Leonardo da Vinci's paradox on the periodic motion of bubbles cracked

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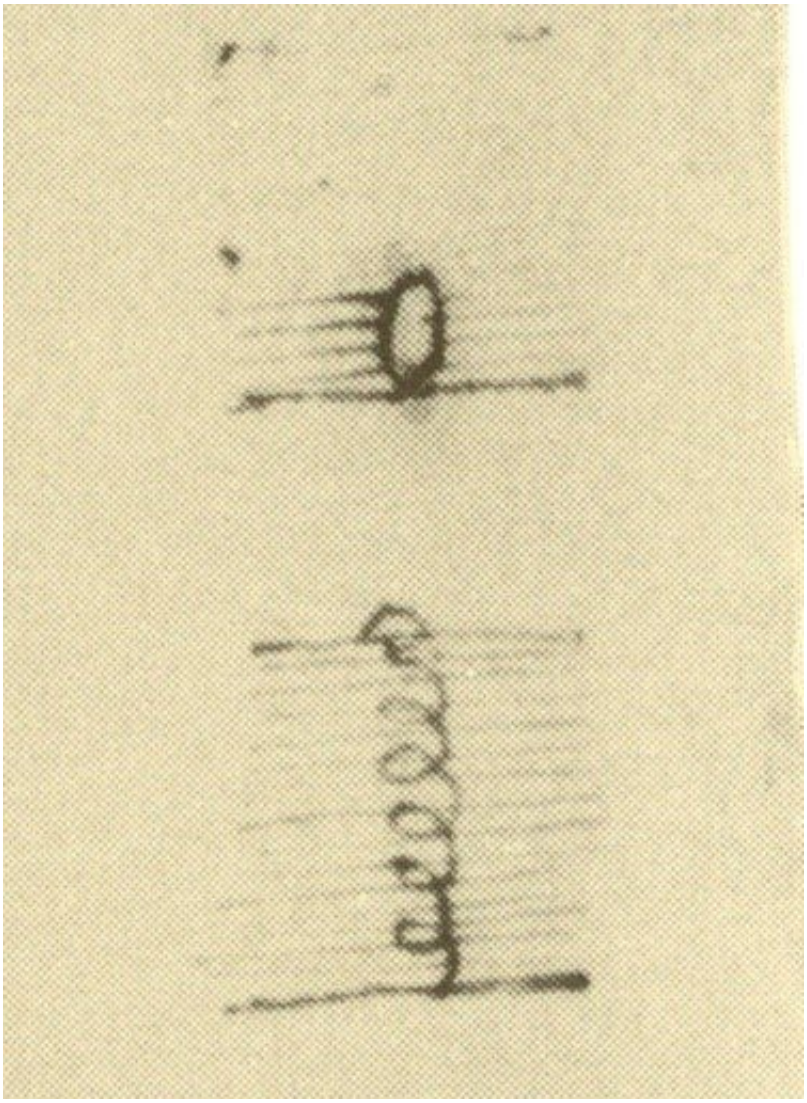

Leonardo’s sketch showing the spiral motion of an ascending bubble from his manuscript known as the Codex Leicester

Prof. Miguel Ángel Herrada, from the University of Seville, and Prof. Jens G. Eggers, from the University of Bristol, have discovered a mechanism to explain the unstable movement of bubbles rising in water. According to the researchers, the results, which are published in the journal *PNAS*, may be useful to understand the motion of particles whose behavior is intermediate between a solid and a gas.

Leonardo da Vinci observed five centuries ago that air bubbles, if large enough, periodically deviate in a zigzag or spiral from straight-line movement. However, no quantitative description of the phenomenon or physical mechanism to explain this periodic motion had ever been found.

The authors of this new paper have developed a numerical discretization technique to characterize precisely the bubble's air-water interface, which enables them to simulate its motion and explore its stability. Their simulations closely match high-precision measurements of unsteady bubble motion and show that bubbles deviate from a straight trajectory in water when their spherical radius exceeds 0.926 millimeters, a result within 2% of experimental values obtained with ultrapure water in the 90s.

The researchers propose a mechanism for the instability of the bubble trajectory whereby periodic tilting of the bubble changes its curvature, thus affecting the upward velocity and causing a wobble in the bubble's trajectory, tilting up the side of the bubble whose curvature has increased.

Then, as the fluid moves faster and the fluid pressure falls around the high-curvature surface, the pressure imbalance returns the bubble to its original position, restarting the periodic cycle.

More information: Miguel A. Herrada et al, Path instability of an air

bubble rising in water, *Proceedings of the National Academy of Sciences* (2023). DOI: 10.1073/pnas.2216830120