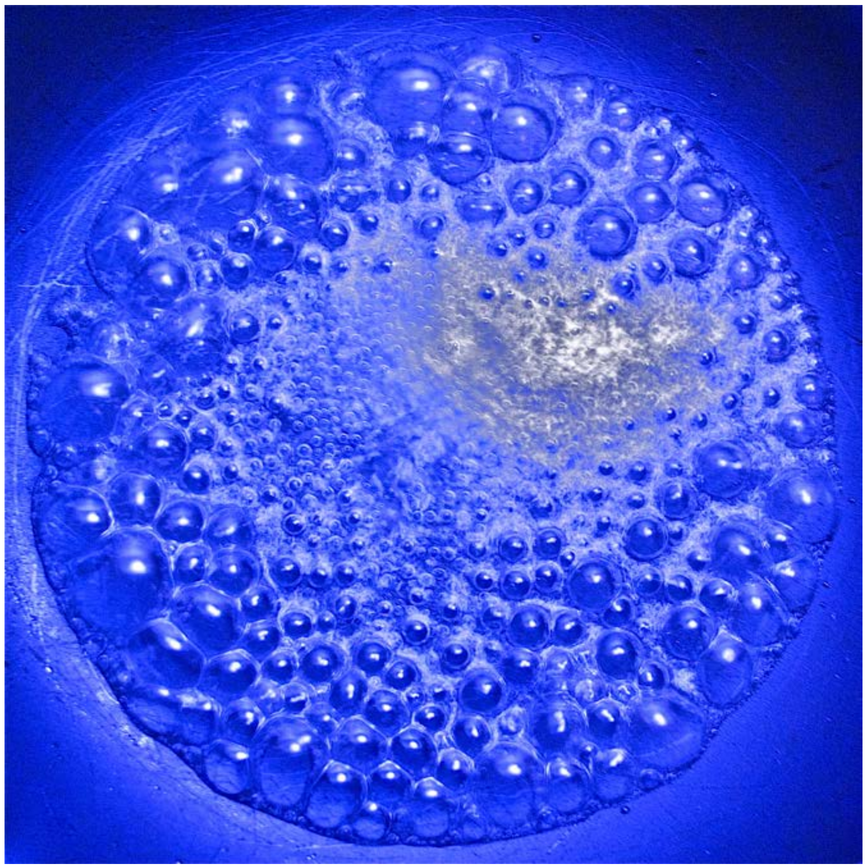

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The purpose of this report is to demonstrate and describe the physics behind a flow phenomenon that is captured in a photograph. For the get wet assignment, the guidelines are limited, thus leaving an opportunity that allows one to explore any particular flow of interest. The vaporization of water, also known as boiling, was the phenomenon captured in the photo. Boiling water is so common that many people take it for granted and do not appreciate the physics and beauty behind it.

Water was boiled on a Teflon coated pan. The heat source used to boil the water was a propane stove. This created a boiling pattern that can be seen in the image. The larger bubbles ended up on the outside edge of the pan and the center of the pan had the smaller due to the way the flames dissipated outwards towards the edge of the pan. The amount of water on the first shot seemed to display the variety of the bubbles the best, however, many different amounts of water were experimented with.

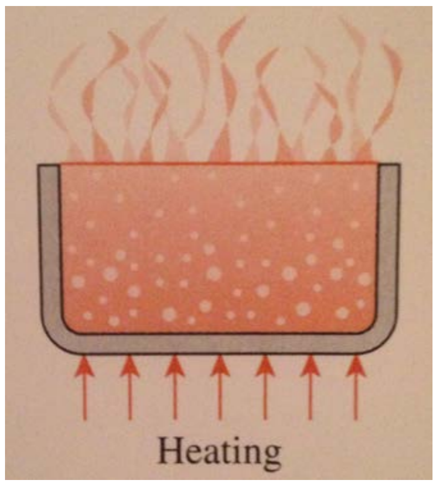

Figure 1. Shows a schematic of the pan being heated with the water

Boiling occurs at the solid-liquid interface where the temperature of the solid surface is higher than that of the saturation temperature of the liquid. It is at this surface that vapor bubbles form and eventually detach when they become too large. The type of boiling involved with boiling water in a pan is called pool boiling due to the fact that the fluid is stationary other than the natural convection currents and the flow of the bubbles. The boiling heat flux from the pan to the surface of the water can be expressed as Newton's law of cooling according to the equation below:

$$\dot{q}_{boiling} = h(T_s - T_{sat}) \quad (W/m^2)$$

$$\dot{q}_{boiling} = (2257\ kJ/kg)(108°C - 100\ °C) = 18{,}056\ kW/m^2$$

where:

h is the heat transfer coefficient

T_s is the temperature at the surface of the pan
T_{sat} is the saturation temperature of the water

The photo was taken with a Nikon D60 camera. This was used in collaboration with a Nikon DX 18-55 mm. To capture the bubbles before they popped, a 1/15 shutter speed was used. There was sufficient light so an aperture of F4 was used with a focal length of 22mm. These settings seemed to provide enough detail and focus to capture the bubbles from boiling. The distance from the pan was only 1.5 feet away. Photo editing was done with iPhoto, where sharpness was increased, temperature and tint were decreased to achieve the blow glow. The blue glow was chosen to emphasize that the fluid boiling was water.

Figure 2. Shows the boiling before and after the photo editing

The get wet image shows a distinct difference in bubble size due to the convection resulting from the propane stove. The edges of the pan created the largest bubbles due to the water depth being smaller than at the center. This picture could have been improved by using different lighting to eliminate the glare that can be seen in the middle right of the photo. Another improvement to ensure image quality would be to take a picture closer to the pan rather than zooming in. The limiting factor in taking a picture closer was the fact that the lens would get covered in condensation from the water vapors of the boiling water.

References:

Cengel, Yunus A. *Heat and Mass Transfer: Fundamentals and Applications.* New York, New York: McGraw-Hill, 2011.