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Why a falling drop does not in general behave like a rising bubble

RAMA GOVINDARAJAN, TIFR Centre for Interdisciplinary Sciences, Tata Institute of Fundamental Research, Hyderabad, MANOJ TRIPATHI, KIRTI SAHU, Indian Institute of Technology Hyderabad, India — Is a settling drop equivalent to a rising bubble? The answer is known to be in general a no, but we show that when the density of the drop is less than 1.2 times that of the surrounding fluid, an equivalent bubble can be designed for small inertia and large surface tension. Hadamard's exact solution is shown to be better for this than making the Boussinesq approximation. Scaling relationships and numerical simulations show a bubble-drop equivalence for moderate inertia and surface tension, so long as the density ratio of the drop to its surroundings is close to unity. When this ratio is far from unity, the drop and the bubble are very different. We show that this is due to the tendency for vorticity to be concentrated in the lighter fluid, i.e. within the bubble but outside the drop. As the Galilei and Bond numbers are increased, a bubble displays underdamped shape oscillations, whereas beyond critical values of these numbers, over-damped behaviour resulting in break-up takes place. The different circulation patterns result in thin and cup-like drops but bubbles thick at their base. These shapes are then prone to break-up at the sides and centre, respectively.

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