Scientists log newfound understanding of water's responses to changing temperatures

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Credit: George Hodan/public domain

A team of chemists has uncovered new ways in which frozen water responds to changes in temperature to produce novel formations. Its findings have implications for climate research as well as other processes that involve ice formation—from food preservation to agriculture.

"The freezing and melting of ice are among the most common events on Earth," explains Michael Ward, a professor of chemistry at New York University and one of the co-authors of the paper, which appears in the journal *Proceedings of the National Academy of Sciences* (*PNAS*). "These processes are surprisingly complex, however, and are not well understood because of the number of variables involved. Our findings reveal some unusual dynamic properties of ice surfaces in contact with liquid water when the isotopic compositions of the solid and liquid differ."

The paper's other authors include Ran Drori, an assistant professor at Yeshiva University; Miranda Holmes-Cerfon, an assistant professor at NYU's Courant Institute of Mathematical Sciences; Bart Kahr, a professor in NYU's Department of Chemistry; and Robert Kohn, a professor in NYU's Courant Institute.

Understanding the dynamics of ice crystallization—otherwise known as ice formation—is vital in not only climate research, but also in several industries: mitigating frost damage in agriculture and construction, optimizing food preservation, and understanding its impact on roads, runways, and rails.

In the *PNAS* study, the researchers focused on multiple forms of water, and, in particular, water containing different isotopes of hydrogen—their differences in neutron count produce distinctions in atomic mass. These forms included light, or "normal," water (H2O) and "heavy water" (D2O), with deuterium (D) increasing the mass of water compared with normal water.

It's long been known that different isotopes confer different properties on these distinct kinds of water—most notably different melting points.

H_2O begins to melt at zero degrees Centigrade (32 degrees Fahrenheit) while D_2O does so at 3.8 degrees Centigrade (nearly 39 degrees Fahrenheit).

The variance in melting point is significant. For example, Antarctic or Greenland ice cores are composed of both H_2O and D_2O. As a result, they were frozen, and melt, at different temperatures. This property is used to estimate global temperatures over past millennia.

This raises the question the researchers focused on: What happens when water types with different freezing and melting points interact?

Here, the scientists found that, under conditions where the temperature was controlled precisely, the surface of a D_2O crystal contacting liquid H_2O assumed a scalloped appearance, with these "wavelike" features oscillating for hours.

Although the NYU team could not simulate all aspects of the oscillating features, they speculated that they reflect a range of phenomena: a complex interplay of exchange of light water for heavy water in the crystal, slight differences in the melting temperature along the scalloped interface, and heat transfer along the wave-like scalloped ice surface.

"If these processes can be unraveled completely, it may advance our understanding of the properties of ice that are important in numerous arenas, including climate research, frost damage in agriculture and construction, glacier dynamics, and food preservation," observes Ward.

More information: Ran Drori el al., "Dynamics and unsteady morphologies at ice interfaces driven by D_2O–H_2O exchange," *PNAS* (2017). www.pnas.org/cgi/doi/10.1073/pnas.1621058114

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