CENTER FOR FLUID MECHANICS
AND
THE FLUIDS, THERMAL AND CHEMICAL PROCESSES GROUP
OF
THE DIVISION OF ENGINEERING
Seminar Series

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On the paradox of thermocapillary flow about a stationary bubble

When a stationary bubble is exposed to an external temperature gradient, Marangoni stresses at the bubble surface result in fluid motion. A straight-forward attempt to calculate the influence of this thermocapillary flow upon the temperature distribution fails to provide a well-behaved solution [Balasubramaniam & Subramanian, *Phys. Fluids* **16**, 3131 (2004)]. This problem is revisited here using a regularization procedure which exploits the qualitative disparity in the long-range flow fields generated by a stationary bubble and a moving one. The regularization parameter is an (exponentially small) artificial bubble velocity, which reflects the inability of any asymptotic expansion to satisfy the condition of exact bubble equilibrium. The solution is obtained using asymptotic matching of two separate Reynolds-number expansions: an inner expansion, valid at the bubble neighborhood, and a remote outer expansion, valid far beyond the familiar Oseen region. This procedure provides a well-behaved solution, which is subsequently used to evaluate the convection-induced correction to the hydrodynamic force exerted on the bubble. The independence of that correction upon the artificial velocity confirms the adequacy of the regularization procedure to describe the stationary-bubble case. The ratio of the calculated force to that pertaining to the classical pure-conduction limit [Young, Goldstein & Block, *J. Fluid Mech.* **6**, 350 (1959)] is given by 1 - Ma/8+o(Ma), where Ma is a radius-based Marangoni number.

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