Postdoctoral position: Coupling non-isothermal compositional liquid gas Darcy and free gas flows

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Flow and transport processes in domains composed of a porous medium and an adjacent free-flow region appear in a wide range of industrial and environmental applications such as food processing, wood or paper production, salinization of agricultural land, prediction of convective heat and moisture transfer at exterior building surfaces, or also the study of the mass and energy exchanges at the interface between a nuclear waste disposal and the ventilation tunnels. Typically, in such processes, the porous medium initially saturated with the liquid phase is dried by suction in the neighborhood of the interface between the porous and free flows. To model such physical processes, one needs to account in the porous medium for the flow of the liquid and gas phases including the vaporization of the water component in the gas phase. In the free flow domain, a single phase gas free flow can be considered assuming that the liquid phase is instantaneously vaporized at the interface. This single phase gas free flow has to be compositional and non-isothermal to account for the change of the relative humidity and temperature in the tunnel which has a strong feedback on the liquid flow rate at the interface.

If many works have been performed to model and discretize the coupling of single phase Darcy and free flows, there is very little work on the coupling of a two phase gas liquid compositional Darcy flow with a single phase compositional free flow. Such a coupled model has been recently proposed in [3, 4] using proper matching conditions at the interface between the porous medium and the free flow regions. This model will be the starting point of our work and will be simplified taking into account the physical characteristics of our problem focusing on the drying processes at the interface between the nuclear waste repository and the ventilation excavated tunnels. To obtain our simplified model, we will assume that the longitudinal dimension of the free flow domain, typically a tunnel, is large compared with its transversal dimensions. This allows to *reduce the model in the tunnel to a 1D free flow coupled with the 3D flow in the porous medium*. In the spirit of [6], we will extend to the non-isothermal case the approach proposed in [5].

The discretization of the 3D non-isothermal compositional liquid gas Darcy flow is based on the nodal Vertex Approximate Gradient scheme [1]. The coupling with the 1D free gas flow will be based on *non-matching meshes* between the 3D Darcy flow domain and the 1D domain in order to account for complex geometries of the tunnels. In order to allow for a modular implementation of the coupled liquid gas Darcy and free gas flows, *a nonlinear Robin Robin domain decomposition algorithm* based on the previous works [2, 7] will be designed.

The coupled liquid gas Darcy and free gas flows will be implemented in the open source parallel code ComPASS [1, 8] http://www.anr-charms.org/page/compass-code. The COMPASS parallelization is based on mesh partitioning and MPI communications. It uses the Petsc and

Hypre libraries for the solution of the linear systems. Since the size of the mesh of the 1D free gas flow is negligible compared with the size of the mesh of the 3D Darcy flow, the domain decomposition approach will allow a simple parallel implementation of the coupled model. The code ComPASS `http://www.anr-charms.org/page/compass-code` is an open source parallel code initiated by LJAD-Inria and BRGM (Bureau de Recherches Géologiques et Minières - French Geological Survey) in 2015 [1, 8]. It is devoted to the simulation of multiphase non-isothermal Darcy flows and includes complex network of fractures/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 2017 by the partners of the ANR CHARMS project including BGRM, LJAD-Inria, Storengy, la Maison de la Simulation and the Jacques Louis Lions laboratory.

Profile: applicants should have a PhD in scientific computing/applied mathematics and be familiar with scientific programming (Fortran and/or C++, Python, MPI), numerical methods for PDEs and collaborative development tools.

Supervision and location: the postdoctoral position will be held in the J.A. Dieudonné department of Mathematics (LJAD) at the University Côte d'Azur (UCA) in collaboration with Roland Masson and Konstantin Brenner from Inria/LJAD. The postdoc will be member of European project EURAD and member of both the LJAD department of Mathematics and of the INRIA team Coffee (Complex Flows For Environment and Energy, `http://www.inria.fr/equipes/coffee`).

Duration and starting date: the position is for 16 months and should start before the end of 2020.

Salary: About 2100 Euros net/month

How to apply: send applications with CV, letter of motivation, and references, to roland.masson@univ-cotedazur.fr.

Key words: scientific computing, parallel computing, domain decomposition methods, Darcy and free flows coupling, coupled 3D-1D models, non-matching meshes.

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