Get Wet

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2/7/06
MCEN 5228
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Images were taken of the sublimation of CO_2 as it escaped two overlapped glasses. Many different orientations of the glasses were tried in order to produce various results. Dry ice with the catalyst of warm water was used to produce very thick flowing fog of CO_2. The purpose of performing an experiment of this manner was to create free three dimensional dynamic flow, and observe any flow phenomenon. Over seventy photos were taken during different tests with very few producing aesthetically pleasing results. This outcome was partly due to my unfamiliarity with the digital camera. The most common mistakes were motion blur caused by a slow shutter speed required for the lack of sufficient lighting. After many failures a strobe flash was introduced to produce the final photo.

There were many different setups during the course of the experiment, but the diagram below is a schematic of the system used to produce the final image:

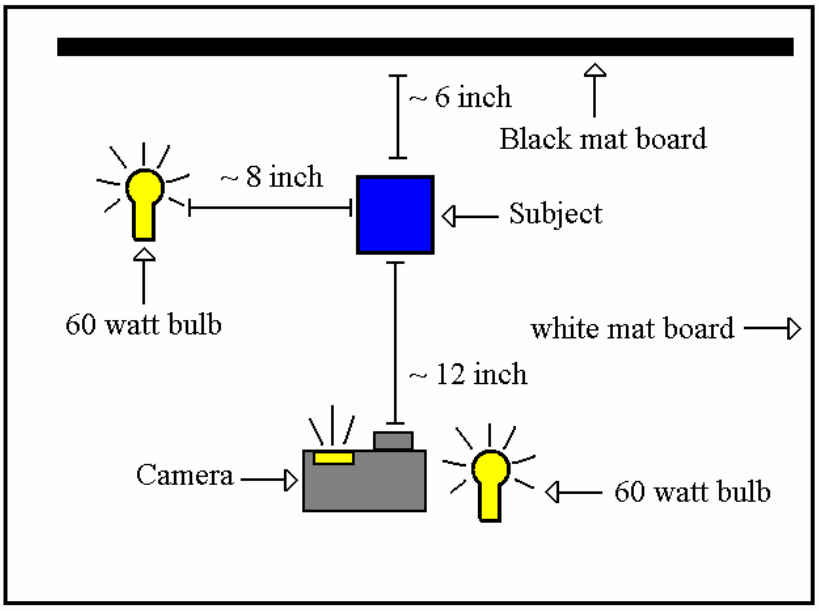

Fig. 1: Experimental Setup

The staging area consisted of two 2 feet by three feet mat boards placed at orthogonal angles. Black mat board was used to contrast with the white fog produce by the CO_2. To elaborate on the setup of the subject figure 2 is shown below:

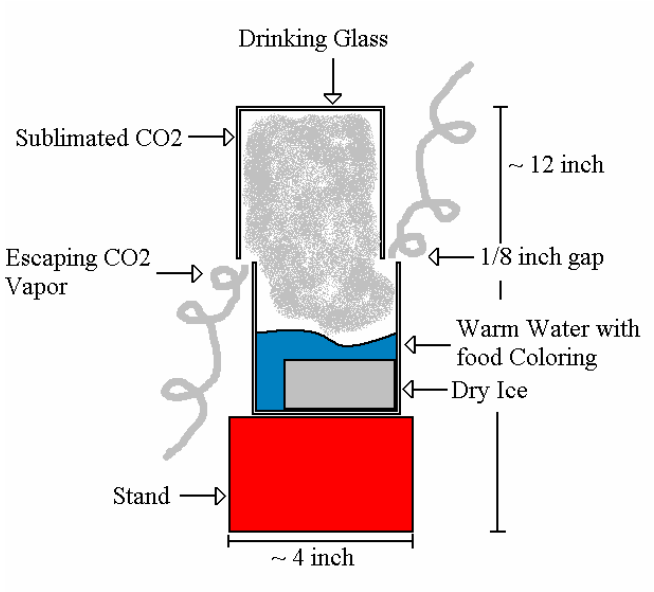

Fig 2: Subject Setup

The overlap of the two drinking glasses created a pressurized chamber which forced out two jets of CO_2. The nondimensional scales of Reynolds number and Grashof number were estimated for this experiment to be: 2227 and 1654 respectively*. Both of these numbers are associated with laminar flow. The area framed in the photograph is about 7 by 4 inches, which makes the special resolution of the photo to be around 14,000 pixels per meter. With an estimated speed of sublimated CO_2 being 6 inches/s or .1524 m/s the resulting motion smear is 18 pixels*. This number is larger than desired, but because there is such a large concentration of pixels/meter no image smear is apparent.

* Actual Calculations in Appendix 1

Figure 3

This photograph was particularly pleasing because of the two well defined vortices. It was my interest in these vortices that provoked my research for a deeper understanding of how and why they formed in this manner. The phenomenon which I believe is being demonstrated is the Kosterlitz-Thouless Transition. According to Vorticity and Turbulence by Alexandre Chorin:

> "there will always be an equal number of positive and negative vortices… the pairs can screen each other, i.e. arrange themselves so as to nearly neutralize each other…the number of pairs increases with temperature…until at a T = Tc there arise a number of "free" vortices, divorced from their partners in the pairs. The transition to a system with free vortices is the Kosterlitz-Thouless transition" (128)

The two vortices in the photograph are of the same sign, spinning in the same directions, which indicates that they are above the given Tc and are now unpaired "free" vortices.

The visualization technique used was the release of CO_2 gas against a black back ground. To illuminate the subject two desk lamp each with 60 watts of power were used as well as the flash strobe of the digital camera. The sublimation of the CO_2 gas would freeze the surrounding water eventually leading to much slower fog formation. This meant that water and blue food coloring had to be changed about every two minutes.

The photographic technique used was to shot in the macro setting. This means that the subject is around one foot from the lens. Taking photographs at this closeness made the field of view for this photo around seven by four inches. The camera used was the Nikon CoolPix 5700 with a resolution of 5 mega-pixels. This camera is equipped with a lens capable of changing focal lengths from 8.9 to 71.2 mm. When shooting in the macro technique the lens is typically in the shorter focal lengths for this shoot it was 23.7mm. This also means that the lens is acting like a wide angle lens. The exposure specs for this photo are as follows: aperture f3.6, shutter speed 1/125sec, resolution was set to high. No Photoshop filters were applied to this photo, it is original besides cropping.

Observing this three dimensional fluid flow allowed for a physical demonstration of the Kosterlitz-Thouless Transition as well as producing a photograph that is aesthetically pleasing. I liked the very defined tightly wound first spiral, as well as the bright blue water with bubbles. What does not appeal to me is the lack of clarity of the physical setup that produced the photo. I would also like to have a deeper understanding of what other aspects effect the Kosterlitz-Thouless Transition besides temperature. In

general this assignment served as a great learning experience with digital photography. If I were to pursue this experiment further I would probably repeat the same procedure to see if the same results could be produce or if the vortices were just chance.

References:

Chorin J., Alexandre. Vorticity and Turbulence. New York: Springer-Verlag, 1994

Appendix 1 attached on next page