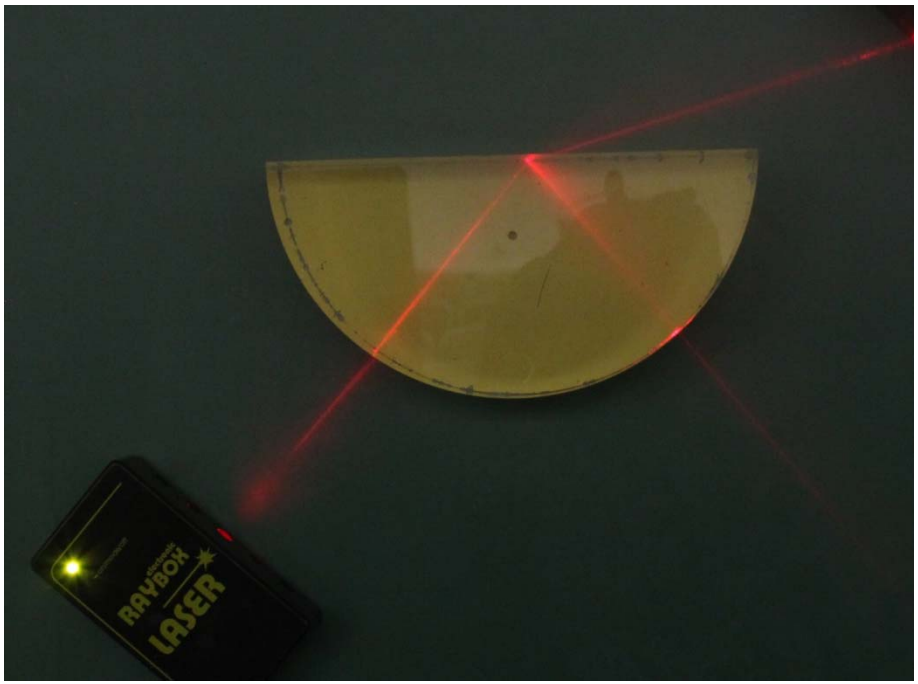
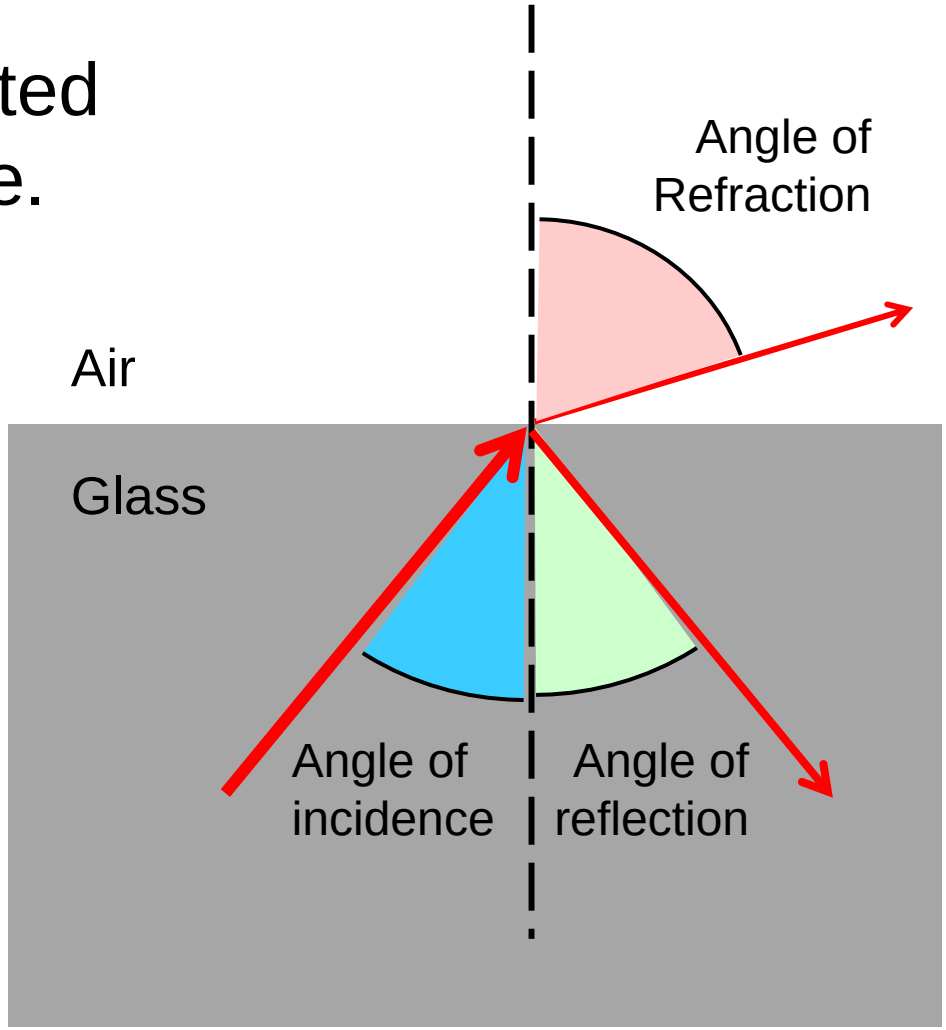
Refraction
Part 2

Reflection & Refraction

Light rays are both reflected and refracted at a surface.

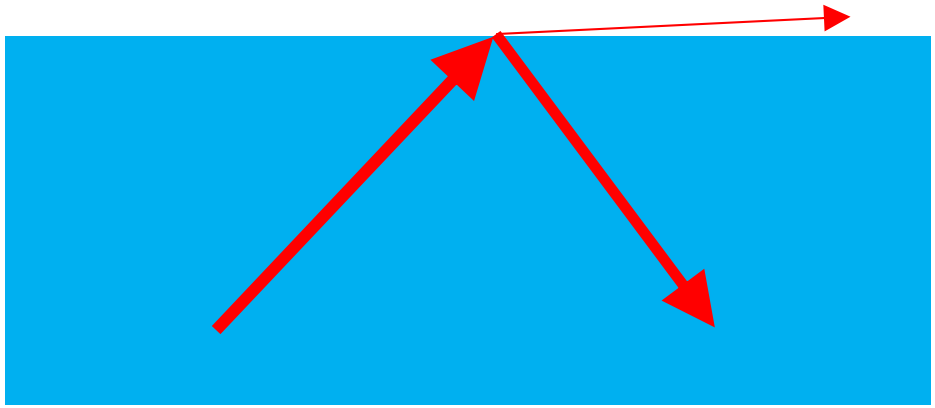


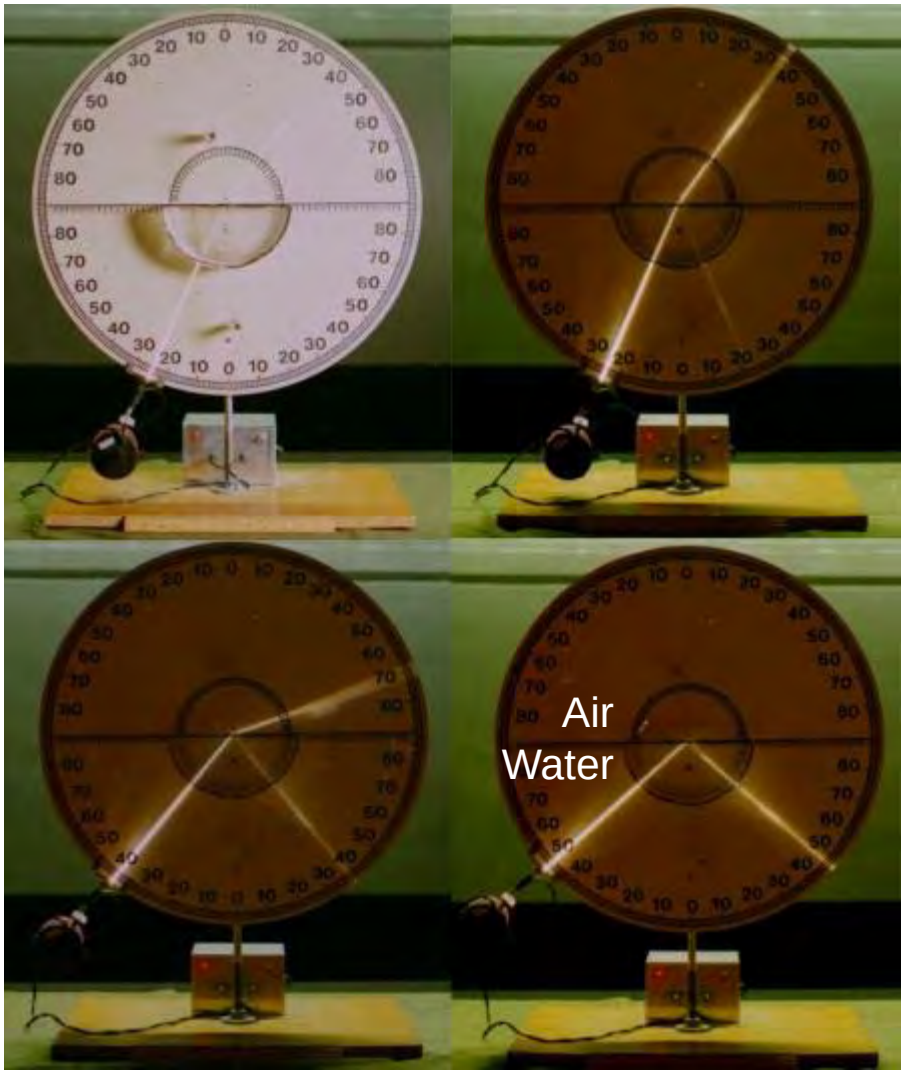


Total Internal Reflection

Due to refraction, sometimes light cannot exit past a certain critical angle.

Just below critical angle

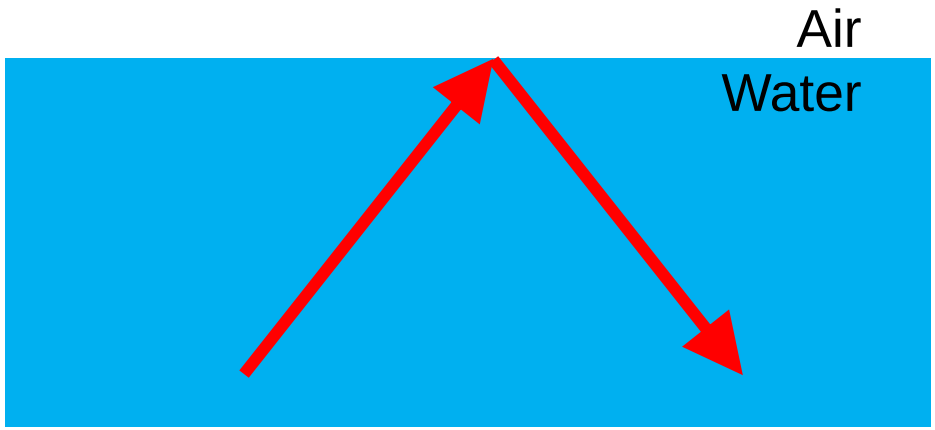




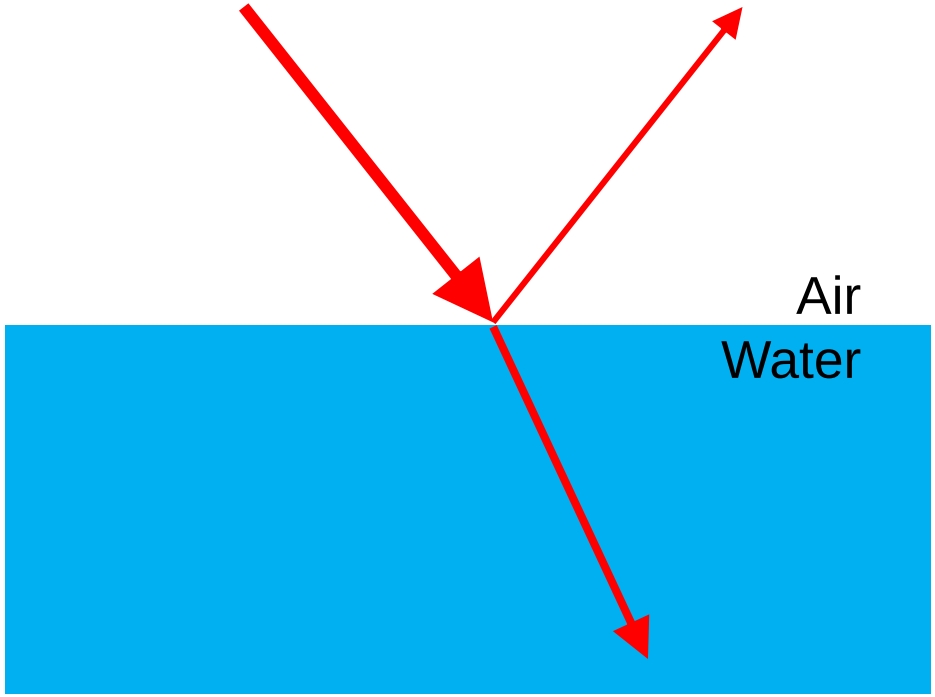
Total Internal Reflection

Total internal reflection only occurs if the incident light is on the side with higher index of refraction.

Water has a higher index of refraction than air.



Total Internal Reflection

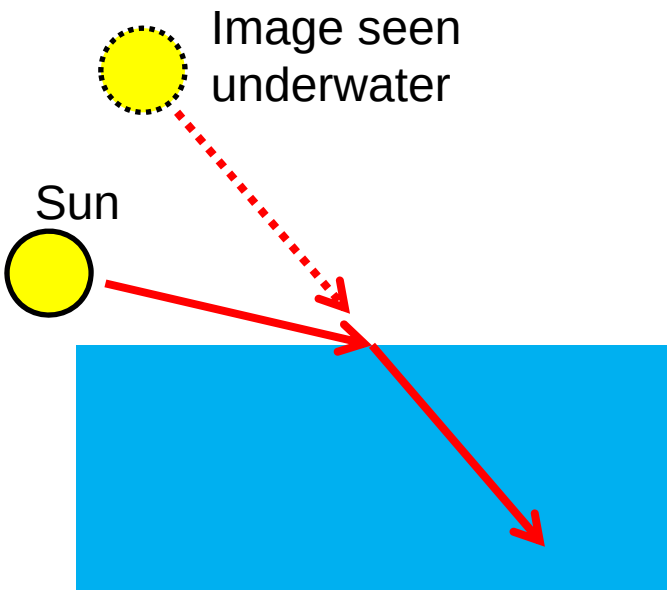


Ordinary Partial Reflection

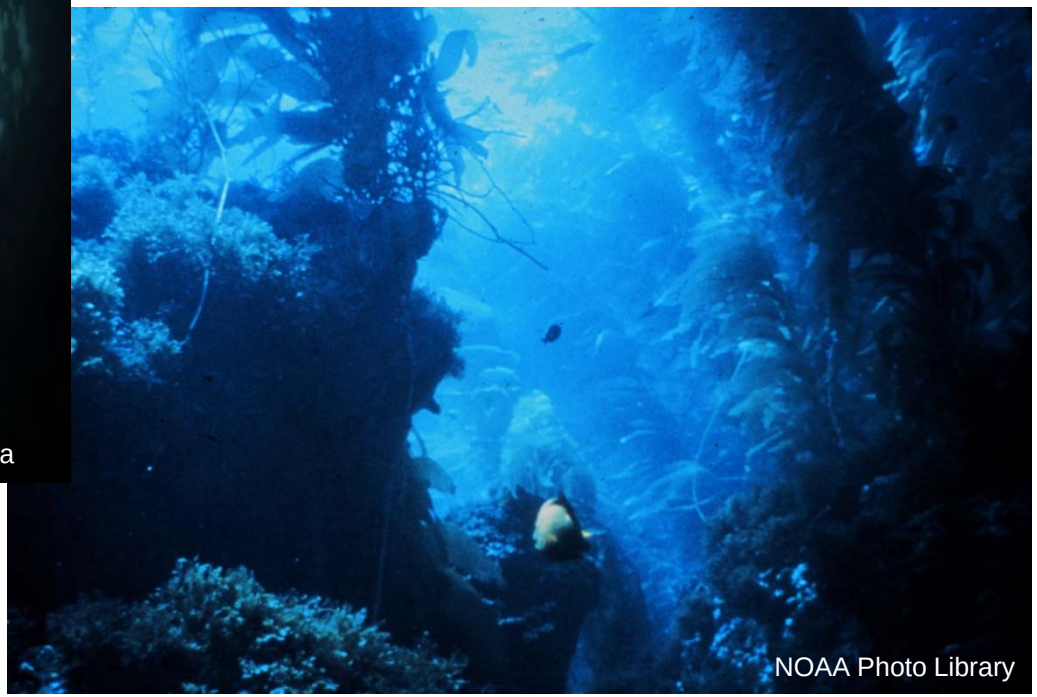
Looking up Underwater

Looking up at more than about a 48° angle underwater you see a mirror reflection.

Underwater Lighting

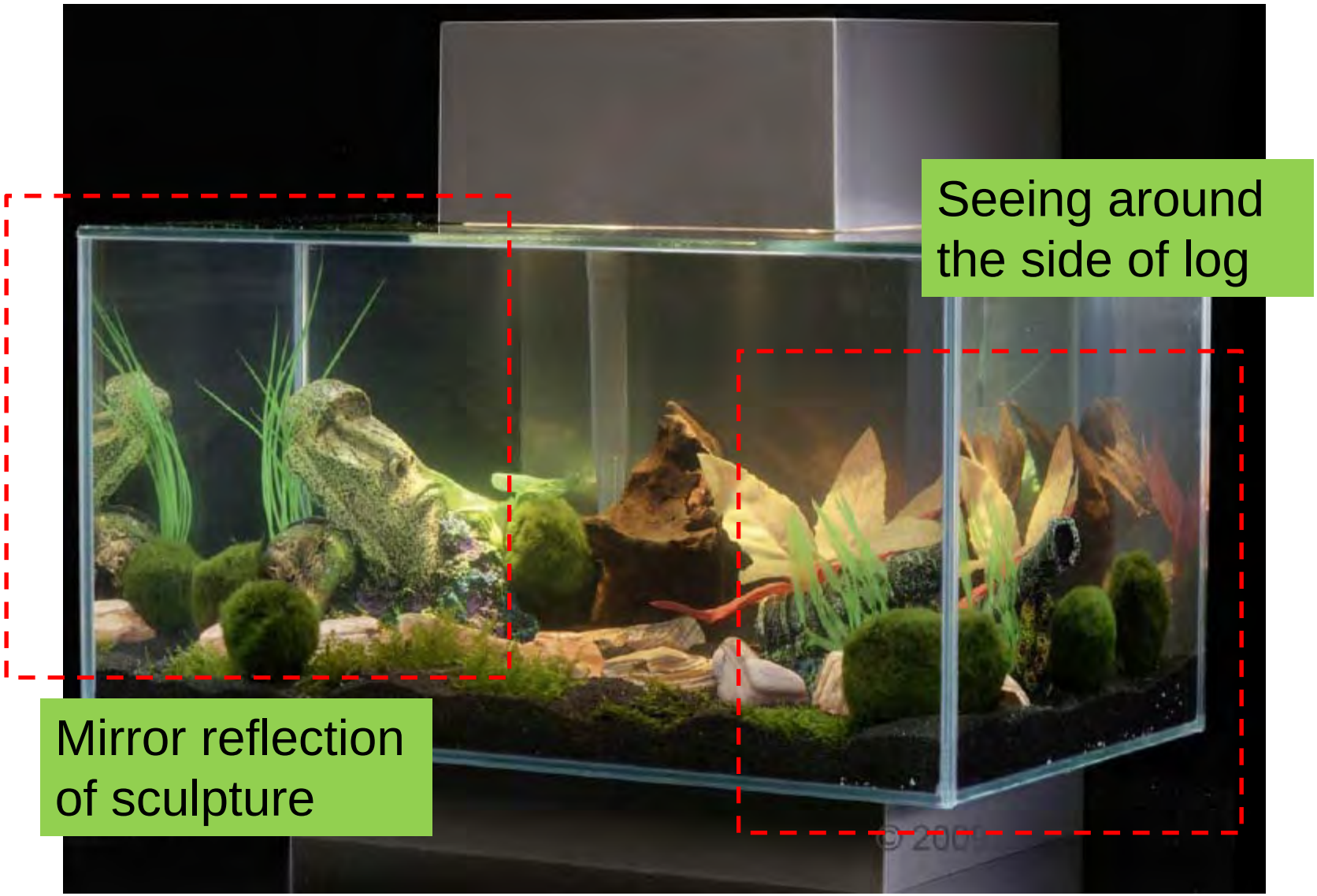


Due to total internal refraction sunlight never enters underwater at more than about a 48° angle.

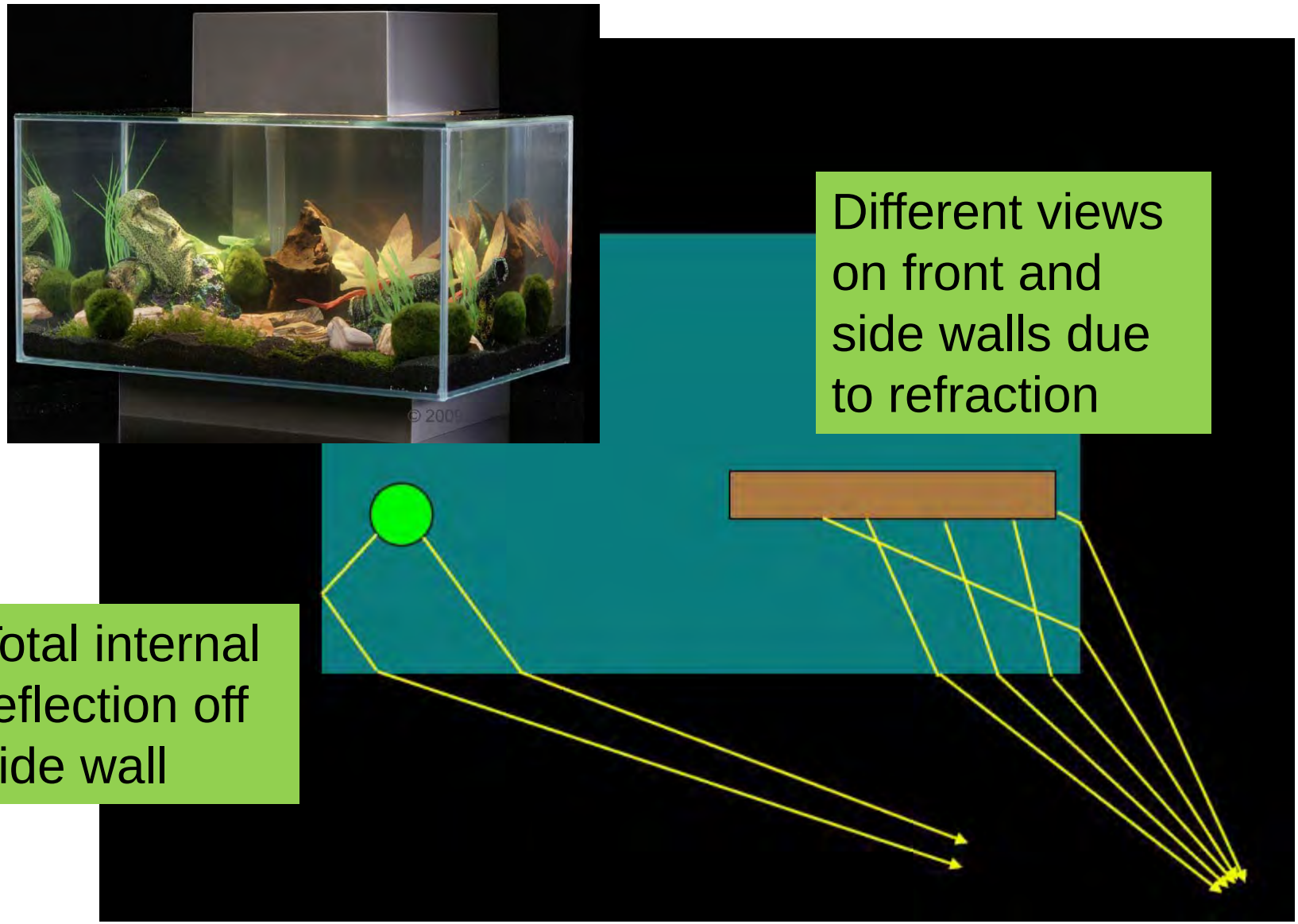


This effect is known as Snell's window.

Refraction in Aquariums



Refraction in Aquariums

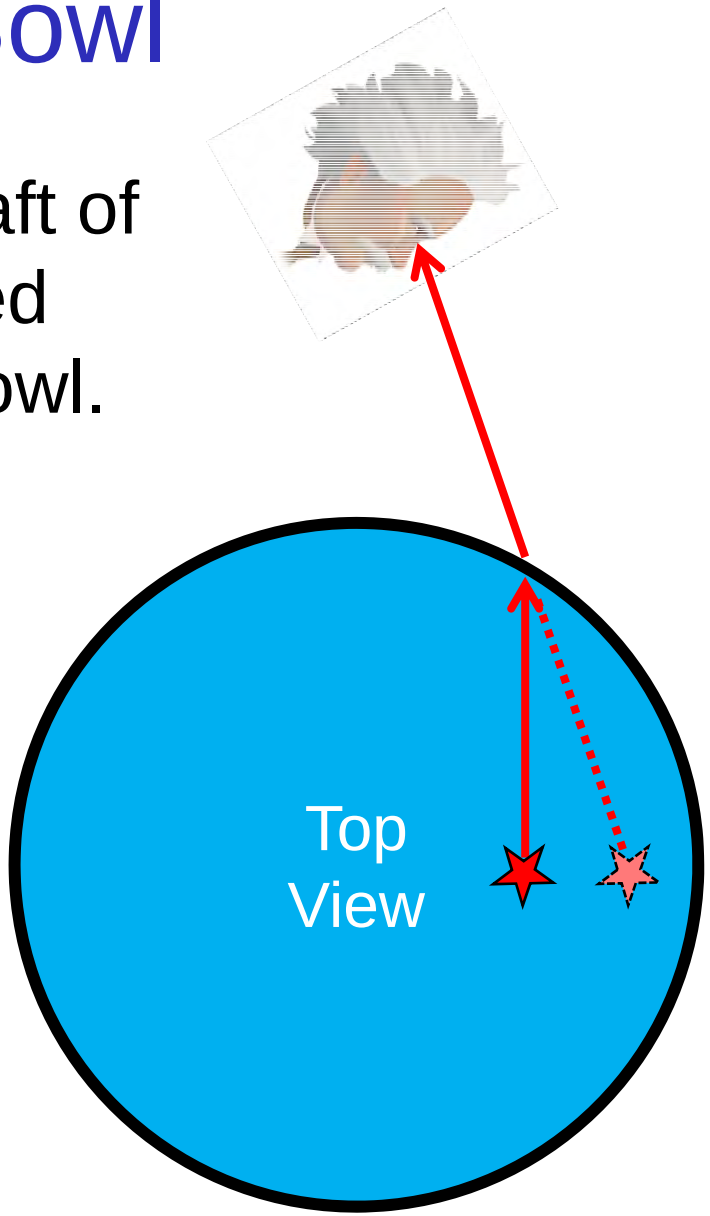


Refraction in a Bowl

Observe the pencil underwater

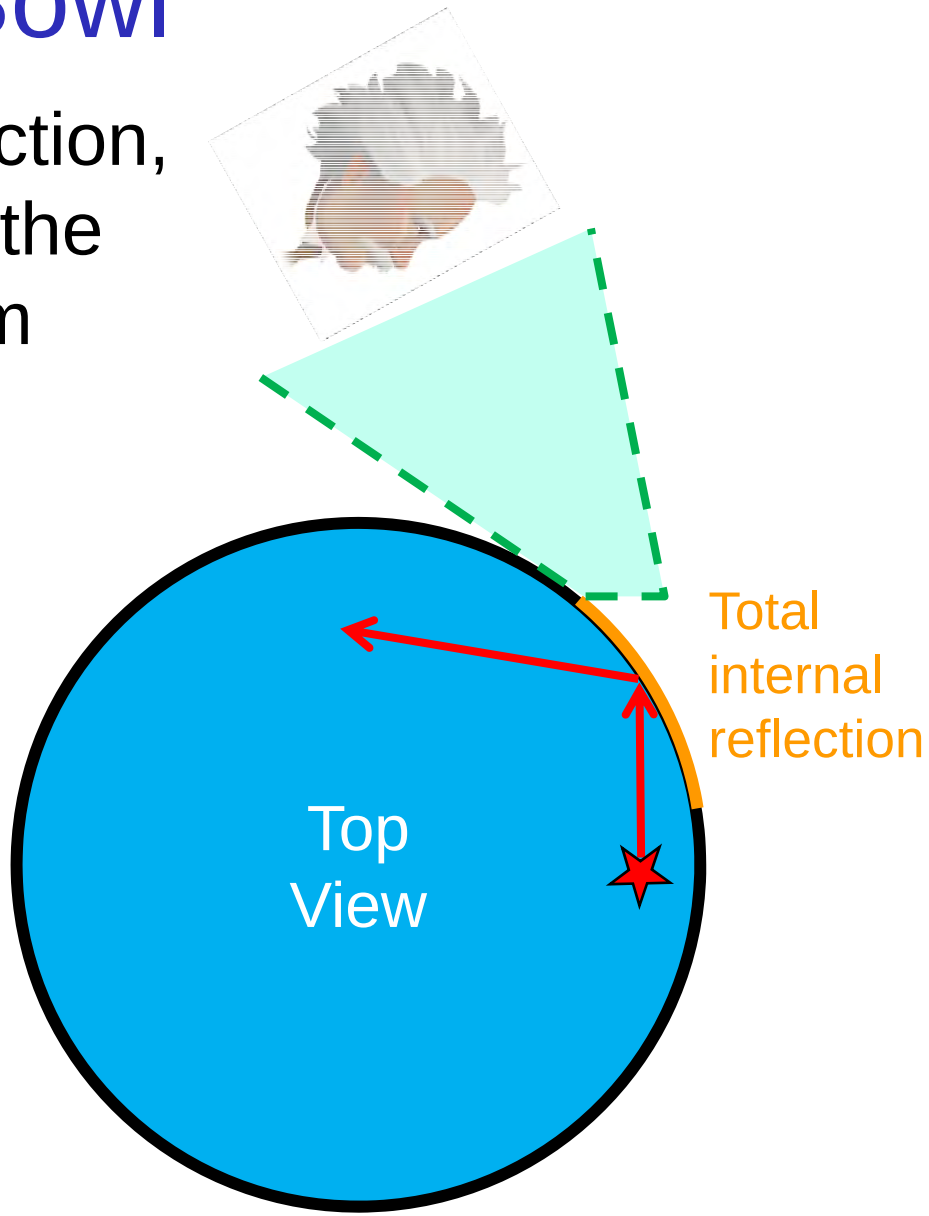
Refraction in a Bowl

Due to refraction the shaft of the pencil appears shifted toward the side of the bowl.

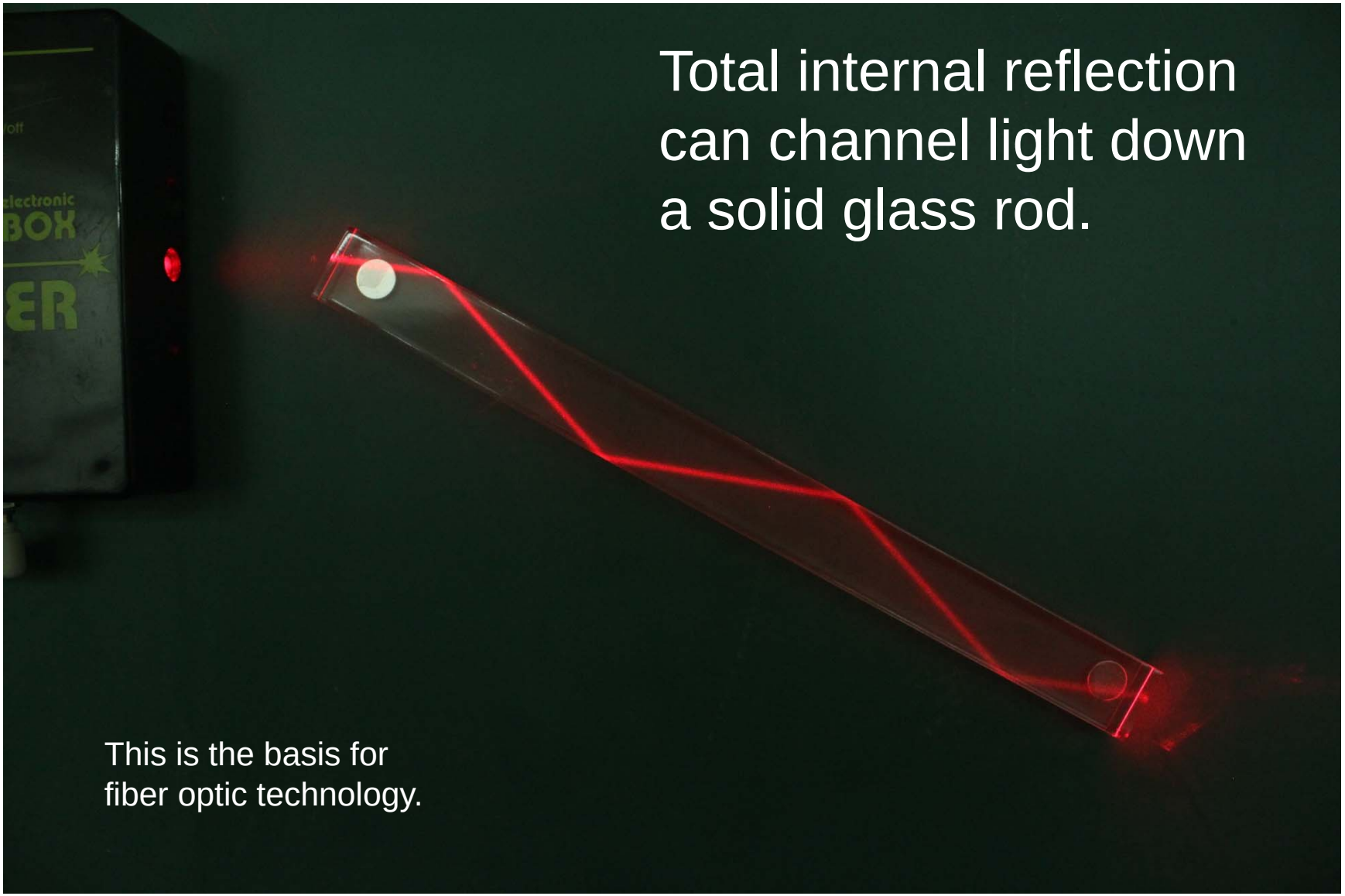


Refraction in a Bowl

Due to total internal reflection, objects near the edge of the bowl cannot be seen from some viewing angles.

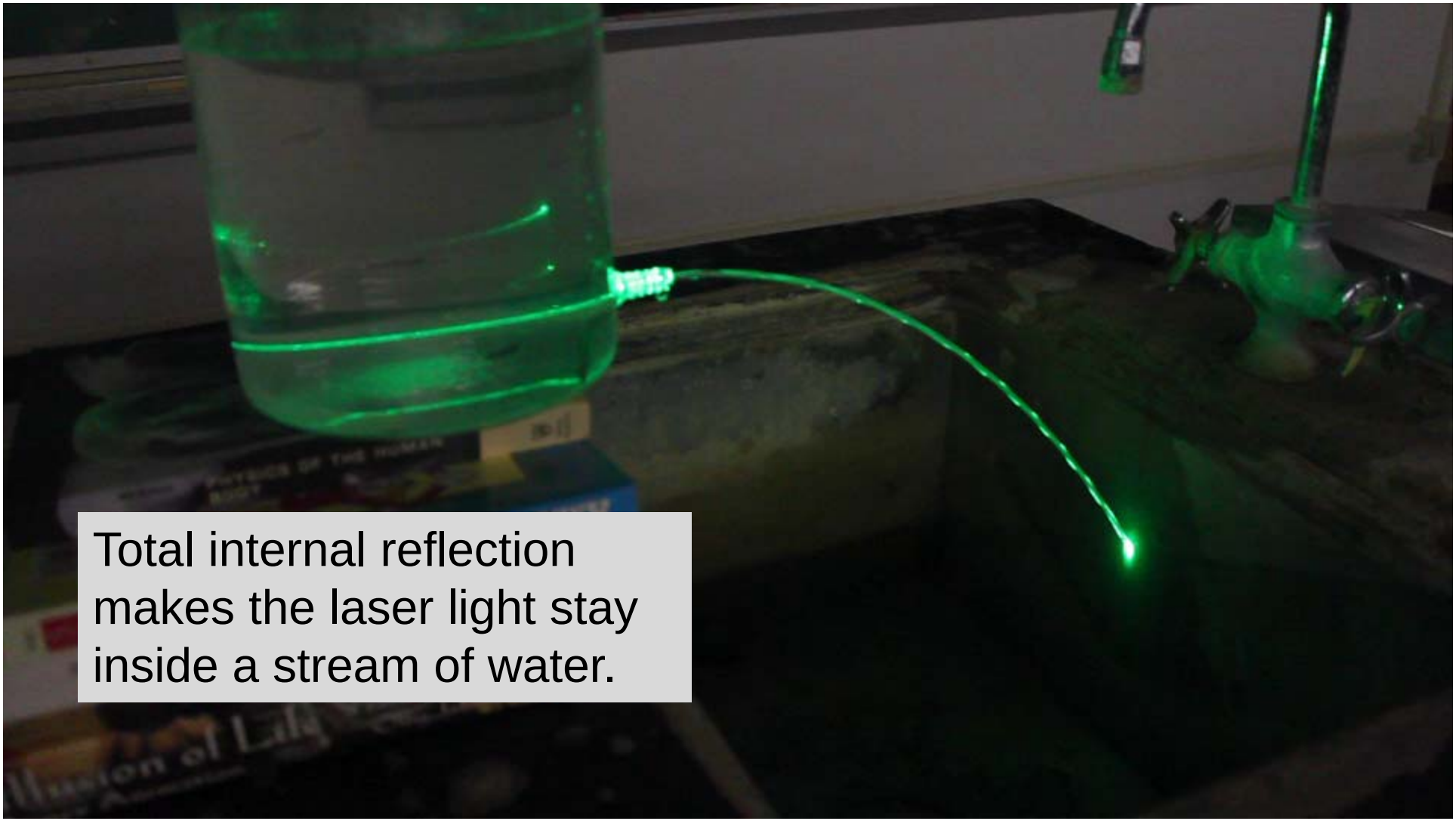


Channeling Light



Laser in a Water Stream

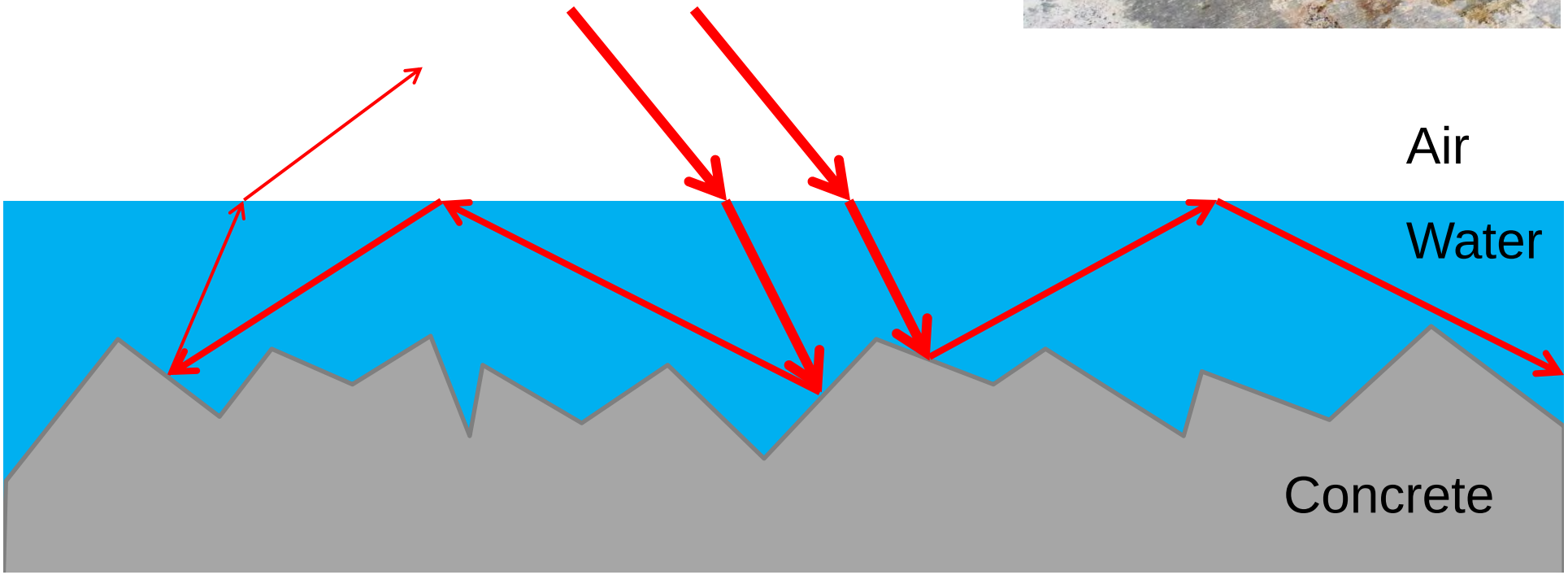
Speed of the water stream is varied by opening and closing the top of the bottle.



Total internal reflection makes the laser light stay inside a stream of water.

Wet Surfaces

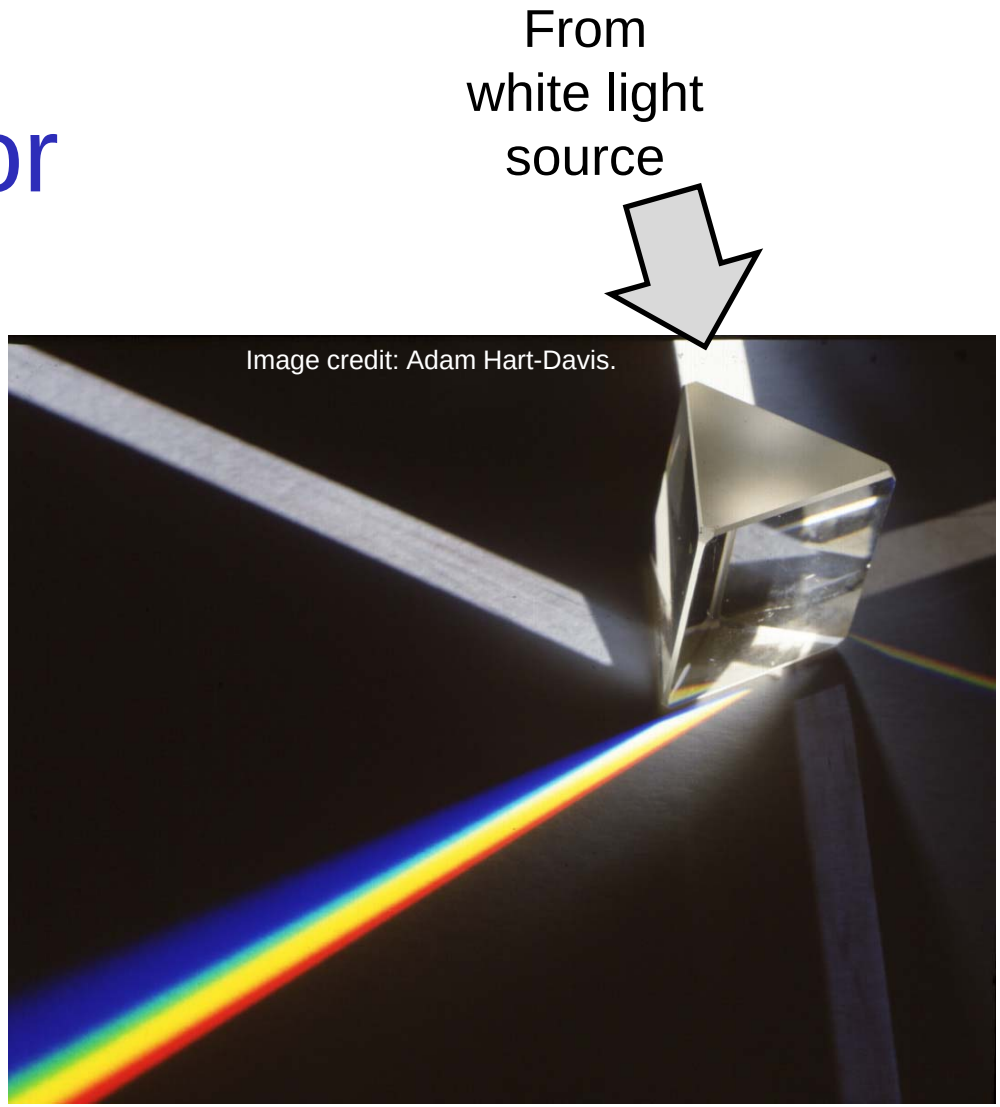
One reason that a wet spot on a diffuse surface looks dark is that total internal reflection makes some light rays return to the surface before exiting.



Refraction & Color

Deflection angle in refraction varies slightly with wavelength.

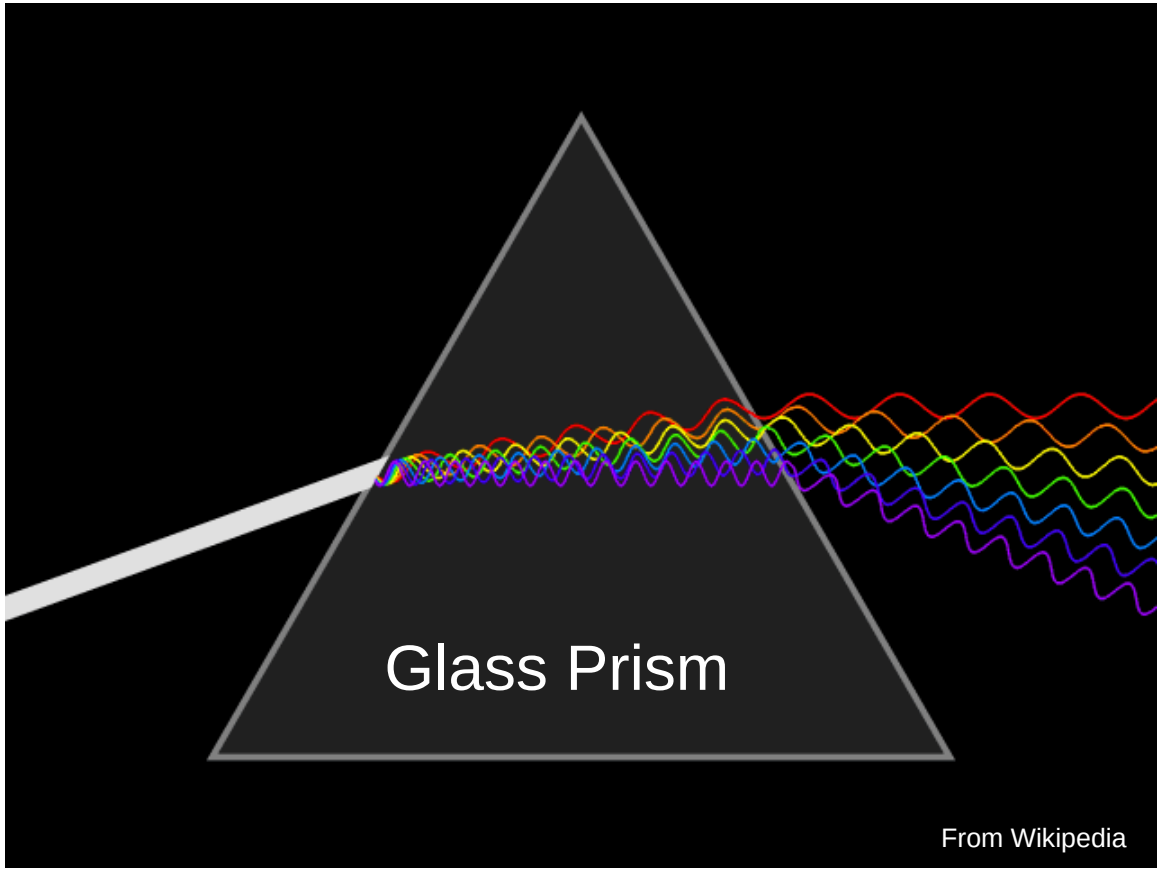
In the right geometry this difference produces a noticeable separation of colors in white light.



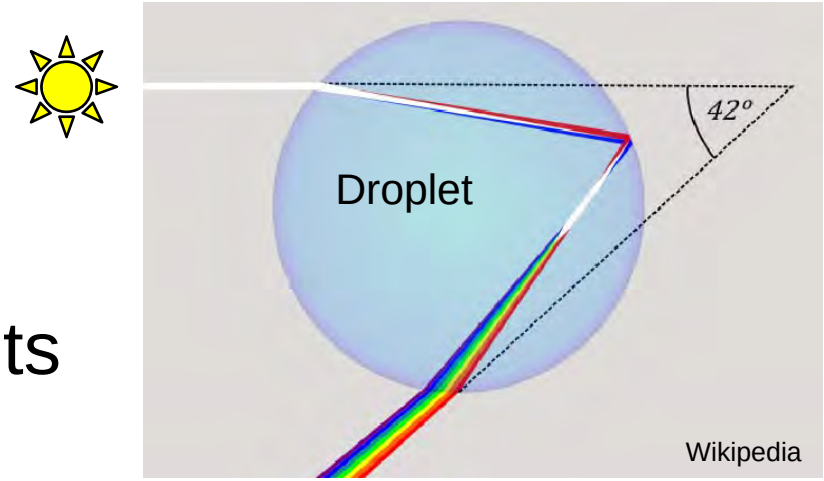
Separating Colors

Short wavelengths of light refract slightly more than long wavelengths.

White light may be separated into a rainbow spectrum due to this effect.



Rainbows



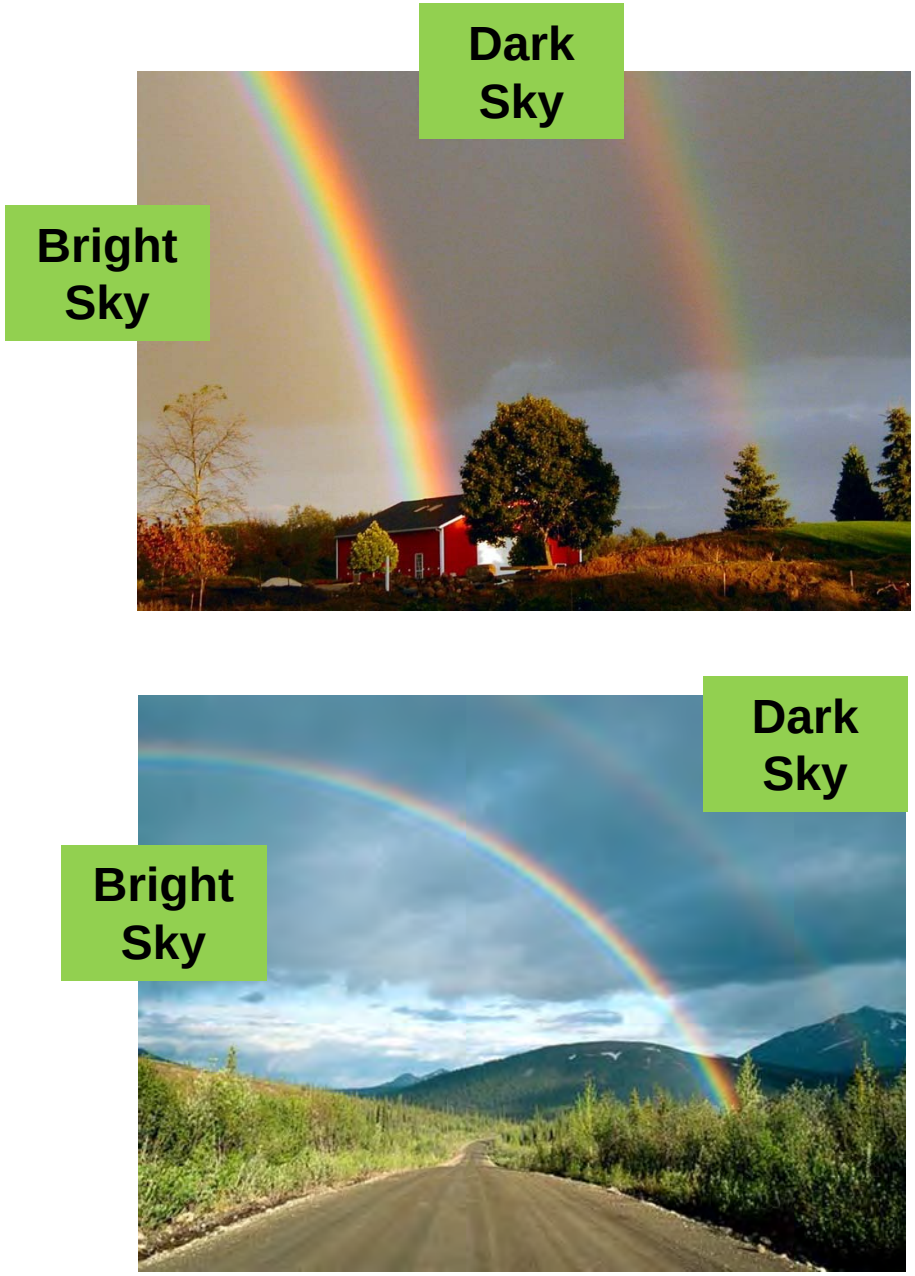
Sunlight reflecting and refracting in water droplets may form a rainbow.

The main rainbow always has blue on the inside rim and red on the outside.

Rainbows

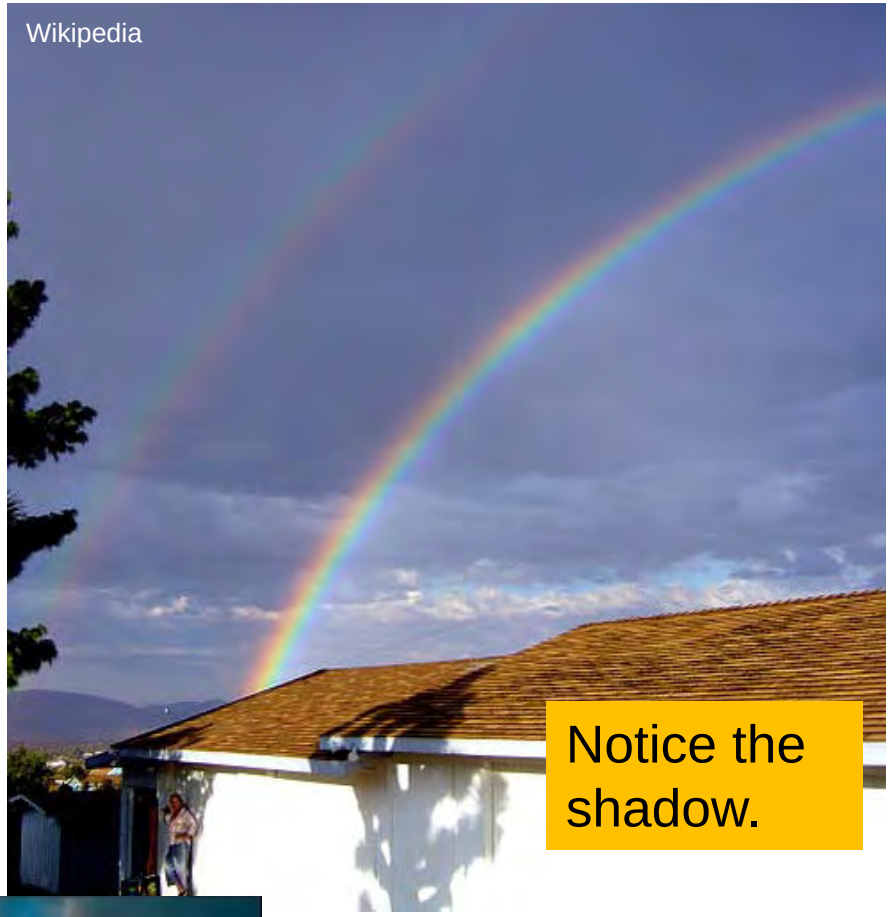
Light that reflects twice inside of a droplet produces a secondary rainbow with reversed colors (red on the inside).

The sky is brighter inside the rainbow and darker outside.



Rainbows

Looking towards a rainbow the Sun is always behind you.



This scene appears magical since the rainbow appears in front of the rising sun.

Summary

- At or past a critical refraction angle all light is reflected at a surface (total internal reflection).
- Total internal reflection only occurs if incident light is on the side of higher refraction index (e.g., light in water reflects off the surface).
- The refraction angle is slightly different for different wavelengths (colors) of light, an effect known as dispersion.
- Rainbows are due to the reflection and dispersion of light in water droplets.