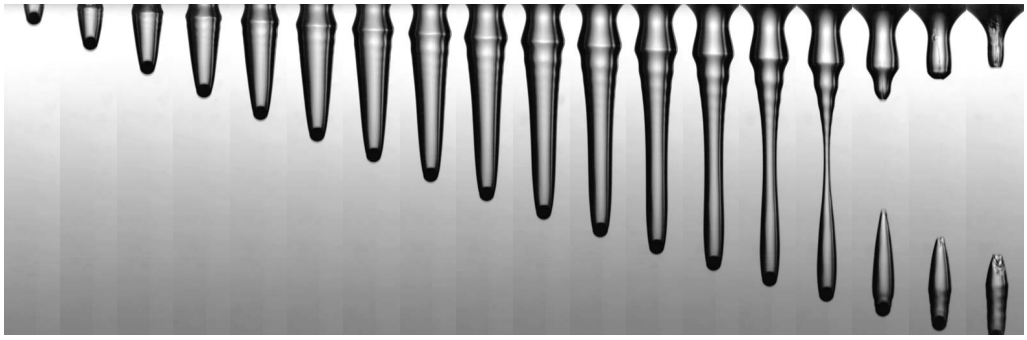

FIG. 1.

FIG. 2.

The water-entry cavity formed by low Bond number impacts

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We examine the evolution of the water-entry cavity formed by millimetric steel spheres with hydrophobic coatings striking the water surface.[1] The impact creates an axisymmetric air cavity that expands radially before closing under the combined influence of hydrostatic pressure, surface tension, and dynamic pressure. At low Bond numbers, $B=\rho g R^2/\sigma \ll 1$, where R is the sphere radius, ρ the liquid density, σ the surface tension, and g the gravitational acceleration, cavity collapse is driven primarily by surface tension and possesses features not readily observed at high Bond numbers,[2–4] $B \gg 1$, including longitudinal cavity ripples and multiple pinchoffs.[1]

The cavity evolution at Weber number, $W=\rho U^2 R/\sigma=110$, $B=0.088$, corresponding to $R=0.80$ mm, $U=310$ cm/s is shown in Fig. 1. The time between successive images is 0.94 ms. Longitudinal ripples are observed to propagate down the cavity walls at speeds less than that of the sphere. The cavity pinches off approximately halfway between the free surface and the sphere. The vertical retraction of the upper cavity results in a Worthington jet, while the lower cavity oscillates while remaining attached to the sphere.[5]

The cavity evolution at $W=420$, $B=0.14$, corresponding to $R=1.0$ mm, $U=540$ cm/s is shown in Fig. 2. Images were captured above and below the free surface with two synchronized cameras. The time between successive images is 1.9 ms. The impact generates a splash curtain that falls inward, creating a dome that seals the cavity from above. Once the cavity is sealed, the cavity pressure decreases as the sphere descends and the cavity volume increases. Note the Rayleigh–Taylor instability that develops, leading to a jet that penetrates the cavity from above. Eventually, pinchoff occurs at depth; this process is repeated several times, with each successive pinchoff producing a bubble of progressively decreasing volume.

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