Post-Doctoral position for 12 months, available immediately

Mathematical modelling and numerical simulation of phase-change materials. HPC simulations of a datacenter.

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Context : This study is part of the research project M2SiNUM (2018-2021) funded by the Normandy county : *Advanced Mathematical Models and Numerical Simulations for innovation, environment and health*. M2SiNUM is a follow-up of the M2NUM project (web site here). In this project, a major research path concerns the mathematical modelling and numerical simulations of Phase Change Materials (PCM). The use of PCM-based solutions to optimise the heat management in datacenters or telecommunication devices will be the focus of the present postdoc program.

Research topic : Solid-liquid phase change systems involving melting or freezing processes are encountered in numerous practical applications, ranging from metal casting and thermal energy storage to food freezing. Recent models include several important physical phenomena, such as gravity effects, convection in the liquid phase, the presence of a mushy region (containing both solid and liquid particles) at the interface between the two phases, etc. In a recent study [1] we developed a numerical system using a single-domain approach based on Navier-Stokes-Boussinesq equations. The implementation used a finite-element method with mesh adaptivity based on FreeFem++ [2]. The numerical method was further improved during a PhD program [3]. It is currently tested on different melting or solidification benchmarks.

Objectives : The postdoc work will focus on further developments of the numerical method and its use for simulating actual 3D configurations.

• The first objective concerns the improvement of the numerical method (high order time-integration schemes, new strategies for mesh adaptivity, etc) when used for 3D configurations. Preliminary results obtained using FreeFem++ and the HPDDM library (web site here) are very promising and encouraging for the simulation of natural convection cases. The candidate should extend this system for the 3D simulation of phase-change systems, involving accurate tracking of interface between solid and liquid phases.

• The second objective involves the mathematical and physical derivation of a simplified model for the natural convection in a room with walls made of PCM. The model will deal with realistic boundary conditions taking into account solar radiation, daily variations, etc. The PCM-wall will be firstly simulated and finally modelled by imposing appropriate time-depending boundary conditions.

• The final objective is the simulation of the real configuration that was studied experimentally in the facilities of Orange Labs [4]. It is a simplified model of a datacenter building, using a free-cooling solution for the heat management. Available experimental data will be used to validate the developed numerical system. This part of the activity will involve an active collaboration with Orange Labs.

Requirements :

The successful candidate is expected to hold (or about to have) a PhD in the area of computational applied mathematics or physics. Programming experience is essential. Experience with FreeFem++ and in using high-performance computing facilities (HPC) would be an advantage.

Bibliography (with links when available) :

[1] I. Danaila, R. Moglan, F. Hecht, S. Le Masson: A Newton method with adaptive finite elements for solving phase-change problems with natural convection, Journal of Computational Physics, **274**, p. 826-840, 2014.

[2] http://www.freefem.org

[3] A. Rakotondrandisa, I. Danaila : Simulation de matériaux à changement de phase par une méthode d'éléments finis adaptatifs, 25ème Congrès Français de Thermique, 30 mai- 2 juin 2017, Marseille.

A. Rakotondrandisa, I. Danaila, L. Danaila : Etude numérique d'un cycle complet fusion-solidification pour un matériau à changement de phase, 26ème Congrès Français de Thermique, 29 mai- 3 juin 2018, Pau.

[4] Y. Kaced, Etudes du refroidissement par free cooling indirect d'un bâtiment exothermique : Application au centre de données, PhD Thesis, Université Bretagne Sud, 2018.