Team Project I: Report

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Introduction

The objective for the first team project is to capture artistic characteristics and physics of fluid flow. My first idea for this project was not accomplished due to time limitations with the high speed camera, so I decided to photograph a phenomenon that I witnessed many times camping with my family. My intent was to capture a multi-colored flame using a copper pipe and a garden hose. The combination of the two creates many colors caused by gas excitation from the fumes of the melting garden hose. I chose this specific image to submit from my collection because it had a good variety of color, mostly in focus, and no distracting elements.

Setup

To setup this image I gathered some old wood boards, a 30" diameter enclosed metal fire place, ¾" diameter copper tube, and a garden hose. The copper tube was cut to a length of 12" and nine holes were drilled along the sides in no particular order. The garden hose was cut to the same length and placed inside the copper tube. This was placed near the base of a well burning fire as shown in the figure below.

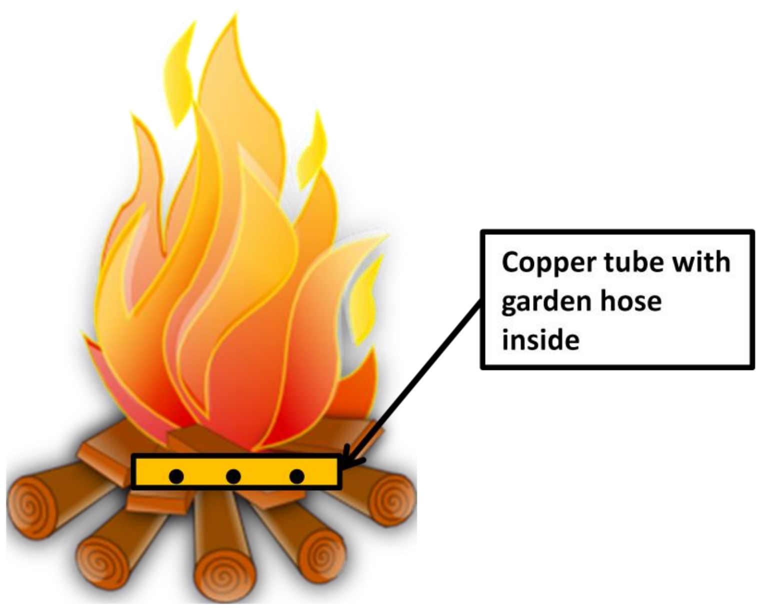

Figure 1: Setup for this photograph

Background

When the copper pipe and garden hose setup is placed into the fire, gas vapors are released. The heat from the fire causes the atoms in the gas to be excited and their electrons are able to move from their ground state to an increased energy state [1]. The atoms are accelerated by the high temperature of the fire near the source leading to low density combustion gases that rise quickly due to buoyancy between the low density combustion gases and the 'high' density ambient air. The atoms are cooled as they travel away from the fire and they emit photons of very specific energy as they return to their ground state. These photons of specific energy correspond to particular wavelengths of light, and therefore produce specific colors of light [2]. The color of the flame is dependent on two things: the temperature and gas excitations. The temperature of the flame correlates to specific colors, this is called the color temperature and the relationship between the two is shown in Table 1, below.

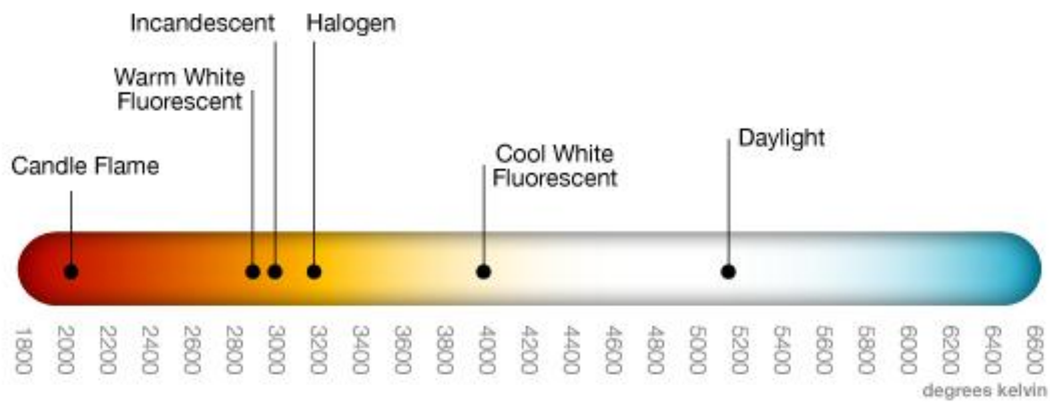

Figure 2: Color Temperature Chart [1]

The blue and orange colors that are typical in most flames are attributed to mainly to the color temperature. The pink, teal, and bright blues colors created by the copper tube/garden hose setup are caused by gas excitations. The color of photons emitted from the gas excitations can be linked to the elements in the vapors coming from the melting hose and the copper tube. Table 1 shows common elements that cause specific colors although their emitted wavelengths may correspond to multiple color wavelengths [2]. Without knowing the exact composition of the garden hose being used it what precise elements contributed to the color as multiple elements may produce similar colors.

Table 1: Flame Colors Caused by Burning Common Elements [2]

Element	Flame Color
Copper	Blue
Lithium and Strontium	Red
Calcium	Orange
Sodium	Yellow
Barium	Green

Visualization Technique

The image was taken at night in an outdoor environment with an ambient air temperature of 48°F. I started the fire and let it burn for a half hour to help create embers and ensure that the copper pipe would get hot enough to bring out as much color as possible. I placed the pipe near the bottom center of the fire and covered it up with some boards. The fire started to change color in about 5 minutes, at which time I began to take pictures until the color faded after 30 minutes. I took the picture at about 4 feet above the fire at a 30° angle from the centerline of the fire to help keep the metal grating on the fireplace out of the picture. The fire provided sufficient light and no other lighting was used.

Photographic Technique

My main goal for this photo was to get an in-focus and accurate image of a fire with a good amount of color to help show the phenomenon being captured. This image was shot using a point-and shoot Sony DSC-H10 8.1MP camera. By knowing the size of the fire and camera distance the field of view is calculated to be 76°. The shutter speed was set to 1/125 of a second at an ISO of 800; this seemed to provide the best combination to help bring out the detail of the fire. The camera was at a focal length of 6.3mm and an aperture stop of 3.5. The original image was 2448x3264 pixels and is shown in Figure 2.

Figure 3: Original unedited image

The original image is dull and some features of the fire don't stick out enough to show any detail, to help out with this I used the curves option in Photoshop to make the background go to black and bring out bright colors. I also cropped the image down to 1836x2922 pixels and used the clone stamp to touch up some minor ghosting effects found at the edges of the flames. The final edited image is shown in Figure 3.

Figure 4: Final edited image

Conclusion

The main scientific phenomenon this image reveals is color created from gas excitations as electrons change from their high energy state to their original state. I really like the range of colors in this picture, but I wish the colors were more visible. The camera did not capture the vibrant colors as well as they actually looked. The image shows the physics really well and is particularly noticeable in the white/green/blue ghosting effects seen by the flames near the top of the fire. If I could redo this image, I would use two or three copper pipe/garden hose combination to help add more color to the flames.

References

[1] Nassau, K. (2001). The Physics and Chemistry of Color:. New York City: John Wiley and Sons Inc.
[2] *Causes of color: fire and flames.* (n.d.). Retrieved from http://www.webexhibits.org/causesofcolor/3B.html