SPECTRAL NUMERICAL TOOLS FOR THE ANALYSIS OF THERMOCAPILLARY CONVECTION

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Physics of thermocapillary flows is very rich, and of difficult access to the experimentalist, in particular with low Prandtl number fluids. Numerical simulations can be quite helpful, but however necessarily based on simplified models with respect to realistic situations. The design of numerical tools is therefore quite relevant for obtaining useful indications on this physics. The numerical experiments on thermocapillary convection are usually performed with codes based on finite precision methods, in particular because the use of spectral methods is rather requiring for these configurations. The correct treatment of the free surface geometry and of the vorticity singularity [1] at the junction free surface/solid boundaries are among other difficulties.

Nevertheless, the accuracy of spectral solutions is very attractive when dealing with nonlinear dynamics analysis, such as, for instance, capturing transitions related to symmetry breaking. Thus, in a simplified floating zone model, these methods have allowed the first observation [2] of steady bifurcated flows associated with the breaking of the mid-plane symmetry of the system. This was the first step before the implementation of several spectral tools designed for enlarging significantly the scope of spectral methods application. Increasingly complex thermocapillary convection models are by now reachable to the spectral accuracy.

To summarize, to date, the state of the available spectral tools, there is (1) a 2D/3D time marching Navier-Stokes code for liquid bridges with straight cylindrical free surface, (2) the associated code dedicated to the 2D/3D linear stability analysis, (3) a code for identifying the flow's sensitivity to local perturbations using the adjoint method [3, 6], (4) a specific Helmholtz solver with an interfacial viscosity in boundary conditions [5] and (5) an efficient 2D code adapted to deformed, possibly moving, free surface configurations [4].

The different methods together with recent results on thermocapillary convection will be presented.

Références

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