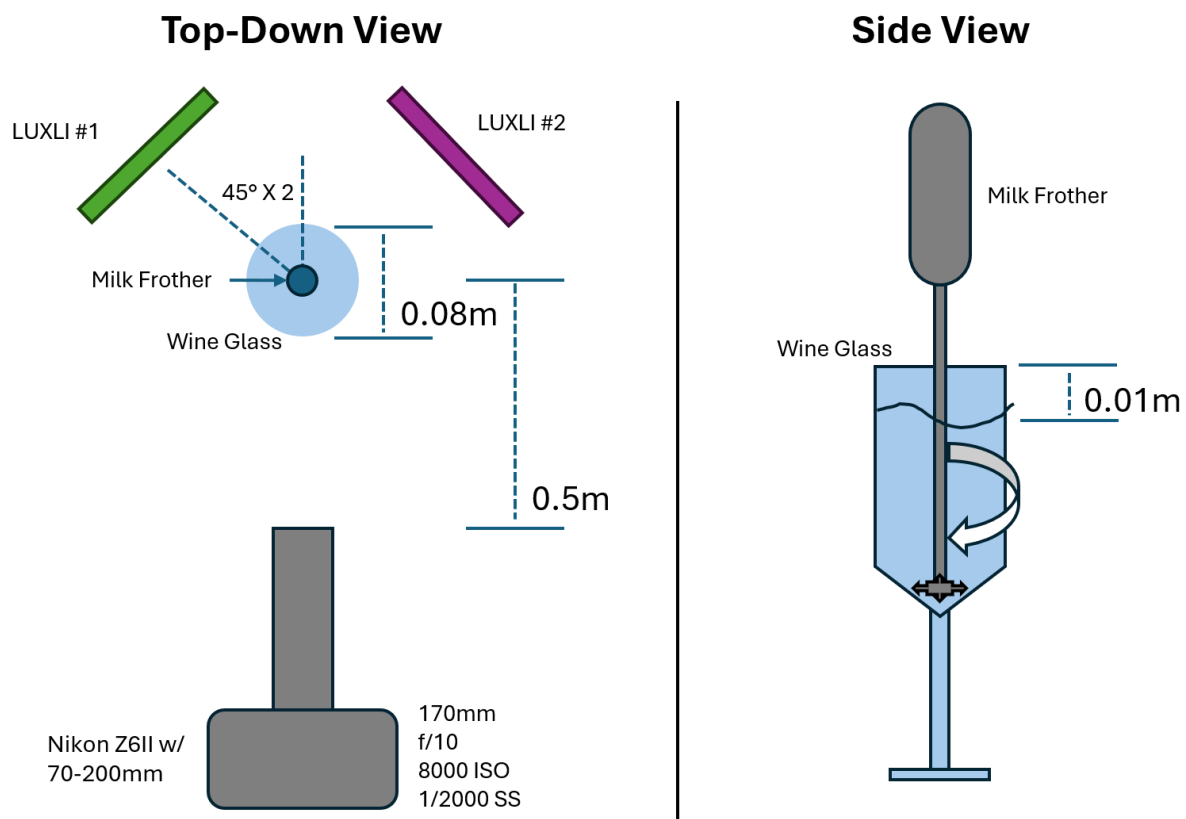


Dual Illuminated Vortex:

The intended purpose of the image was to create a dual-colored, high-speed photograph of fluid spilling over the rim of a cocktail glass, driven by rotational inertia. Executing this concept proved mechanically challenging as a solo photographer. Despite utilizing a 3-second shutter delay, the manual agitation of the glass caused the fluid's focal point to shift unpredictably, a problem that was exacerbated by the telephoto focal length of 170mm and narrow depth of field, even with an f-stop of f/10. For artistic effect and to enhance the contrast of the image, I incorporated two LUXLI RGB light panels to backlight the wine glass. One was set to a bright green color and the other a magenta hue. To try and achieve the spilling effect, I tried using a milk frother and a wine glass. This instead created a large rotational velocity inside the glass; combining the viscous shear stress generated by the wine glass boundary layer, it created a chaotic vortex at the center of the wine glass. This ultimately became the primary subject of the report.

The apparatus consisted of a standard wine glass with a bowl diameter of approximately 0.08 meters, filled with water to within 0.01 meters of the top of the glass. A motorized milk frother was inserted in the center of the fluid volume and turned on to activate the rotational flow. The vortex effect was maximized when the frother end was put to the bottom of the glass.



Schematic of Apparatus Setup

As the frother applies a shear stress to the fluid, velocity transfers momentum outward, resulting in a rotating body of fluid. The resulting centripetal acceleration is balanced by a pressure gradient, which causes the free surface of the water to dip in the center, forming a forced vortex. The Reynolds number (Re) can be estimated based on the velocity of the fluid and the diameter of the glass. Assuming a tangential fluid velocity (U) of approximately 0.5 m/s, a glass diameter (D) of 0.08 m, and the kinematic viscosity of water (ν) at room temperature as $1.004 \times 10^{-6} \text{ m}^2/\text{s}$:

$$Re = \frac{UD}{\nu} = \frac{\left(0.5 \frac{\text{m}}{\text{s}}\right)(0.08\text{m})}{1.004 \times 10^{-6} \frac{\text{m}^2}{\text{s}}} = 39800$$

A Reynolds number of 39,800 indicates a highly turbulent flow. The macro-structure of the vortex appears relatively stable and defined in the photo itself. The stability in the surface contour is what allows the lighting to clearly highlight the boundaries of the depression. To verify the time resolution of the photograph, the distance the fluid moved during exposure was calculated. Given the estimated tangential fluid velocity (U) and the cameras shutter speed (t) of 1/2000s, the motion blur distance (d) is:

$$d = U \times t = 0.5 \frac{\text{m}}{\text{s}} \times \frac{1}{2000} \text{s} = 0.0003\text{m}$$

A displacement of 0.3 mm during the exposure is very minimal relative to the 0.08 m glass diameter and the field of view. This highlights that the time resolution is sufficient, effectively freezing the fluid flow and air bubbles without noticeable motion blur.

This visualization technique relied purely on the optics of the wine glass and fluid interface. The primary environmental control was a darkened room to minimize ambient light. Lighting was provided by two LUXLI LED lights placed to the back left and right of the glass, pointing directly towards the glass. They were approximately 45 degrees left and right off the back of the wine glass. Due to the geometry of the wine glass acting as a symmetrical lens, the physical grid lights of the LED panels can be seen as curved reflections on their opposite respective sides. The theory here is that the light passing through the rotating fluid bends along with the cylindrical geometry of the wine glass itself. The right side of the vortex is illuminated by the magenta light crossing through, while the left side catches the green. This creates sharp, contrasting colors that form a gradient in the center of the vortex.

The photograph was captured using a digital full-frame Nikon Z6II mirrorless camera equipped with a 70-200 mm lens. The lens was set to a focal length of 170mm, and the camera was positioned approximately half a meter from the subject. This allowed for a tight

field of view that filled the frame with the wine glass, purposefully capturing the details of the fluid and the light. To attempt to freeze the fluid in motion, a fast shutter speed of $1/2000$ seconds was selected. The aperture was set to $f/10$ to ensure a sufficient depth of field, keeping the center and front side of the glass in focus. To compensate for the fast shutter speed and narrow aperture, the ISO of the camera was set at 8000. The original RAW (.NEF) image was processed in Adobe Lightroom Classic, where adjustments were made to deepen the black levels to isolate the glass from the background, and the saturation and luminance of the green and magenta channels were enhanced to amplify the visual separation of the lights. The RAW photo had dimensions of 4024×6048 pixels, and the cropped post-processed image had dimensions of 3194×4801 . For submission to FlowVis.org, the final image was padded and resized into a frame of 1300×900 pixels. The size of the field of view in the final image was approximately $9 \text{ cm} \times 11 \text{ cm}$.

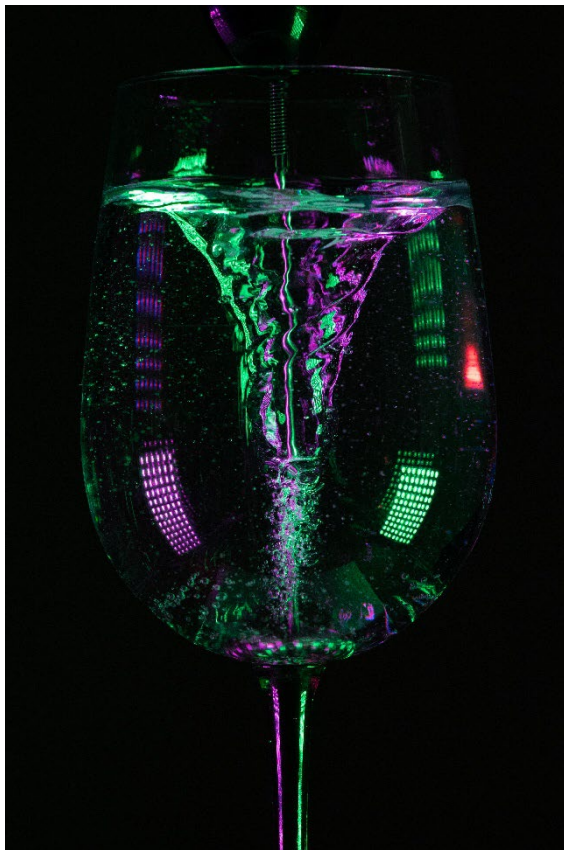
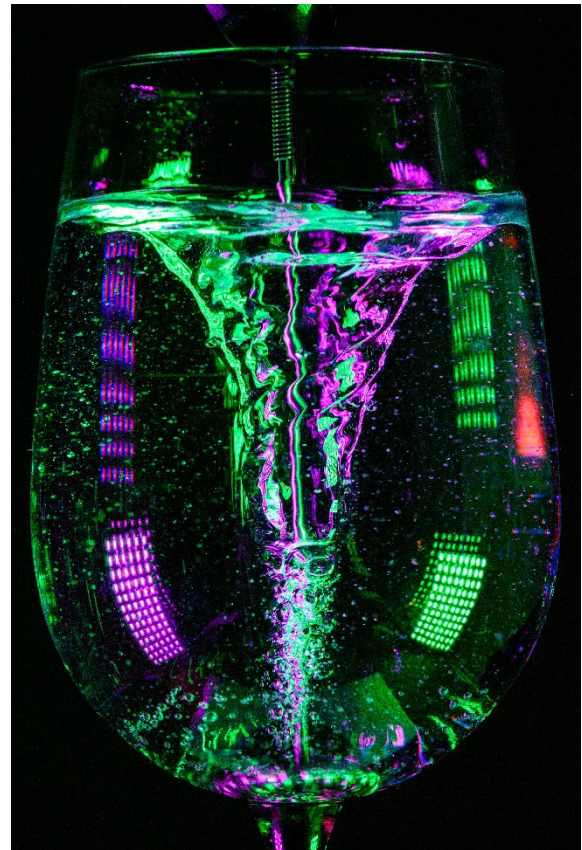


Image Before Processing



Post-Processed Image

The final image successfully reveals the intricate geometric curvature of a forced vortex, using light refraction to act as a map of the fluid's surface. The air bubbles trace the secondary flow outside of the vortex. I personally like the harsh contrast between the green and magenta lights, as well as the flipped reflections of the LED panels themselves. The fluid physics are well

represented, clearly representing a vortex from the spinning milk frother. There are two distracting elements: the visual presence of the frother wand itself, which disrupts the symmetry of the vortex, and the distinct reflection of the LED grids on the glass. In future iterations, developing this idea further could involve using a magnetic stir plate beneath the glass to drive the flow from the bottom, removing the mechanical arm from the field of view and allowing for an unobstructed visualization of the flow.

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