Analyzing the Singularities of Freezing Sessile Water Droplets

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INTRODUCTION

The purpose of this project is to investigate the cusp that emerges at the top of frozen sessile water droplets.

- Singularities are a unique occurrence in the solidification of fluids that expand during freezing [1]
- The shape of solidifying water droplets is important in understanding freezing rain on roads and wing surfaces in tribology and aerodynamics [2]

EXPERIMENT METHODS

We constructed a cold plate apparatus (Fig. 1) in order to drop water directly in front of the ProScope camera on the metal plate, cooled from below by liquid Nitrogen.

- Water droplets on the plate freeze up from the base
- A pointy tip forms only in the final moments

Analysis of our high resolution videos allows us to obtain data on the solidification rate and other characteristics of the freezing process.

RESULTS AND CONCLUSIONS

Our model predicts the formation of singularities, but it does not accurately predict pointy frozen water droplets. We are currently working on:

- A real-time demo of the physical transformation of a solidifying water droplet
- A program to quantitatively compare the experimental observations and numerical results

COMPUTER SIMULATION

Our computer-based simulation and interface allows us:

- To generate graphical plots of the numerical results to our geometric model (Fig. 5)
- To analyze the stability and theoretical limits of our differential equations: 0.75 is the critical density ratio for pointy drops to appear (Fig. 4)

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