Post-doctoral Position

Isolated bubble growth and detachment in a shear flow in microgravity

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Link for the application :
https://emploi.cnrs.fr/Offres/CDD/UMR5502-CATCOL-002/Default.aspx

Context

Boiling is encountered in many engineering fields such as energy conversion, environmental applications, food and chemical process industries and space applications. There is consequently a great diversity of situations in which boiling processes are present and must be well understood. The correlations available in the literature are usually obtained in very specific conditions of pressure, heat flux or wall superheat, liquid mixtures, wall material, surface structure, etc. Consequently, these empirical laws are valid only when they are used in the range of parameters they were developed for. The main reason for this restriction is the huge number of physical phenomena governing the heat and mass transfer process, bubble vaporisation, unsteady conduction in the liquid after bubble departure, convection between the nucleation sites. Advanced heat transfer models take into account the different modes of heat transfers but require detailed analysis at the scale of individual bubbles. This is the objective of the Experimental set-up RUBI (Reference mUltiscale Boiling Investigation), which has been designed for more than a decade by several European teams involved in the ESA Project BOILING to study the dynamics and heat transfer around of isolated bubbles vaporising on a heated plate in microgravity conditions. Low gravity environment allows the observation of effects that are too fast and too small to be measured under normal gravity conditions. In this experiment, IMFT is especially involved in the study of vapour bubble growth and detachment in a shear flow. Experiments and data processing are performed in a the frame of an international collaboration with several European Universities (TU Darmstadt, University of Pisa, University Aix-Marseille, Université Libre de Bruxelles, University of Thessaloniki, University of Ljubljana…)..

Objectives

The RUBI experiment (Figure 1) is devoted to investigate the dynamics of a bubble growth and the local heat transfer at the bubble foot in microgravity conditions. Bubble growth and detachment are filmed with a high speed camera and the local distribution of the heat flux at the bubble foot is determined from high speed, high resolution Infrared camera images (Figure 2). This experiment was launched on the International Space Station in July 2019 and operated until February 2021. Experiments were performed in pool boiling conditions but also under the effect of external forces due to an electric field or a shear flow. For more detail about the set-up and operations on orbit see [1]. The data are now under processing by the different European teams. The results of a benchmark on the image processing techniques of the black and white camera have been published [2]. The data will be now used for the validation of theoretical models and numerical simulations.

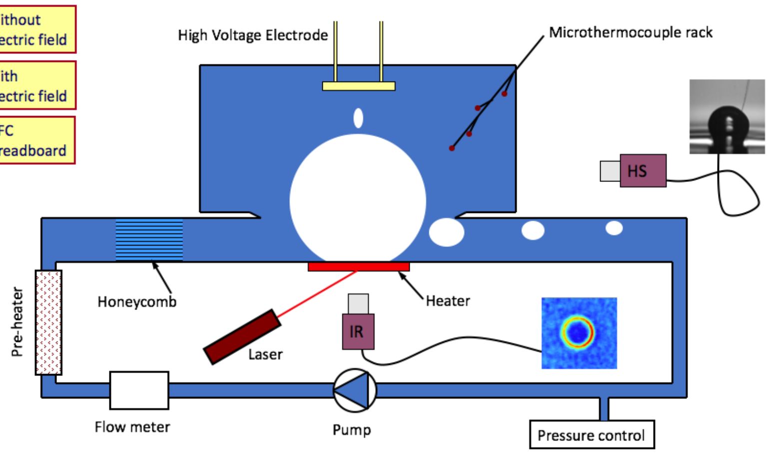

Figure 1 : Scheme of the RUBI experiment

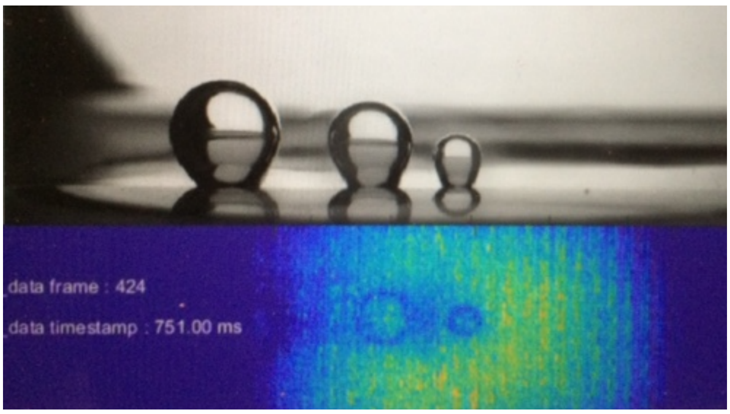

Figure 2: visualisation of the bubble growth and sliding along the wall (black and white images on the top and Infrared Images on the bottom)

The post-doctorate will be involved in the process of the data, especially for the thermal analysis of the bubble growth due to evaporation at the bubble foot and around the bubble. The wall temperature measurements with the infrared camera will be used to determine the local instantaneous heat transfer at the wall during the bubble growth, thank to unsteady conduction computation with COMSOL Multiphysics software.

From the process of black and white images, the bubble growth rate will be determined and compare with theoretical models and numerical simulations performed at IMFT. IMFT has also developed theoretical models to predict bubble detachment in a shear flow [3] in the case of air bubble injection [4] or bubble vaporising on a heated surface [5]. The data of RUBI will be used to improve these analytical models.

The post-doctorate will have a PhD thesis in fluid mechanics or thermal science, with an expertise on signal/ image processing. Expertise in the use of CFD codes will be appreciated. He (she) will be in charge of the post processing of the data, their evaluation and the development of theoretical modelling. He (she) will be in contact with researchers of several foreign Universities (TU Darmstadt, University of Pisa, University Aix-Marseille, ENEA Roma, Université Libre de Bruxelles, …).

The post-doc position is for one year starting in February or March 2023.

References

[1] SIELAFF A. et al., The multiscale boiling investigation on-board the International Space Station: An overview, Applied Thermal Engineering, 205 ATE 117932, 2022 https://doi.org/10.1016/j.applthermaleng.2021.117932,

[2] OIKONOMIDOU O. et al., Bubble growth analysis during subcooled boiling experiments on-board the international space station: Benchmark image analysis, Advances in Colloid and Interface Science 308, 2022, 102751 (https://www.sciencedirect.com/science/article/pii/S0001868622001531?via%3Dihub)

[3] LEBON M., Etude de la dynamique de bulles formées en paroi par injection ou ébullition: effet de la gravité et des forces hydrodynamiques, PhD Thesis University of Toulouse, Institut National Polytechnique, 2016. (https://oatao.univ-toulouse.fr/17480/7/lebon_michel.pdf)

[4] DUHAR G., COLIN C., Dynamics of Bubble growth and detachment in a viscous shear flow, Phys of Fluids, 077101,18, 2006. (https://www.researchgate.net/publication/27333776_Dynamics_of_bubble_growth_and_detachment_in_a_viscous_shear_flow)

[5] DUHAR G., RIBOUX G., COLIN C., Vapour bubble growth and detachment at the wall of shear flow, Heat and Mass Transfer, 45, 847-855, 2009. (https://www.researchgate.net/publication/227135176_Vapour_bubble_growth_and_detachment_at_the_wall_of_shear_flow)