Evaporated whisky inspires new type of coating technique

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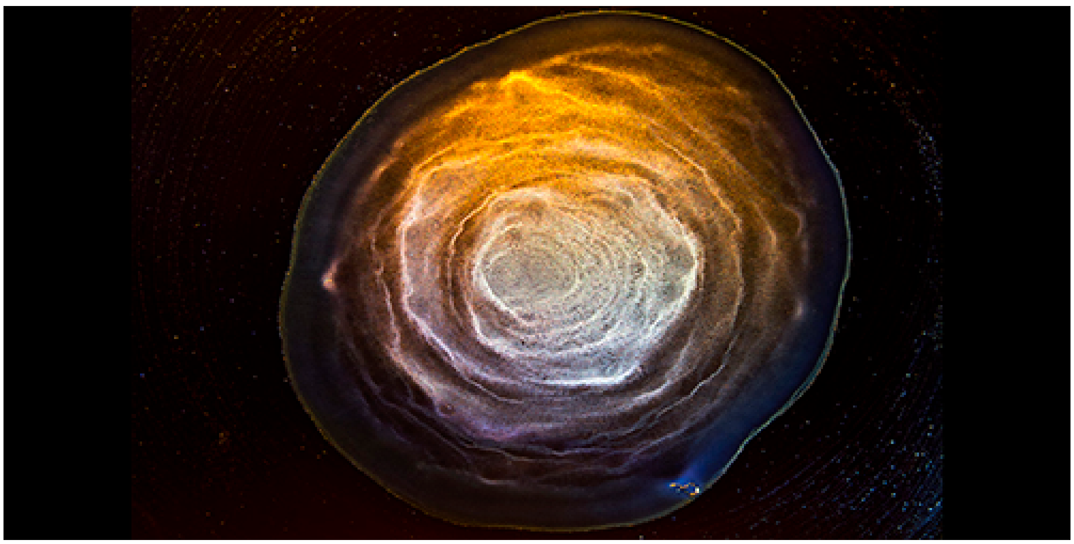

Credit: arXiv:1602.07937 [physics.flu-dyn]

(Phys.org)—A team of researchers at Princeton University, along with assistance from a photographer in Arizona, has uncovered the secret behind why whisky does not leave behind "coffee rings" when in dries. In their paper published in *Physical Review Letters*, the team describes their analysis of various whiskies and other fluids and why they believe their results suggest the possibility for a new type of industrial coating.

When coffee is spilled and allowed to evaporate on a surface, it typically leaves behind a ring, which has come to be known logically enough, as the coffee ring effect. It happens because the coffee evaporates more quickly at the edges, which leads to a change in surface tension, which causes more coffee (and the bean residue) to be pulled to the edges where it dries. Not all liquids behave this way though.

Ernie Button, a photographer living in Arizona noticed one day that the residue left behind when whisky (or 'whiskey' for some brands) dried in a clear drinking glass, was starkly dramatic when lit from below with various colors—he began photographing such residue and eventually noticed that not all whiskies left behind interesting patterns—that led him to ask a physics friend what was happening with the whiskies. That friend set up a team at Princeton to investigate the drying properties of whisky.

Upon taking a close look, the research team found that those whiskies that did not leave behind a coffee ring type pattern when they evaporated, had two important features: the first was fat-like molecules that lowered surface tension–as the liquid evaporated they collected on the edges of the drying surface which in turn caused the creation of a tension gradient that pulled the liquid back inward. The second feature was plant-derived polymers that caused a sticking effect, which in turn helped to channel particles in the liquid to the base material (the drinking glass) where they stayed stuck.

The researchers confirmed their findings by creating liquids that behaved in the same way as whisky, and then by removing either the polymers or surfactants—doing so prevented the liquid from leaving behind non-coffee ring characteristics. The researchers also noted that because of its even coating distribution characteristics, whisky-type liquids could very well prove suitable for industrial coatings or even as a type of ink for 3D printers.

More information: Hyoungsoo Kim et al. Controlled Uniform Coating from the Interplay of Marangoni Flows and Surface-Adsorbed

Macromolecules, *Physical Review Letters* (2016). DOI: 10.1103/PhysRevLett.116.124501 , On *Arxiv*: arxiv.org/abs/1602.07937

ABSTRACT
Surface coatings and patterning technologies are essential for various physicochemical applications. In this Letter, we describe key parameters to achieve uniform particle coatings from binary solutions. First, multiple sequential Marangoni flows, set by solute and surfactant simultaneously, prevent nonuniform particle distributions and continuously mix suspended materials during droplet evaporation. Second, we show the importance of particle-surface interactions that can be established by surface-adsorbed macromolecules. To achieve a uniform deposit in a binary mixture, a small concentration of surfactant and surface-adsorbed polymer (0.05 wt% each) is sufficient, which offers a new physicochemical avenue for control of coatings.