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Dynamics of the liquid film around elongated bubbles rising in vertical capillaries MIRCO MAGNINI, Ecole Polytech Fed de Lausanne, SEPIDEH KHODAPARAST, Princeton University, OMAR K MATAR, Imperial College, HOWARD A STONE, Princeton University, JOHN R THOME, Ecole Polytech Fed de Lausanne — We performed a theoretical, numerical and experimental study on elongated bubbles rising in vertical tubes in co-current liquid flows. The flow conditions were characterized by capillary, Reynolds and Bond numbers within the range of $\mathrm{Ca} = 0.005 - 0.1$, $\mathrm{Re} = 1 - 2000$ and $\mathrm{Bo} = 0 - 20$. Direct numerical simulations of the two-phase flows are run with a self-improved version of OpenFOAM, implementing a coupled Level Set and Volume of Fluid method. A theoretical model based on an extension of the traditional Bretherton theory, accounting for inertia and the gravity force, is developed to obtain predictions of the profiles of the front and rear menisci of the bubble, liquid film thickness and bubble velocity. Different from the traditional theory for bubbles rising in a stagnant liquid, the gravity force impacts the flow already when $\mathrm{Bo} < 4$. Gravity effects speed up the bubble compared to the $\mathrm{Bo} = 0$ case, making the liquid film thicker and reducing the amplitude of the undulation on the surface of the bubble near its tail. Gravity effects are more apparent in the visco-capillary regime, i.e. when the Reynolds number is below 1.

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