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INSTABILITY OF THERMOCAPILLARY-BUOYANCY CONVECTION IN WEAKLY EVAPORATING LIQUID

Abstract

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The variation in temperature of a liquid-gas interface results in the formation of surface tension gradients which induce tangential stresses, known as Marangoni stresses. The thermocapillary flow associated with Marangoni stresses may lead to instabilities for the first time experimentally observed by Schwabe[1]. The stability of the thermocapillary flow has been studied extensively in the geometry of a thin liquid layer and in a cylindrical liquid bridge. Lately, the effect of ambient gas on the stability of a flow inside a liquid bridge has become an object of investigation. The results of a numerical study on instability caused by a gas stream along the interface of an axisymmetric liquid bridge [2] have shown that the cooling of the interface may cause Pearson-like type of instability prior to the appearance of typical hydrothermal waves. This study is connected to the microgravity experiment JEREMI (Japanese European Research Experiment on Marangoni Instabilities) where the use of a forced coaxial gas stream is proposed to control the hydrothermal instabilities in liquid bridges. We present an experimental study on flow stability in a liquid bridge whose interface is surrounded by gas with well-controlled temperature. The experiments are conducted in ground laboratories where the stationary flow appears at arbitrary tiny values of imposed T due to thermocapillary stresses and evolves under the action of both Marangoni and buoyancy forces. We have observed that the appearance of oscillatory flows depends on the temperature of the surrounding gas as well as the mean temperature of the liquid. The experimental observations are supported by two-phase non-linear numerical simulations.

[1] D. Schwabe, Thermocapillary Liquid Bridges and Marangoni Convection under Microgravity—Results and Lessons Learned, Microgravity Sci. Technol. 26, 1–10, (2014)

[2] V. Shevtsova, Y. A. Gaponenko and A. Nepomnyashchy, Thermocapillary flow regimes and instability caused by a gas stream along the interface, J. Fluid Mech., 714., 644-670 (2013).