The Effect of Gravity on the Dynamics of a Sessile Drop

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Liquid drop is a very common phenomenon occurring in various natural and industrial processes, e.g. thermal management, combustion systems, etc. Although there is a lot of investigations on sessile drops in the literature, there is only a few performed under different gravity conditions.

In this work we present experimental results on sessile drops obtained under normal gravity (1g), microgravity (μg) and hypergravity (up to 20g). The microgravity experiment was conducted during the 52nd and 53rd ESA Parabolic Flight Campaigns in Bordeaux, France, Fig. 1a. The hypergravity experiment was carried out in the ESA Large Diameter Centrifuge in Noordwijk, Netherlands, Fig. 1b.

(a) (b)

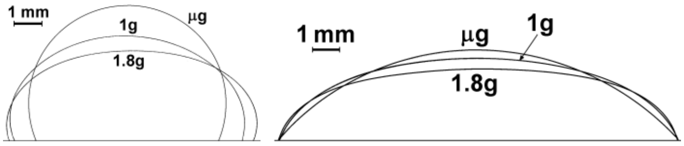
Figure 1: (a) - setup for parabolic flight experiments (52-53 ESA Campaigns); (b) - ESA Large Diameter Centrifuge.

The goal of the experiment is to study the effect of the gravity 1) on the shape of a static sessile drop; and 2) on the dynamic advancing contact angle in a growing sessile drop.

Eleven different smooth and rough surfaces are used, with different contact angles (CA) and different contact angle hysteresis (CAH). Water is used as the working liquid. The main variable parameters are: gravity (μg–20g); drop volume (1μl–5ml); liquid flow rate (0.0625–16 ml/min); CA (30–130º). The drop shape is visualized from the top with the help of the Phase Schlieren System, and from the side with the help of the shadow technique with resolution of 6 μm/pix. In terrestrial conditions the DSA10 Contact Angle Measuring System by KRUSS is also used.

Numerical algorithms for a solution of the Young-Laplace equation describing the shape of sessile drops are developed and tested for different types of initial conditions. A set of direct and inverse problems is solved on determination of the capillary length and CA from the measured values of drop dimensions: height, diameter, diameter of the wetted spot, volume.

For the first time the spreading of a sessile drop under the effect of gravity has been experimentally observed on surfaces with low CAH, Fig. 2a. For surfaces with high CAH the contact line is pinned while CA adjusts for different gravity levels, Fig. 2b. Good agreement is obtained between the modeling and experiment, Fig. 3. The dynamic advancing CA is found to increase with the gravity, Fig. 4.



(a) (b)

Figure 2: Gravity effect on drop shape (experimental data). (a) - 0.146 ml water drop on Teflon (CAH=12.6º); (b) - 0.313 ml water drop on Polyvinylacetate (CAH=34.5º).

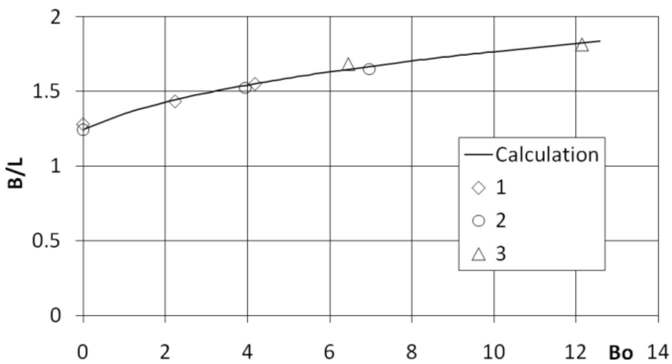


Figure 3: Dependence of dimensionless diameter of wetted spot, B/L, on Bo number, $L^2 g\rho/\sigma$, for water drops on Teflon under different gravity (B- diameter of wetted spot, m; $L=V^{1/3}$, where V is drop volume, m^3; ρ - liquid density, kg/m^3; σ - surface tension, N/m). Calculation is for CA=113º. Experiment: 1- V=0.067 ml, 2- V=0.146 ml, 3- V=0.340 ml.

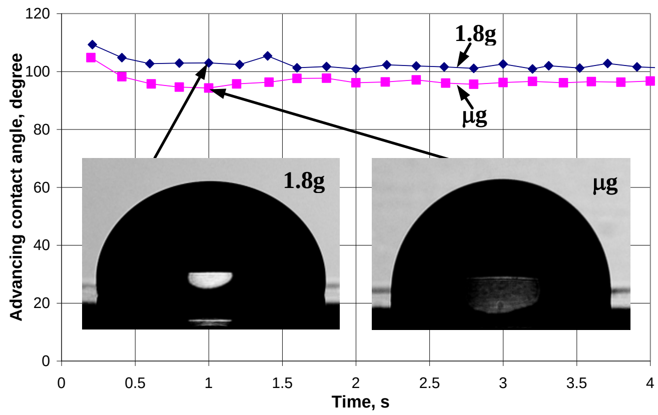


Figure 4: Advancing CA vs. time in growing water drop on Copper under different gravity. Flowrate is 1 ml/min. Shown are 16 μl drops.

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