When millimetre sized drops are sprayed on a flat horizontal substrate they deform substantially under the influence of the ambient air that needs to be squeezed out from below the drop. Depending on impact conditions they get deposited on the surface, or disintegrate in a splash before the liquid actually touches the solid. They even can bounce multiple times on the substrate irrespective of its wettability, provided that a micrometre-thick air layer is sustained below the droplet. We have investigated this bouncing behaviour \[1\], by analysing the centre of mass motion and its shape oscillations during a bounce series using high speed side view recordings of the droplet. From the centre of mass motion the droplet-substrate interaction force \( F = ma_{CM} + mg \) is determined. This force acts always upwards, even just before lift-off of the droplet. This is rather surprising if you note that at these impact speeds the air speed under the droplet is much smaller than the speed of sound. Hence, the flow in the air film is incompressible and the reaction force on the droplet is purely dissipative. In a simple lubrication picture air is sucked in during the retraction phase of the bounce, which suggests a downwards force on the droplet. At lift-off shape oscillations are excited which pertain during the flight phase in between the bounces, indicating that hardly any energy is dissipated during the in-flight oscillations. Hence, most of the dissipation, leading to non-perfect restitution, occurs during the bouncing process itself, despite the continuous presence of a lubricating air film below the droplet.

Reflection interference microscopy was used not only to confirm the existence of the non-vanishing air layer but also to study the role of this air film \[2\]. We quantify its thickness (typically a few micrometre) with 30nm resolution \[3\]. Our measurements reveal a strong asymmetry in the air film shape between the approach and retraction phase of the bounce.

Water drop bouncing on a hydrophilic glass substrate. (a) Side-view images of a water drop impacting at \( v = 0.22 \) m/s. Using reflection interference microscopy (b) we obtain interference patterns (c) from which the radial profiles of the air film thickness (d) are calculated. Scale bars: 1 mm.
The rim of the film moves outward and downward in the approach phase, but inward rather than upward in the retraction phase. This asymmetry turns out to be crucial for an effective momentum reversal of the droplet. Taking this effect into account, lubrication theory shows that indeed the dissipative force is repulsive throughout each bounce, even near lift-off, which leads to a high restitution coefficient and only a limited transfer of energy to the internal oscillation modes. The corresponding dissipation in the air film is strongly concentrated near the rim of the air film. Because this region could be observed only partially, we can only roughly estimate the dissipation in the air film. It contributes between fifty to eighty percent of the total energy loss during the bouncing series, in line with the above mentioned low dissipation during the flight phase.

**REFERENCES**