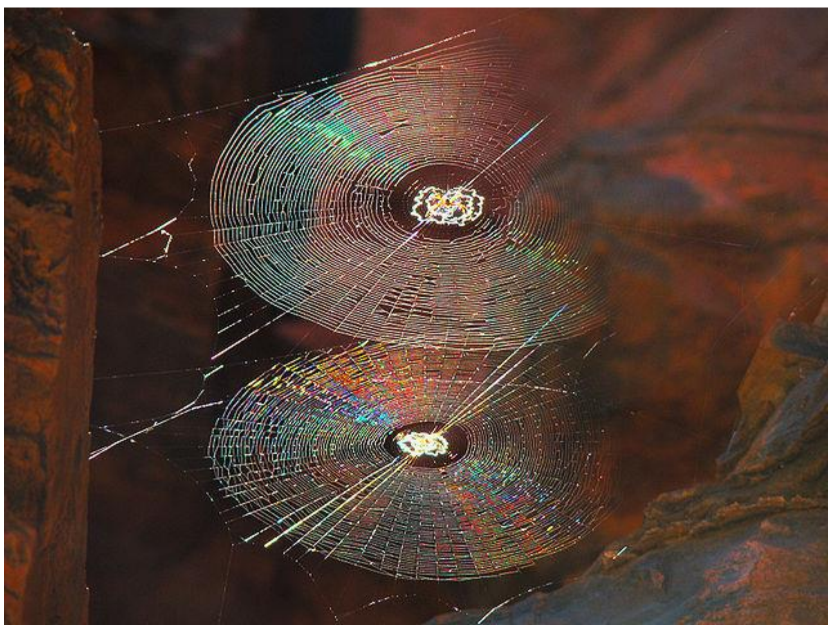
UNIT 2: WAVE PROPERTIES OF LIGHT

1. Diffraction of light
2. Young’s Double Slit Experiment
3. Polarization
4. EM waves

1. DIFFRACTION OF LIGHT

This is the bending of light observed when it passes through small openings or near sharp edges. Different colours bend at different angles.

Diffraction through the aperture of a camera lens and through a circular opening. Photos: M. Nenkova

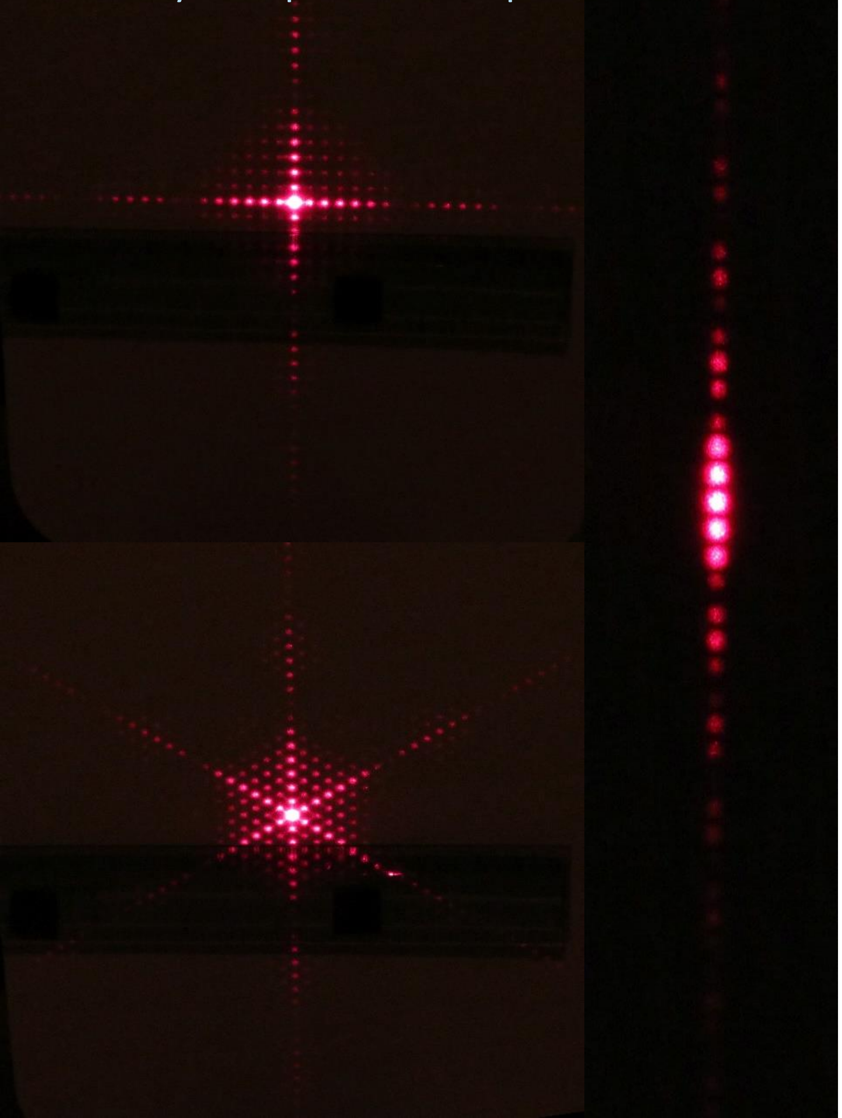


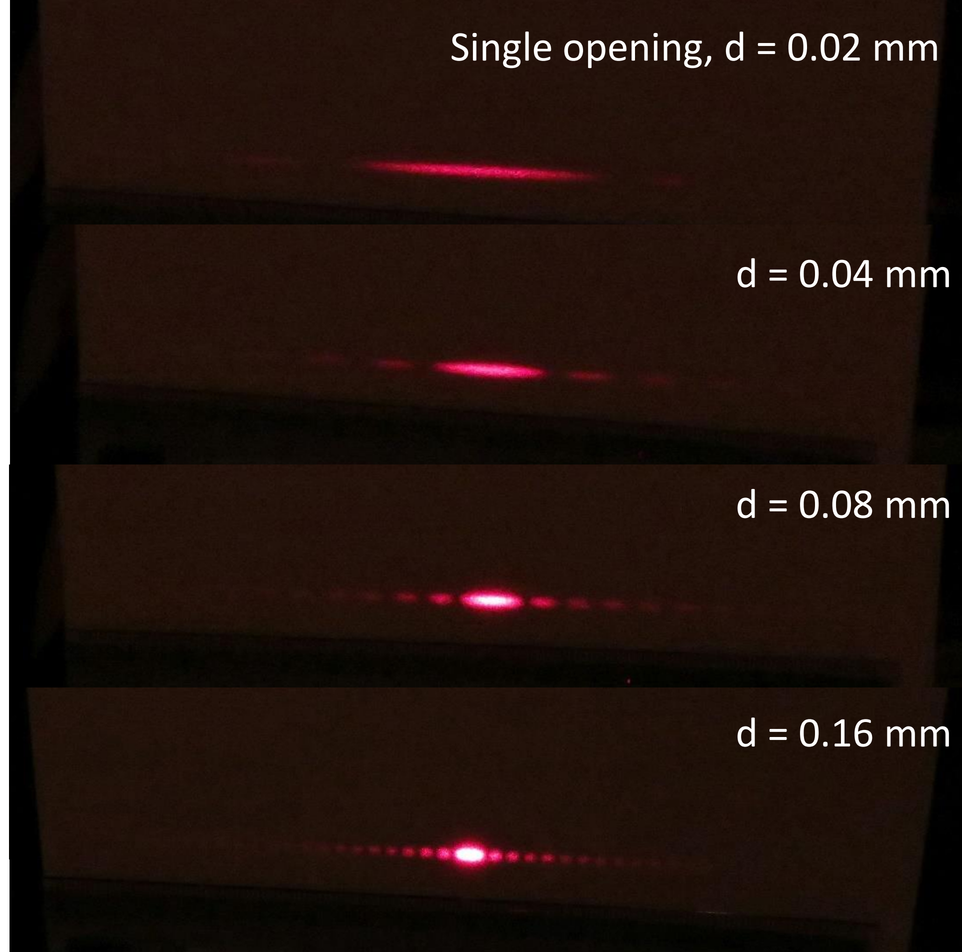
Spiral orb webs showing some colours in the sunlight in a gorge in Karijini National Park, Western Australia, Australia. Author: Bjørn Christian Tørrissen.

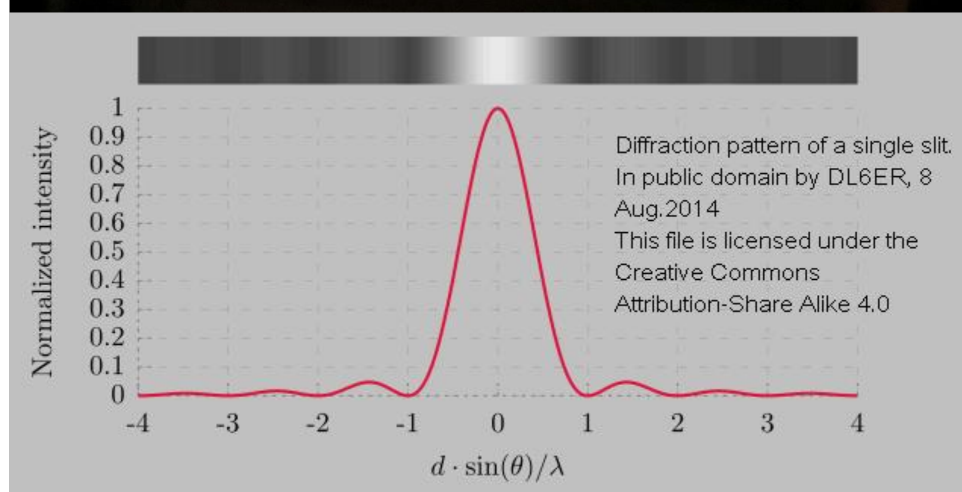
EXAMPLES OF DIFFRACTION USING OUR EXPERIMENTAL SET

Diffraction from more than one openings.

How do you explain the shapes?







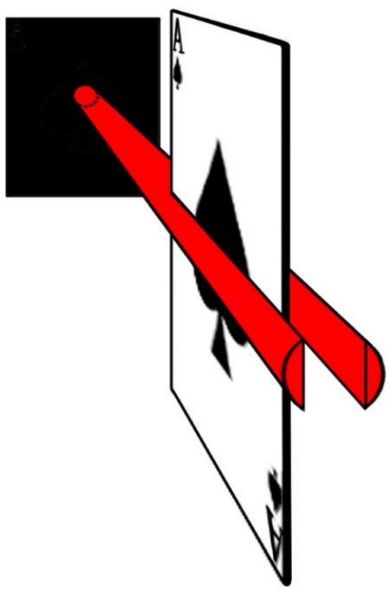
Thomas Young
(1773 – 1829)

2. YOUNG'S DOUBLE SLIT EXPERIMENT

Young's experiment (1801): https://www.quora.com/What-is-the-conclusion-of-Young-Double-Slit-Experiment

Young's experiment showed that light passing through two small openings interferes and produces bright and dark bands on the screen.

The sources must be coherent (in sync), so Young used an edge to split the beam of light.



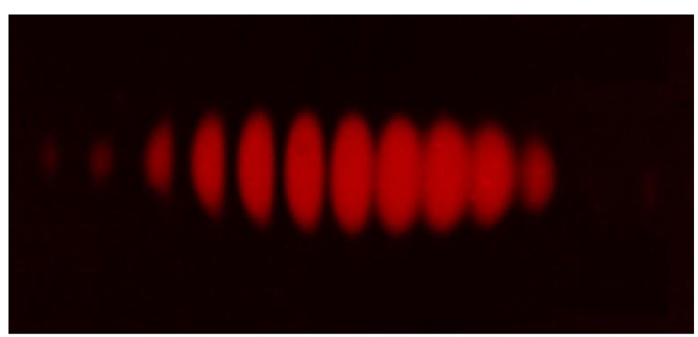
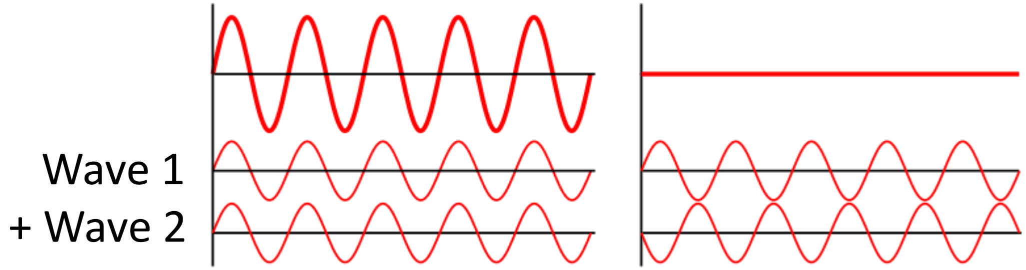


Fig.1-3

WHERE WILL BE THE INTERFERENCE MAXIMA?

Constructive interference if the added waves are in phase:

Destructive interference



There will be constructive interference at points where the peaks of each wave meet – where they arrive "in phase".

This happens where the difference between the distance travelled by waves is a whole number of wavelengths.

Make a conceptual sketch and label the parameters in the formula for interference maxima.

$$d \sin \theta = n\lambda,$$

where n = 0, 1, 2, 3...

d is the distance between the slits.

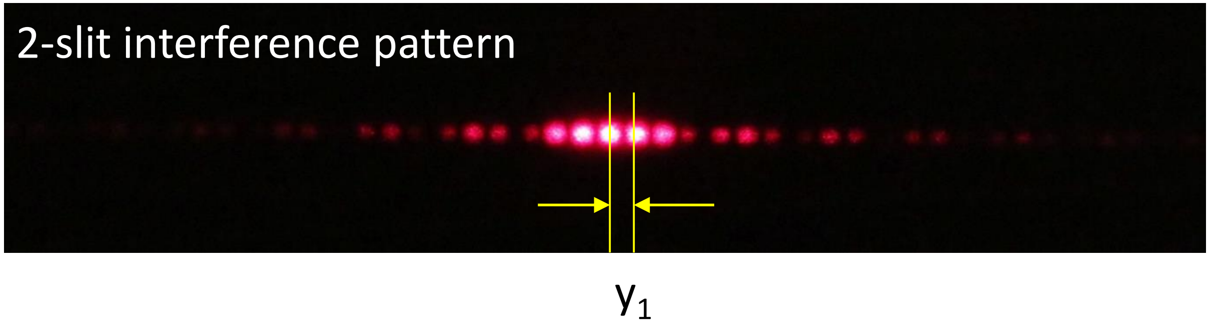
Compare your sketch to the one here: http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/slits.html

In small angle approximation: $d\,(y/D) = n\lambda$

MEASURE THE WAVELENGTH OF LIGHT

Using the experiments setup in class reproduce Young's experiment using red laser light and a double slit from the diffraction kit OS-8515C.

How will you choose the distance to the screen L in order to get a wider pattern?



Given: the distance between the slits: d = 0.125 mm
Choose L and measure y1 (the position of first maximum next to the central peak).

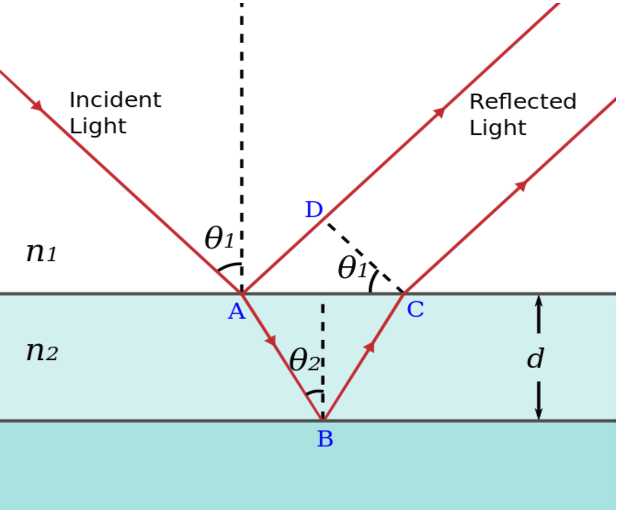
$$\lambda = d\,\frac{y_1}{L}$$

Use this app to find unknown wavelengths:
http://www.physicsclassroom.com/Physics-Interactives/Light-and-Color/Youngs-Experiment/Youngs-Experiment-Interactive

EXAMPLES OF INTERFERENCE OF LIGHT IN THIN FILMS

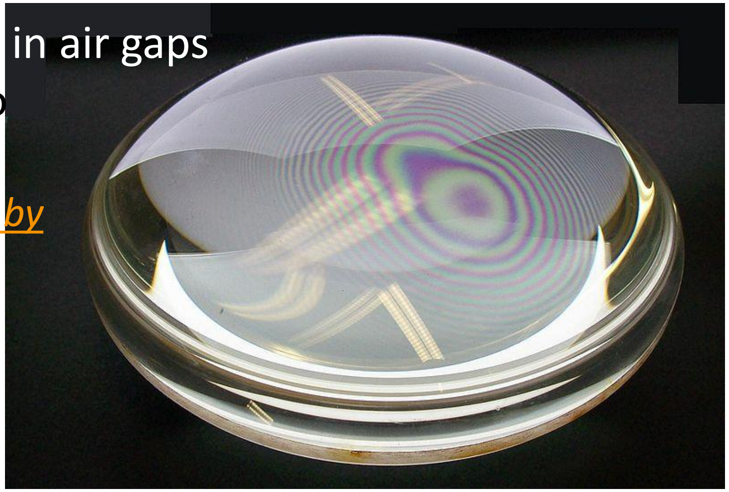
Interference in thin film of diesel fuel.
In public domain [by user John]

Interference in soap bubbles.
Public domain image by Brocken Inaglory. This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license.

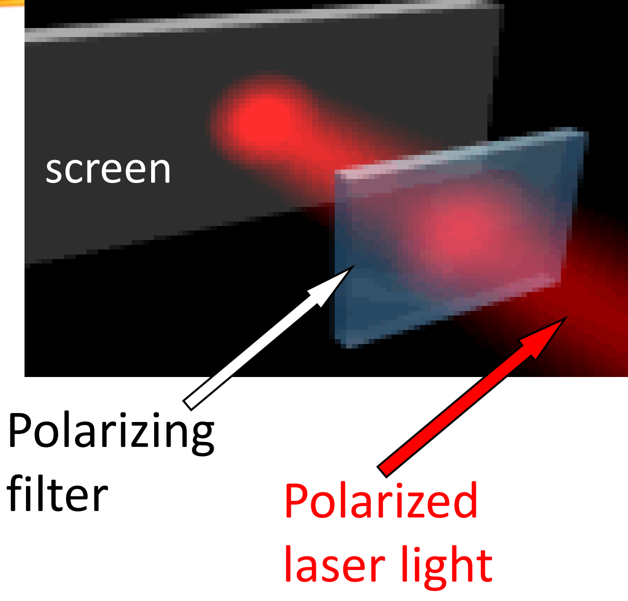


In public domain by Nicoguaro. 8 June 2016.

Interference in air gaps between two lenses. *In the public domain by user Ulfbastel*

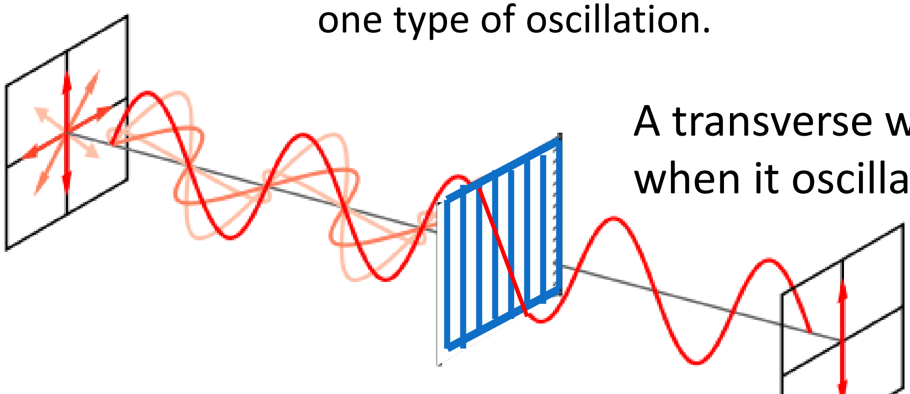


3. POLARIZATION OF LIGHT



The polarizing filter passes only one type of oscillation.

A transverse wave is polarized when it oscillates in one plane:



In the public domain by B. Mellish.

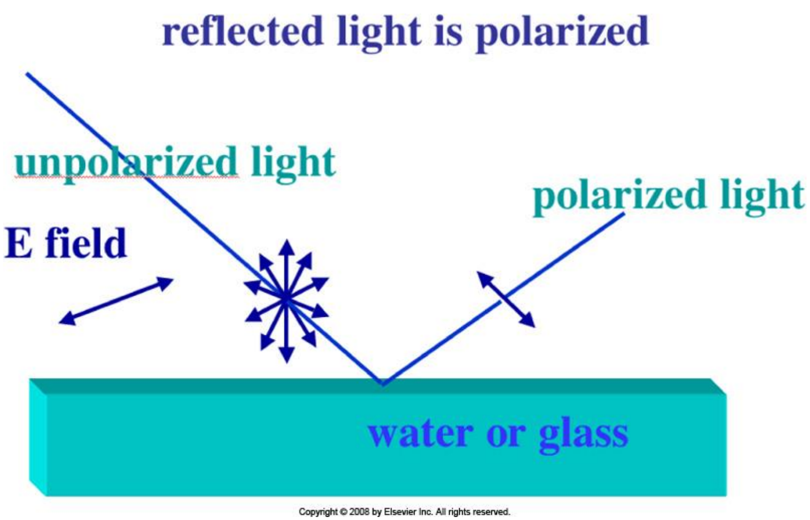
Use polarizers in class to find out sources of polarized light.

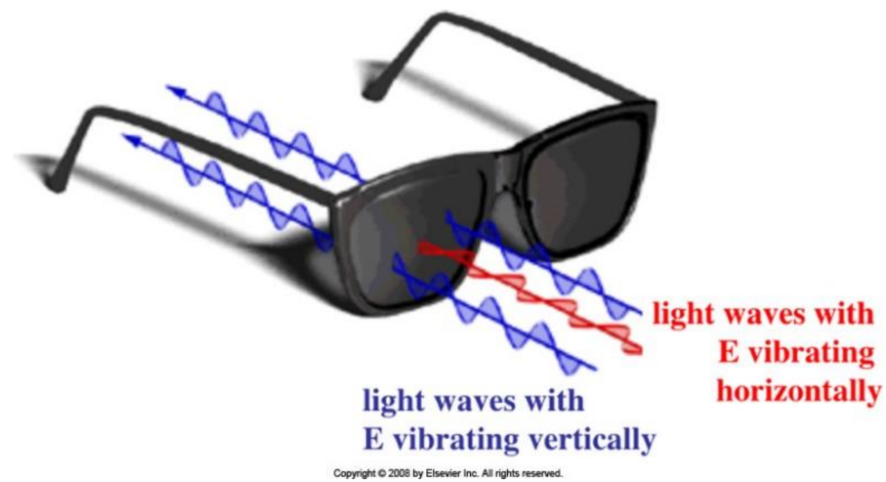
Polarizing filter in front of a LCD monitor (public domain)

POLARIZING FILTERS REDUCE GLARE.

You can see under the water surface if you use a polarizing filter. Fig. from the public domain.

Reflected light is partially polarized parallel to the surface. A polarizing filter reduces the reflected light.





Figs.1-7 and 1-8

EXAMPLES OF USING POLARIZING FILTERS

Which photo is taken with a polarizing filter?

Photos: M. Nenkova

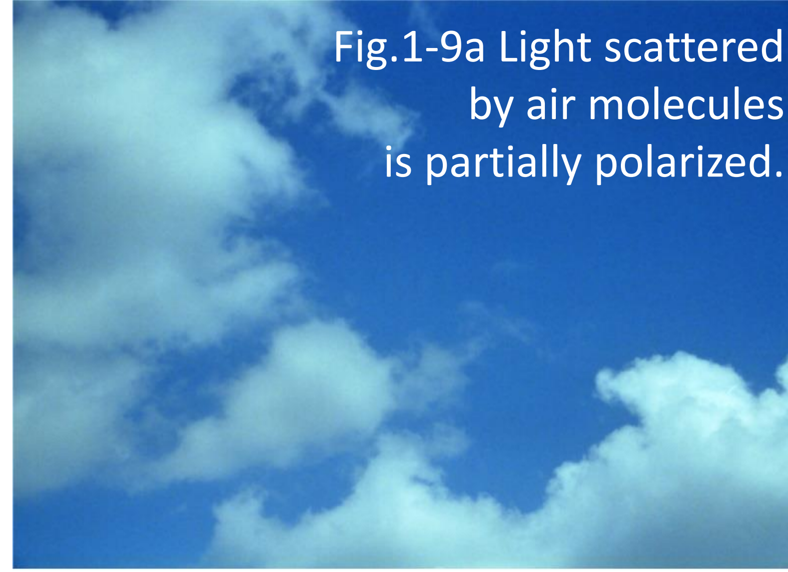


Fig.1-9a Light scattered by air molecules is partially polarized.

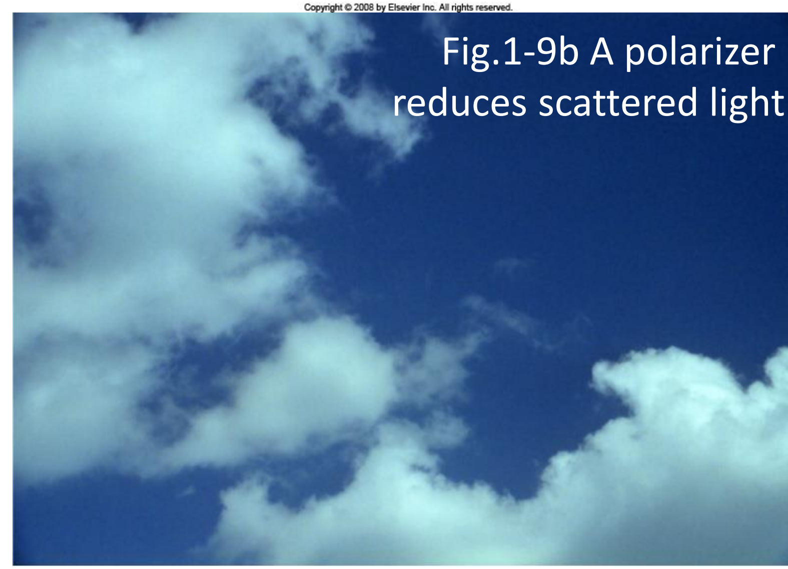
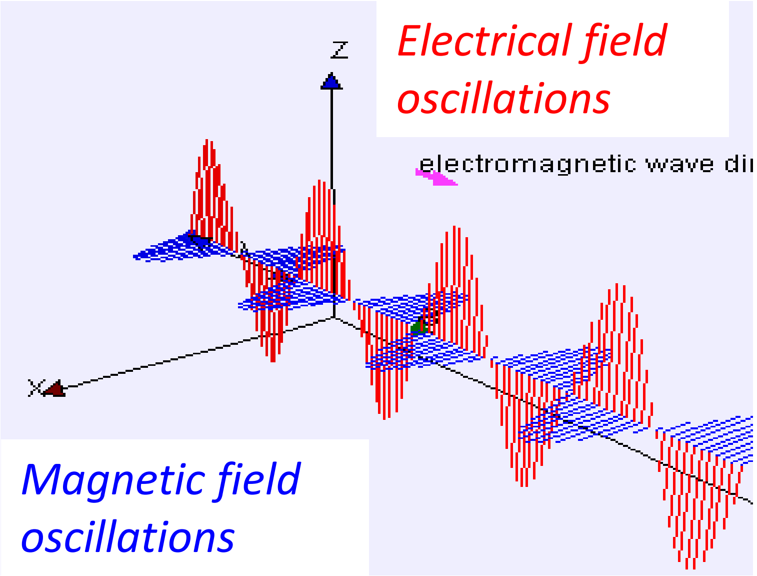


Fig.1-9b A polarizer reduces scattered light

4. LIGHT AS ELECTROMAGNETIC (EM) WAVES

The observed interference and diffraction of light are evidence that light is a wave.
The effects of polarization show that it is a transverse wave.



Different sources emit different wavelengths (frequencies) of EM waves.

The energy carried by EM waves is proportional only to their frequency.

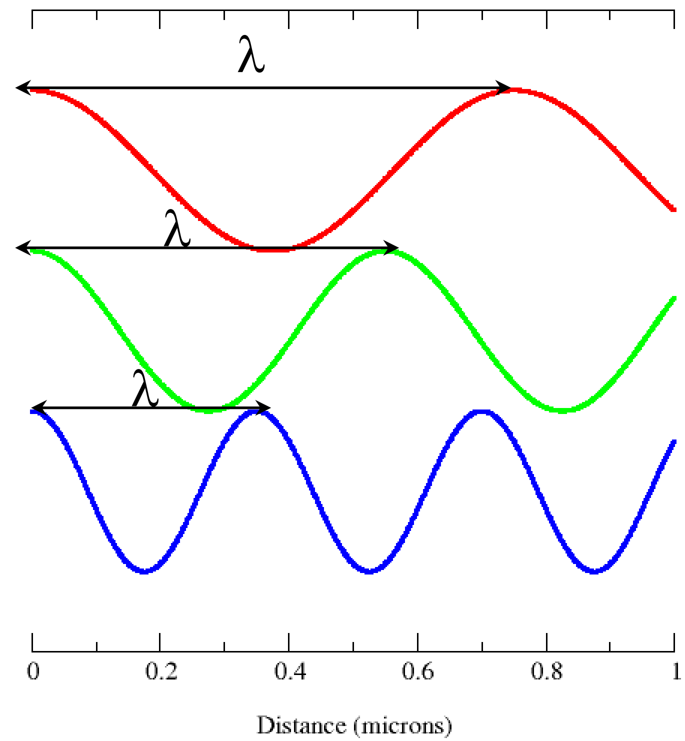
Fig.by Lookang in the public domain

VISIBLE LIGHT IS EM WAVES IN A RANGE OF WAVELENGTHS

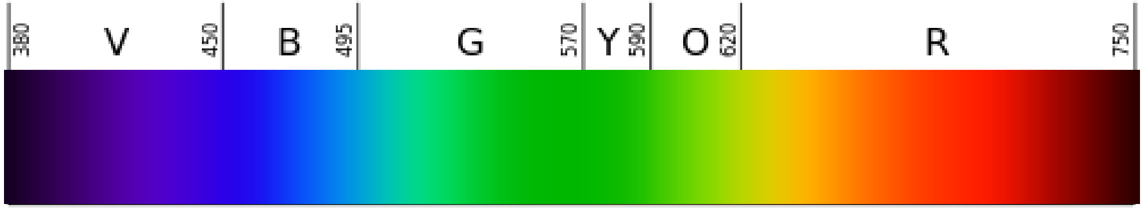
Experiments showed that light has the properties of waves. Different colors have different wavelengths.

The average wavelength of visible light is about
5×10^{-7} m = 0.5 μm = 500 nm

50 wavelengths of visible light would fit across the thickness of a sheet of paper.

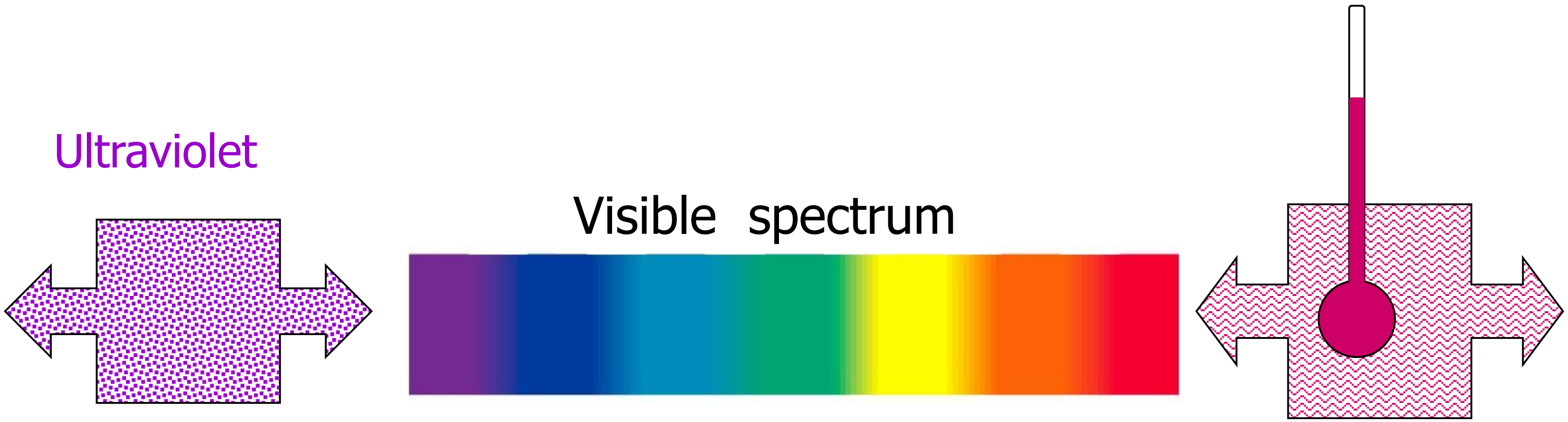


Public domain fig.



Public domain – visible spectrum wavelengths shown in nanometers.

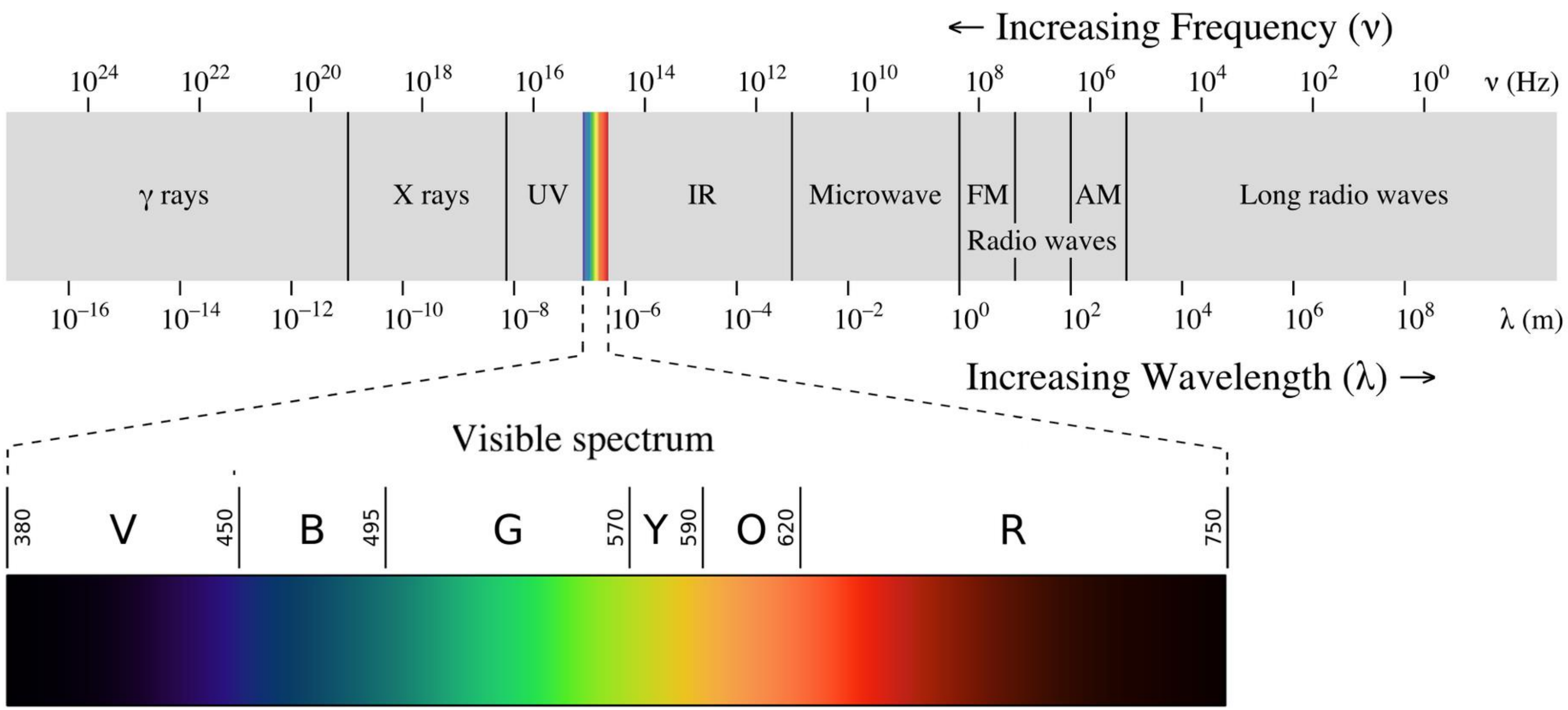
IN THE EARLY 1800’S WILLIAM HERSHEL DISCOVERED THAT THERE IS “INVISIBLE LIGHT” BEYOND THE RED COLOR OF THE SPECTRUM.



Another invisible energy was detected beyond the violet end of the spectrum.

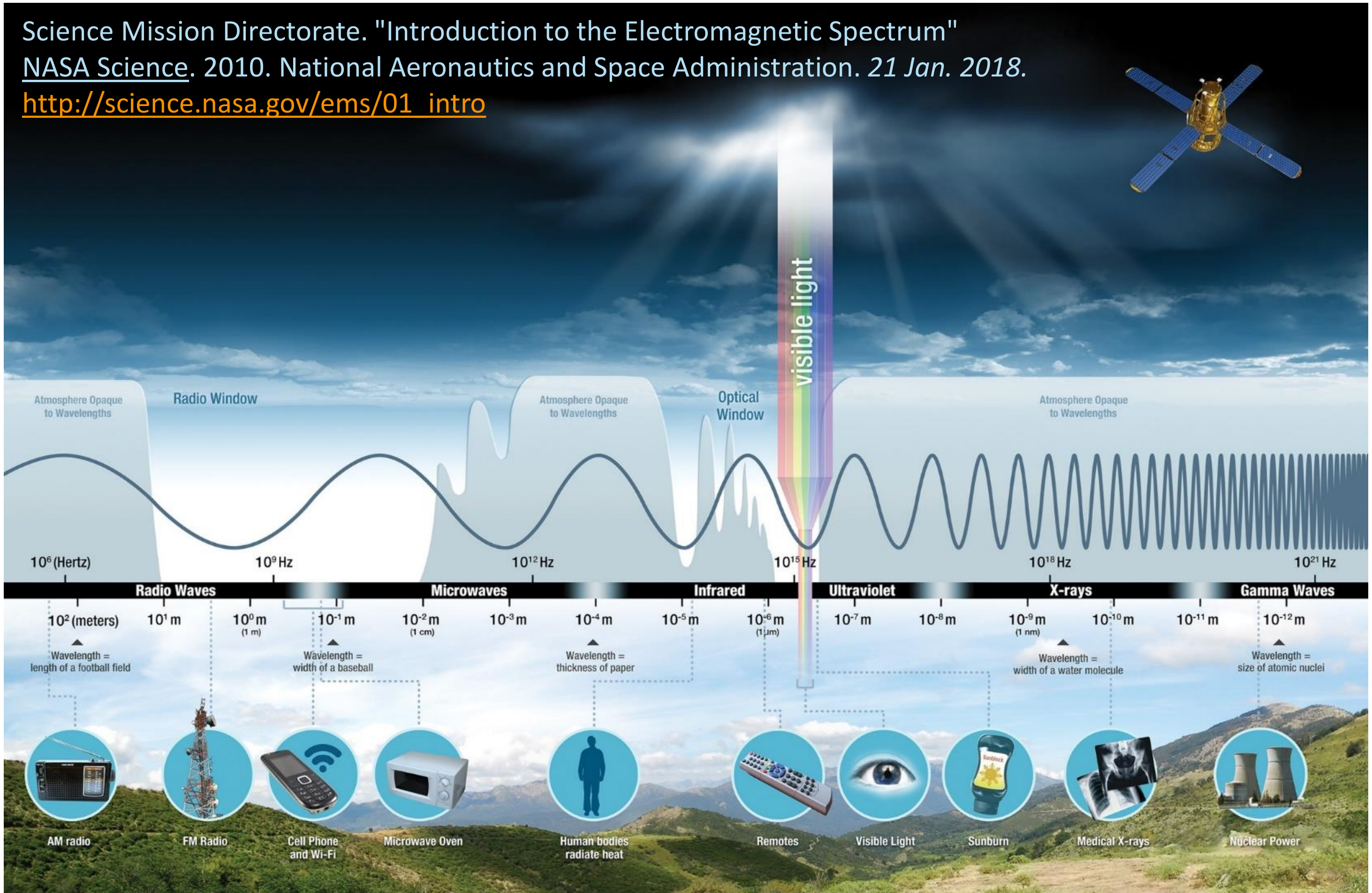
Q: What other types of invisible light do you know?

Visible light is a small part of a whole range of energies.



WHAT ARE THE SIMILARITIES AND DIFFERENCES BETWEEN ALL THESE TYPES OF EM WAVES?

Read about the various types of EM waves: https://science.nasa.gov/ems/



Science Mission Directorate. "Introduction to the Electromagnetic Spectrum" NASA Science. 2010. National Aeronautics and Space Administration. *21 Jan. 2018.* http://science.nasa.gov/ems/01_intro