



FIG. 1. (Color) Liquid jetting caused by an expanding and collapsing cavitation bubble created close to the apex of the drop. The lower frames [(b)–(d)] show snapshots of the droplet and the bubble activity at times $40\ \mu\text{s}$, $120\ \mu\text{s}$, and $200\ \mu\text{s}$ after bubble creation. Please note that the stretched and toroidal bubble in (d) and its remains are still visible $200\ \mu\text{s}$ later in the top frame. The width of the droplet base is 6 mm.

Cavitation within a droplet

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(Received 12 May 2009; published online 11 September 2009)
[doi:10.1063/1.3200931]

The rapid dynamics of vapor bubbles, the so-called cavitation bubbles, in confined geometries may lead to surprisingly rich dynamics.^{1,2} The example presented here in Fig. 1(a) shows a cavitation bubble expanding and collapsing inside a liquid droplet,³ which creates two high-speed liquid jets shooting upwards. The primary jet is formed during the initial bubble expansion and collapse, and the secondary cylindrical jet forms when the bubble rebounds, i.e., after the collapse. The top picture captures both jets taken $400\ \mu\text{s}$ after the cavitation bubble has been created. The central jet is surrounded by the circular one. Both jet tips become unstable and pinch off droplets. The cavitation bubble inside the droplet creates a jet flow downwards and transforms into a torus, which disintegrates; its remains are still visible. The bottom row shows the stages leading to the double jet. Figure 1(b) depicts the bubble $40\ \mu\text{s}$ after creation at the apex of the

droplet. Bubble collapse occurs around $120\ \mu\text{s}$ [Fig. 1(c)], leading to flow separation, with an upward jet and a jet inside the droplet flowing through the bubble's center, deforming the bubble into a torus. During re-expansion of the bubble a second upward pointing, now cylindrical, jet emanates; see Fig. 1(d).

Technical details: a Nd:YAG laser ($\lambda=532\ \text{nm}$) with 6 ns pulse duration is focused with a $40\times$ microscope objective from below through a microscope slide into a sessile water droplet. The laser pulse (energy 3 mJ) explosively vaporizes the water and creates a bubble of approximately 1 mm maximum radius. The stroboscopic pictures are taken with a commercial digital camera (Nikon D200) equipped with a macrolens. The droplet is illuminated from behind with a high power light emitting diode (Seoul Semiconductor, P7) with a strobe (duration $2\ \mu\text{s}$). The light is mildly diffused to obtain a clear view into the droplet interior. For each picture, a new droplet is placed with a precision syringe onto a partially hydrophobic microscope slide.

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