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Microgravity Sciences Onboard the International Space Station and Beyond - Part 1 (6)

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BOILING PHENOMENA IN NEAR-CRITICAL SF6 OBSERVED IN WEIGHTLESSNESS

Abstract

Key mechanisms of the boiling phenomena in the two-phase region of SF6 close to its critical point have been observed using the high-quality thermal and optical environment of the CNES dedicated facility ALI-DECLIC on board the ISS. Indeed, the weightlessness environment of the fluid which cancels buoyancy forces and favorites the three-dimensional spherical shape of the gas bubble is an irreplaceable powerful tool for boiling studies. Moreover, the ALI-DECLIC experiments have benefited i) from the well-adapted design of the test cells, ii) from the high capability of the ALI insert teleoperation when long-duration exposure to thermal and microgravity environment are required and iii) from the high repeatability of the controlled thermal disturbances in a common microgravity environment when many experimental runs are required to identify each key mechanism and to conduct statistical validity. Here boiling phenomena were observed by light transmission and interferometry when the liquid-gas cells filled with pure SF6 at a near-critical density are driven away from equilibrium using well-designed heaters directly implemented in the bulk or near a boundary such as the sapphire optical window. The bulk massive heater distinguishes two symmetrical two-phase domains in the interferometry cell, leading to observe the modification of the gas bubble shape during heating. In the direct observation cell, the gas bubble is separated by a liquid film from the thin layered transparent heater deposited under the sapphire window, leading to observe the liquid film drying and the triple contact line motion during heating. We note that the experiments have been performed in a temperature range of 10K below the critical temperature Tc, with special attention to the range 0.1mK<T-Tc<3mK very close to the critical temperature. The main originalities of these investigations are then provided by monitoring of low heat fluxes and fine control of the liquid-vapor properties, by adjustment of the distance to the critical point, taking advantage of the simplifications due to the low temperature gradients and the universal description of critical phenomena. We show the key observations of the gas bubble spread over the heating surface which permits to characterize the regime where vapor bubbles nucleate separately and grow, as well as the key mechanisms – liquid drying, vapor film formation, triple contact line motion - at the origin of the boiling crisis when the formed vapor film reduces drastically the heat transfer at the heater wall.