Reply to Comment on "Pointy ice-drops: how water freezes into a singular shape", Am. J. Phys. 80, 764-771 (2012)

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We agree with the Comment by M. Nauenberg that the shape of the freezing front is far from horizontal. The trick to remove the unfrozen liquid with a syringe is simple and very elegant, and provides easy access to the shape of the ice halfway the freezing process. We have recently been able to visualize the detailed dynamics of the freezing front, while it propagates through the unfrozen drop[1]. The movie of the freezing dynamics was a winning entry for the Gallery of Fluid Motion 2011[2], and can be viewed on the internet[3]. The movie indeed reveals a strongly concave ice-front, perfectly consistent with the images in M. Nauenberg's Comment. We agree that this concave shape is likely to explain why the model is unable to explain the cusp formation at a density ratio $\nu \approx 0.9$. In particular, the movies exclude the slope discontinuity at the triple-line where the ice, liquid and vapor meet. We also like to remark that the "conical drops" observed by Nauenberg can indeed be reproduced in the model, by playing with the initial conditions (cf. Fig. 4 in the paper).

The interesting Comment illustrates that the cusp formation is very robust, and indeed, with a block of dry ice it can even be reproduced and analyzed in the kitchen.

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[1] O.R. Enriquez, A.G. Marin, K.G. Winkels and J.H. Snoeijer, "Freezing singularities in water drops", Phys. Fluids **24**, 053103 (2012).

[2] The Gallery of Fluid Motion is an exhibit held at the annual meeting of the American Physical Society, Division of Fluid Dynamics. http://pof.aip.org/gallery_of_fluid_motion

[3] http://www.youtube.com/watch?v=9VIRtyKSNVI