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Ringin' the water bell: dynamic modes of curved fluid sheets

JOHN KOLINSKI, HILLEL AHARONI, JAY FINEBERG, ERAN SHARON, Racah Institute of Physics, Hebrew University of Jerusalem, Jerusalem 91904, Israel — A water bell is formed by fluid flowing in a thin, coherent sheet in the shape of a bell. Experimentally, a water bell is created via the impact of a cylindrical jet on a flat surface. Its shape is set by the splash angle (the separation angle) of the resulting cylindrically symmetric water sheet. The separation angle is altered by adjusting the height of a lip surrounding the impact point, as in a water sprinkler. We drive the lip's height sinusoidally, altering the separation angle, and ringin' the water bell. This forcing generates disturbances on the steady-state water bell that propagate forward and backward in the fluid's reference frame at well-defined velocities, and interact, resulting in the emergence of an interference pattern unique to each steady-state geometry. We analytically model these dynamics by linearizing the amplitude of the bell's response about the underlying curved geometry. This simple model predicts the nodal structure over a wide range of steady-state water bell configurations and driving frequencies. Due to the curved water bell geometry, the nodal structure is quite complex; nevertheless, the predicted nodal structure agrees extremely well with the experimental data. When we drive the bell beyond perturbative separation angles, the nodal locations surprisingly persist, despite the strikingly altered underlying water bell shape. At extreme driving amplitudes the water sheet assumes a rich variety of tortuous, non-convex shapes; nevertheless, the fluid sheet remains intact.

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