Team First

Michael Guenther

Flow Visualization: 4151-4200-001

The image depicted below is that of a flame displaying the columnar instability of a buoyant jet produced by a black rag dipped in a solution of 91% isopropyl alcohol. Its purpose is to demonstrate one of the many interesting forms a flame can occupy through its instabilities. I captured this image with the help of Lara Buri, Cara Medd, Michael Johnson, and Madison Emmett

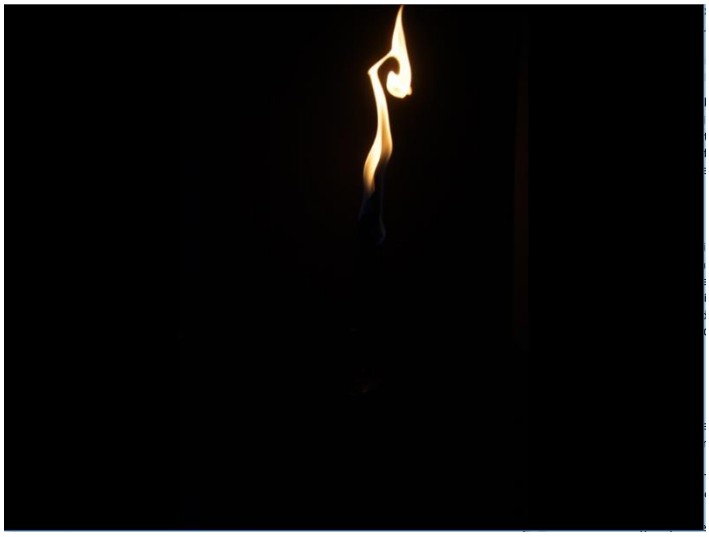

Figure 1: Original Picture

The form of this instability is not unlike the sinuous mode discussed in B. M. Cetegen and Y. Dong's experiments on buoyant flames. In their experiment Cetegen and Dong evaluated flames produced by a circular nozzle. The sinuous mode they observed was characterized by a stable flame origin followed by asymmetric oscillations and vortices forming further along the flame's column. This behavior is thought to be caused by the size of the fuel source of the flame. The sinuous mode tends to form in thin columnar flames with fuel sources that have diameters of 5.1 cm or less, intense buoyant acceleration, and ambient disturbances occurring around them. These criteria are met in the setup of this picture. The tip of the rag had a diameter less than 5 cm wide, the isopropyl alcohol provided a large buoyant acceleration for the flame, and the garage the picture was taken in was not sealed off from outside disturbances.

Figure 2: Supplies used in taking the picture

This experiment was carried out in my garage. To ensure that the experiment was carried out in a safe environment, a large section was cleared and doors and windows were set to allow clean air to flow through the garage, in case of harmful aerosols. A fire extinguisher was on hand and any team members handling the funnel or the lighter were required to wear hand protection. A black poster board was set up on a portion of the garage wall and the funnel was placed on top of a small (1.5ft x 2.5ft) table in front of the black background. The camera was put on a tripod and placed 2.5 feet away from the bottle on the table. All the photos were taken in portrait orientation, so the camera was tilted on its side on the tripod. The setup described is shown in Figure 2.

Materials needed for this experiment included a glass funnel, a black rag, 91% Isopropyl Alcohol, and a lighter. The alcohol can be found at any generic grocery store and a multi-purpose lighter was used to ignite the flame. To carry out the experiment, the rag was dipped into a small amount of isopropyl alcohol. The rag was then threaded through the bottom of the funnel, and the funnel was placed on the table upside-down. All the windows were blacked out and the lights were turned off. The lighter was placed next to the rag, and as soon as the lighter was triggered the person in charge of the camera started taking photos to capture the entire reaction. Once the reaction was over, the rag was disposed of and the funnel was cleaned.

The photo was taken using a Canon EOS 5D Mark II camera with a 28-75 mm, 1:2.8 lens. The shutter speed was 1/80 second, the f-number was f/2.8, and the ISO speed was ISO-1000. The camera was placed 2.5 feet away from the glass funnel. The field of view of the original images is 6.6 inches from the left side of the flame to the right side. In editing the image, I first adjusted the settings of the picture as seen in figure 3. Then I adjusted the level, exposure, and curve as seen in figures 4, 5, and 6. The dimensions of the original images were 3744 x 5616 pixels and the cropped dimensions of the final image was 2136 x 2016 pixels.

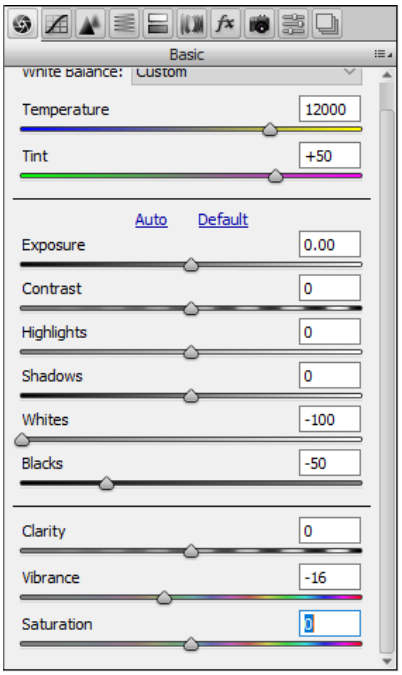

Figure 3: Adjusted Settings

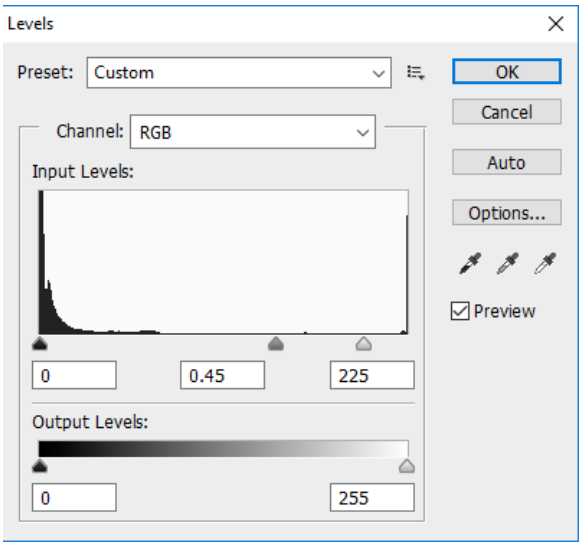

Figure 4: Adjusted Level

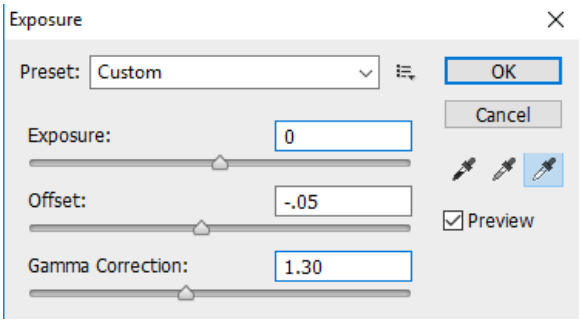

Figure 5: Adjusted Exposure

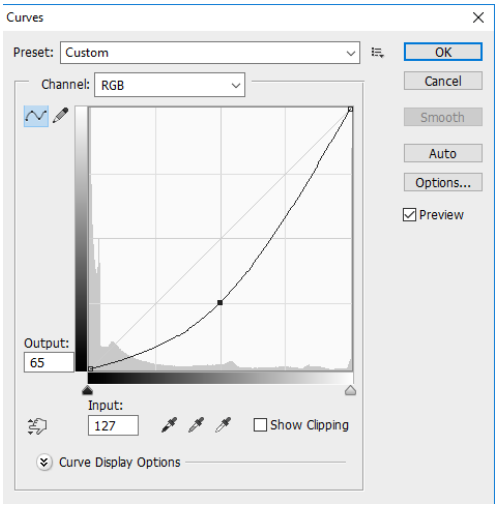

Figure 6: Adjusted Curves

In the end, this image demonstrated some interesting buoyant flame instabilities. The colors are vibrant and attractive, and the shape is not something that you see in a flame too often. I believe if anything was to be done to improve this picture it would have to occur in the post processing stage of its creation. However, as of right now I really enjoy the color scheme and the defined edges of the flame so I would not attempt to change it. This picture has peaked my interest in flame instabilities, and it is more than likely I will be returning to the subject again in future pictures.

Sources:

Cetegen, B. M., & Dong, Y. (2000). Experiments on the instability modes of buoyant diffusion flames and effects of ambient atmosphere on the instabilities. *Experiments in Fluids,28*(6), 546-558. doi:10.1007/s003480050415