Icicle Visualization

Purpose and Intent

The image shown is of an icicle with red dye on it. The dye highlights how quickly water flows down an icicle. The icicle is an interesting formation that formed outside my house. The photograph strikes me as something that is a bit haunting, since red dye was used for the visualization. Several drops were placed at the top of the icicle and flowed down due to the effects of gravity. It was important to me to catch a drop at the bottom of the icicle, as shown. The icicle was kept in focus and the background was left in as well.

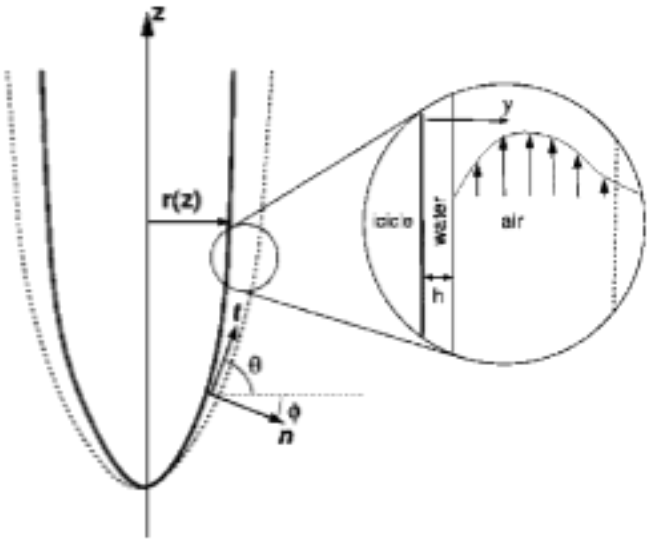
Figure 1: Icicle Dye Visualization

Concepts and Theory

When ice droplets move down an icicle, a small amount of heat is released, which then rises upward and slows the growth of the top, whereas the tip continues to grow rapidly. The warm air acts as an insulator, which is thin at the tip of an icicle and very thick at the top. This phenomenon causes the icicle to grow slowly at the top and the tip to grow thin, like a carrot. This helps create the shape of an icicle and their inherent mathematical shapes.

Researchers at the University of Arizona developed a theory, which posits the ideal shape of a dripping icicle. The profile is given below, along with the equation that

describes how the volumetric flow rate Q varies on the surface S. Q varies along the arc length s of the icicle as water turns into ice. The flowing layer, with water is much thinner than the rising thermal layer. The thermal layer gets larger, moving up the icicle, since hot air rises.



$$\frac{dQ}{ds} = 2\pi r v_s,$$

Experimental Set Up

The icicle was photographed using a point and shoot with an icicle that had formed during the later days of February in my backyard. Dye was added to the top of the icicle and allowed to flow to the tip of the icicle.

Camera specifications

The image was taken using a Canon Photoshot with an aperture of f/6.3 and the ISO used was 200. Photoshop was used to crop the image and to bring out the contrast between the red.

Further Work

Further work would involve measuring the time it takes for the dye to move down the icicle and replicating the experiment with different types of icicles in different locations.

References

1. Short, Baygents, and Goldstein. "A Free-boundary Theory for the Shape of the Ideal Dripping Icicle." *Physics of Fluids* (2006): 1-5. Print.

2.http://www.sciencedaily.com/videos/2007/0202-why_icicles_are_long_and_thin.htm