Distortion of water droplet surface may increase the likelihood of the droplet freezing

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For 50 years, scientists have struggled with a mystery around how ice nucleates. They lacked an explanation for the efficient ice nucleation that happens when a particle contacts a supercooled water drop. New research addresses this mystery. Credit: Pixabay

Clouds are a big source of uncertainty in computer simulations used to study Earth systems. To reduce that uncertainty, researchers study the formation of ice in clouds. This formation influences precipitation rates, large-scale cloud motions, and cloud optical properties. This research helps to address a long-standing mystery. For more than 50 years, scientists wanted to know why water droplets will freeze at a higher temperature when they are impacted by a particle. It's the pressure of the impact, according to new observations. A new study suggests the warmer freezing point is due to pressure changes resulting from the contact.

In most predictive models of cloud formation and growth, temperature is the most important variable, followed by the material properties of atmospheric particles, in determining whether or not a cloud is composed of water droplets or ice crystals. These new results imply that it may also be important to consider collisions, or dynamic properties, that influence the water surface.

In the atmosphere, droplets of liquid water are frequently found at temperatures below the freezing point of water (0 degrees Celsius) down to temperatures as cold as around minus 40 degrees Celsius. These cold liquid droplets are referred to as "supercooled." Supercooled drops can freeze into ice crystals in the presence of a class of small particles known as ice-nucleating particles. Understanding which particles serve as ice-nucleating particles under which circumstances and at which temperatures is an active research area because the formation of ice in clouds influences precipitation rate, large-scale cloud motions, and cloud optical properties. Much of the ice formation in the atmosphere is a result of catalysis by ice-nucleating particles, and the many different types of ice-nucleating materials are usually characterized by the temperature at which they trigger freezing. A long-standing mystery is the observation that supercooled water droplets freeze at a higher temperature when an ice-nucleating particle impacts the water surface, compared to the same particle being immersed in the droplet. Researchers performed laboratory experiments where they held the droplet temperature constant and agitated pure water drops and drops contaminated with a small amount of oil on two different surfaces. The drops were mechanically agitated using a frequency-controlled speaker and photographed with a high-speed camera. With this approach, scientists detected whether freezing occurred and if so, when and where on the drops. These experimental results show that ice nucleation initiated by mechanical agitation is strongly related to the moving and distorted three-phase contact line, suggesting pressure perturbations as a cause.

More information: Fan Yang et al. Nonthermal ice nucleation observed at distorted contact lines of supercooled water drops, *Physical Review E* (2018). DOI: 10.1103/PhysRevE.97.023103