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Icicle Ripples: examining a phase transition with impurities (G)*

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Icicles are an ideal test-case for understanding the free-boundary shape of "wet" ice growth. Icicles observed in nature and the laboratory often exhibit ribs or ripples with a wavelength close to 1cm around their circumference. Previous experiments on laboratory-grown icicles have shown that the existence of these ripples depends on the presence of (very small) concentrations of impurities in the feed water. However, all existing theoretical models of the icicle ripple instability have ignored the purity of the water.

We have presented a model of solid icicle growth incorporating the effects of impurities on the freezing point. This model is based on previous work that assumed a thin-film flow over solid ice. We introduced realistic, physically derived boundary conditions for both heat transfer and impurity concentration.

Linear stability analysis shows that this more physically complete one-sided model of solid icicle growth cannot account for the 1cm wavelength of the ripple instability, because the effects of impurities are inherently too weakly coupled to the freezing dynamics. This suggests that more complex physics are involved, possibly so-called "spongy" ice. Models of the freezing and growth of spongy ice are more strongly affected by impurities in the water.

We present our latest experimental results investigating the nature of ice in laboratory-grown icicles.

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