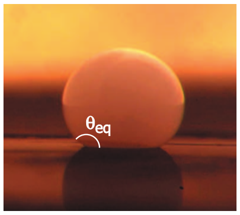

FIG. 1. (Color) Statics: A drop of milk displaying very large equilibrium contact angle on a superhydrophobic disk.

“Black hole” nucleation in a splash of milk

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It is well-known that a drop of water deposited on a superhydrophobic surface adopts a quasispherical shape to minimize its interaction with the substrate. As a result, the equilibrium contact angle, θ_{eq}, that the drop makes with the surface can approach 180° (Fig. 1). Also, the literature documents the impact dynamics of fluid droplets on such surfaces.[1] In particular, a water droplet can bounce off of a superhydrophobic substrate.[2] Here, we use rotational effects to further spread out the drop during impact.

We experiment with releasing a millimeter-size drop of milk above the center of a spinning disk whose surface is covered by soot to create a superhydrophobic substrate (Fig. 1). By varying the velocity of impact V and the rotation rate ω of the disk, we observe a rich variety of dynamics including bouncing, retracting, and dewetting.

Figure 2 shows high-speed images illustrating a typical dewetting experiment obtained for large values of both V and ω. Upon impact, the drop deforms into a liquid sheet that spreads out until it reaches a maximum diameter [Figs. 2(a) and 2(b)]. At the same time, due to rotational effects, its thickness continually decreases [Fig. 2(c)] and upon reaching a critical value, the drop dewets via the nucleation of a dry spot at the center of the spreading liquid sheet [Fig. 2(d)]. The hole in the sheet then grows, which leads to the ejection of the drop from the substrate [Figs. 2(e) and 2(f)]. We rationalize these results using simple physical arguments comparing the surface tension effects with rotation-driven spreading and thinning. For lower values of V and ω, the drop bounces while for intermediate speeds the drop spreads on the substrate, retracts, and then breaks up into smaller droplets (Fig. 3). In conclusion, by varying the values of V and ω, we obtain a variety of new dynamical behaviors for drop impact on superhydrophobic substrates, from a simple bounce to “spiders” and “black holes” [Figs. 3(a)–3(c)].

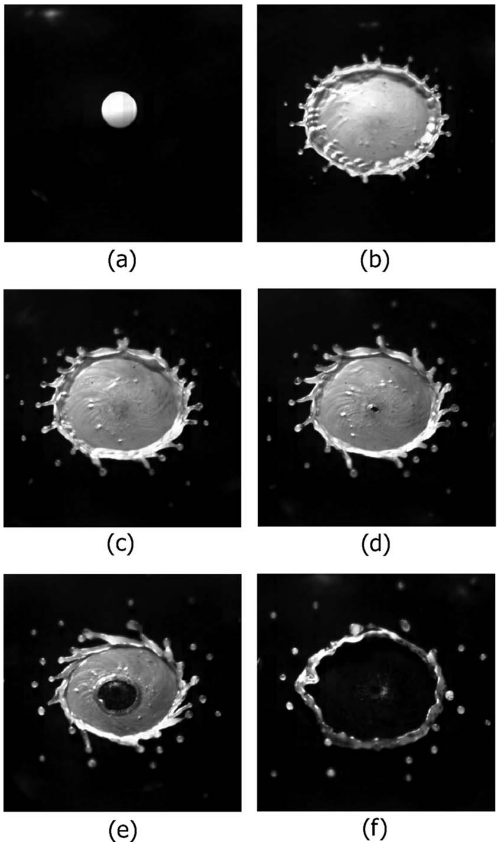

FIG. 2. Time evolution in a dewetting experiment: (a) 0 ms; (b) 4.5 ms; (c) 7 ms; (d) 8 ms; (e) 10 ms; and (f) 14 ms. Impact parameters are $V=2\ \mathrm{m\,s^{-1}}$ and $\omega=634\ \mathrm{rad\,s^{-1}}$.

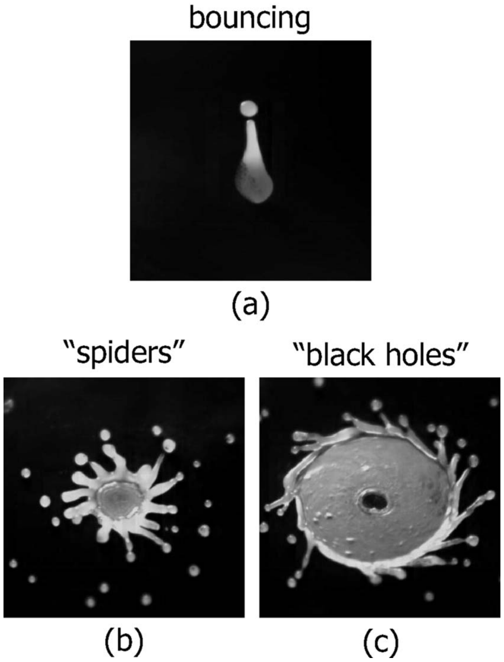

FIG. 3. Dynamics: Various behaviors on impact. Impact parameters are (a) $V=0.85\ \mathrm{m\,s^{-1}}$, $\omega=79\ \mathrm{rad\,s^{-1}}$; (b) $V=1.8\ \mathrm{m\,s^{-1}}$, $\omega=141\ \mathrm{rad\,s^{-1}}$; and (c) $V=2\ \mathrm{m\,s^{-1}}$, $\omega=634\ \mathrm{rad\,s^{-1}}$ (enhanced online).

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