Linear stability of double-diffusive natural convection in under-ice melt ponds

Sílvia C. Hirata[*], **Benoît Goyeau** [†1], **Dominique Gobin**[†2]

[*] Laboratoire de Mécanique de Lille (UMR CNRS 8107)
Université Lille 1, Bld Paul Langevin - 59655 Villeneuve d'Ascq Cedex, France.
e-mail: silvia.hirata@univ-lille1.fr

[†1]Laboratoire EM2C (UPR CNRS 288)
Ecole Centrale Paris, Grande Voie des Vignes - 92295 Châtenay-Malabry, France.
e-mail: benoit.goyeau@em2c.ecp.fr

[†2]Laboratoire FAST (UMR CNRS 7608)
Univ. Paris-Sud 11, Univ. Pierre et Marie Curie, CNRS, Bat 502, F-91405 Orsay Cedex, France.
e-mail: gobin@fast.u-psud.fr

ABSTRACT

During the Arctic summer, sea ice begins to melt forming surface melt puddles. Fresh meltwater can percolate into the ice floe, getting discharged under the ice and forming a so-called under-ice melt pond [1]. The fresh meltwater in the under-ice melt pond is thus in contact with a much colder ($\approx -1.6^o$C) and denser layer of salty sea water. Due to water density inversion near 4^oC, the system is submitted to a destabilizing temperature gradient, and hence natural convection can occur [2]. The aim of the present study is to investigate the onset of double diffusive natural convection in under-ice melt ponds. We present a mathematical model consisting of a three-layer system, namely the melt pond, the ice matrix, and the under-ice melt pond. The ice floe is modeled as a saturated porous medium which is sandwiched between two layers of binary fluid. The problem is addressed adopting a one-domain approach formulation [3], where the governing equations for the porous and fluid regions are combined into a unique set of equations valid for the entire domain. We show, through a linear stability analysis, that the thickness of the ice layer is the key parameter affecting stability. Other relevant parameters are the temperature difference on the external boundaries and the permeability of the ice matrix.

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