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Numerical study of Marangoni instability: effect of interface deformation

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The Marangoni instability has been studied over the last century using theoretical, numerical and experimental approaches. This instability was found to be dependent on many physical parameters. In experiments, the effect of gravity cannot be suppressed without using extremely expensive studies in microgravity. Numerical simulations are a good alternative to understand this instability and have shown excellent agreement with experiments in the past. However, in most of the numerical studies performed in the past, the interface is assumed to be flat or slightly deformed. This study proposes to investigate a wide range set of parameters using direct numerical simulations to analyse the effect of interface deformations.

Within this work we develop a new numerical implementation of thermocapillary effects based on the Coupled Levelset-Volume of Fluid approach, [1, 2]. The new method is presented along with canonical validations. A series of simulations of the Marangoni instability are carried out. The reference case is the one proposed by Eckert *et al.* [3], which is also used as a cross-validation. The figure 1 shows the temperature and velocity field of this reference simulation.

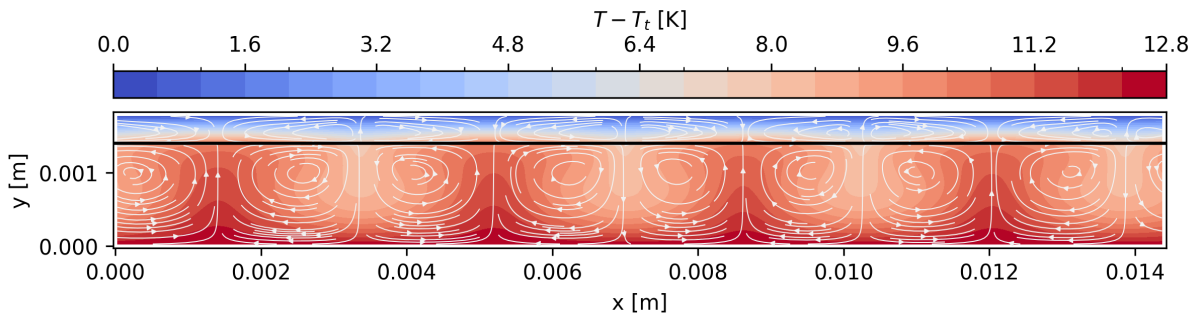


FIG. 1: Temperature field and velocity streamlines of the reference test case.

First, many 2D simulations are performed by varying the dimensionless numbers. The effect of thermal expansion and surface tension is studied by varying the Rayleigh (Ra) and Capillary (Ca) numbers respectively. The reference case shows small changes due to thermal expansion, which appear only when the Ra is increased. On the other hand, a large Ca shows larger deformations of the interface. However, due to the high density ratio, the interface remains almost flat. A diagram in the $Ra - Ca$ plane is proposed to show the different behaviours.

Then, some selected simulations are performed in 3D. Similar behaviour is observed, but with different region boundaries. The interface patterns are studied using classical metrics.

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