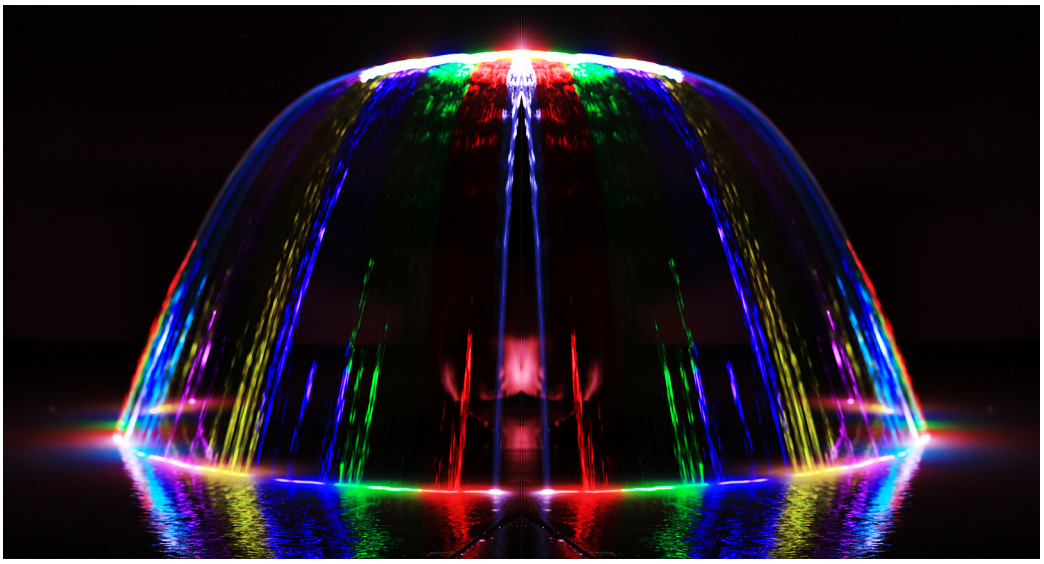
MCEN 4151
Flow Visualization
Get Wet Report

Ryan Daniel

September 26, 2016



1 Introduction

The purpose of this image was to capture the physical phenomena occurring in a laminar stream and display it using an artistic photo. Initially the goal was to design and construct a laminar flow nozzle and use video to capture the beautiful physical phenomena. After struggling to capture good video in a very low light environment, a long exposure shot was found to have a really nice look. The goal for the final image was to illustrate special properties of laminar flow (described in Section 2) using lots of color and water.

2 Flow Apparatus

To create a laminar stream of water, a special apparatus had to be constructed. Laminar flow can be visualized by imagining water molecules traveling in parallel with each other. Turbulent flow is the opposite of laminar where water molecules are traveling in a turbulent manner. A sketch of these two flow types is shown in Figure 1.

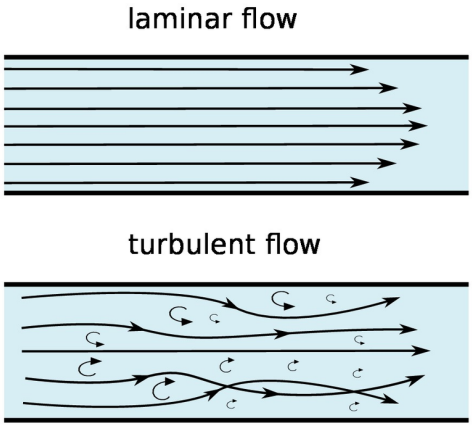


Figure 1: Sketch of Laminar vs. Turbulent flow from [1].

The apparatus constructed and used for this image is shown in Figures 2 and 3. PVC pipe that was 4" in diameter was cut to about 18" in length for the main body of the nozzle. A garden hose adapter was then glued into a 4" PVC cap that was sealed onto one side of the pipe. After that a 1/2" copper pipe about 15" long was routed through the center of the pipe. This

is where the fiber optic strands were ran through and connected to a 16 watt red, green, blue, and white LED driver shown in Figure 4. To create the laminar flow, an array of 10" straws was inserted into the pipe held in place by securing two screen meshes on either side of the straws. Another 4" PVC cap was fixed to the other end of the pipe with a 1/2" nylon washer serving as the orifice to create a 1/2" laminar stream.

Figure 2: Outside view of flow apparatus

Figure 3: Inside view of straw array and copper tube containing fiber optic strands

Figure 4: 16W RGBW LED Driver attached to 150 fiber optic strands purchased from Amazon [2].

3 Visualization Technique

Laminar flow has an awesome physical phenomena called total internal reflection which causes it to behave as a fiber optic. This phenomena is illustrated in Figure 5 where the glass material would be substituted for a laminar stream.

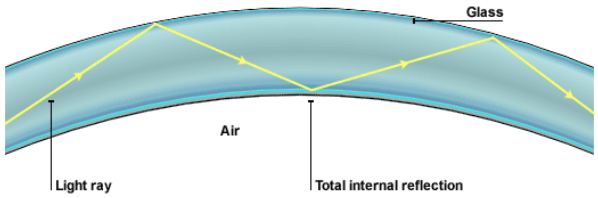


Figure 5: Sketch of total internal reflection from [3]

To capture this phenomena in the best way possible, the environmental conditions had to be dark and outside since access to a garden hose was needed. No external light was used, just the light produced from the LED being routed through the laminar stream. This ensured that the only light in the image was coming from the smooth stream of water. A picture of the functioning apparatus is shown in Figure 6 where only the white LED was illuminated.

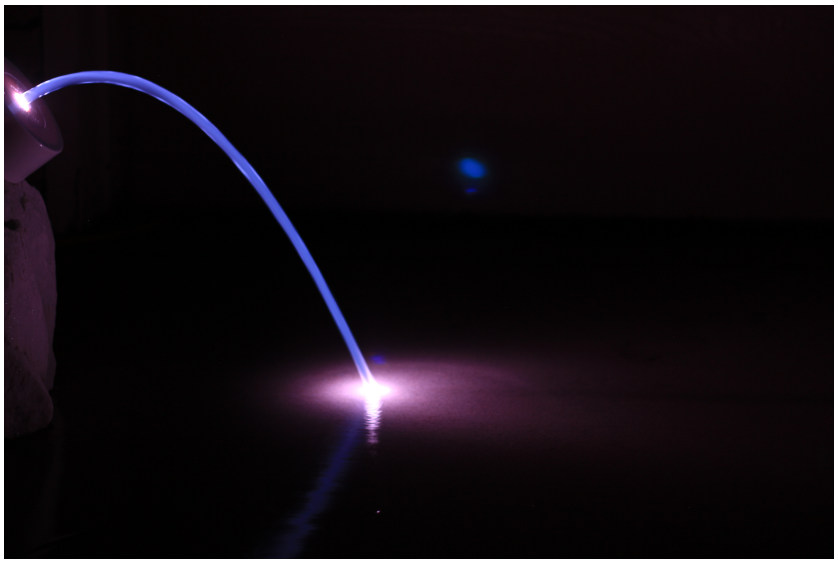


Figure 6: Operation of flow nozzle with white LED illuminated.

4 Photographic Technique

The original untouched image is shown in Figure 7 to help describe the technique used. A top view sketch of the physical layout of equipment is shown in Figure 8.

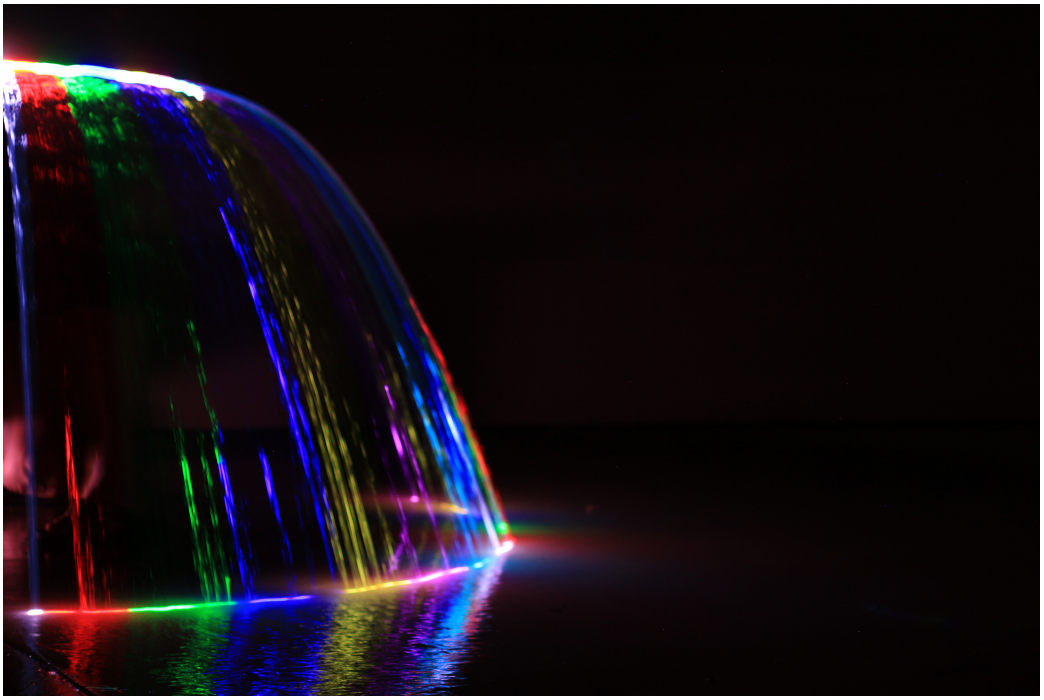


Figure 7: Original untouched image

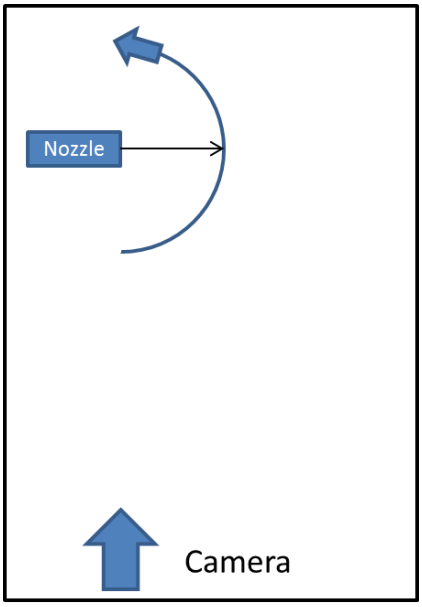


Figure 8: Top view sketch of equipment layout

The field of view in Figure 7 is about four feet where the stream of water extends about two feet from the very leftmost part of the image and is approximately two feet off the ground. As seen in the layout, the nozzle was rotated in a sweeping arch motion and captured by a Canon EOS REBEL T4i using a 10 second exposure time. The LED was cycling colors every second to create the rainbow of colors in the image. The long exposure time and F-stop value of f/2.2 really helped to capture the light emanating from the laminar stream. The camera was positioned about 10 feet from the nozzle and was set up on a tripod to ensure no movement during the shot. A focal length of 50mm and ISO-200 were used to focus on the crisp detail of the flow and capture the buildup of light. The original image was 5184x3456 pixels in size while the final image was 6480x3456 after being adjusted in Photoshop.

Several manipulations were applied using Photoshop where the most obvious one is the mirror effect. A simple adjustment to enhance the colors was achieved through the uses of Curves and Contrast as shown in Figures 9 and 10

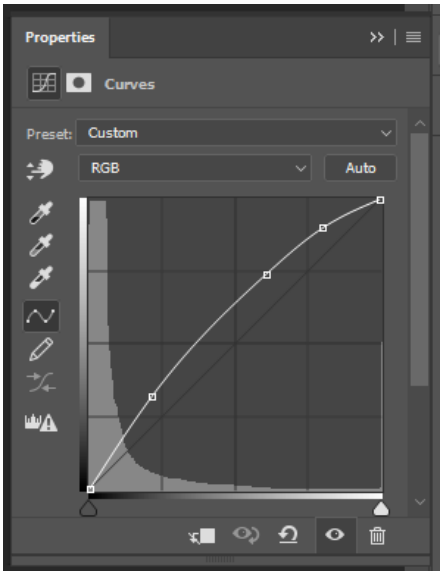


Figure 9: Curve properties

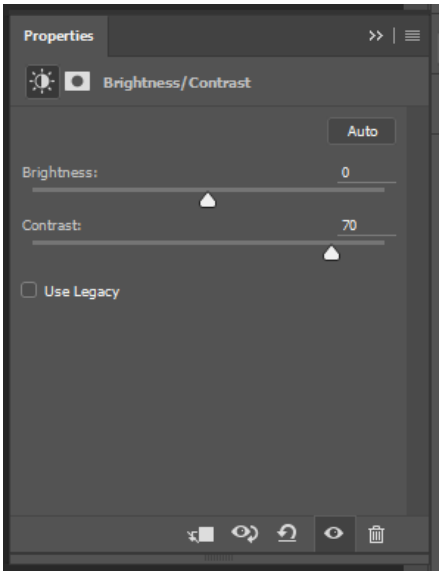


Figure 10: Contrast properties

5 Conclusion

This image reveals the beautiful fiber optic phenomena caused by laminar flow. I really like how well the long exposure shot came out looking like a waterfall of colors and especially the reflection caused by the stream hitting the ground. The physics of laminar flow are shown vividly here by demonstrating the transmission of light through total internal reflection of the stream. To develop this flow visualization further, a smooth apparatus to move the nozzle could be constructed to create a more uniform waterfall of light.

References

[1] `http://www.cfdsupport.com/OpenFOAM-Training-by-CFD-Support/node263.html`

[2] `https://www.amazon.com/gp/product/B01EDIDYMU/ref=oh_aui_detailpage_o05_s01?ie=UTF8&psc=1`

[3] `http://www.bbc.co.uk/bitesize/standard/physics/telecommunications/communication_using_cables/revision/2/`