How do we “know” the Universe?... (Mostly) through Light!

...but, what is “Light”?
Direction of wave motion

Undisturbed pond surface
LED
Unpolarized light
Polarizing filter
Polarized light

Vertically polarized light
Horizontally polarizing filter

(Cannot pass light.)

Vertically polarized light
Vertically polarizing filter

(Passes light)

Light Passing Through Crossed Polarizers
Polarizer 1 (Vertical)
Polarizer 2 (Horizontal)

Incident Beam (Unpolarized)
Vertically Polarized Light Wave
unpolarized light

light partially polarized in the horizontal plane by reflection

glasses transmit only vertically polarized light

glare greatly reduced
direct light not reduced as much as glare

Polarizing 3D Glasses
Two waves interfering

Resulting wave
Ultraviolet “vision”...?

The birds do it, and the bees do it!

Because we cannot see UV light, the colors in these photographs are representational, but the patterns are real.
Multiwavelength Milky Way
The “Planck Spectrum” for Thermal Radiation from Objects:
The Different *Temperature Scales*... (Scientists use **Kelvin**!)

<table>
<thead>
<tr>
<th></th>
<th>Fahrenheit</th>
<th>Celsius</th>
<th>Kelvin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen fuses</td>
<td>18,000,032</td>
<td>10,000,000</td>
<td>10,000,273</td>
</tr>
<tr>
<td>Water boils</td>
<td>212</td>
<td>100</td>
<td>373</td>
</tr>
<tr>
<td>Water freezes</td>
<td>32</td>
<td>0</td>
<td>273</td>
</tr>
<tr>
<td>All thermal motion stops</td>
<td>-459</td>
<td>-273</td>
<td>0</td>
</tr>
</tbody>
</table>
The Amount ("Flux") of Radiation from Hot/Warm Objects:

\[ F = \sigma T^4 \]

- Energy per unit area
- Temperature to the fourth power
- Constant
(a) Frequency = 6.2 x 10^{15} Hz
Wavelength = 48 \mu m
T = 60 K

(b) Frequency = 6.2 x 10^{15} Hz
Wavelength = 4.8 \mu m
T = 600 K

(c) Frequency = 6.2 x 10^{14} Hz
Wavelength = 490 nm
T = 8000 K

(d) Frequency = 6.2 x 10^{15} Hz
Wavelength = 48 nm
T = 60,000 K
Infrared light cuts through dust...
...can see the Galactic Center, home of the Milky Way’s giant Black Hole!