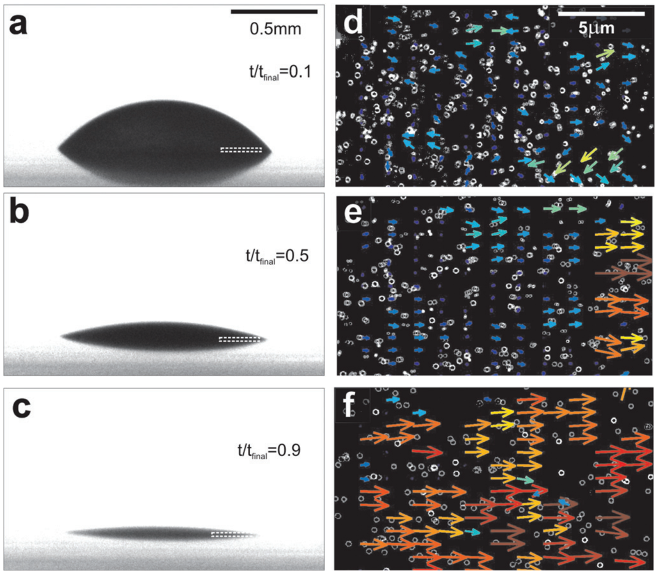

FIG. 1. (Color) Left column: an evaporating colloidal sessile droplet at three different moments in time: (a) at 10% of the total droplet life time, (b) at 50%, and (c) at 90%. Right column: particle velocity fields deduced from μPIV measurements performed in an area close to the contact line (white square in a, b, and c), at (d) 10%, (e) 50%, and (f) 90% of the total droplet life time (enhanced online) [URL: http://dx.doi.org/10.1063/1.3640018.1].

Rush-hour in evaporating coffee drops

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When a colloidal dispersion droplet evaporates from a surface, particles are dragged towards the contact line to form the well-known coffee-stain ring.[1] In this work, we use micro particle image velocimetry to show that the particle velocity increases dramatically in the last moments of evaporation. This "rush-hour" for particles in an evaporating colloidal solution occurs when the contact angle and the droplet height tend to zero (see Figs. 1(a)–1(f)).

The rush-hour behavior can be explained by simple mass-balance considerations.[2] The volume flow towards the contact line inside the drop is driven by the evaporation from the drop surface.[1] It turns out that the rate of evaporation is approximately constant over time.[3] To replenish this evaporated liquid, a continuous volume flow towards the contact line is generated inside the drop. However, the drop height is decreasing during evaporation, and hence, the same amount of liquid has to be squeezed through an area which is vanishing. Indeed, this induces a diverging radial velocity toward the end of the evaporation process.

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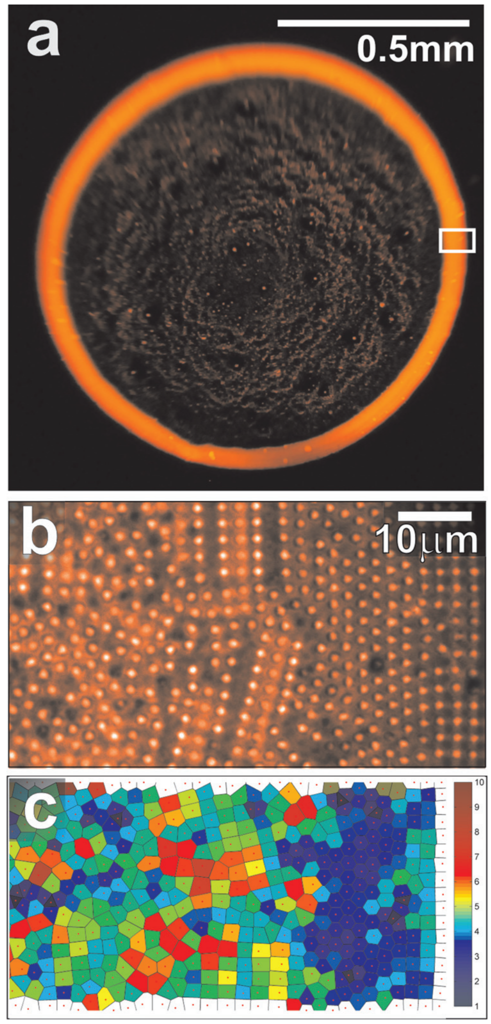

FIG. 2. (Color) (a) Image of the ring-shaped stain of red-fluorescent particles left on the substrate after evaporation, (b) a close-up of the stain (contact line is on the right-hand side). The different particle arrangement is shown in the Voronoi cell analysis in (c), where the color code represents the area of each cell. Those particles close to the contact line (right-hand side), which are arranged in a crystalline way, present smaller and more homogeneous areas (blue) than the particles that belong to the disordered phase far from the contact line (multicolored) (enhanced online) [URL: http://dx.doi.org/10.1063/1.3640018.2].

The rush-hour behavior explains the different characteristic packing of particles in the layers of the ring (see Figs. 2(b) and 2(c)) (Ref. 2): the outer one forms a crystalline array (particles at the right-hand side in Figs. 2(b) and 2(c)), while the inner one looks more like a jammed granular fluid (left-hand side in Figs. 2(b) and 2(c)). Such effect resembles the popular computer game *Tetris*®, where at the beginning of the game slowly falling objects are easily arranged in regular structures, while as the game evolves, the fast falling objects become jammed and disordered.

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