consider systems of PDEs of hydrodynamic type or hybrid fluid/kinetic systems. The problems we have in mind involve unusual coupling, which in turn leads to challenging difficulties for mathematical analysis and the need of original numerical solutions. By nature many different scales arise in the problems, which allows to seek hierarchies of reduced models based on asymptotic arguments. The topics require a deep understanding of the modeling issues and, as far as possible boosted by the mathematical analysis of the equations and the identification of key structure properties, we wish to propose innovative and performing numerical schemes. To this end, the development of innovative Finite Volumes schemes with unstructured meshes on complex geometries will be a leading topic of the team activity.

3. Research Program

3.1. Research Program

Mathematical modeling and computer simulation are among the main research tools for environmental management, risks evaluation and sustainable development policy. Many aspects of the computer codes as well as the PDEs systems on which these codes are based can be considered as questionable regarding the established standards of applied mathematical modeling and numerical analysis. This is due to the intricate multiscale nature and tremendous complexity of those phenomena that require to set up new and appropriate tools. Our research group aims to contribute to bridging the gap by developing advanced abstract mathematical models as well as related computational techniques.

The scientific basis of the proposal is two–fold. On the one hand, the project is "technically–driven": it has a strong content of mathematical analysis and design of general methodology tools. On the other hand, the project is also "application–driven": we have identified a set of relevant problems motivated by environmental issues, which share, sometimes in a unexpected fashion, many common features. The proposal is precisely based on the conviction that these subjects can mutually cross-fertilize and that they will both be a source of general technical developments, and a relevant way to demonstrate the skills of the methods we wish to design.

To be more specific:

- We consider evolution problems describing highly heterogeneous flows (with different phases or with high density ratio). In turn, we are led to deal with non linear systems of PDEs of convection and/or convection–diffusion type.

- The nature of the coupling between the equations can be two–fold, which leads to different difficulties, both in terms of analysis and conception of numerical methods. For instance, the system can couple several equations of different types (elliptic/parabolic, parabolic/hyperbolic, parabolic or elliptic with algebraic constraints, parabolic with degenerate coefficients....). Furthermore, the unknowns can depend on different sets of variables, a typical example being the fluid/kinetic models for particulate flows. In turn, the simulation cannot use a single numerical approach to treat all the equations. Instead, hybrid methods have to be designed which raise the question of fitting them in an appropriate way, both in terms of consistency of the discretization and in terms of stability of the whole computation. For the problems under consideration, the coupling can also arises through interface conditions. It naturally occurs when the physical conditions are highly different in subdomains of the physical domain in which the flows takes place. Hence interface conditions are intended to describe the exchange (of mass, energy...) between the domains. Again it gives rise to rather unexplored mathematical questions, and for numerics it yields the question of defining a suitable matching at the discrete level, that is requested to preserve the properties of the continuous model.

- By nature the problems we wish to consider involve many different scales (of time or length basically). It raises two families of mathematical questions. In terms of numerical schemes, the multiscale feature induces the presence of stiff terms within the equations, which naturally leads to stability issues. A clear understanding of scale separation helps in designing efficient methods, based on suitable splitting techniques for instance. On the other hand asymptotic arguments can be used to derive hierarchy of models and to identify physical regimes in which a reduced set of equations can be used.

We can distinguish the following fields of expertise

- Numerical Analysis: Finite Volume Schemes, Well-Balanced and Asymptotic-Preserving Methods
    - Finite Volume Schemes for Diffusion Equations
    - Finite Volume Schemes for Conservation Laws
    - Well-Balanced and Asymptotic-Preserving Methods
- Modeling and Analysis of PDEs
    - Kinetic equations and hyperbolic systems
    - PDEs in random media
    - Interface problems

4. Application Domains

4.1. Porous Media

Clearly, the analysis and simulation of flows in porous media is a major theme in our team. It is strongly motivated by industrial partnerships, with Total, GdF-Suez, ANDRA, BRGM, etc. with direct applications in geothermy, geological storages, and oil and gas recovery.

Our research has first dealt with the discretization and convergence analysis of multiphase Darcy flows on general polyhedral meshes and for heterogeneous anisotropic media. We have investigated both the Vertex Approximate Gradient (VAG) scheme using both cell and vertex unknowns and the Hybrid Finite Volume (HFV) scheme using both cell and face unknowns. It is remarkable that the VAG scheme is much more accurate than existing nodal approaches (such as CVFE) for heterogeneous test cases: since it avoids the mixing of different rocktypes inside the control volumes, while preserving the low cost of nodal discretizations thanks to the elimination of cell unknowns without any fill-in. The convergence of the numerical discretizations has been studied for the problem of contaminant transport with adsorption in the case of HFV scheme and for two phase Darcy flows in global pressure formulation using particular VAG or HFV schemes, as well as the more general framework of gradient schemes. To reduce the Grid Orientation Effect, a general methodology is proposed in on general meshes. It is based on the recombination of given conservative fluxes to define new conservative fluxes on a richer stencil. On the same token, we have considered the transport of radionucleides by water in porous media. The question is naturally motivated by security studies of nuclear waste storage. We have dealt with the non linear Peaceman system, set on a heterogeneous domain, typically a layered geological medium. The system couples anisotropic diffusion equation and a diffusion-dispersion equation for the pollutant concentration. We have developed and analyzed a specific DDFV scheme to investigate such flows

4.2. Particulate and mixture flows

We investigate fluid mechanics models referred to as "multi–fluids" flows. A large part of our activity is more specifically concerned with the case where a disperse phase interacts with a dense phase. Such flows arise in numerous applications, like for pollutant transport and dispersion, the combustion of fuel particles in air, the modelling of fluidized beds, the dynamic of sprays and in particular biosprays with medical applications, engine fine particles emission... There are many possible modelings of such flows: microscopic

models where the two phases occupy distinct domains and where the coupling arises through intricate interface conditions; macroscopic models which are of hydrodynamic (multiphase) type, involving non standard state laws, possibly with non conservative terms, and the so–called mesoscopic models. The latter are based on Eulerian–Lagrangian description where the disperse phase is described by a particle distribution function in phase space. Following this path we are led to a Vlasov-like equation coupled to a system describing the evolution of the dense phase that is either the Euler or the Navier-Stokes equations. It turns out that the leading effect in such models is the drag force. However, the role of other terms, of more or less phenomenological nature, deserves to be discussed (close packing terms, lift term, Basset force...). Of course the fluid/kinetic model is interesting in itself and needs further analysis and dedicated numerical schemes. In particular, in collaboration with the Atomic Energy Commission (CEA), we have proposed a semi-Lagrangian scheme for the simulation of particulate flows, extending the framework established in plasma physics to such flows.

We also think it is worthwhile to identify hydrodynamic regimes: it leads to discuss hierarchies of coupled hydrodynamic systems, the nature of which could be quite intriguing and original, while they share some common features of the porous media problems. We are particularly interested in revisiting the modeling of mixture flows through the viewpoint of kinetic models and hydrodynamic regimes. We propose to revisit the derivation of new mixture models, generalizing Kazhikov-Smagulov equations, through hydrodynamic asymptotics. The model is of "hybrid" type in the sense that the constraint reduces to the standard incompressibility condition when the disperse phase is absent, while it involves derivatives of the particle volume fraction when the disperse phase is present.

4.3. Biological degradation, biofilms formation and algae proliferation

Members of the team have started an original research program devoted to biofilms formation and algae proliferation. We started working on this subject through a collaboration with Roberto Natalini and a group of experts in Firenze interested in preventing damages on historical monuments. It is also motivated by Ostreopsis proliferation in the Mediterranean Sea. The multidisciplinary character of this research relies on discussions with researchers of the Oceanography Laboratory in Villefranche-sur-Mer, a leading marine research unit, and the Inria team BIOCORE, led by J-L Gouzé. This research is supported by a ANR-project, led by M. Ribot, and it is the main topic of the PhD thesis of B. Polizzi.

5. New Software and Platforms

5.1. APPartFlow

FUNCTIONAL DESCRIPTION

We are developing experimental codes, mainly based on Finite Differences, for the simulation of particulate flows. A particular attention is paid to guaranty the asymptotic properties of the scheme, with respect to relaxation parameters.

- Contact: Thierry Goudon

5.2. Compass

FUNCTIONAL DESCRIPTION

Compass is a parallel code for the discretization of polyphasic flows by Finite Volumes methods. The code is mainly devoted to applications in porous media. It works on quite general polyhedral meshes.

- Participants: Thierry Goudon, Roland Masson, Cindy Guichard, Chang Yang and Robert Eymard
- Contact: Roland Masson
- URL: http://math.unice.fr/~massonr/ComPASSHighEnergyGeothermy.html

5.3. NS2DDV

Functional Description

It is devoted to the simulation of non-homogeneous viscous flows, in two-dimensional geometries. The code is based on an original hybrid Finite Volume/Finite Element scheme, it works on unstructured meshes and can include mesh refinements strategies.

- Contact: Creusé Emmanuel
- URL: math.univ-lille1.fr/~simpaf/SITE-NS2DDV/home.html

5.4. SimBiof

Functional Description

We are developing numerical methods, currently by using Finite Differences approaches, for the simulation of biofilms growth. The underlying system of PDEs takes the form of multiphase flows equations with conservation constraints and vanishing phases. The numerical experiments have permitted to bring out the influence of physical parameters on the multidimensional growth dynamics.

- Contact: Thierry Goudon

6. New Results

6.1. A few words on the results of the year

- Analysis of wave propagation in mechanics, partly in collaboration with phsyicsts [40], [24]
- Analysis of PDE system in chromatography [5] and in traffic flows modelling [30]
- Analysis of conservation laws, with many application like traffic flows, fluid mechanics, etc [29], [36], [37], [11], [18]
- Modeling of attractive dynamics between individuals, pattern formation, with the derivation, the analysis and simulations of hierarchies of mathematical models, from microscopic to macroscopic, [9], [17]
- Derivation and simulation of hydrodynamic models in biology (biofilms growth, intestinal gut), partly in collaboration with INRA, [4], [7], [16], [41], [2]
- Modeling and simulation of compositional multiphase flows in porous media, with many indisutrial collaborations with ANDRA< BRGM, EdF... [22], [32], [23], [33], [21], [34], [39], [42], [6], [20]
- Analysis of Finite Volume schemes in fluid mechanics [35], [15], [12], [38]
- Domain decomposition methods [43], [31]
- Many particles systems, effect of stochasticity [27], [1], [28], [8], [13], [10], [19], [3]

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Grants with Industry

The project has industrial collaborations with Total, GDFSuez EP and Storengy on oil and gas recovery and gas storage.

The collaboration with Andra is concerned with the modelling and the simulation of mass and heat exchanges between porous media and ventilation channels. It leads to consider porous medium equations and hydro-dynamic systems, coupled through intricate boundary conditions. Clearly one of the difficulties relies on the multiphase nature of the flows (at least water and air are present). We identify relevant physical scales, typical of the flows under consideration in nuclear waste engineering. We start by dealing with quite simple geometries, in order to discuss properly the order of magnitude of the different phenomena, and to design suitable schemes.

COFFEE has also a collaboration with BRGM, funded through the program "Carnot Institutes", devoted to the setting of a parallel computing platform for the simulation of geothermal reservoirs. We aim at contributing to the design of a new generation of parallel tools of simulations, addressing the stiffness issues of actual reservoirs, a large variety of mesh geometries, able to handle faulted media.

A large part of these works is based on the development of the software COMPASS.

8. Partnerships and Cooperations

8.1. Regional Initiatives

The team is involved in the recently granted project UCA-JEDI.

8.2. National Initiatives

8.2.1. ANR

The ANR-project Monumentalg, led by M. Ribot, is devoted to the modeling and simulation of biological damage on monuments and algae proliferation.

Coffee is among the partners of the project CHARMS, with a funding starting in 2016; the project is devoted to the modeling of reservoirs in complex hydrothermal networks.

8.2.2. National and European networks

- GdR MANU.

  The research group MANU has activities centered around scientific computing, design of new numerical schemes and mathematical modelling (upscaling, homogenization, sensitivity studies, inverse problems,...). Its goal is to coordinate research in this area, as well as to promote the emergence of focused groups around specific projects

- S. Junca is involved in the GdR-e "Wave Propagation in Complex Media for Quantitative and non Destructive Evaluation".

8.3. International Initiatives

8.3.1. Declared Inria International Partners

Team COKLYCO

Title: Modeling, analysis and simulation of kinetic and fluid models for MEMS

International Partner (Institution - Laboratory - Researcher):

Kyoto (Japan) - Department of Mechanical Engineering and Science (ME) - Aoki Kazuo

Start year: 2014 End year: 2016.

See also: https://team.inria.fr/coffee/?page_id=323

We wish to elaborate and analyse new models of microscopic and macroscopic type for Micro-Electro-Mechanical Systems (MEMS). The tiny scales of such technical devices induce new and challenging difficulties. A specific attention will be paid to the treatment of coupling conditions from moving boundaries, and to the multi-scale character of the problem. The project is based on a strong interplay between mathematical analysis, experiments and numerical simulations, made possible by the composition of the team.

8.3.2. Informal International Partners

Quite recently, S. Junca has started a collaboration with Mathias Legrand, from the Mechanical Engineering department at Mc Gill, Montréal with the supervision of the internship of a master student (S. Heng, 6 months, June-Nov. 2013). Furthermore, S. Junca is an active member of the European network "Wave propagation in complex media for quantitative and non destructive evaluation" [1]

S. Krell has a collaboration with Martin Gander (University of Geneva, Switzerland) on domain decomposition methods, adapted to DDFV discretizations.

M. Ribot started a collaboration with Roberto Natalini a couple of years ago. Connections with experts in Firenze was the starting point of the research on biofilm formation and algae proliferation. M. Ribot and R. Natalini have also worked on new well-balanced strategy — the so-called AHO schemes — in order to preserve equilibria and to capture correctly large time solutions for complex PDEs system, without knowing explicitly the equilibrium solution. They have co-advised 2 PhD thesis.

Finally, we have many international collaborations, with variable peaks of activity, in our research networks: A. Vasseur (U. T. Austin), P.E. Jabin (Univ. Maryland), J.-A. Carrillo (Imperial College London), S. Jin (U. W. Madison and Jiao Tong Univ.), R. Aavatsmark (Univ. of Bergen), etc.

M. Ribot spent a semester, funded by CNRS at ICL, UK.

8.4. International Research Visitors

Kazuo Aoki, from Taiwan, Satushi Taguchi, Takeru Yano, Shingo Kosuge from Kyoto and Osaka University.

9. Dissemination

9.1. Promoting Scientific Activities

9.1.1. Scientific Events Organisation

9.1.1.1. General Chair, Scientific Chair

We do not keep track of such activities.

9.1.1.2. Member of the Organizing Committees

We do not keep track of such activities.

9.1.2. Scientific Events Selection

9.1.2.1. Chair of Conference Program Committees

We do not keep track of such activities.

9.1.2.2. Member of the Conference Program Committees

We do not keep track of such activities.

9.1.2.3. Reviewer

We do not keep track of such activities.

9.1.3. Journal

9.1.3.1. Member of the Editorial Boards

T. Goudon if founding editor and co-Editor in chief of SMAI-J. Computational Mathematics

9.1.4. Invited Talks

We do not keep track of such activities.

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[1] http://www.gdre-us.cnrs-mrs.fr/spip.php?rubrique8

9.1.5. Scientific Expertise

FONDECYT (Chili), CERG (Hong-Kong), National Evaluation and Foresight Agency (Espagne), FRS-FNRS (Belgique), ANR and AERES/HCERES.

T. Goudon is member of Scientific Committees of CIRM and FSMP.

9.1.6. Research Administration

Roland Masson is the head of the team PDE and Numerical Analysis of the laboratory J.A. Dieudonné.

Thierry Goudon is member of the Evaluation Committee of Inria.

Thierry Goudon is Scientific Officer at the French Ministry of Education and Research.

9.2. Teaching - Supervision - Juries

9.2.1. Teaching

Members of the team are faculties of University Nice Sophia Antipolis and they teach in all degrees of the University.

T. Goudon is President of the national competition to hire teachers (agregation de mathematiques).

9.2.2. Supervision

PhD : Arthur Vavasseur, Kinetic models for particles interacting with their environment , Univ. Côte d'Azur, Oct. 2016, supervised by T. Goudon

PhD : Nathalie Ayi, Influence of stochasticity on many-scale problems, Univ. Côte d'Azur, Sept. 2016, supervised by F. Berthelin & L. Saint Raymond (DMA-ENS)

PhD : Bastien Polizzi, Modeling and numerical simulations for fluid mechanics systems with constraints ; application to biology and road traffic, Univ. Côte d'Azur, Sept. 2016, supervised by M. Ribot & T. Goudon

PhD : Maya Grozza, Modelization and discretization of two-phase flows in porous media with discrete fracture networks Univ. Côte d'Azur, Nov. 2016, supervised by R. Masson with Laurent Jeannin (GDFSuez EP), and Jean Frédéric Thebault (Storengy)

PhD in progress : Laurence Beaude, started in november 2015, co-supervised by R. Masson, K. Brenner from LJAD and S. Lopez, F. Smai from BRGM, Discretization of high energy geothermal systems in faulted porous media

PhD in progress : Julian Hennicker, started in june 2014, co-supervised by R. Masson, K. Brenner and P. Samier from TOTAL, Discretization of multiphase Hybrid dimensional Darcy flow models in fractured porous media.

PhD in progress : Julie Llobell, stated Sept. 2015, co-supervised by T. Goudon and S. Minjeaud (team Castor), Staggered schemes for conservation laws of gas dynamics.

PhD in progress : Giulia Lissoni, started Sept. 2016, co-supervised by T. Goudon and S. Krell, Domain decomposition and DDFV methods.

PhD in progress : Thi Huong, started June 2014, Le, supervised by S. Junca, vibrations and mechanical systems, nonlinear modes with an unilateral constraint.

PhD in progress : Pierre Castelli, started Sept. 2013, supervised by S. Junca, smoothing effect for conservation laws (P. Castelli is teacher at Lycée d'Audiberti, Antibes)

The bibliography is automatically extracted form hal; it looks far from complete.

10. Bibliography

Publications of the year

Doctoral Dissertations and Habilitation Theses

[1] N. AYI. *Stochastic influence on change of scale problems*, Université Nice Sophia Antipolis [UNS], September 2016, https://tel.archives-ouvertes.fr/tel-01407438

[2] B. POLIZZI. *Modeling and numerical simulations for fluid mechanics systems with constraints; application to biology and road traffic*, Université Nice Sophia Antipolis, September 2016, https://hal.archives-ouvertes.fr/tel-01421823

[3] A. VAVASSEUR. *Kinetic models for particles interacting with their environment*, Universite Cote d'Azur, October 2016, https://hal.archives-ouvertes.fr/tel-01421822

Articles in International Peer-Reviewed Journals

[4] F. BERTHELIN, D. CHIRON, M. RIBOT. *Stationary solutions with vacuum for a one-dimensional chemotaxis model with non-linear pressure*, in "Communications in Mathematical Sciences", 2016, vol. 14, n° 1, pp. 147–186, https://hal.archives-ouvertes.fr/hal-01070625

[5] C. BOURDARIAS, M. GISCLON, S. JUNCA, Y.-J. PENG. *Eulerian and Lagrangian formulations in BV s for gas-solid chromatography*, in "Communications in Mathematical Sciences", August 2016, vol. 14, n° 6, pp. 1665 – 1685 [*DOI : 10.4310/CMS.2016.V14.N6.A10*], https://hal.archives-ouvertes.fr/hal-01258286

[6] K. BRENNER, J. HENNICKER, R. MASSON, P. SAMIER. *Gradient discretization of hybrid-dimensional Darcy flow in fractured porous media with discontinuous pressures at matrix-fracture interfaces*, in "IMA Journal of Numerical Analysis", September 2016 [*DOI : 10.1093/IMANUM/DRW044*], https://hal.archives-ouvertes.fr/hal-01192740

[7] F. CLARELLI, C. DI RUSSO, R. NATALINI, M. RIBOT. *A fluid dynamics multidimensional model of biofilm growth: stability, influence of environment and sensitivity*, in "Mathematical Medicine and Biology", 2016, https://hal.archives-ouvertes.fr/hal-01070624

[8] S. DE BIÈVRE, A. VAVASSEUR, T. GOUDON. *Particles interacting with a vibrating medium: existence of solutions and convergence to the Vlasov–Poisson system*, in "SIAM Journal on Mathematical Analysis", 2016, vol. 48, n° 6, pp. 3984–4020, https://hal.archives-ouvertes.fr/hal-01286519

[9] T. GOUDON, R. J. ALONSO, P. AMORIM. *Analysis of a chemotaxis system modeling ant foraging*, in "Math. Mod. Meth. Appl. Sci. (M3AS)", 2016, vol. 26, n° 9, pp. 1785–1824, https://hal.archives-ouvertes.fr/hal-01421688

[10] T. GOUDON, R. J. ALONSO, A. VAVASSEUR. *Damping of particles interacting with a vibrating medium*, in "Annales de l'I.H.P. - Nonlinear Analysis", 2016, https://hal.archives-ouvertes.fr/hal-01421710

[11] T. GOUDON, K. AOKI, S. KOSUGE, T. FUJIWARA. *Unsteady motion of a slightly rarefied gas caused by a plateoscillating in its normal direction*, in "Physical Review Fluids", 2016, https://hal.archives-ouvertes.fr/hal-01421732

[12] T. GOUDON, A. BERNARD-CHAMPMARTIN, C. FOCHESATO, B. JEAN-FRANCOIS. *A Semi-Lagrangian approach for dilute non-collisional fluid-particle flows*, in "Communications in Computational Physics", 2016, vol. 19, n⁰ 3, pp. 801-840, https://hal.inria.fr/hal-01270343

[13] T. GOUDON, V. BONNAILLIE-NOËL, J. A. CARRILLO, P. GREG. *Efficient numerical calculation of drift and diffusion coefficients for the diffusion approximation of kinetic equations*, in "IMA Journal of Numerical Analysis", 2016, https://hal.inria.fr/hal-01270345

[14] T. GOUDON, V. BONNAILLIE-NOËL, J. A. CARRILLO, G. PAVLIOTIS. *Efficient numerical calculation of drift and diffusioncoefficients in the diffusion approximation of kineticequations*, in "IMA Journal of Numerical Analysis", 2016, https://hal.inria.fr/hal-01150161

[15] T. GOUDON, S. MINJEAUD, F. BERTHELIN. *Multifluid flows: a kinetic approach*, in "Journal of Scientific Computing", 2016, vol. 66, n⁰ 2, pp. 792–824, https://hal.inria.fr/hal-01270341

[16] T. GOUDON, M. RIBOT, B. POLIZZI, S. LABARTHE, B. LAROCHE, T. EL BOUTI, R. TESSON, A. RACHAH. *A mixture model for the dynamic of the gut mucus layer*, in "ESAIM: Proceedings and Surveys", 2016, https://hal.archives-ouvertes.fr/hal-01421708

[17] T. GOUDON, L. URRUTIA. *Analysis of kinetic and macroscopic models of pursuit–evasion dynamics*, in "Communications in Mathematical Sciences", 2016, vol. 14, n⁰ 8, pp. 2253–2286, https://hal.inria.fr/hal-01270351

[18] T. GOUDON, A. F. VASSEUR. *On a model for mixture flows: Derivation, dissipation and stability properties*, in "Archive for Rational Mechanics and Analysis", 2016, vol. 220, n⁰ 1, pp. 1-35, https://hal.inria.fr/hal-01270344

[19] T. GOUDON, A. VAVASSEUR. *Mean field limit for particles interacting with a vibratingmedium*, in "Annali dell'Universita di Ferrara", 2016, vol. 62, n⁰ 2, pp. 231-273, https://hal.archives-ouvertes.fr/hal-01421703

[20] R. MASSON, L. TRENTY, Y. ZHANG. *Coupling compositional gas liquid Darcy and free gas flows at porous and free flow domains interface*, in "Journal of Computational Physics", June 2016 [*DOI :* 10.1016/J.JCP.2016.06.003], https://hal.archives-ouvertes.fr/hal-01238530

[21] F. XING, R. MASSON, S. LOPEZ. *Parallel Vertex Approximate Gradient discretization of hybrid dimensional Darcy flow and transport in discrete fracture networks*, in "Computational Geosciences", December 2016 [*DOI :* 10.1007/S10596-016-9606-Z], https://hal.archives-ouvertes.fr/hal-01272498

Conferences without Proceedings

[22] L. BEAUDE, K. BRENNER, S. LOPEZ, R. MASSON, F. SMAI. *Simulation d'écoulements compositionnels thermiques. Applications à la géothermie haute énergie*, in "13èmes Journéess d'études des Milieux Poreux 2016", Anglet, France, October 2016, https://hal.archives-ouvertes.fr/hal-01394578

[23] K. BRENNER, J. HENNICKER, R. MASSON, P. SAMIER. *Hybrid dimensional two phase flow in fractured porous media*, in "13èmes Journéess d'études des Milieux Poreux 2016", Anglet, France, October 2016, https://hal.archives-ouvertes.fr/hal-01394589

[24] S. JUNCA, B. LOMBARD. *Interactions between ultrasonic waves and nonlinear cracks with finite compressibility*, in "Journées d'Analyse Appliquée Nice-Toulon-Marseille", Porquerolles, France, May 2016, https://hal.archives-ouvertes.fr/hal-01310479

Scientific Books (or Scientific Book chapters)

[25] T. GOUDON. *Mathematics for Modeling and Scientific Computing*, Wiley-ISTE, 2016, 472 p. , https://hal.inria.fr/hal-01377721

[26] T. GOUDON. *Mathematiques pour la modelisation et le calcul scientifique*, ISTE, 2016, https://hal.inria.fr/hal-01286454

Other Publications

[27] N. AYI, T. GOUDON. *Regularity of velocity averages for transport equations on random discrete velocity grids*, December 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01407411

[28] J. BARRE, D. CRISAN, T. GOUDON. *Two-dimensional pseudo-gravity model*, October 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01379951

[29] F. BERTHELIN. *Theoretical study of a multi-dimensional pressureless model with unilateral constraint*, May 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01313258

[30] F. BERTHELIN, T. GOUDON, B. POLIZZI, M. RIBOT. *Asymptotic problems and numerical schemes for traffic flows with unilateral constraints describing the formation of jams*, December 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01413613

[31] C. BESSE, F. XING. *Domain decomposition algorithms for the two dimensional nonlinear Schrödinger equation and simulation of Bose-Einstein condensates*, March 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01285359

[32] K. BRENNER, C. CANCÈS. *Improving Newton's method performance by parametrization: the case of Richards equation*, 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01342386

[33] K. BRENNER, M. GROZA, L. JEANNIN, R. MASSON, J. PELLERIN. *Immiscible two-phase Darcy flow model accounting for vanishing and discontinuous capillary pressures: application to the flow in fractured porous media*, June 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01338512

[34] K. BRENNER, J. HENNICKER, R. MASSON, P. SAMIER. *Hybrid Dimensional Darcy Flow in Fractured Porous Media with discontinuous pressures at the matrix fracture interfaces*, October 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01383877

[35] C. CALGARO, E. CREUSÉ, T. GOUDON, S. KRELL. *Simulations of non homogeneous viscous flows with incompressibility constraints*, 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01246070

[36] P. CASTELLI, P.-E. JABIN, S. JUNCA. *Fractional spaces and conservation laws*, December 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01407099

[37] P. CASTELLI, S. JUNCA. *On the maximal smoothing effect for multidimensional scalar conservation laws* , February 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01290871

[38] D. A. A. DI PIETRO, S. KRELL. *A Hybrid High-Order method for the steady incompressible Navier–Stokes problem*, July 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01349519

[39] J. DRONIOU, J. HENNICKER, R. MASSON. *Numerical analysis of a two-phase flow discrete fracture model*, December 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01422477

[40] H. LE THI, S. JUNCA, M. LEGRAND. *Periodic solutions of a two-degree-of-freedom autonomous vibro-impact oscillator with sticking phases*, April 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01305719

[41] B. POLIZZI, O. BERNARD, M. RIBOT. *A time-space model for the growth of micro-algae biofilms for biofuel production*, December 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01408045

[42] F. XING, R. MASSON, S. LOPEZ. *Parallel numerical modeling of hybrid-dimensional compositional non-isothermal Darcy flows in fractured porous media*, December 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01420361

[43] F. XING. *New optimized Schwarz algorithms for one dimensional Schrödinger equation with general potential*, February 2016, working paper or preprint, https://hal.archives-ouvertes.fr/hal-01280675