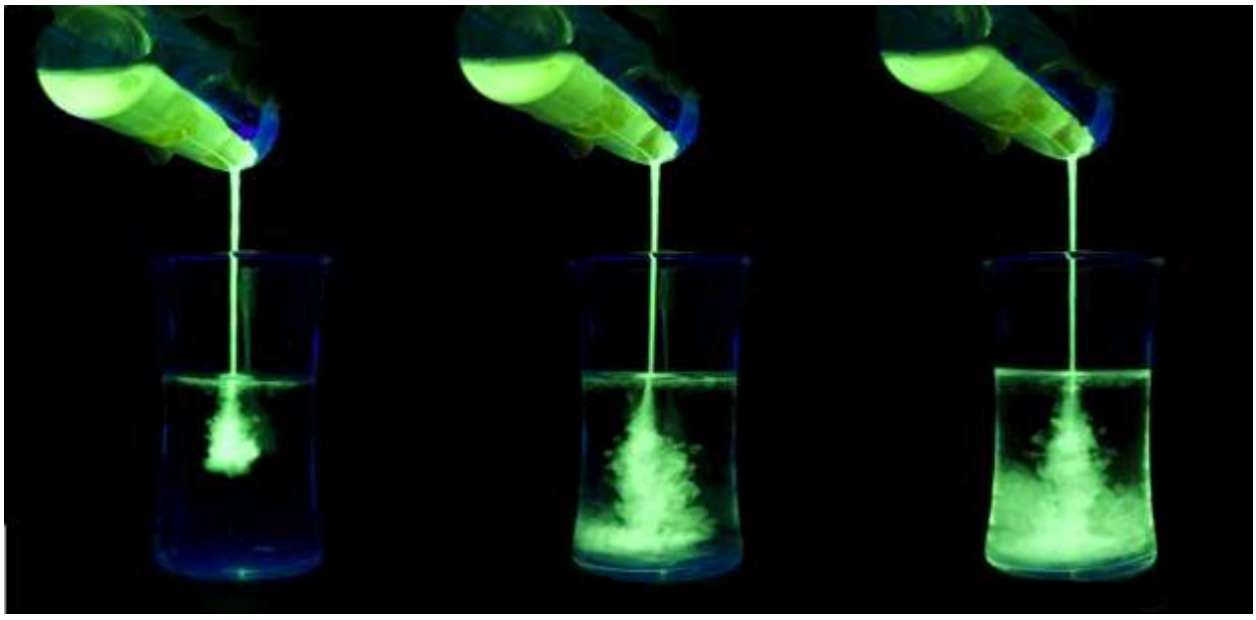
Black Light Visualization



By Davis Fogerty

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University of Colorado

Professor Jean Hertzberg

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I. Introduction

This image was created for the third group project image for the University of Colorado at Boulder Flow Visualization course. The inspiration for this photo came from watching gin and tonic drinks served at a bar with black lights. The drinks would glow under the black light but look completely normal under standard fluorescent lighting. This concept was tested and imaged with vortices, swirling, and mixing as well as with highlighter, tonic water, and laundry detergent. The resulting composition was the simplest, highlighter being poured into water.

II. Set-Up, Methods and Post-Processing

This image was created using a standard fluorescent black light or UV light as they are sometimes called, and highlighter ink. The ink tube from a yellow highlighter was drained into about 8 oz of water. It was then poured into a vase about half full of tap water. The black light was suspended over the vase to illuminate the pour from above. The highlighter liquid was poured from about 10 inches above the water and the camera was about 2 feet from the pour. The set-up can be seen in Figure 1.

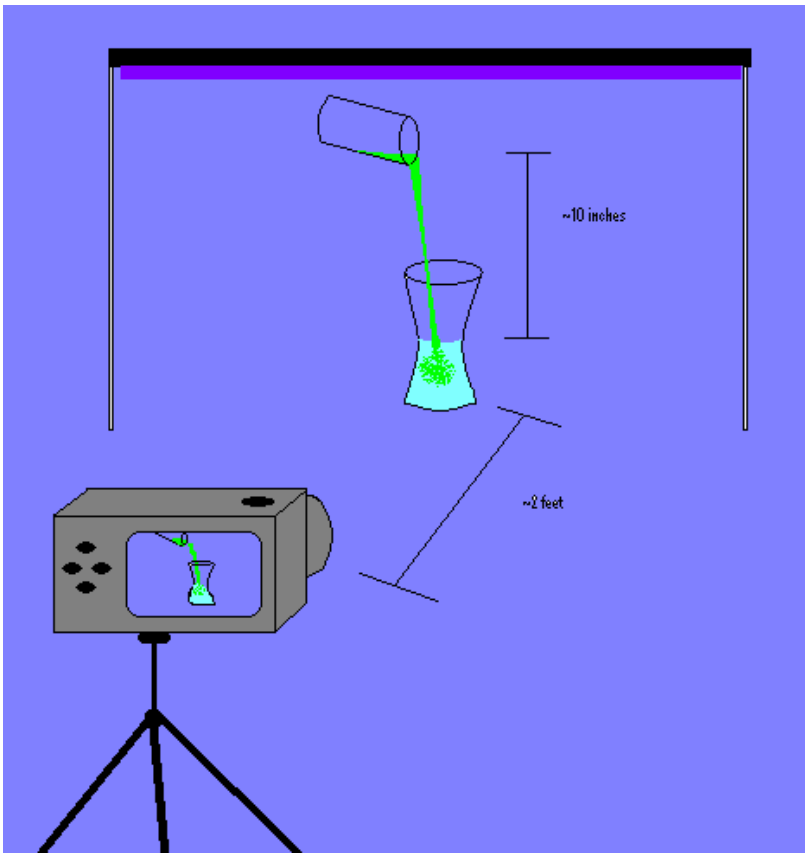

Figure 1: Set-up diagram

Although many different set-ups were attempted by swirling the water and with laundry detergent and tonic water, this simple pour proved to be the most dramatic. The camera used was a Pentax K2000. The image was taken on April 17, 2011. The shutter speed was 1/20 of a second with an aperture priority exposure program. The F-Stop was 4.0 with an ISO of 800. The focal length was 20mm with compulsory flash suppression. Flash suppression was required because the camera would try to use the flash to illuminate the subject. The post-processing for this image was fairly basic. First the images had to be added together and this was done using GIMP photo editing software. Since the camera was on a tripod no cropping was needed, the vase was already centered in the fame. After the 3-photo series was set, the colors were adjusted slightly. The cyan and magenta was brought out to make the toxic green glow a little more. The saturation of the image was increased slightly as well. The final size of the image after compilation was 3918 x 1908 pixels.

III. Analysis

Black lights and fluorescent ink have been used in everything from authenticating currency, to make-up and masks, to tagging molecules for microbiology and even to identify cracks and weaknesses in non-destructive material testing. Its unique properties make it an extremely useful in cases where other inks or dyes might not work. For this image, it is simply used to illuminate the turbulent mixing of two fluids. First, to understand why a highlighter glows under UV light, the basics of UV must be examined. Black lights or UV lights emit electromagnetic radiation that is almost exclusively in the ultraviolet range, although some visible light can be seen that appears purple or violet in color. The glass the fluorescent tubes are doped with a special nickel-oxide that blocks almost all visible light with a wavelength greater than 400 nanometers. The highlighter fluid absorbs high frequency light in the UV range and excites the electrons to higher states within the atoms. Then the electrons drop back down into a non-excited state they emit a photon at a lower frequency than the UV light which is in the visible range making the substance appear to glow. The wavelength spectrum can be seen in Figure 2 [1].

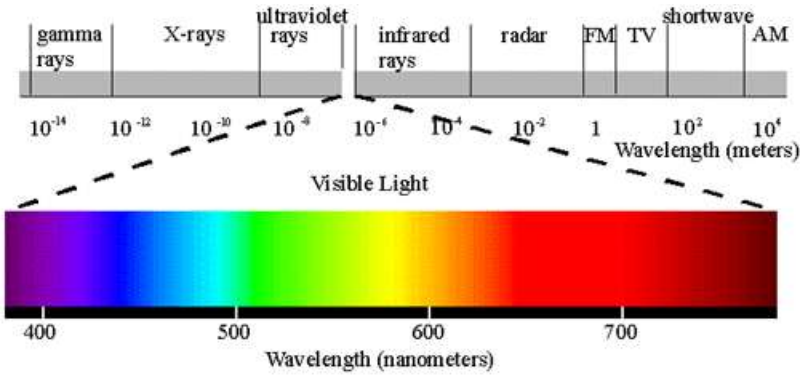

Figure 2: Wavelength Light Spectrum [1]

Do to the illumination of the highlighter fluid, the turbulent mixing can be seen clearly in the image. Since the fluid was being poured from about 10 inches above the water, it was calculated that the flow was moving at around 2.2 m/s.

$$v = \sqrt{2gh}$$ Equation 1

As the highlighter flow hits the water it becomes turbulent creating some small vortices that can be seen on the edges of the flow. The turbulence slowly starts to mix the 2 fluids as seen in the far right image. Some of the highlighter fluid splashes on the surface where the turbulence hasn't mixed the fluid yet. It can be seen illuminating the surface of the water and remaining relatively buoyant. The turbulence dissipates as the viscous forces take over and return the water to a steady state. After the highlighter fluid was completely poured into the vase the 2 fluids were completely mixed. This is mainly due to the nearly exact same viscosities and turbulence created during the pour.

IV. Conclusions

Overall, I believe the set-up and the image were successful. The phenomenon of visualizing a turbulent mixing of 2 fluids using UV illumination was completely captured and displayed with the 3 image series. The post-processing of the image helped to show this mixing while not losing any information in the image.

If I were to do this experiment again, I might try using a high speed camera to show the entire mixing, instead of just 3 instances. The black light made it difficult to fully illuminate the flow. Possibly more black lights could be used to help capture more details and get better focus on the flow.

V. References

[1] Victoria Supply Inc. (2010), http://www.topbulb.com/find/full_spectrum.asp

[2] Anderson, John D. (1995), Computational Fluid Dynamics, The Basics With Applications.

[3] Baker, Andre. (2003), The Characteristics of Turbulence. http://www.bakker.org/cfm/turbulence.pdf