RESEARCH CENTRE

Sophia Antipolis - Méditerranée

IN PARTNERSHIP WITH:

CNRS, Université Côte d'Azur

2020
ACTIVITY REPORT

Project-Team
COFFEE

COmplex Flows For Energy and Environment

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

DOMAIN

Digital Health, Biology and Earth

THEME

Earth, Environmental and Energy Sciences

Contents

Project-Team COFFEE

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

Keywords

Computer sciences and digital sciences

A6.1.1. – Continuous Modeling (PDE, ODE)

A6.1.4. – Multiscale modeling

A6.1.5. – Multiphysics modeling

A6.2.1. – Numerical analysis of PDE and ODE

A6.2.7. – High performance computing

A6.5. – Mathematical modeling for physical sciences

A6.5.2. – Fluid mechanics

A6.5.3. – Transport

A6.5.4. – Waves

Other research topics and application domains

B1.1.5. – Immunology

B1.1.8. – Mathematical biology

B3.3.1. – Earth and subsoil

B4.1. – Fossile energy production (oil, gas)

B4.2. – Nuclear Energy Production

B7.1. – Traffic management

1 Team members, visitors, external collaborators

Research Scientists

- Thierry Goudon [Team leader, Inria, Senior Researcher, HDR]
- Laurent Monasse [Inria, Researcher]

Faculty Members

- Florent Berthelin [Univ Côte d'Azur, Associate Professor, HDR]
- Konstantin Brenner [Univ Côte d'Azur, Associate Professor]
- Remi Catellier [Univ Côte d'Azur, Associate Professor, from Sep 2020]
- Stéphane Junca [Univ Côte d'Azur, Associate Professor, HDR]
- Stella Krell [Univ Côte d'Azur, Associate Professor]
- Gilles Lebeau [Univ Côte d'Azur, Emeritus]
- Roland Masson [Univ Côte d'Azur, Professor, HDR]

Post-Doctoral Fellows

- Francesco Bonaldi [Inria]
- Daniel Castanon-Quiroz [Univ Côte d'Azur]
- Florent Chave [CNRS, from Nov 2020]
- Sean Mc Govern [Inria, from Jul 2020]
- El Houssaine Quenjel [Univ Côte d'Azur, until Sep 2020]

PhD Students

- Kokou Atsou [Inria]
- Nadine Dirani [Inria]
- Billel Guelmame [Univ Côte d'Azur, until Sep 2020]
- Sean Mc Govern [Inria, until Jun 2020]
- Paul Paragot [Univ Côte d'Azur, from Oct 2020]
- Leo Vivion [Univ Côte d'Azur, until Sep 2020]

Interns and Apprentices

- Pierre Clavier [Inria, from Apr 2020 until Jul 2020]

Administrative Assistant

- Marie-Cecile Lafont [Inria]

2 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

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 and Viscous Flows
  - Finite Volume Schemes for Conservation Laws
  - Well-Balanced and Asymptotic-Preserving Methods
  - Domain Decomposition Methods
- Modeling and Analysis of PDEs
  - Kinetic equations and hyperbolic systems
  - PDEs in random media
  - Interface problems

4 Application domains

4.1 Multiphase porous media flows and multi-physics coupling

Our research focuses on the numerical modeling of multiphase porous media flows accounting for complex geology and for nonlinear and multi-physics couplings. It is applied to various problems in the field of energy such as the simulation of geothermal systems in collaboration with BRGM, of nuclear waste repositories in collaboration with Andra, and of oil and gas recovery in collaboration with Total. Our research directions include the development of advanced numerical schemes adapted to polyhedral meshes and highly heterogeneous media in order to represent more accurately complex geologies. A special focus is made on the modeling of multiphase flows in network of faults or fractures represented as interfaces of co-dimension one coupled to the surrounding matrix. We also investigate nonlinear solvers adapted to the nonlinear couplings between gravity, capillary and viscous forces in highly heterogeneous porous media. In the same line, we study new domain decomposition algorithms to couple non-isothermal compositional liquid gas flows in a porous medium with free gas flows occurring at the interface between the ventilation gallery and the nuclear waste repository or between a geothermal reservoir and the atmosphere. We have begun exploring the coupling between the multiphase flow in the porous matrix and the solid mechanics involved in opening fractures.

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 Fungal network growth

Members of the team have started an original research program devoted to fungal network growth. We started working on this subject through a collaboration with biologists and physicists at LIED (Université Paris Diderot) and probabilists in CMAP (Ecole Polytechnique) and Université Paris Sud, involving Rémi Catellier and Yves D'Angelo in LJAD in Nice. The motivation is to understand branching networks as an efficient space exploration strategy, with fungus *Podospora Anserina* being the biological model considered. This research is submitted as an ANR-project and has been supported by various local fundings.

4.4 Tumor growth and immune response

We have developed a size and space structured model describing interaction of tumor cells with immune cells based on a system of partial differential equations. This model is intended to describe the earliest stages of this interaction and takes into account the migration of the tumor antigen-specific cytotoxic effectors cells towards the tumor microenvironment by a chemotactic mechanism. This study reveals cancer persistent equilibrium states as expected by biologists, as well as escape phases when protumoral immune responses are activated. This effect which leads to persistent tumors at a controlled level was inferred from clinical observations and demonstrations using mouse model. Therefore, the maintenance of cancer in a viable equilibrium state represents a relevant goal of cancer immunotherapy. The mathematical interpretation of the equilibrium state by means of eigenvalue problems and constrained equations, has permitted us to develop new numerical algorithms in order to predict at low numerical cost the main features of the equilibrium and to discriminate, in biologically relevant cases, the parameters that are the most influential on the equilibrium.

4.5 Self organization in population dynamics

This topic is addressed mainly with Paulo Amorim (Univ. Federal Rio de Janeiro) and Fernando Peruani (Lab. de Physique Théorique et Modélisation, Cergy Paris Université).

There are interested in the mathematical modeling of physico-biological phenomena that drive towards a self-organization a population of individuals reacting to external signals. It might lead to the formation of remarkable patterns or the following of travelling external signal. we develop microscopic and hydrodynamic models for such phenomena, with a specific interest in the modulin of ant foraging.

5 Social and environmental responsibility

T. Goudon is Scientific officer for Mathematics, General Directorate for Research and Innovation, Ministry of Higher Education and Research, since 2016. As such he also contributes to the national design of the AI policy.

6 New software and platforms

6.1 New software

6.1.1 AP_PartFlow

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

6.1.2 Mka3d

Name: Mka3d

Keywords: Scientific computing, Elasticity, Elastodynamic equations

Functional Description: The Mka3d method simulates an elastic solid by discretizing the solid into rigid particles. An adequate choice of forces and torques between particles allows to recover the equations of elastodynamics.

URL: http://cermics.enpc.fr/~monassel/Mka3D/

Contact: Laurent Monasse

Partners: Ecole des Ponts ParisTech, CEA

6.1.3 Compass

Name: Computing Architecture to Speed up Simulation

Keywords: Finite volume methods, Porous media, High performance computing

Functional Description: Compass is a parallel code initiated in 2012 and co-developed by LJAD-Inria Coffee and BRGM since 2015. It is devoted to the simulation of multiphase flows in porous media, it accounts for non isothermal and compositional flows and includes complex network of fractures or faults represented as interfaces of co-dimension one coupled to the surrounding matrix. The discretization is based on vertex and cell unknowns and is adapted to polyhedral meshes and heterogeneous media. The ComPASS code is co-developed since december 2016 by the partners of the ANR CHARMS project including BGRM, LJAD-Inria Coffee, Storengy, MdS and LJLL with the objective to develop a new generation simulator for geothermal systems focusing on fluids and accounting for complex fault networks and wells.

URL: http://www.anr-charms.org/page/compass-code

Authors: Cindy Guichard, Robert Eymard, Roland Masson, Chang Yang, Thierry Goudon

Contacts: Thierry Goudon, Roland Masson

Participants: Simon Lopez, Farid Smai, Michel Kern, Yacine Ould Rouis, Nabil Birgle, Laurence Beaude, Konstantin Brenner, Roland Masson

Partners: Université de Nice Sophia Antipolis (UNS), BRGM

6.1.4 NS2DDV-M

Name: 2D Navier-Stokes equations with variable density

Keywords: Partial differential equation, Finite volume methods, Finite element modelling

Functional Description: The NS2DDV Matlab toolbox is an open-source program written in Matlab for simulating 2D viscous, incompressible and inhomogeneous flows. The computation kernel of the code is based on Finite Elements - Finite Volumes hybrid methods applied on the 2D Navier-Stokes equations. It works on unstructured meshes and can include mesh refinements strategies. We develop and freely distribute a new version of the Matlab code NS2DDV-M (equipped with a graphic interface and an accurate documentation) to promote new collaborations in the domain, allow some easy comparisons with concurrent codes on the same benchmark cases, and compare alternative numerical solution methods.

URL: https://wikis.univ-lille1.fr/painleve/ns2ddv

Contacts: Creusé Emmanuel, Caterina Calgaro

Partner: Laboratoire Paul Painlevé

6.1.5 SimBiof

Keywords: Bioinformatics, Chemistry

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

6.1.6 CELIA3D

Name: CELIA3D

Keywords: Fluid mechanics, Multi-physics simulation

Functional Description: The CELIA3D code simulates the coupling between a compressible fluid flow and a deformable structure. The fluid is handled by a Finite Volume method on a structured Cartesian grid. The solid is handled by a Discrete Element method (Mka3d scheme). The solid overlaps the fluid grid and the coupling is carried out with immersed boundaries (cut cells) in a conservative way.

URL: http://cermics.enpc.fr/~monassel/CELIA3D/

Contacts: Laurent Monasse, Alexandre Ern

Partners: Ecole des Ponts ParisTech, CEA

7 New results

See the publications list.

8 Bilateral contracts and grants with industry

- Contract with Andra financing the two year postdoctoral position of Joubine Aghili (october 2017 - september 2019) and dealing with the simulation of compositional liquid gas Darcy flows in highly heterogeneous porous medium with network of fractures using Discrete Fracture Matrix models (DFM). It is applied to the simulation of the desaturation of the nuclear waste storage in the neighbourhood of the galleries. Supervision Roland Masson and Konstantin Brenner from LJAD-Inria, Jean-Raynald de Dreuzy from Geosciences Rennes and Laurent Trenty from Andra.

- The team has also on-going collaboration with Storengy (post-doc of Daniel Constantin-Quiroz).

9 Partnerships and cooperations

9.1 International initiatives

HDTHM

Title: Mathematical and numerical methods for thermo-hydro-mechanical models in porous media with discontinuities

Duration: Continuing

Coordinator: Roland Masson

Partners:

- Math. Dept., Monash University (Australia)

Inria contact: Roland Masson

Summary: The objective of this project is to extend a recent successful joint work between the two project leaders into a tight collaboration between the Monash and the Coffee teams involving several permanent members and students. The present project focuses on challenging directions of research related to the numerical simulation of thermo-hydro-mechanical models in fractured porous media that take advantage of the complementarity of both teams' expertise as well as of the recent arrival of Laurent Monasse in the Coffee team. It is an opportunity to extend our collaborations with the Coffee team industrial partners in geosciences as well as to submit in common a research project to the Australian Research Council toward the end of the project.

9.2 National initiatives

9.2.1 ANR

- ANR CHARMS (Quantitative Reservoir Models for Complex Hydrothermal Systems), Roland Masson and Konstantin Brenner: december 2016 - december 2020, partners BRGM (leader), LJAD-Inria, Storengy, MdS, LJLL.

- ANR JCJC PRECIS (Effect of a shock wave on a structure with contact using mesh refinement and parallelism), Laurent Monasse: april 2018 - april 2021, partners Inria (leader), Ecole des Ponts, CEA, Université Paris-Est.

- ANR TOP-UP, Konstantin Brenner, Roland Masson: LJLL CNRS-Sorbonne Univ., Ecole des Ponts, LNCC Brazil. The project is devoted to the numerical modeling of urban floods, helping to size and position protective systems including dams, dikes or rainwater drainage network.

9.2.2 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

- GdR Mamovi

  The team is involved in the activities of the research group dedicqted to applications to life sciences.

- S. Junca is involved in GdR 3437 DYNOLIN “Dynamique non linéaire” and GdR MecaWave.

- LJAD-Inria and BRGM are the French partners of the Norvergian, German French project InSPiRE "International Open Source Simulation Software Partnership in Research and Education” which has just been accepted by the Research Council of Norway with the code ComPASS as one of the softwares of this project together with Dune, Dumux and OPM.

10 Dissemination

Member of the editorial boards T. Goudon is Founding Editor and Co-Editor in Chief of SMAI Journal of Computational Mathematics.

Reviewer - reviewing activities All members of the team are regular reviewers in journal of mathematics, numerical analysis and scientific computing.

10.0.1 Research administration

T. Goudon is Scientific Officer at the Ministry for research and innovation. As such he is member of the Board of CIRM, CIMPA, IHES, IHP.

10.1 Teaching - Supervision - Juries

10.1.1 Teaching

- Florent Berthelin, Master2 Mathématiques fondamentales, Université Côte d’Azur, 120h.
- Florent Berthelin, Chair of the Master 2 Mathématiques fondamentales, Université Côte d’Azur.
- Florent Berthelin, Analysis, L2, Université Côte d’Azur, 72h.
- Laurent Monasse, Numerical analysis, L3, Université Côte d’Azur, 40h.
- Thierry Goudon is President of the national competition to hire teachers (agregation de mathematiques).
- Thierry Goudon: Ecole Centrale de Marseille, CliMaths program. lecture on traffic flows modeling
- Thierry Goudon: Master, lectures on signal processing
- Thierry Goudon: Master, lecture on PDEs
- Stella Krell: Master, Finite Volume methods

10.1.2 Supervision

- PhD: Kevin Atsou, Mathematical modeling of tumor growth, analysis and simulation, 18 December 2020, Thierry Goudon
- PhD: Billel Guelmame, Conservation laws in mechanics, 23 September 2020, Stéphane Junca
- PhD: Leo Vivion, Dynamical model of a Lorentz gas: kinetic approach, analysis and asymptotic issues, 8 September 2020, Thierry Goudon
- PhD: Frédéric Marazzato, Modeling of fracture and fragmentation using a Discrete Element method, 29 May 2020, Alexandre Ern, Karam Sab and Laurent Monasse.
- PhD in progress: Nadine Dirani, Effect of a shock wave on a structure with contact, 01 November 2018, Thierry Goudon and Laurent Monasse.
- PhD in progress: Paul Paragot, Numerical analysis, Modeling and Data analysis : characterizing and localizing calcium sources in the neuronal denditric tree, to understand the foundations of cognitive development, 01 October 2020, Stella Krell and Claire Guerrier

10.2 Popularization

10.2.1 Education

Laurent Monasse participated in the program "Regards de géomètres" for the popularization of mathematics in high-schools.

11 Scientific production

11.1 Publications of the year

International journals

[1] K. Atsou, F. Anjuère, V. Braud and T. Goudon. ‘A size and space structured model describing interactions of tumor cells with immune cells reveals cancer persistent equilibrium states in tumorigenesis’. In: *Journal of Theoretical Biology* 490 (Apr. 2020), p. 110163. DOI: 10.1016/j.jtbi.2020.110163. URL: https://hal.archives-ouvertes.fr/hal-02527648.

[2] I. Berre, W. M. Boon, B. Flemisch, A. Fumagalli, D. Gläser, E. Keilegavlen, A. Scotti, I. Stefansson, A. Tatomir, K. Brenner, S. Burbulla, P. R. B. Devloo, O. Duran, M. Favino, J. Hennicker, I.-H. Lee, K. Lipnikov, R. Masson, K. Mosthaf, M. G. C. Nestola, C.-F. Ni, K. Nikitin, P. Schädle, D. Svyatskiy, R. Yanbarisov and P. Zulian. ‘Verification benchmarks for single-phase flow in three-dimensional fractured porous media’. In: *Advances in Water Resources* (21st Sept. 2020). DOI: 10.1016/j.advwatres.2020.103759. URL: https://hal.archives-ouvertes.fr/hal-02867256.

[3] C. Bourdarias, M. Gisclon and S. Junca. ‘Kinetic formulation of a 2×2 hyperbolic system arising in gas chromatography’. In: *Kinetic and Related Models* 13.5 (2020), pp. 869–888. DOI: 10.3934/krm.2020030. URL: https://hal.archives-ouvertes.fr/hal-01471783.

[4] K. Brenner, R. Masson and E. H. Quenjel. ‘Vertex Approximate Gradient Discretization preserving positivity for two-phase Darcy flows in heterogeneous porous media’. In: *Journal of Computational Physics* (15th May 2020). DOI: 10.1016/j.jcp.2020.109357. URL: https://hal.archives-ouvertes.fr/hal-02483161.

[5] C. Cancès, C. Chainais-Hillairet, M. Herda and S. Krell. ‘Large time behavior of nonlinear finite volume schemes for convection-diffusion equations’. In: *SIAM Journal on Numerical Analysis* 58.5 (16th Sept. 2020), pp. 2544–2571. DOI: 10.1137/19M1299311. URL: https://hal.archives-ouvertes.fr/hal-02360155.

[6] M. J. Gander, J. Hennicker and R. Masson. ‘Modeling and Analysis of the Coupling in Discrete Fracture Matrix models’. In: *SIAM Journal on Numerical Analysis* 59.1 (13th Jan. 2021), pp. 195–218. DOI: 10.1137/20M1312125. URL: https://hal.archives-ouvertes.fr/hal-02437030.

[7] S. S. Ghoshal, B. Guelmame, A. Jana and S. Junca. 'Optimal regularity for all time for entropy solutions of conservation laws in BV^s'. In: *Nonlinear Differential Equations and Applications* 27.5 (2020), p. 46. DOI: 10.1007/s00030-020-00649-5. URL: https://hal.archives-ouvertes.fr/hal-02495036.

[8] T. Goudon, J. Llobell and S. Minjeaud. 'An asymptotic preserving scheme on staggered grids for thebarotropic Euler system in low Mach regimes'. In: *Numerical Methods for Partial Differential Equations* 36.5 (2020), pp. 1098–1128. URL: https://hal.inria.fr/hal-02418641.

[9] T. Goudon, J. Llobell and S. Minjeaud. 'An explicit MUSCL scheme on staggered grids with kinetic-like fluxes for the barotropic and full Euler system'. In: *Communications in Computational Physics* 27.3 (2020), pp. 672–724. URL: https://hal.archives-ouvertes.fr/hal-02350773.

[10] H. Le Thi, S. Junca and M. Legrand. 'First return time to the contact hyperplane for n-degree-of-freedom vibro-impact systems'. In: *Discrete and Continuous Dynamical Systems - Series B* (2020). DOI: 10.3934/dcdsb.2021031. URL: https://hal.archives-ouvertes.fr/hal-01957546.

[11] F. Marazzato, A. Ern and L. Monasse. 'A variational discrete element method for quasi-static and dynamic elasto-plasticity'. In: *International Journal for Numerical Methods in Engineering* (2020). DOI: 10.1002/nme.6460. URL: https://hal.archives-ouvertes.fr/hal-02343280.

International peer-reviewed conferences

[12] C. Chainais-Hillairet and S. Krell. 'Exponential decay to equilibrium of nonlinear DDFV schemes for convection-diffusion equations'. In: FVCA 2020 - 9th Conference on Finite Volumes for Complex Applications. Bergen, Norway, 15th June 2020. URL: https://hal.archives-ouvertes.fr/hal-02408212.

Conferences without proceedings

[13] F. Bonaldi, K. Brenner, J. Droniou and R. Masson. 'The Gradient Discretisation Method for Two-phase Discrete Fracture Matrix Models in Deformable Porous Media'. In: FVCA 2020 - 9th Conference on Finite Volumes for Complex Applications. Bergen, Norway, 15th June 2020. DOI: 10.1007/978-3-030-43651-3_26. URL: https://hal.archives-ouvertes.fr/hal-02454360.

[14] T. Goudon, S. Krell and G. Lissoni. 'Convergence study of a DDFV scheme for the Navier-Stokes equations arising in the domain decomposition setting'. In: FVCA 2020 - 9th Conference on Finite Volumes for Complex Applications. Bergen, Norway, 15th June 2020. URL: https://hal.archives-ouvertes.fr/hal-02496823.

[15] G. Lissoni. 'DDFV Schemes for semiconductors energy-transport models'. In: ALGORITMY 2020 - Conference on Scientific Computing. Podbanske, Slovakia, 10th Sept. 2020. URL: https://hal.archives-ouvertes.fr/hal-02899787.

Doctoral dissertations and habilitation theses

[16] L. Vivion. 'Classical and quantum particles interacting with their environment : stability analysis and asymptotic issues'. Université Côte d'Azur, 8th Sept. 2020. URL: https://tel.archives-ouvertes.fr/tel-03135254.

Reports & preprints

[17] J. Aghili, J.-R. De Dreuzy, L. Trenty and R. Masson. *A hybrid-dimensional compositional two-phase flow model in fractured porous media with phase transitions and Fickian diffusion.* 17th Nov. 2020. URL: https://hal.archives-ouvertes.fr/hal-02994152.

[18] K. Atsou, S. Khou, F. Anjuère, V. Braud and T. Goudon. *Analysis of the equilibrium phase in immune-controlled tumors predicts best strategies for cancer treatment.* 19th Jan. 2021. URL: https://hal.archives-ouvertes.fr/hal-03115518.

[19] F. Bonaldi, K. Brenner, J. Droniou and R. Masson. *Gradient discretization of two-phase flows coupled with mechanical deformation in fractured porous media*. 30th Nov. 2020. URL: https://hal.archives-ouvertes.fr/hal-02549111.

[20] F. Bonaldi, K. Brenner, J. Droniou, R. Masson, A. Pasteau and L. Trenty. *Gradient discretization of two-phase poro-mechanical models with discontinuous pressures at matrix fracture interfaces*. 11th Nov. 2020. URL: https://hal.archives-ouvertes.fr/hal-02997396.

[21] C. Bourdarias, A. P. Choudhury, B. Guelmame and S. Junca. *Entropy solutions in* BV^s *for a class of triangular systems involving a transport equation*. 9th July 2020. URL: https://hal.archives-ouvertes.fr/hal-02895603.

[22] K. Brenner, J. Droniou, R. Masson and E. H. Quenjel. *Total-velocity-based finite volume discretization of two-phase Darcy flow in highly heterogeneous media with discontinuous capillary pressure*. 4th Oct. 2020. URL: https://hal.archives-ouvertes.fr/hal-02957054.

[23] C. Cancès, V. Ehrlacher and L. Monasse. *Finite Volumes for the Stefan-Maxwell Cross-Diffusion System*. 20th July 2020. URL: https://hal.archives-ouvertes.fr/hal-02902672.

[24] M. J. Gander, L. Halpern, F. Hubert and S. Krell. *Discrete Optimization of Robin Transmission Conditions for Anisotropic Diffusion with Discrete Duality Finite Volume Methods*. 9th Apr. 2020. URL: https://hal.archives-ouvertes.fr/hal-02539124.

[25] T. Goudon, S. Krell and G. Lissoni. *Non-overlapping Schwarz algorithms for the Incompressible Navier-Stokes equations with DDFV discretizations*. 21st Jan. 2020. URL: https://hal.inria.fr/hal-02448007.

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