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Two Fates in Bubble Breakup against Azimuthal Perturbations

LIPENG LAI, WENDY W. ZHANG, James Franck Institute & Physics Department, The University of Chicago — Cylindrically-symmetric breakup of an air bubble underwater is unstable against azimuthal perturbations. As perturbations in the initial shape of the bubble neck excite vibrations that persist over time, the breakup dynamics always becomes nonlinear. As a consequence, experiments find various breakups with small variation in control parameters. Here we analyze a simplified process where the dynamics is perturbed by an n=2 single mode and the only variation is the initial phase of perturbation. Using boundary integral method, our simulation classifies qualitatively different breakups into two categories. One is characterized by a topological change of the bubble neck via smooth contact between different parts of air-water interface. This dynamics is dominated by lower fundamental vibrational modes. The other is characterized by the formation of near cusp (high local curvature) along the interface which requires contribution from higher modes. Switching from one outcome (smooth contact) to the other (highly curved surface) as initial phase varies coincides with transition from constructive to destructive interference between wave modes 2 and 4.

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