

Get Wet Image

Purpose

The goal of this experiment was to observe the formation of a Worthington Jet. Images of crown and jet formation in Newtonian fluids have become common recently. Originally several jets and crowns were photographed. In order to add a new element to a common image the impacting objects (droplets of Saline solution) were allowed to drop through a soap bubble. This created unique framing of the Worthington Jet. In addition the soap bubble had the unplanned effect of creating an interference pattern visualized by the rainbow of colors that can be seen “sweeping” through the bubble background and behind the secondary droplet of the Worthington Jet.



Figure 1: Final Photograph

Description of Apparatus

Overhead lighting was supplied by 3 60-Watt fluorescent light bulbs. Two 20-Watt desk lamps (labeled Light 1 and Light 2 in figure 2) provided direct lighting. A Pyrex brand 9”x9” clear, glass cooking pan was used as a reservoir. The reservoir was filled with approximately .5” of water. The camera’s flash was deactivated. A ruler was laid across the Pyrex dish and used to focus the camera. A separate bowl was filled with dish soap. Soap bubbles were blown using a straw. If a bubble “wandered” away from the point of focus it was realigned using the straw. Droplets of saline solution were then squeezed out of the dropper bottle. The camera was fired several times for each dropper. In future experiments an automated firing apparatus is suggested. The experiment occurred at 65 F.

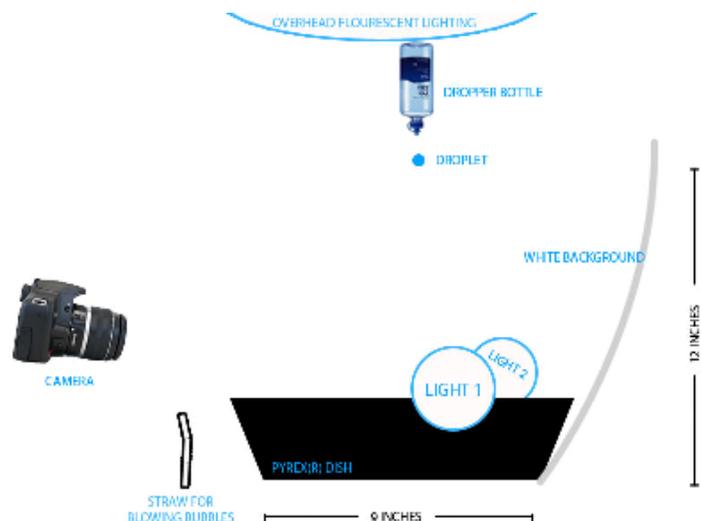


Figure 2: Apparatus

Flow

This image visualizes three separate flow phenomena: bubble formation on a liquid surface, light interference through a fluid, and impact dynamics (Worthington Jet).

a. Bubble Formation

The main bubble in the image was created when the end of a straw was filled with dish soap. This end of the straw was then placed on the water surface. Air was then blown through the straw, creating a bubble. When the edge of the bubble contacted the water surface, the bubble began to expand away from the water surface. Bubbles, when forming, minimize surface energy. This causes the bubble to take on a hemispherical shape with the water acting as a bubble surface. This mechanism can also be observed in the bubbles to the right of the image. Each bubble shares one of its walls with another bubble or surface in order to minimize surface energy.

b. Light Interference

As a result of different wavelengths of light being refracted at different angles by the bubble surface, the camera (and thus the viewer's eyes) captures the visible spectrum of colors. In layman's terms a rainbow is observed. In real time the position of each color changes as the bubble moves or vibrates.

c. Impact Dynamics

A Worthington Jet occurs in the wake of an object penetrating a Newtonian liquid surface. A crater is formed as the impacting object pulls liquid downward. When this crater collapses liquid is forced upward, creating a Worthington Jet. The Reynold's number for this experiment is estimated as:

$$Re = \frac{\rho DV_0}{\mu} = 5610$$

This suggests a laminar flow downward of the impacting droplet. From the image turbulence is not observed below the water surface.

Visualization Techniques

A single camera was used with a quick shutter. The camera was fired at approximately 3.5 fps (camera limit) for 3-5 seconds while droplets were allowed to impact the bubble and water surfaces. Lighting was supplied from 3 points: indirect illumination from overhead lights, direct illumination from a desk lamp from the right of the image, and direct illumination from a desk lamp from the left of the image.

Photographic Information

Field of View: 7"x4"

Distance from lens to object: 14"

Camera: (Digital) Canon EOS Rebel XSi

Picture Dimensions (X-Y)(Pixels): 4272-2848 (Original), 3222-2201 (Final)

Shutter Speed: 1/160 sec

Aperture: F/16

ISO: 1600

Focal Length: 55 mm

Post Processing

Photoshop CS4 was used to process the image. The image was first cropped to the final dimensions of 3222px-2201px to remove unnecessary portions of the photograph. The levels were then adjusted to increase the contrast of the image and bring out the bubble. The clone stamp tool was used to remove the "Pyrex" lettering at the bottom of the image as well as blend the background.