

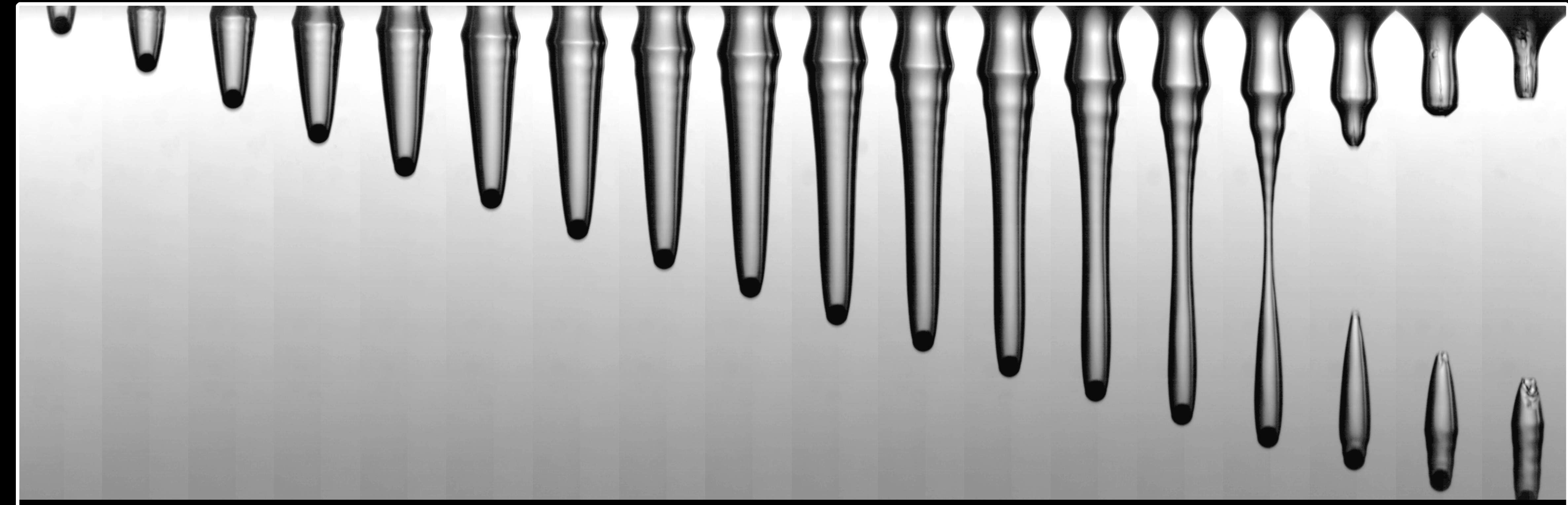
The Life of a Water-Entry Cavity at Low Bond Number

Jeffrey M. Aristoff, Tadd T. Truscott,
Alexandra H. Techet, John W. M. Bush



Jet emanating from the water surface following the collapse of the cavity generated by the impact of a 1mm steel sphere.

We examine the evolution of the water-entry cavity formed by millimetric steel spheres with hydrophobic coatings. 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 number, $B = \rho g R^2 / \sigma \ll 1$, where R is the sphere radius, ρ is the liquid density, σ is the surface tension, and g is the gravitational acceleration, cavity collapse is driven primarily by surface tension and possesses features not readily observed at high Bond number (e.g. longitudinal cavity ripples and multiple pinch-offs).



The cavity evolution at Weber number $W = \rho U^2 R / \sigma = 109$, $B = 0.088$, corresponding to $R = 0.8$ mm, $U = 310$ cm/s. 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 half-way between the free-surface and the sphere. The retraction of the upper cavity results in a Worthington jet (see image far left), while the lower cavity oscillates while remaining attached to the sphere.



The cavity evolution at $W = 420$, $B = 0.14$, corresponding to $R = 1.0$ mm, $U = 540$ cm/s. The time between successive images is 1.9 ms. Impact creates 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 finger that penetrates the cavity from above. Eventually, pinch-off occurs at depth; this process is repeated several times, with each pinch-off producing a bubble of decreasing volume.



**Massachusetts
Institute of
Technology**