



# Incense Wisps

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Get Wet Report

Flow Visualization Spring 2018

Prof. Jean Hertzberg

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This image was produced and selected for Prof. Jean Hertzberg's class on Flow Visualization for the initial photography assignment, "Get Wet." I occasionally use incense as a way to alter the fragrance of my room, but was motivated to capture the essence of its wispy smoke flows. This undertaking was helpful for me to gain awareness of stage photography. I learned how to control the environment in order to produce images that clearly depicted what I was trying to show. My deepest appreciation goes out to my dad, Matt, for letting me borrow his camera.

The flow depicted in the photograph is characterized by a smoldering combustion and the diffusion of its resultant particles into slowly moving air. The air comes from the right, the same direction the arrows are pointing in Fig. 1. Speed was clocked at about 0.2m/s as shown in Fig. 2. In the figure, it appears that the smoke slows down and floats gently up. This may be due to the box added to slow the flow and the black background: the no-slip condition causes fluid to match the velocity of the solid object it approaches.

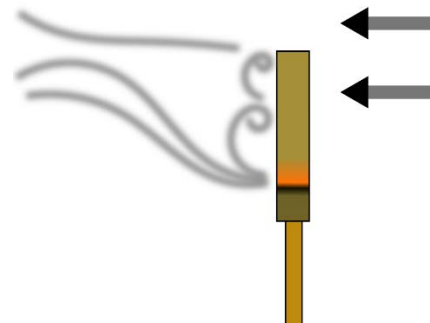


Fig. 1 Smoldering combustion interacts with air flow

Thus, the Reynolds number near the 3mm-diameter stick is  $Re = \frac{U \cdot D}{\nu} = \frac{(0.2 \text{ m/s}) \cdot (3 \cdot 10^{-3} \text{ m})}{(1.488 \times 10^{-5} \text{ m}^2/\text{s})} = 40$  while the Reynolds number on the bigger-scale room (about 2m in diameter,  $D$ ) is about 30,000. As the scale of the smoke increases, vortices become more apparent.

At least one main stream originates from the glowing combustion site, while one small stream appears to sneak up the incense stick and emerge from the top. This could be due to vortex drag (pictured)

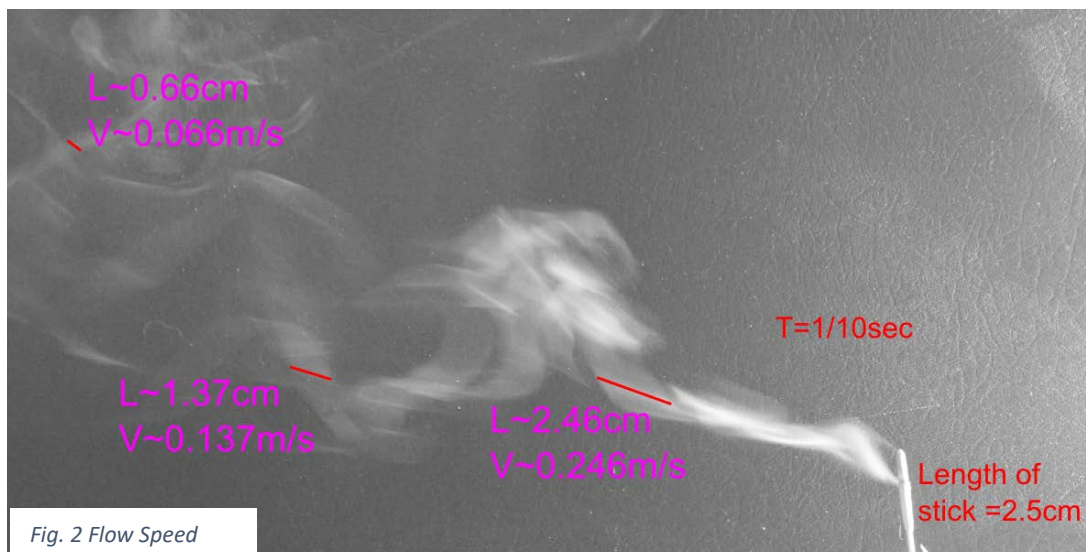


Fig. 2 Flow Speed

from the wind combined with buoyant heated air rising from the combustion. This may not be obvious due to the shadow caused by the incense stick.

Another unique element of this picture is that the smoke's color varies in different parts of the image. Some parts are more burgundy while others have a blue tint. This may be due to the fact that there are interacting shadows and reflections beyond the bounds of the image (see Fig. 2). It turns out that the floor is maroon and the box to the left is dark blue. They could be reflecting their colors onto the gray smoke. The smoke particles themselves all reflect the same color they receive due to Mie scattering: the interaction between a micro-sized particle and light. According to Yang, et. al., the mean visible particle size was found to be 262 nm. This is larger than 10% of the wavelength of visible light (400-700nm), thus it scatters all wavelengths of visible light biased toward the direction the light was already going.

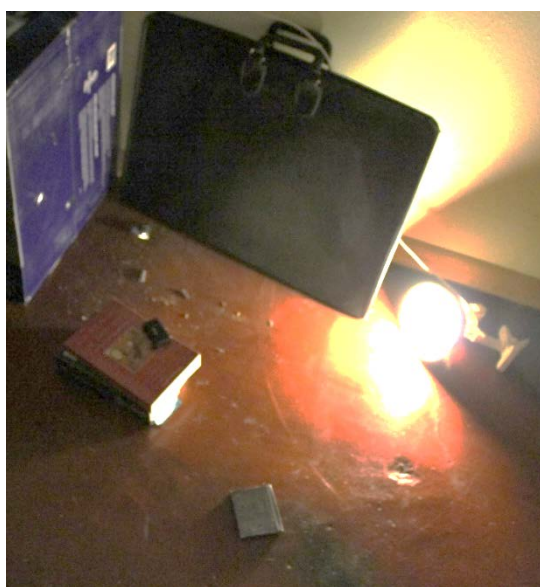


Fig. 3 Visualization Scene Setup

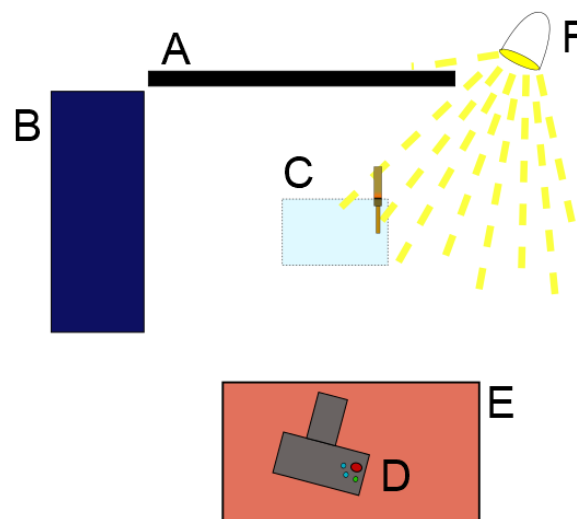


Fig. 4 Drawing of setup (not to scale)

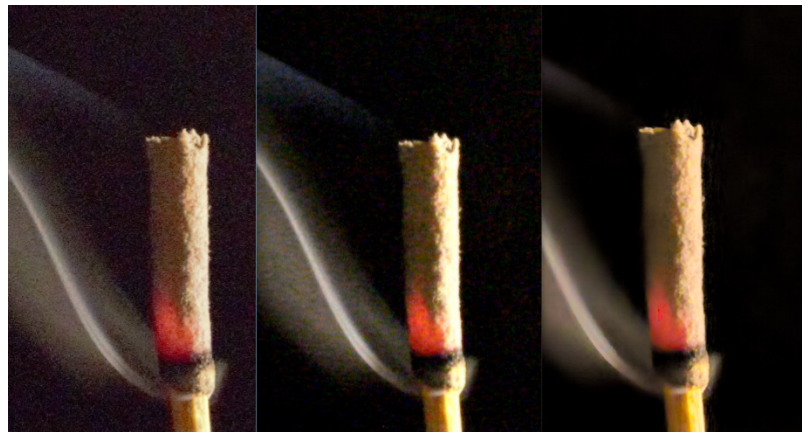
The flow visualization setup evolved as I learned more about the materials available. At first, there was the incense stick on its base (C), the background (A), and the [60W standard fluorescent] light [pic] (F) – and of course the camera (D). Smoke tends to be a very subtle medium to try to visualize. It is slightly opaque thus a black background is optimal for this technique. The background was a simple 2ft x 3ft black leather canvas bag. I found that the light had to be at least slightly behind the background in order to only light up the smoke and stick but not the textured black leather. The incense selected was Satya brand, Celestial fragrance incense (See Fig. 7). The smoke rose up and to the left due to either a convection current or a draft in the room – a phenomenon that influenced my decision to use a box (B) as a barrier

in order to let the flow linger and develop. I needed a sharp shot so I made a platform (E) out of books. By altering my setup technique, I became increasingly able to control my environment.

The scene may be set up, but to capture and transfer the scene digitally to others requires a camera. I used a Canon 60D-model DSLR capable of shooting 18MP images. The 18-55mm lens was zoomed out to 18mm. As can be seen in Fig. 2, the FOV was wide for this image: the camera platform (the books) was close to the incense (shown by crumbs, Fig. 2), about as close as the camera could focus (6ish in.). The image was cropped to 3253x2439px in post-processing due to extraneous information beyond the black background. As for capturing the light, the ISO was set high which resulted in a grainy picture that was difficult in post-processing. The F-stop remained f/5.6; looking back, a decrease in F-stop would allow a lower ISO resulting in a clear picture. The exposure time in this picture was a quick 1/250 sec which depicted a sharp view of the smoke. Since it was already in flow, little information was lost.

The post-processing included increasing brightness and contrast in the image, while darkening the right corner and touching up the bottom where the floor was pictured, in addition to cropping. The first edit of the image in GIMP required surgically touching up noise particles present in the image due to high ISO. The updated edit (shown, title page) was done on the raw image using a batch edit program called RawTherapee (see Fig.6). Its features allowed for reduction of high-chrominance noise due to over-amplified signals in the image sensor.

All in all, this Get Wet image allowed for me to practice setting up a scene in order to run an experiment and produce a photograph that clearly



*Fig. 5 Post-Processing Noise: Raw, First process (GIMP), Final process (RawTherapee)*

depicts the results of the experiment. The turbulence of the flow was well communicated as transitional, where it looks laminar close in, but turbulent as the scale increases. The camera's settings could be adjusted to make for a clear photo that requires less post-processing. By lighting the smoke with various colors and dark surroundings has the potential to depict whether the colors are caused by Mie scattering of colored light or Rayleigh scattering (what makes the sky blue). In a prolonged smoke experiment, masks would prevent inhalation of toxic smoke. Even though it was not an experiment that I had big hopes for, I enjoyed the experience of setting up a fluid experiment and producing a photo of my findings.

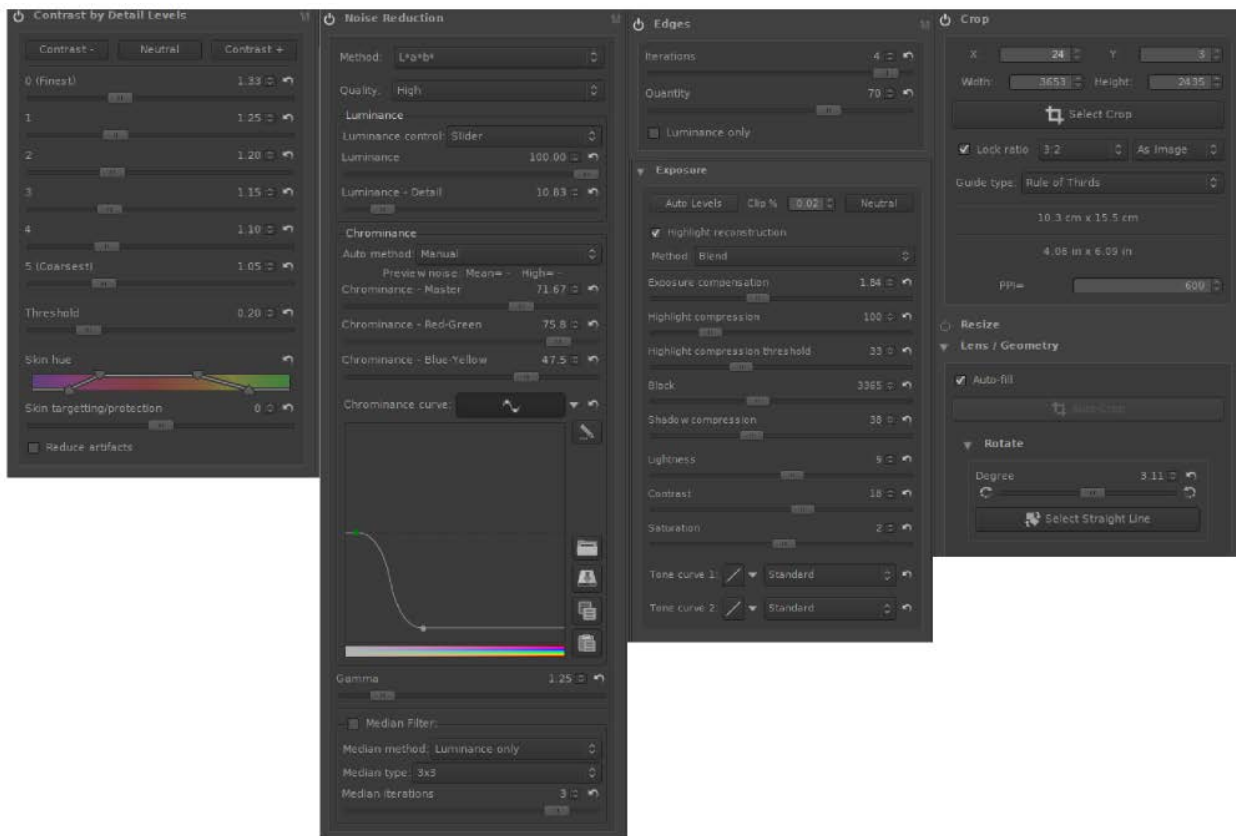


Fig. 6 RawTherapee Settings



Fig. 7 Incense Used in Project

### Works Cited

Chu-Ru Yang, Ta-Ching Lin, and Feng-Hsiang Chang. "Particle size distribution and PAH concentrations of incense smoke in a combustion chamber" *Environmental Pollution Vol. 145 Issue 2*, Jan 2007. 14 Feb 2018.