Quarknet Masterclass

Activities with Polarized Light

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Department of Physics

August 9, 2016
10:30 am-noon

Electromagnetic waves

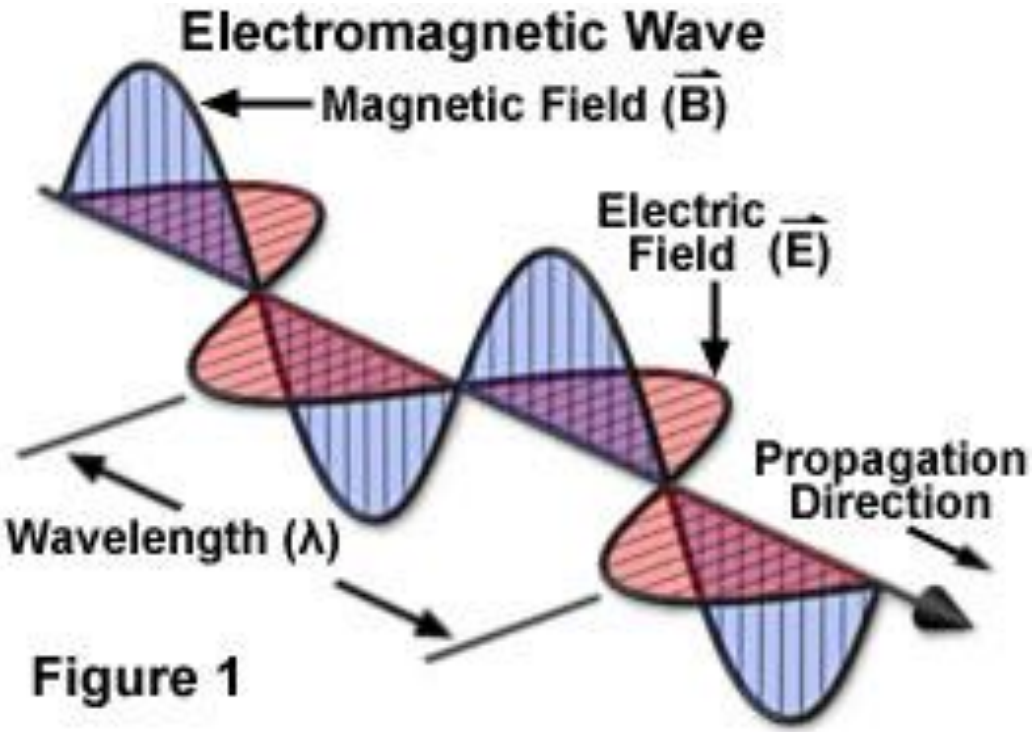


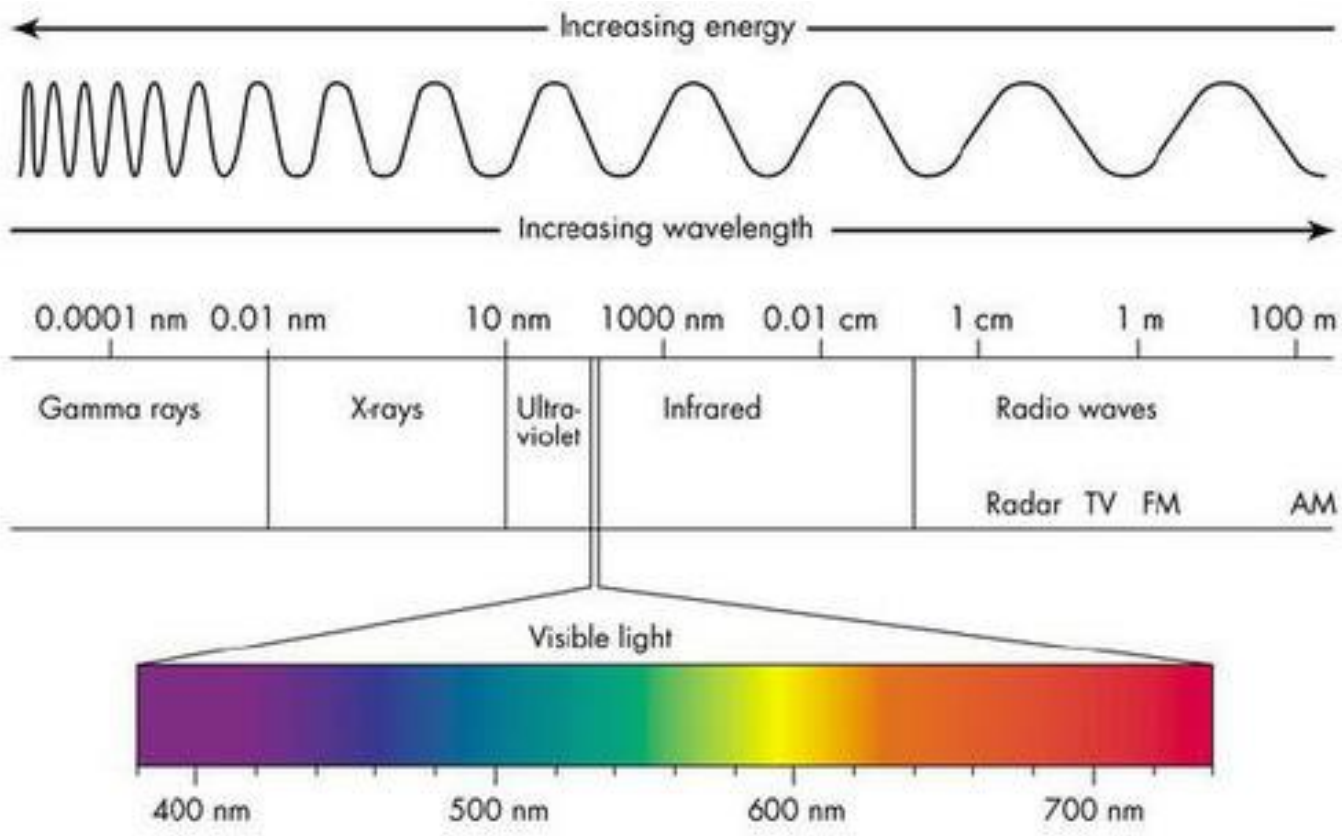
Figure 1

Electromagnetic radiation is a self-propagating composite of an electric field plus a magnetic field

Changing electric field produces

Changing magnetic field produces

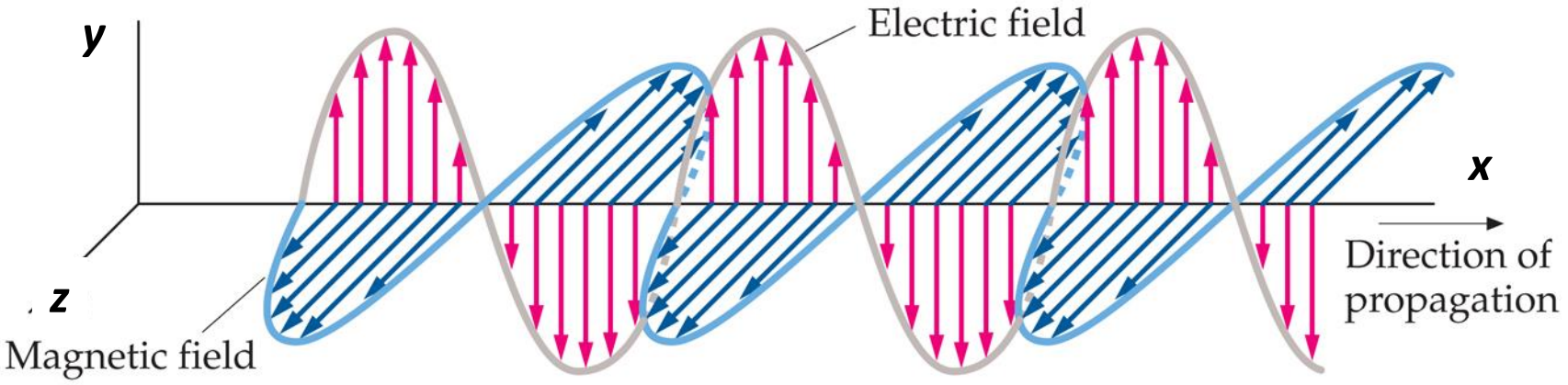
Light as an electromagnetic wave



Electromagnetic Wave Polarization

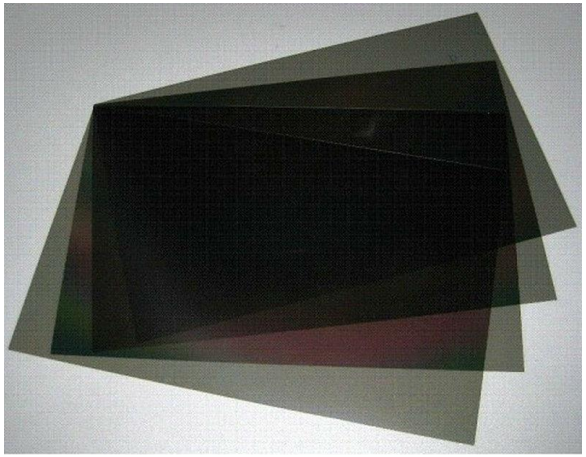
- **The direction of the electric field is perpendicular to the direction of propagation**
- **The direction of the magnetic field is perpendicular to the direction of propagation and the electric field**

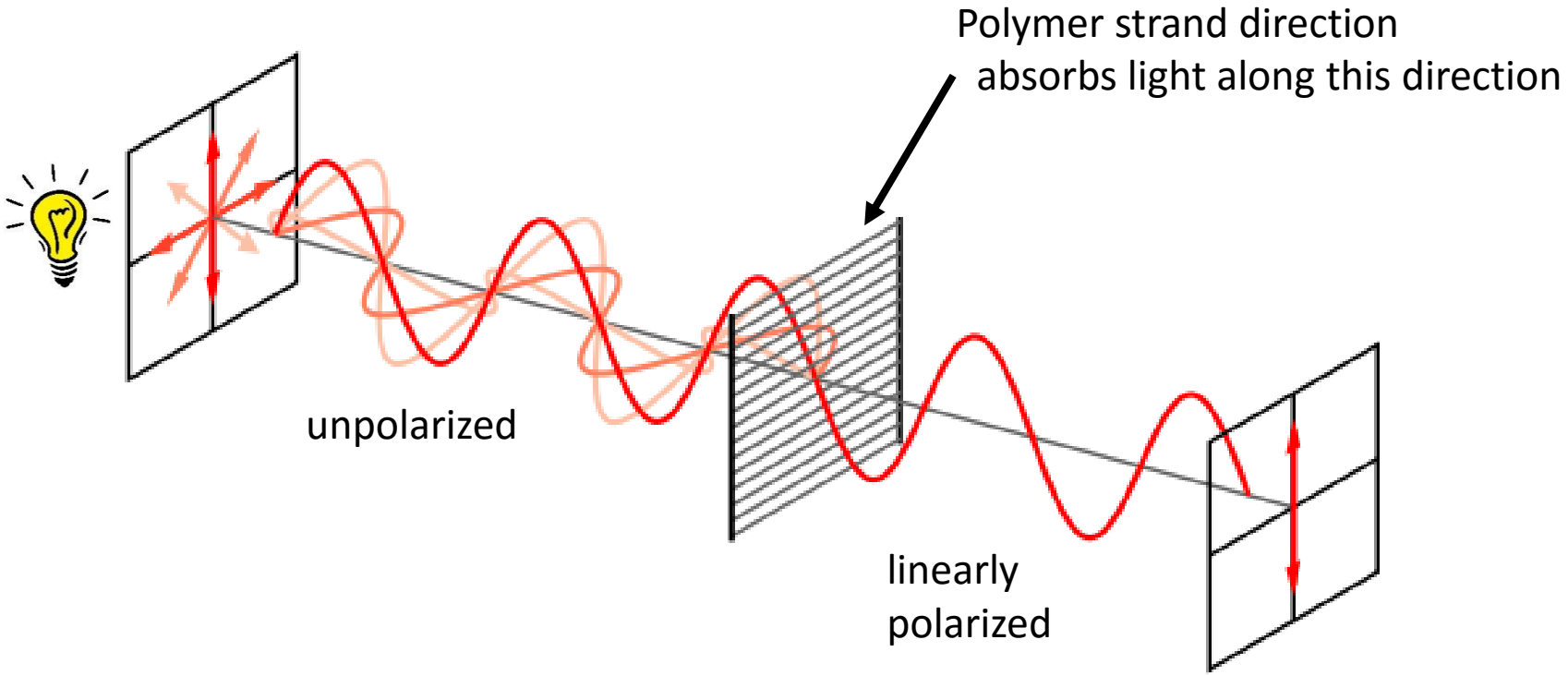
Polarization : the orientation of the direction of the electric (and magnetic) field with respect to the propagation direction

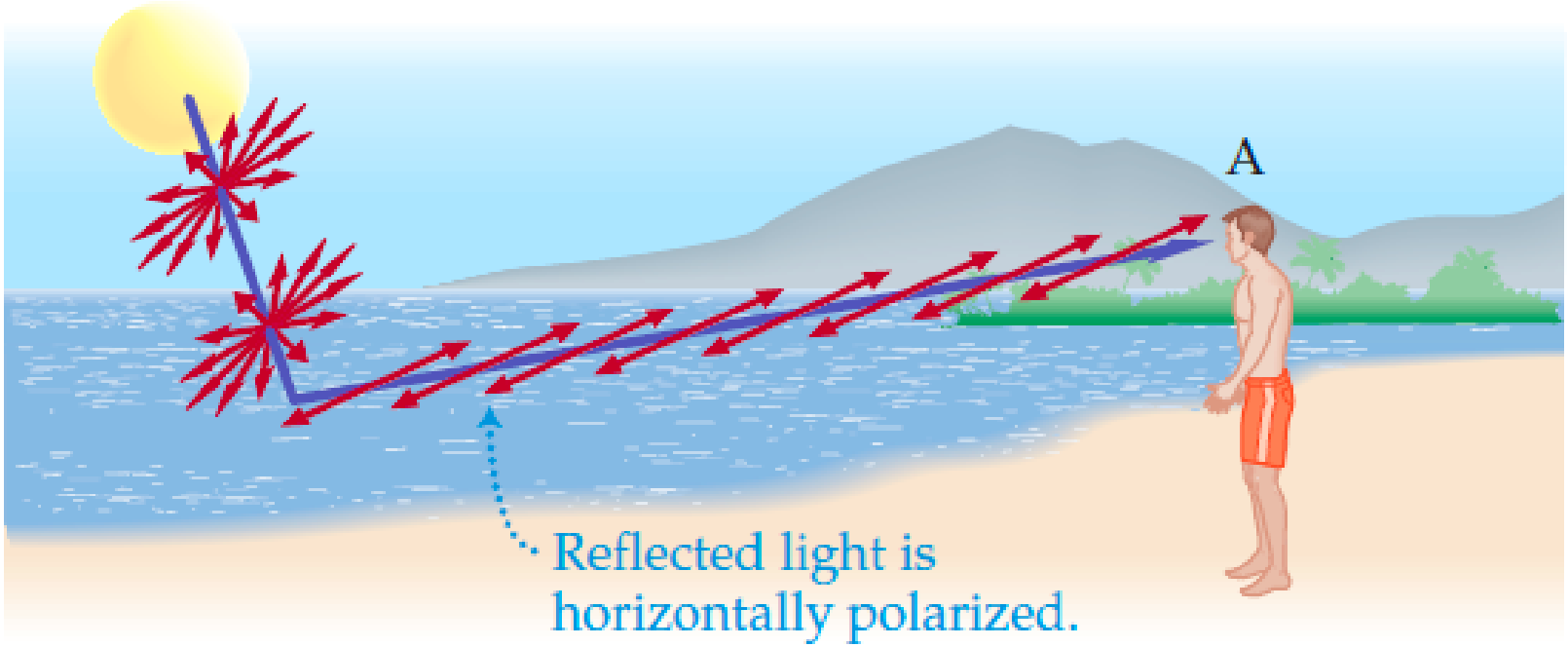


Linearly Polarized Light

Film polarizers (polaroid)






A
Reflected light is
horizontally polarized.

Activity with Polarized Glasses

Round rimmed glasses

Put on the round rimmed of glasses. Close your right eye and observe at your partner wearing the same glasses, looking specifically at their lenses. Draw and describe what you see.

Now close your left eye and observe at your partner wearing the same glasses, looking specifically at their lenses. Draw and describe what you see.

Activity with Polarized Glasses

Round rimmed glasses

Put on the round rimmed of glasses. Close your right eye and observe at your partner wearing the same glasses, looking specifically at their lenses. Draw and describe what you see.

Both lenses look equally dark.

Now close your left eye and observe at your partner wearing the same glasses, looking specifically at their lenses. Draw and describe what you see.

Same as before. Both lenses look equally dark.

Activity with Polarized Glasses

Horned-rimmed glasses

Put on the pair of horned-rimmed glasses. Close your right eye and observe at your partner wearing the same glasses, looking specifically at their lenses. Draw and describe what you see.

Now close your left eye and observe at your partner wearing the same glasses, looking specifically at their lenses. Draw and describe what you see.

Activity with Polarized Glasses

Horned-rimmed glasses

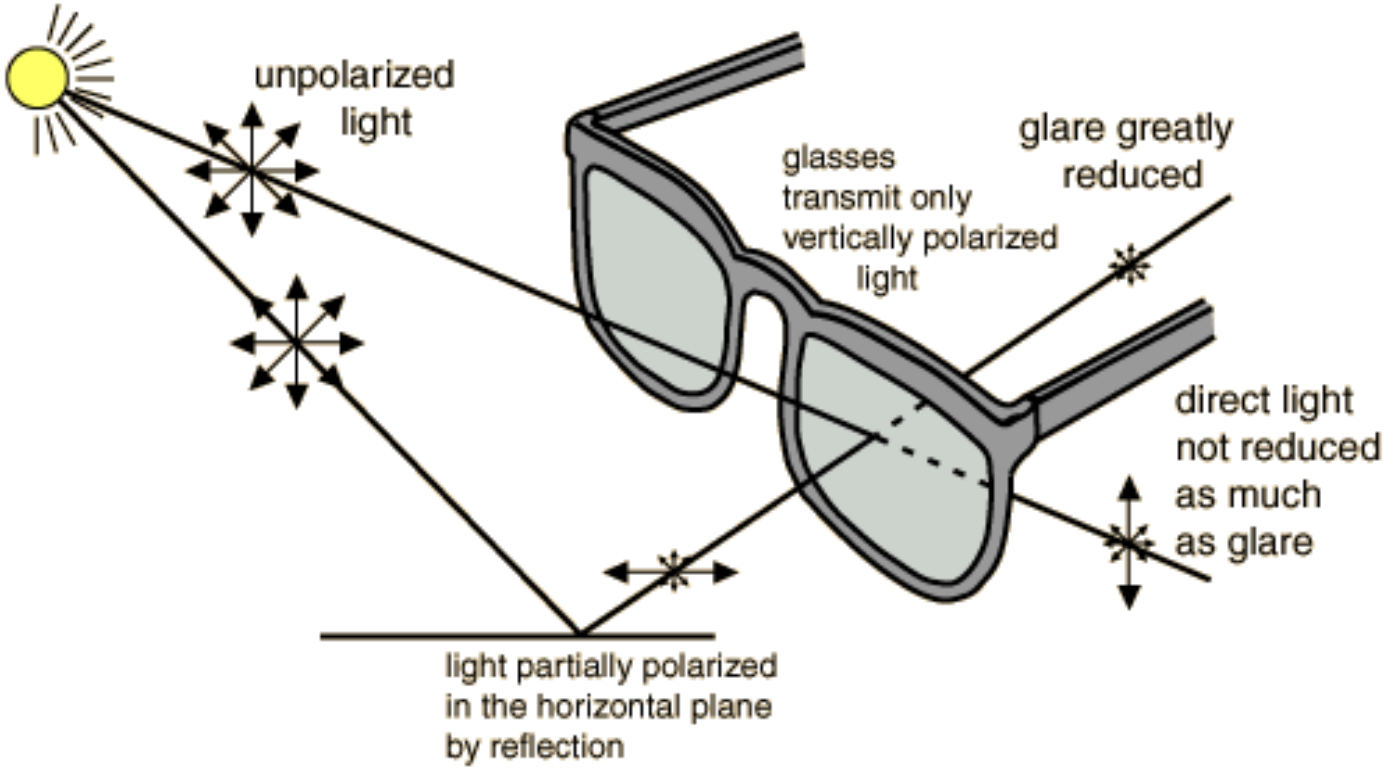
Put on the pair of horned-rimmed glasses. Close your right eye and observe at your partner wearing the same glasses, looking specifically at their lenses. Draw and describe what you see.

The lens on my left (my partner's right) looks darker.

Now close your left eye and observe at your partner wearing the same glasses, looking specifically at their lenses. Draw and describe what you see.

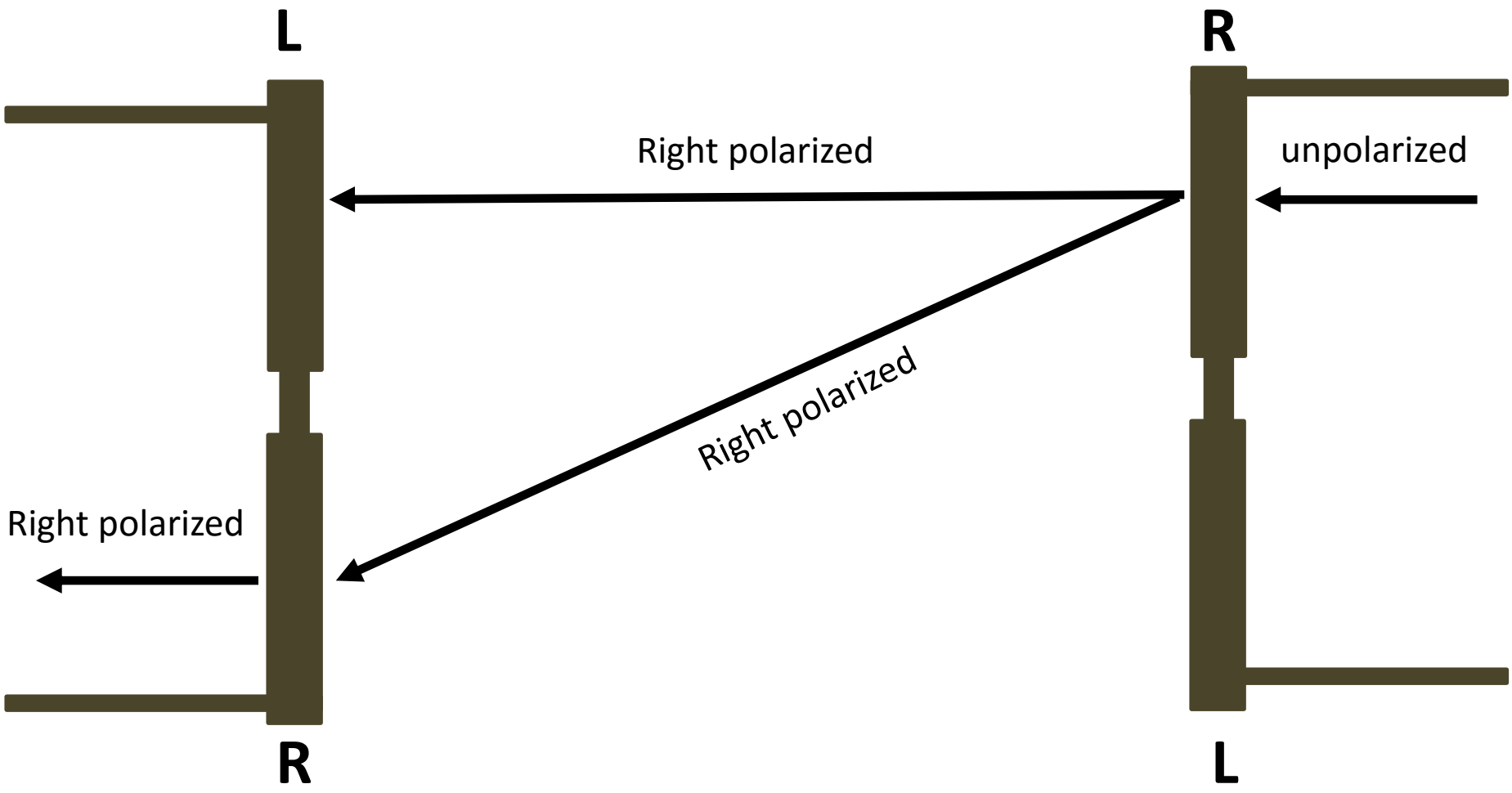
The lens on my right (my partner's left) looks darker.

Polarized sun glasses




real D 3D

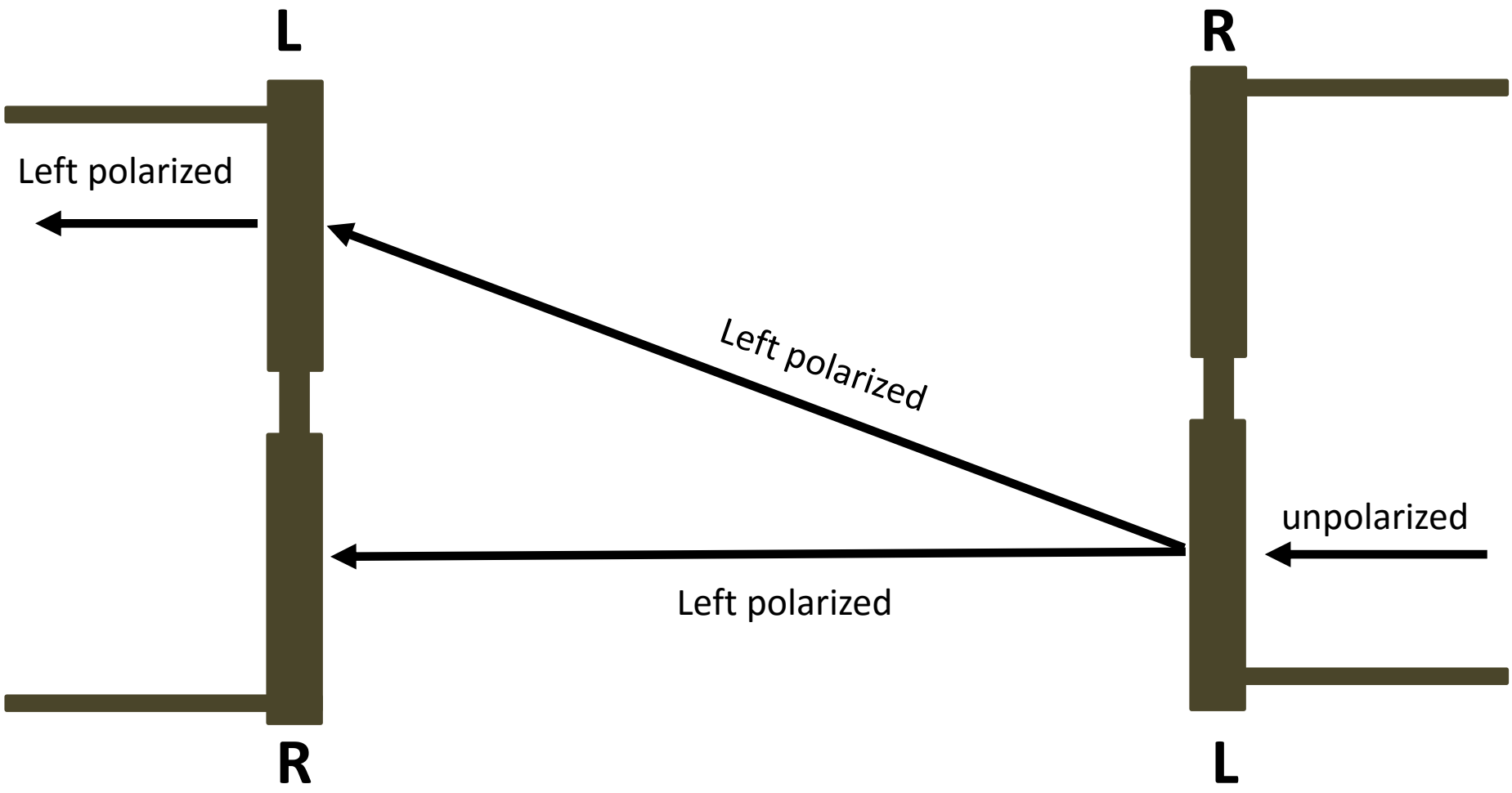
Polarized Glasses: Top View



YOU

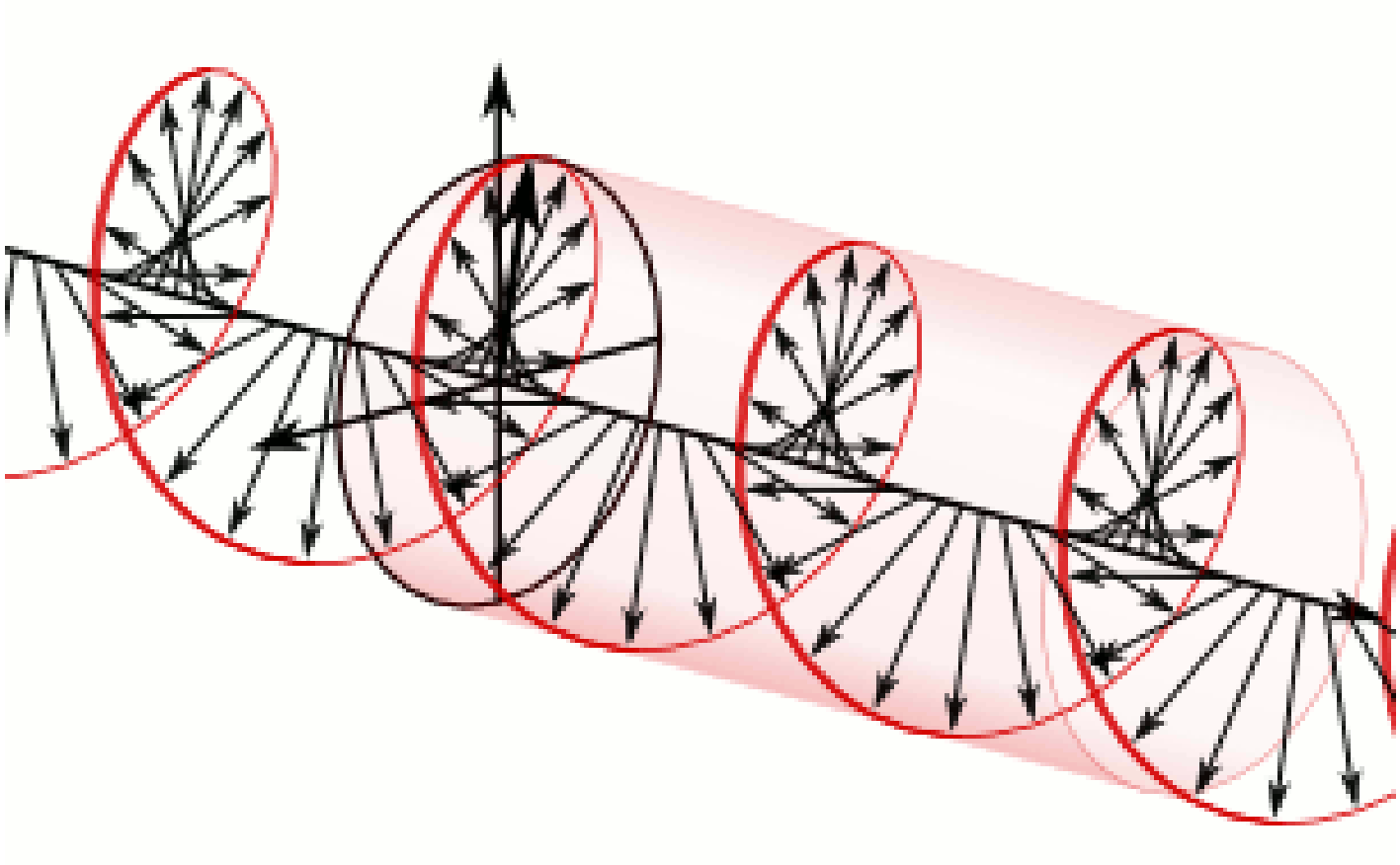
Partner

Polarized Glasses: Top View

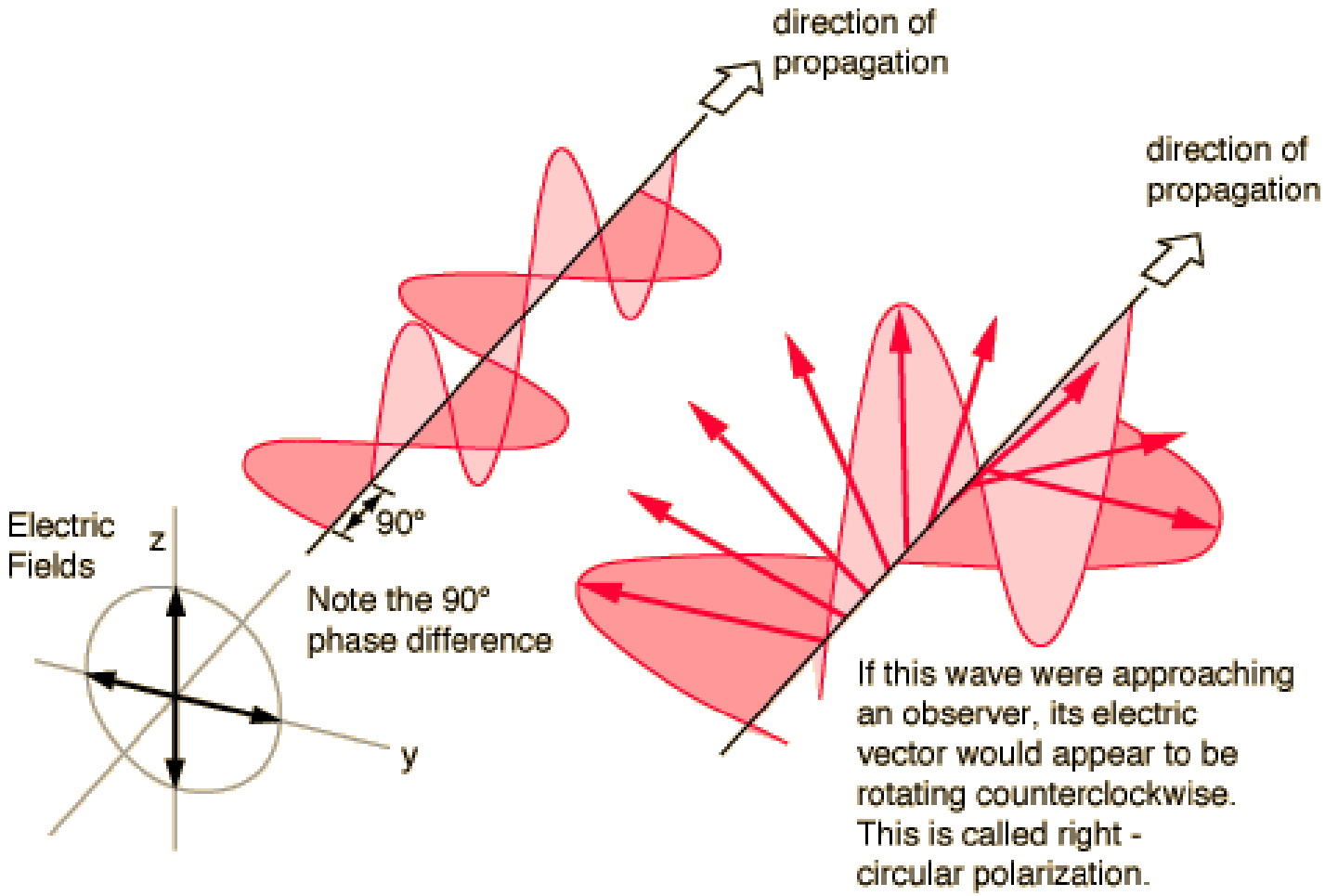


YOU

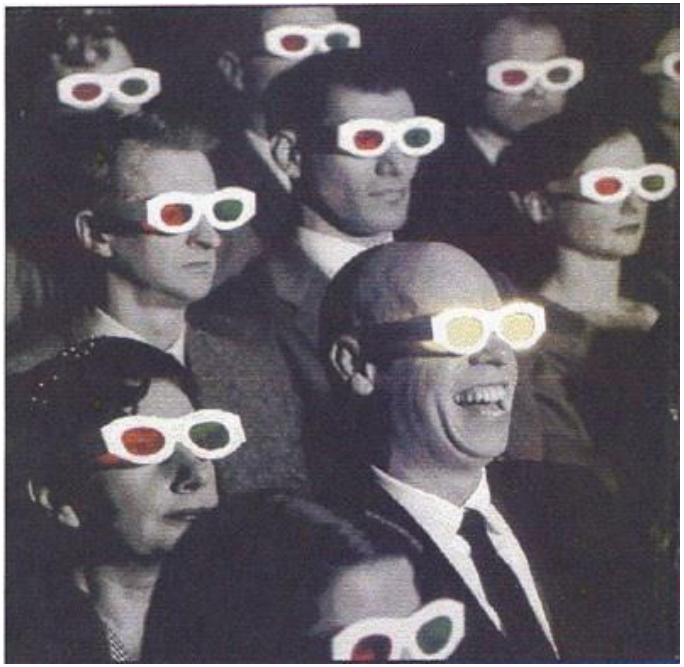
Partner



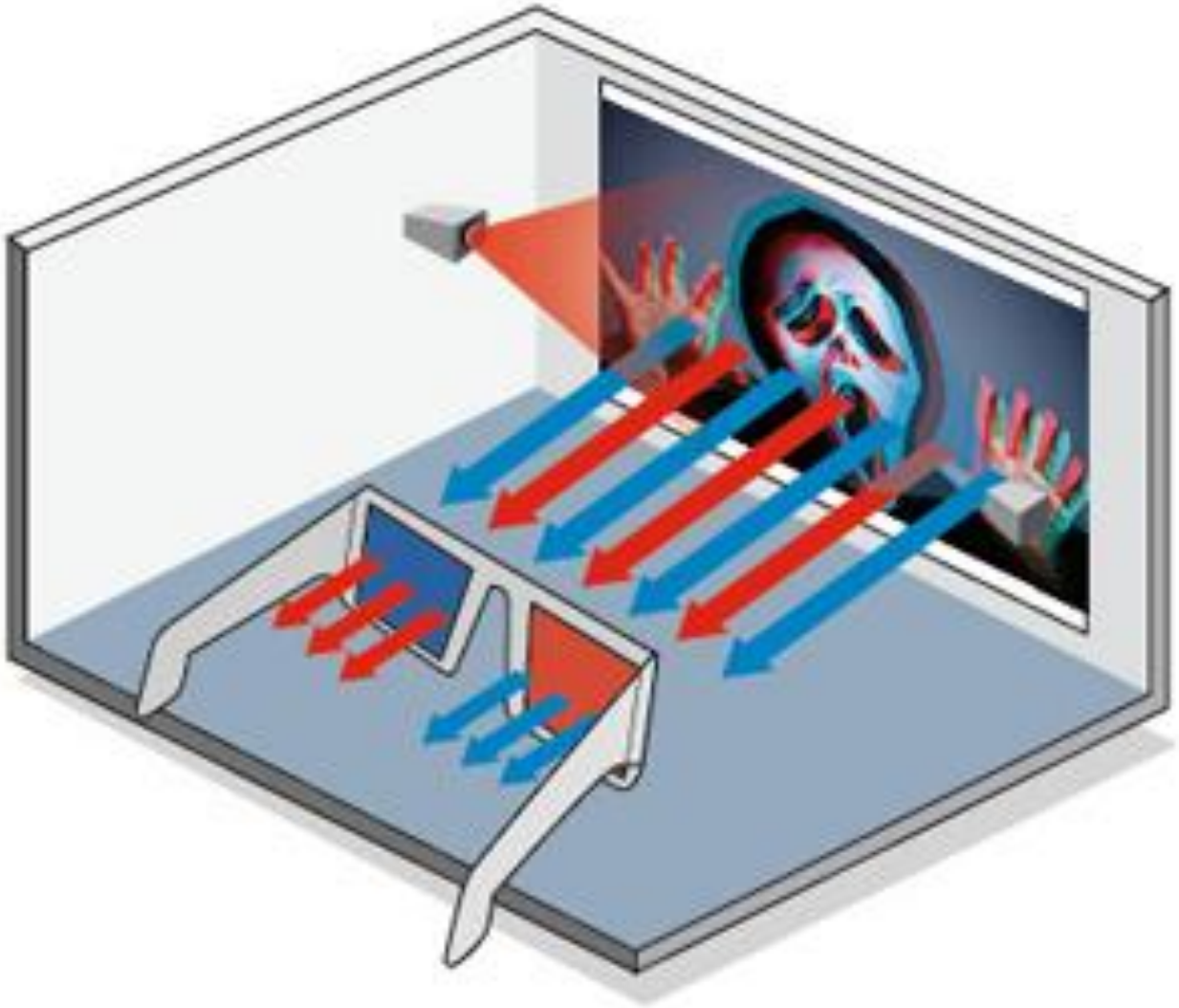
http://upload.wikimedia.org/wikipedia/commons/8/81/Circular.Polarization.Circularly.Polarized.Light_Right.Handed.Animation.305x190.255Colors.gif


direction of
propagation
direction of
propagation
90°
Electric
Fields
z
y
Note the 90°
phase difference
If this wave were approaching
an observer, its electric
vector would appear to be
rotating counterclockwise.
This is called right -
circular polarization.


SONY
3D
PARALLAX
FILM PRODUCTIONS

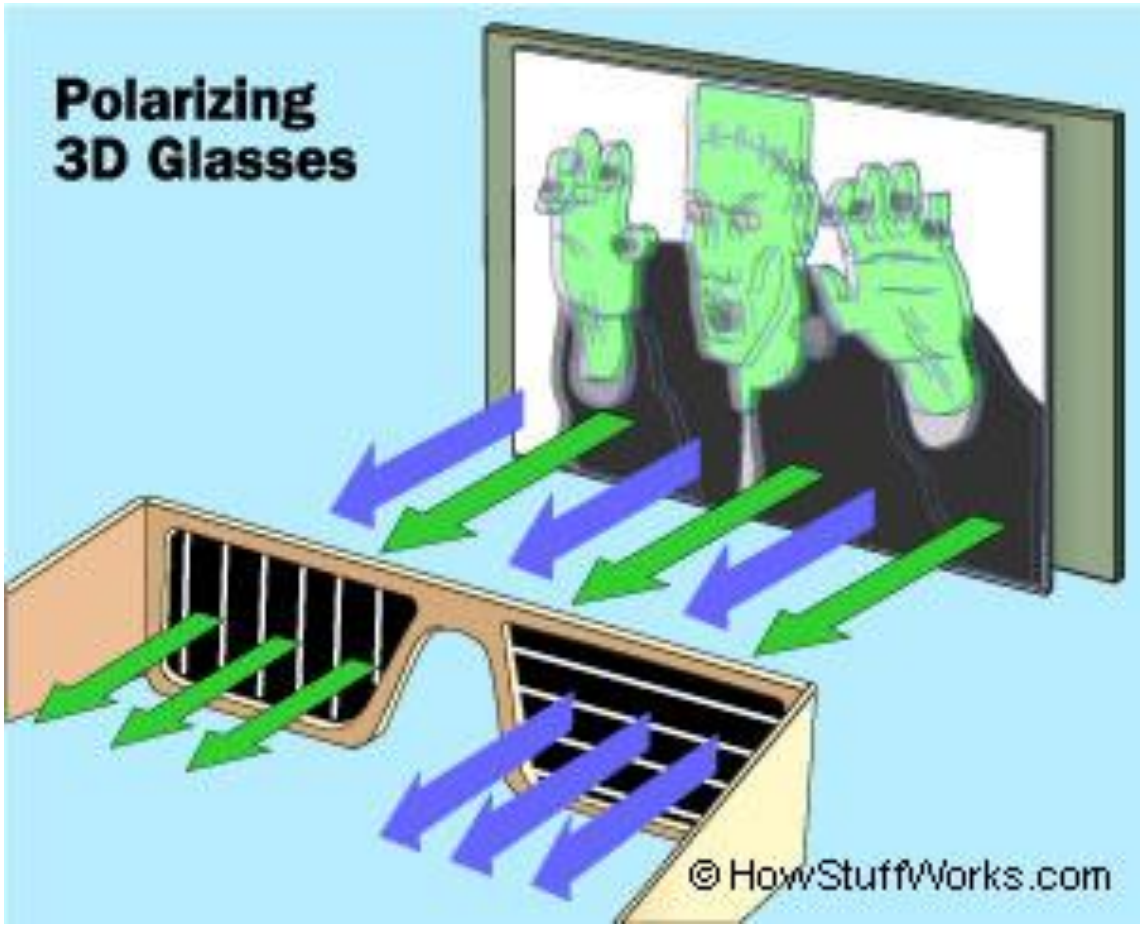


1954

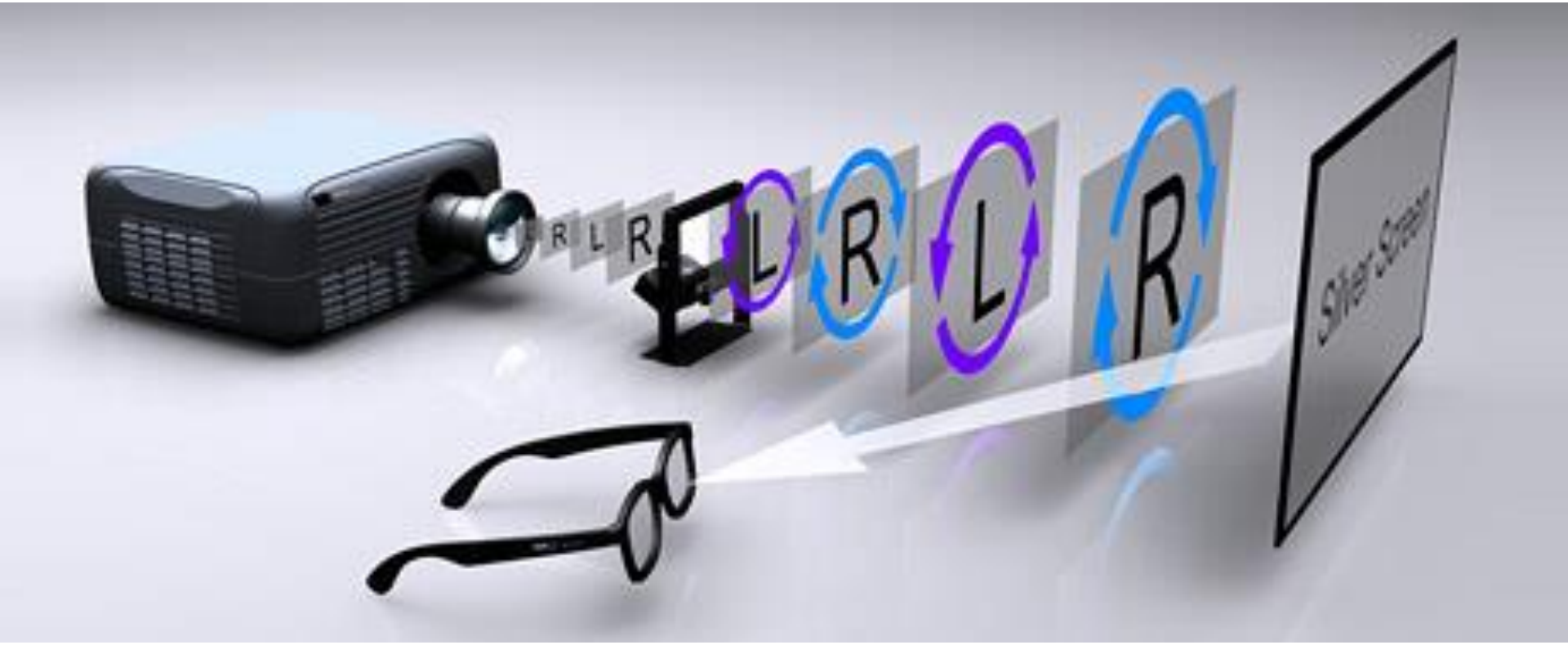



CAPTAIN EO
WE ARE HERE TO CHANGE THE WORLD.
GEORGE LUCAS presents A 3-D MUSICAL MOTION PICTURE SPACE ADVENTURE
Directed by FRANCIS COPPOLA starring MICHAEL JACKSON · CAPTAIN EO

1986


Polarizing
3D Glasses
© HowStuffWorks.com


DepthQ
Polarization Modulator
Control Unit
Power
Signal
FREQ:144.13Hz 23.89U
DELAY: 8ms L/R
OUTPUT:Enabled 3D
IP:192.168.1.254
DepthQ
Polarization Modulator
3D/2D


R L R
L
R
L
R
Silver Screen

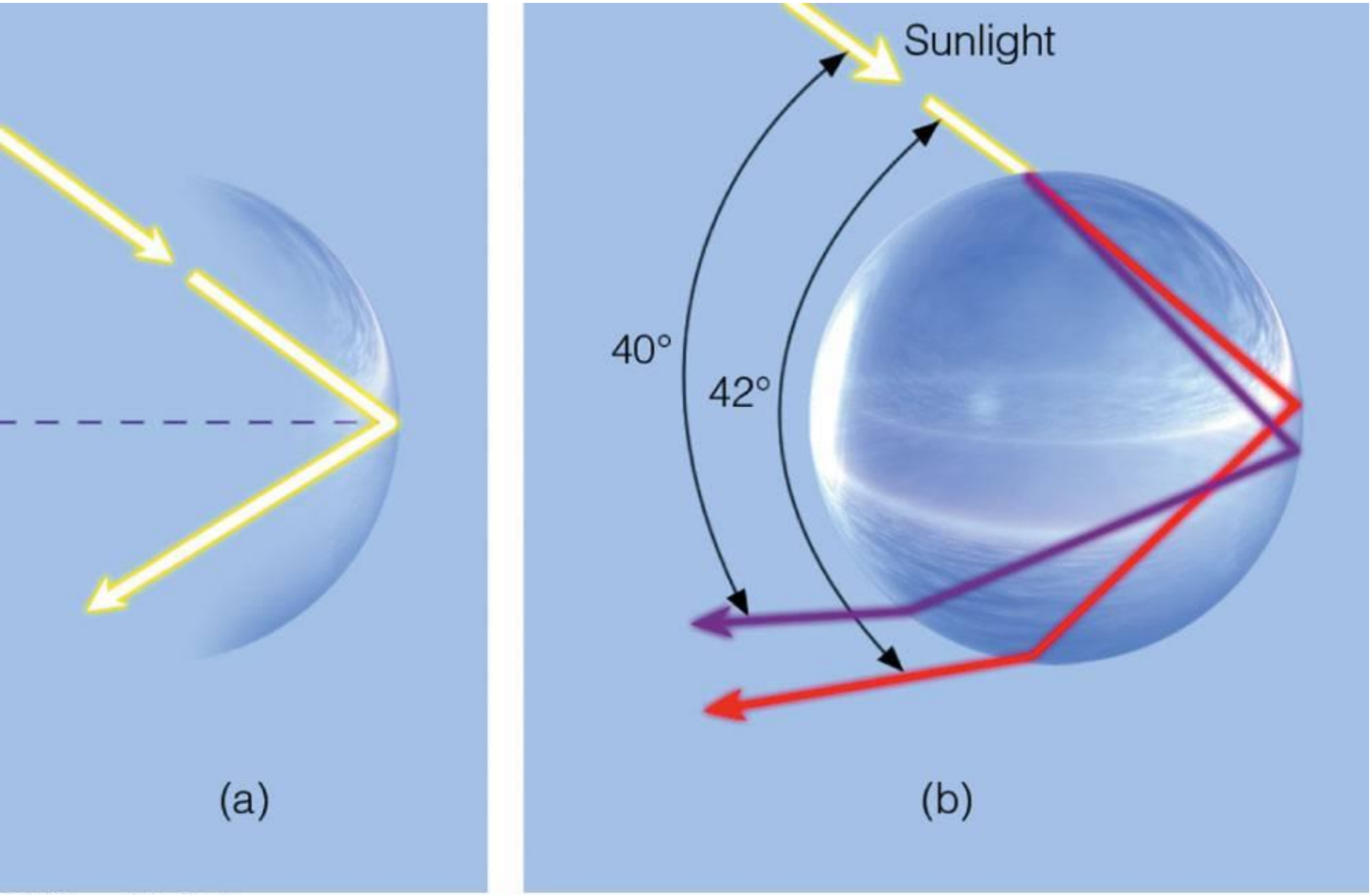

Grand Re-Opening
CJ DRIVE-IN
C-J DRIVE-IN
ENTRANCE
LEFT TURN
YIELD
ONLY

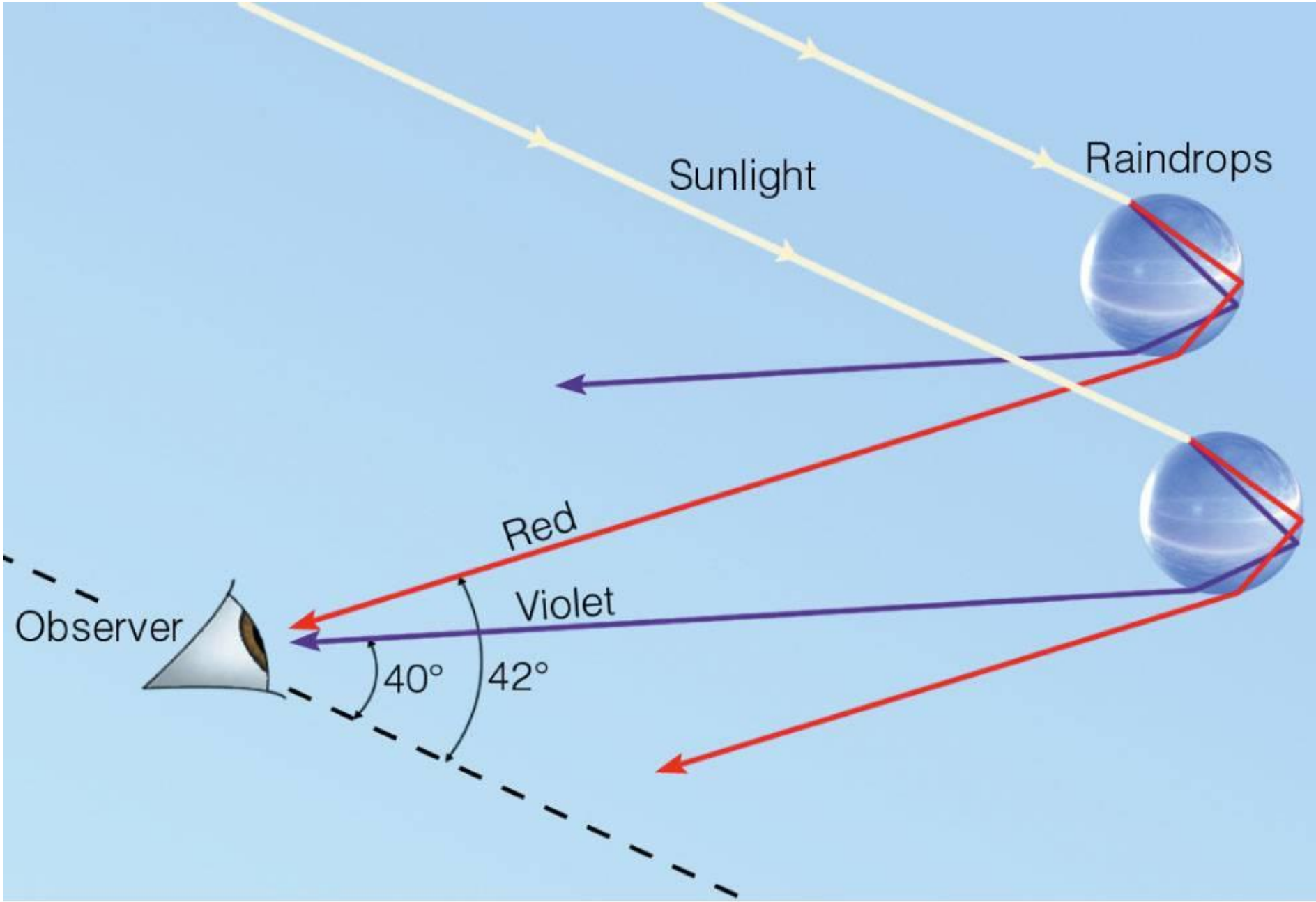
Polarized sun glasses will only pass vertically polarized light

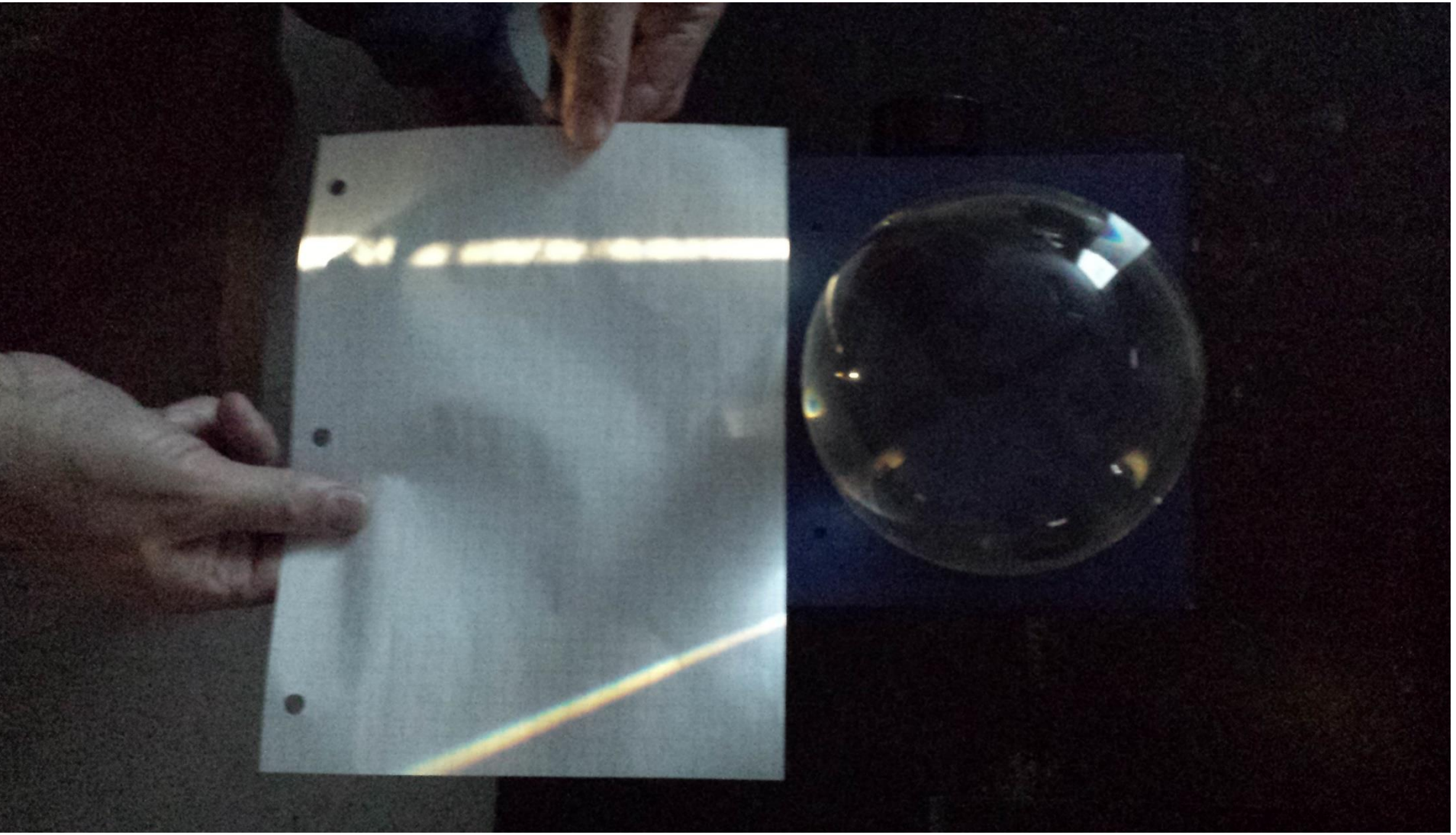
Polarized sun glasses will only pass vertically polarized light

Polarized sun glasses will only pass vertically polarized light

Polarized sun glasses will only pass vertically polarized light



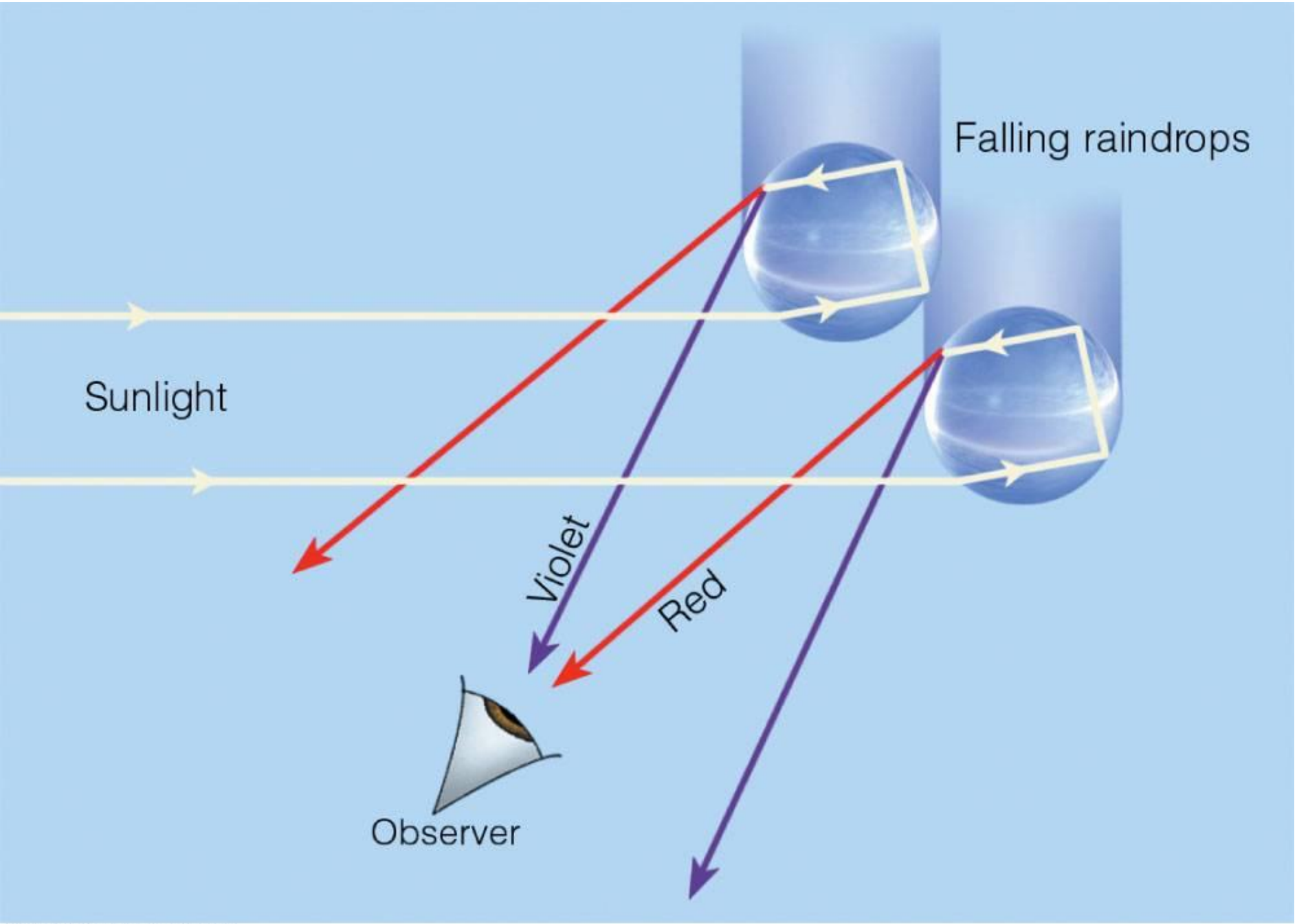


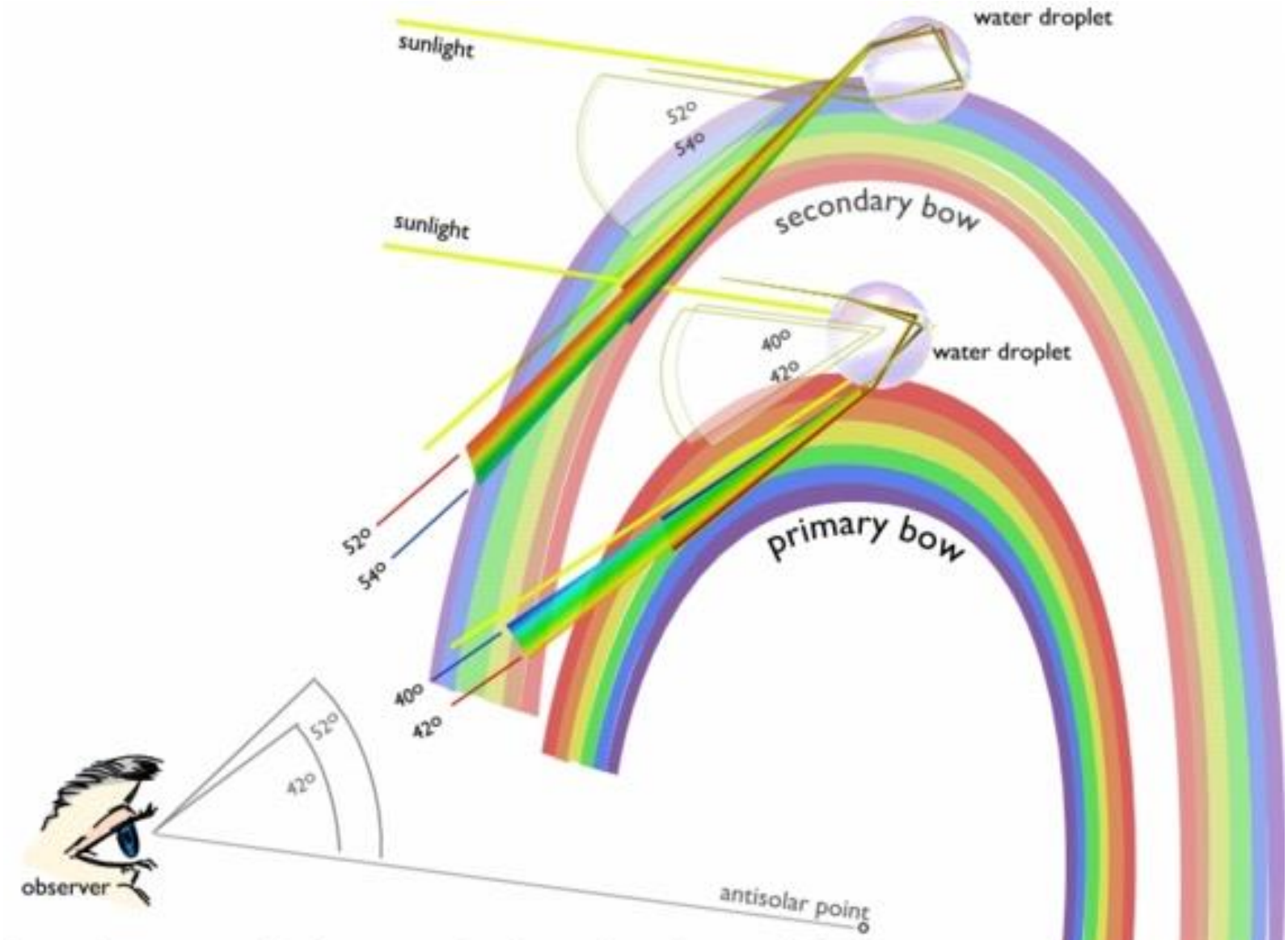


Done

Double rainbow! After learning about this in Engineering Physics, it makes it so much cooler. See More

21 Likes
2 Comments

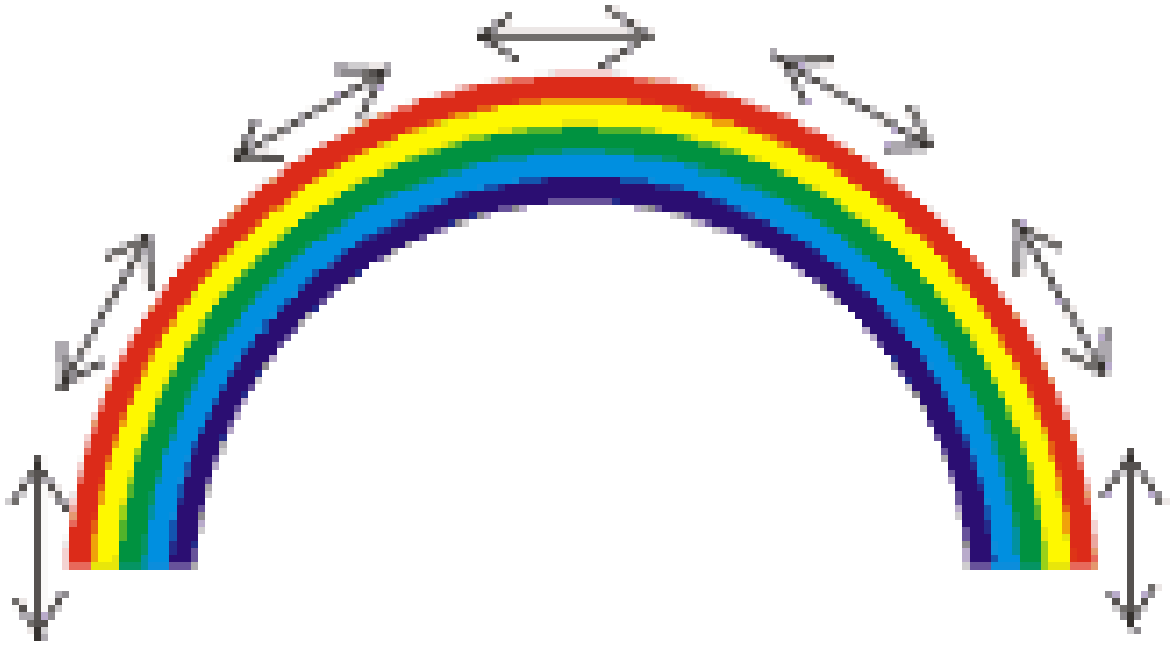




Primary Bow viewing angles: from sun - to droplet - to observer's eye = 40° to 42°

Secondary Bow viewing angles: from sun - to droplet - to observer's eye = 52° to 54°
colors are reversed in the secondary bow!

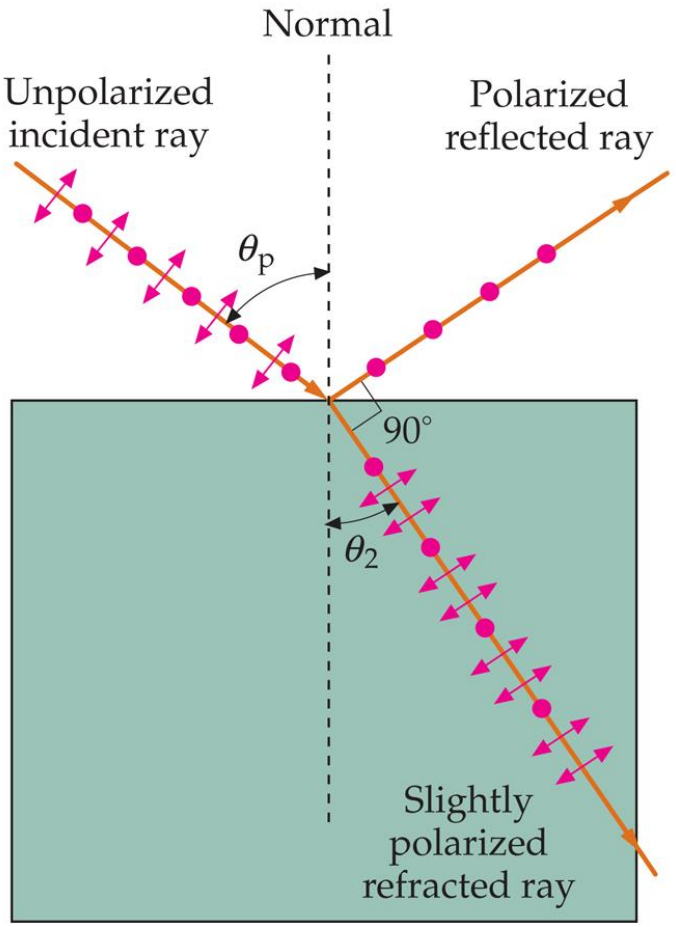
Light from a rainbow is highly polarized (internal reflection near Brewster angle)



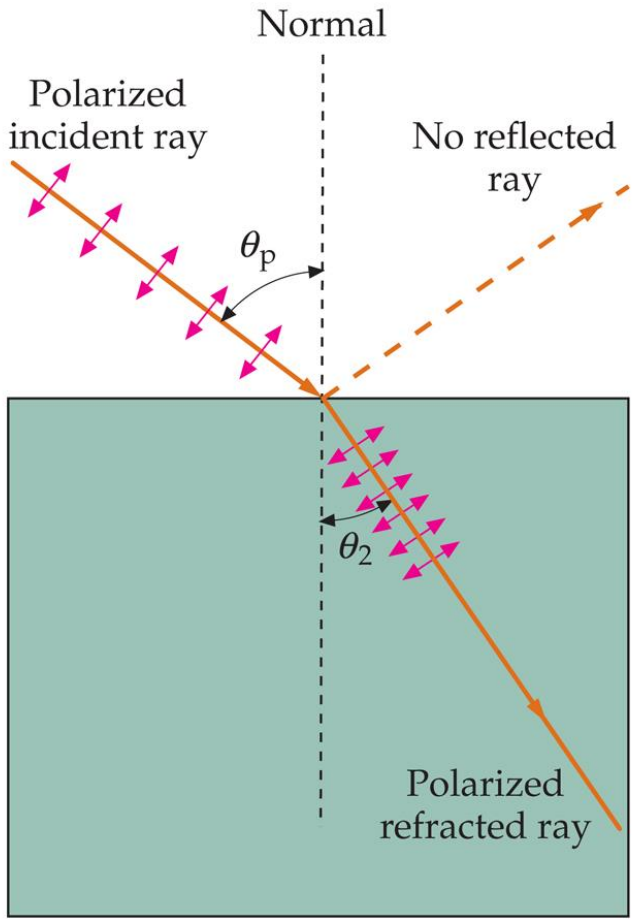
Polarization Orientation Along Rainbow

Brewster Angle

Unpolarized light becomes polarized upon reflection



Reflection of polarization parallel to surface (perpendicular to plane of incidence)



No component parallel to surface (perpendicular to plane of incidence)
No reflected wave

Is this a real picture of a double rainbow?

A. Real

B. Fake

Is this a real picture of a double rainbow?

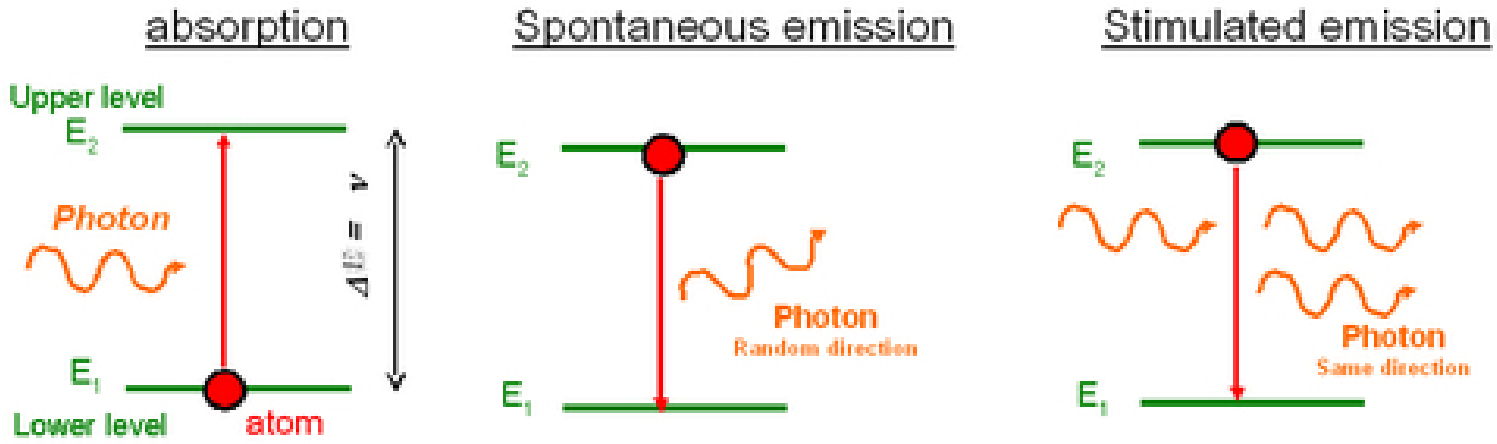
A. Real

B. Fake

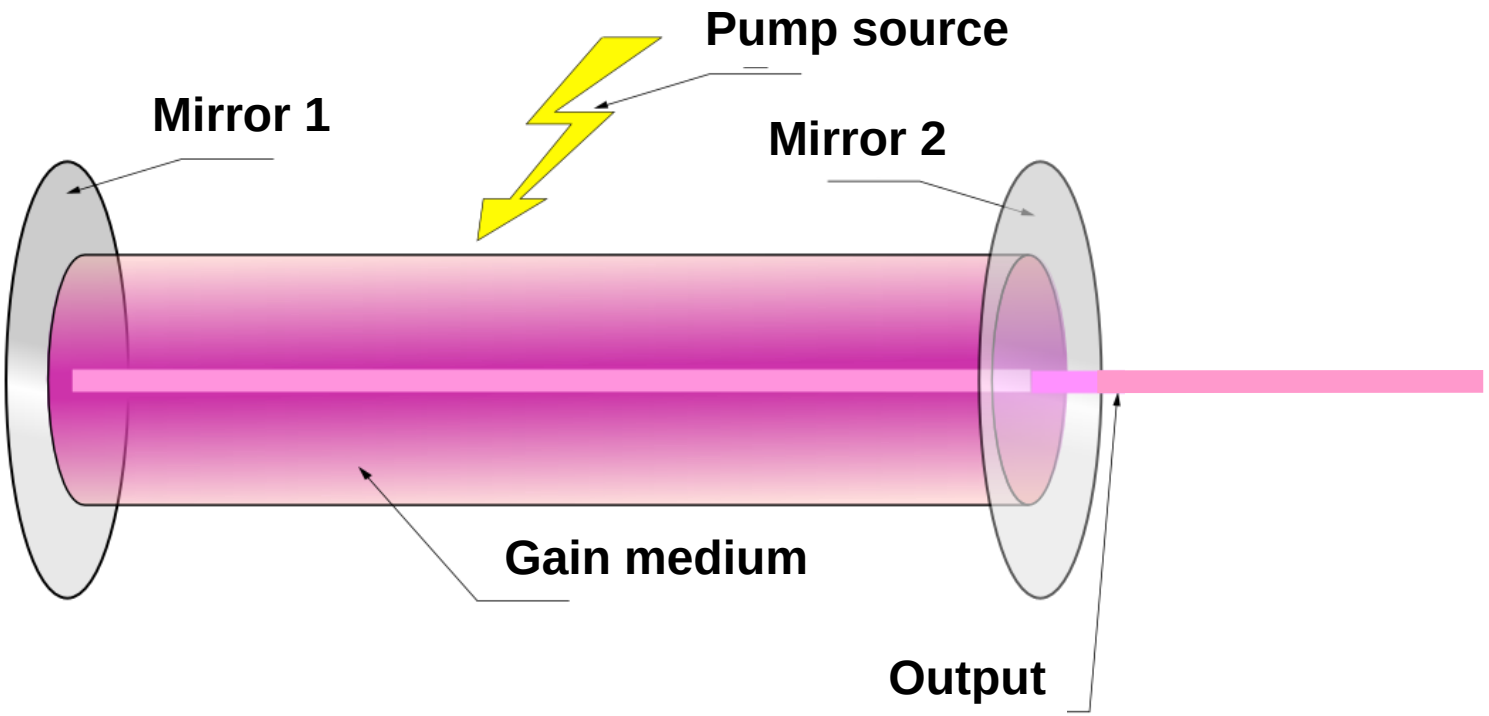
Lasers and the Nobel Prize

1st Nobel Prize in physics for the laser was in 1964

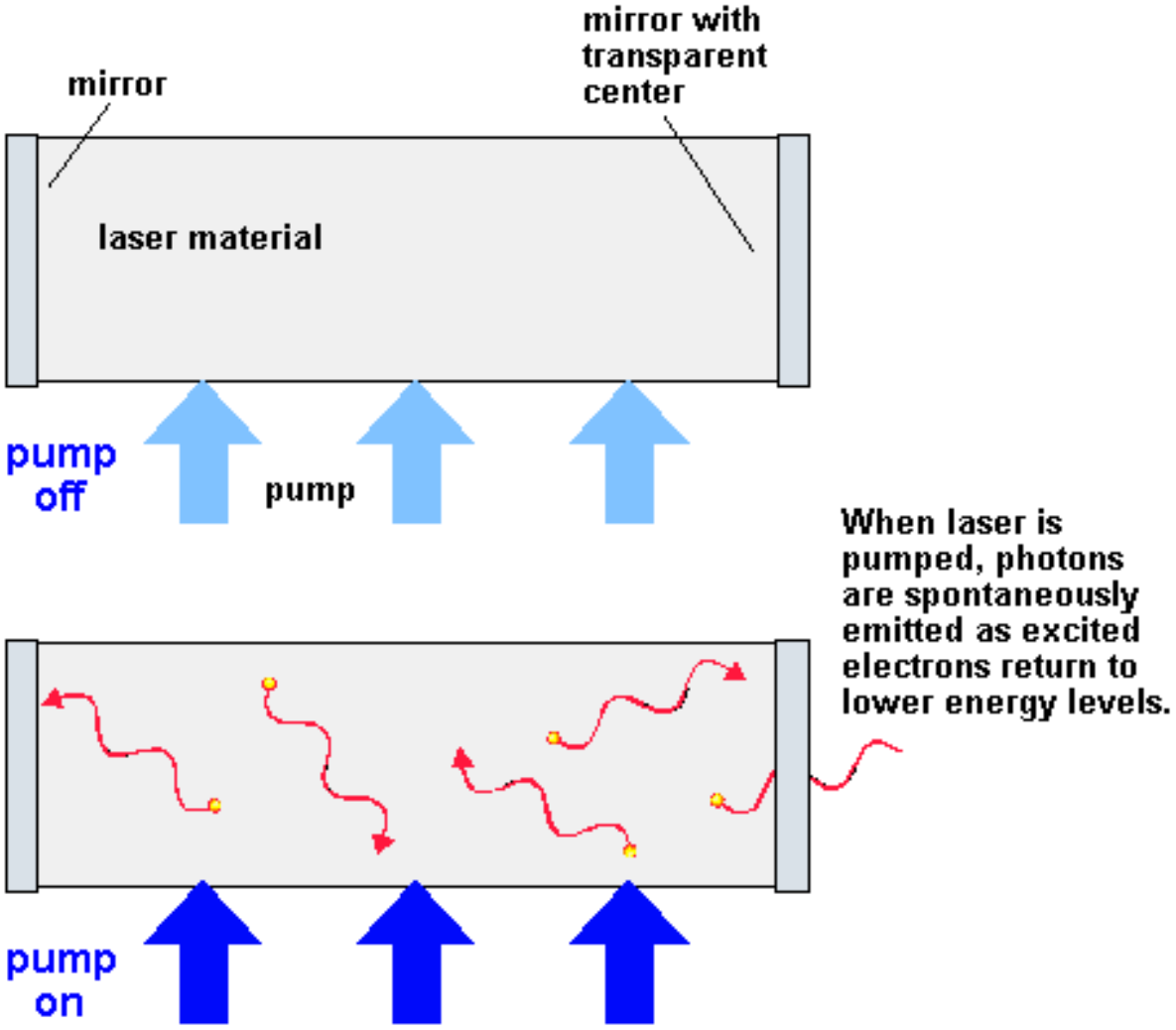
Optics and Photonics New May 2014

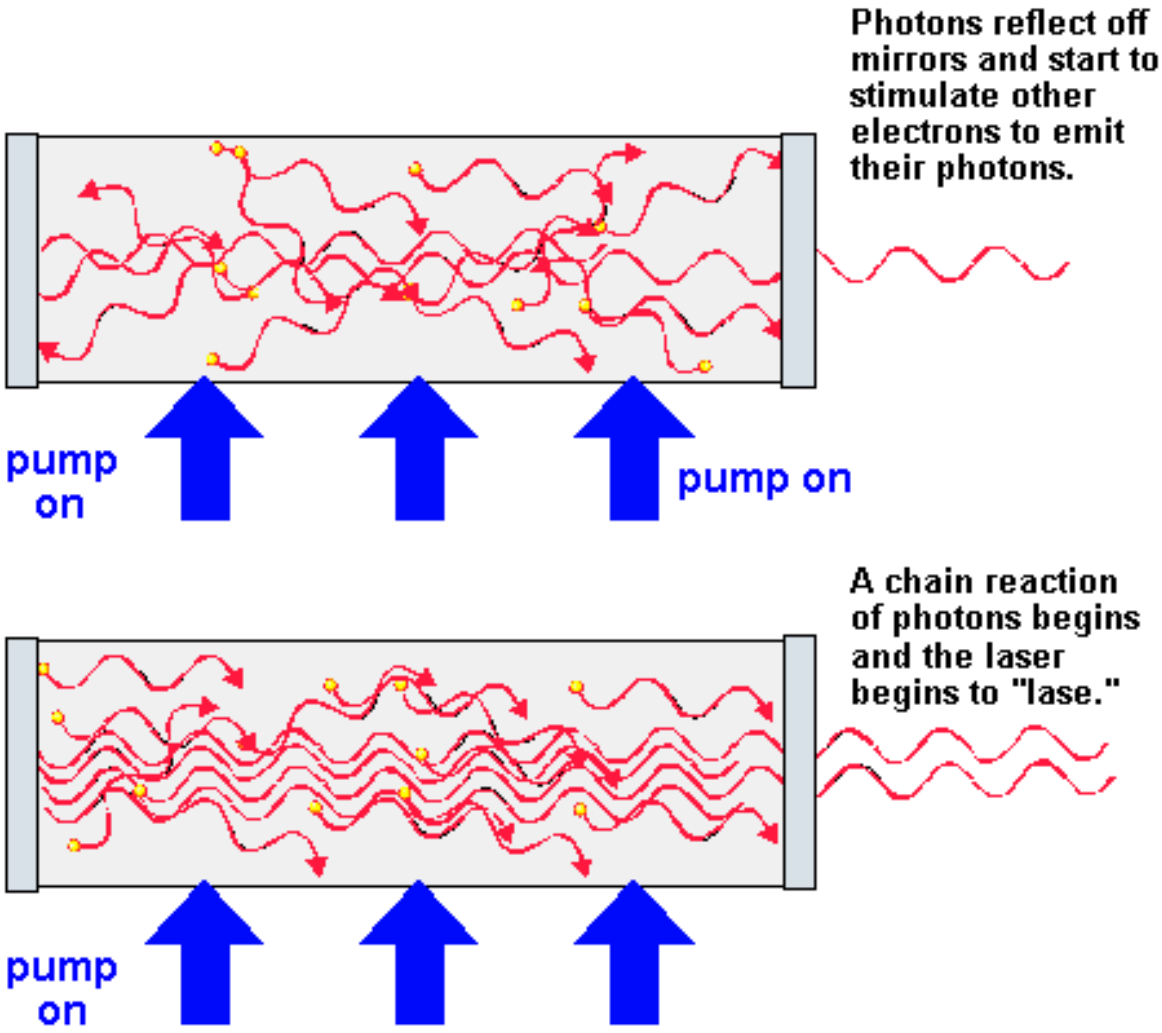


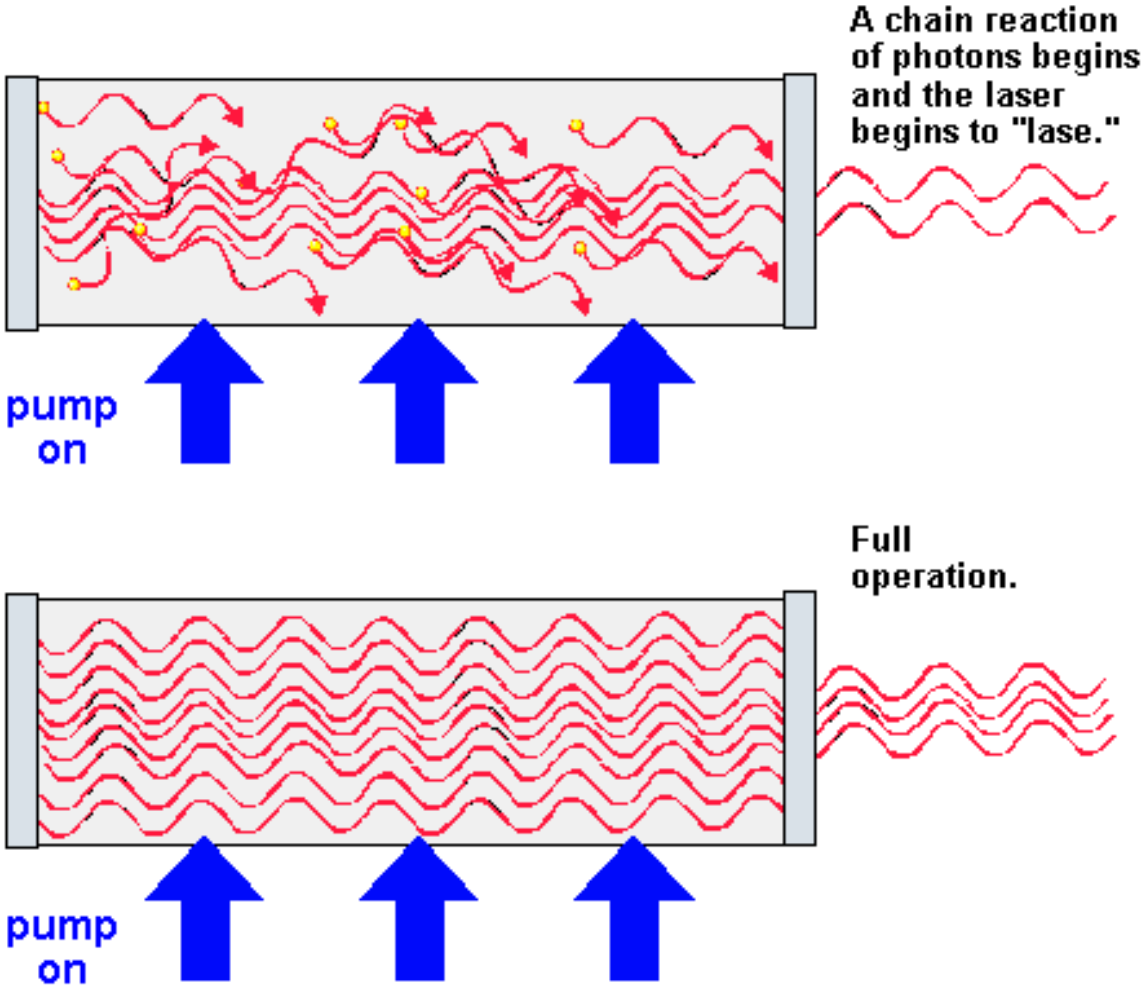
Laser Schematic



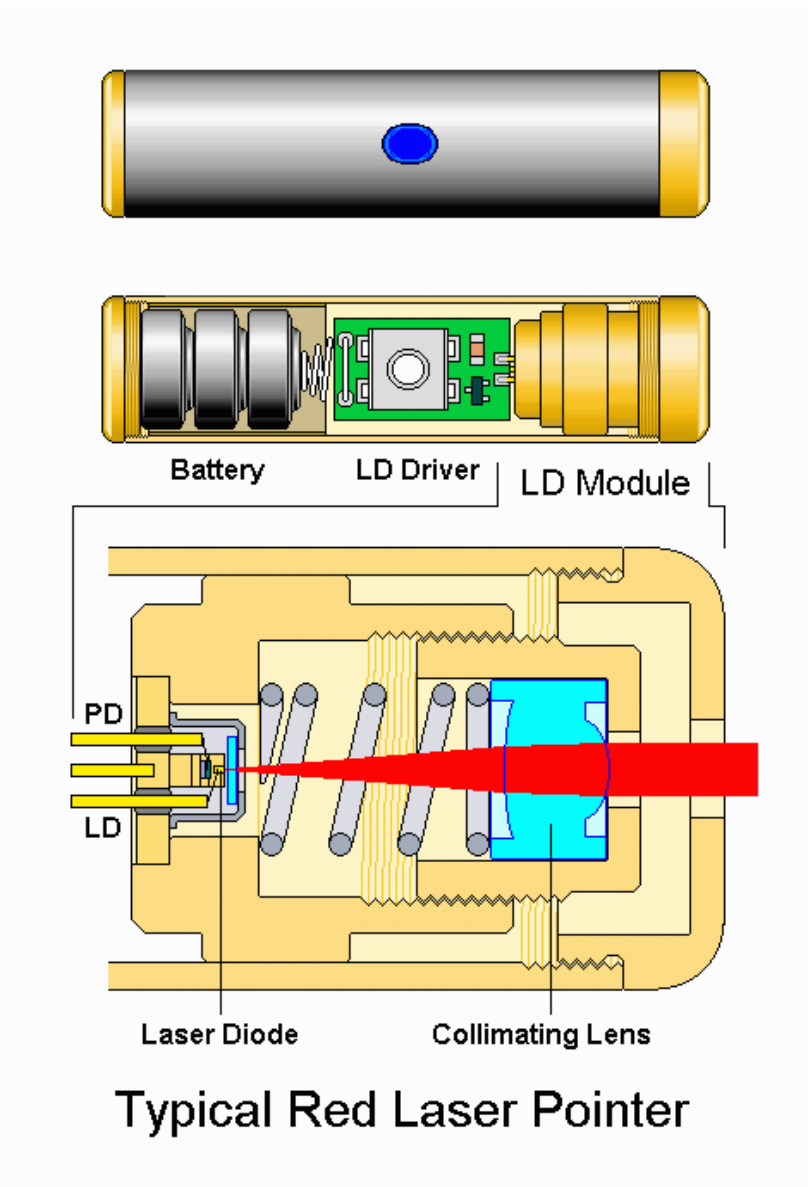
1. Gain medium (gas, crystal, semiconductor)
2. Pump source (electrical discharge, optical source)
3. Mirror 1: High reflector (R=1)
4. Mirror 2: Output coupler (R=0.9)


mirror
mirror with transparent center
laser material
pump off
pump
When laser is pumped, photons are spontaneously emitted as excited electrons return to lower energy levels.
pump on


Photons reflect off mirrors and start to stimulate other electrons to emit their photons.
pump on
pump on
A chain reaction of photons begins and the laser begins to "lase."
pump on

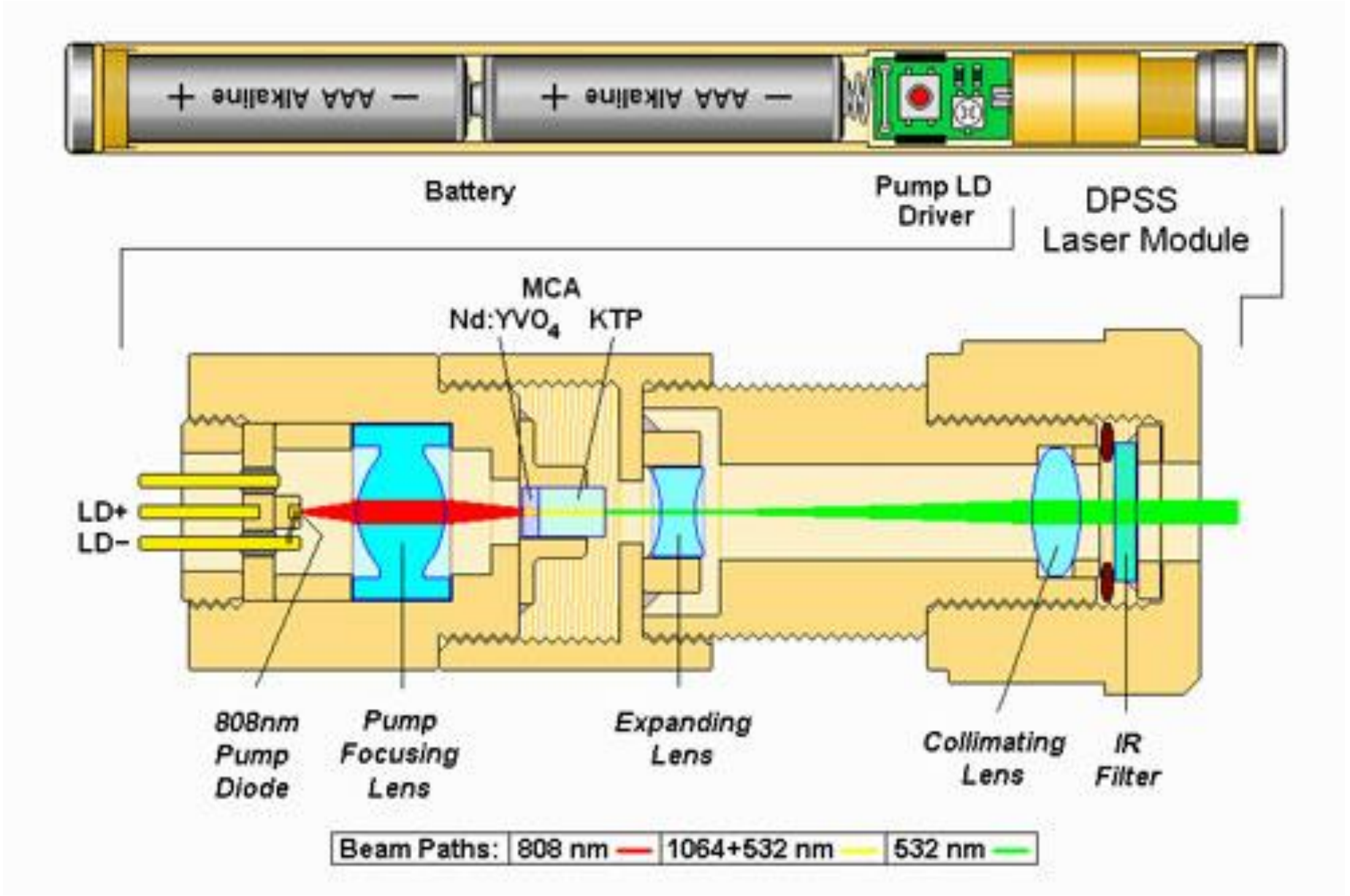

A chain reaction of photons begins and the laser begins to "lase."
pump on
Full operation.
pump on

Red Laser Pointer



Typical Red Laser Pointer

Green Laser Pointer



Quantum Picture of Light and Matter

Classical physics: particle or wave

Light → wave

matter → particle

<u>Principle of Complementarity</u>

Although the classical concepts of wave and particle are mutually exclusive concepts, compliments of each other, it is necessary to use both concepts together to understand the quantum nature of light and matter.

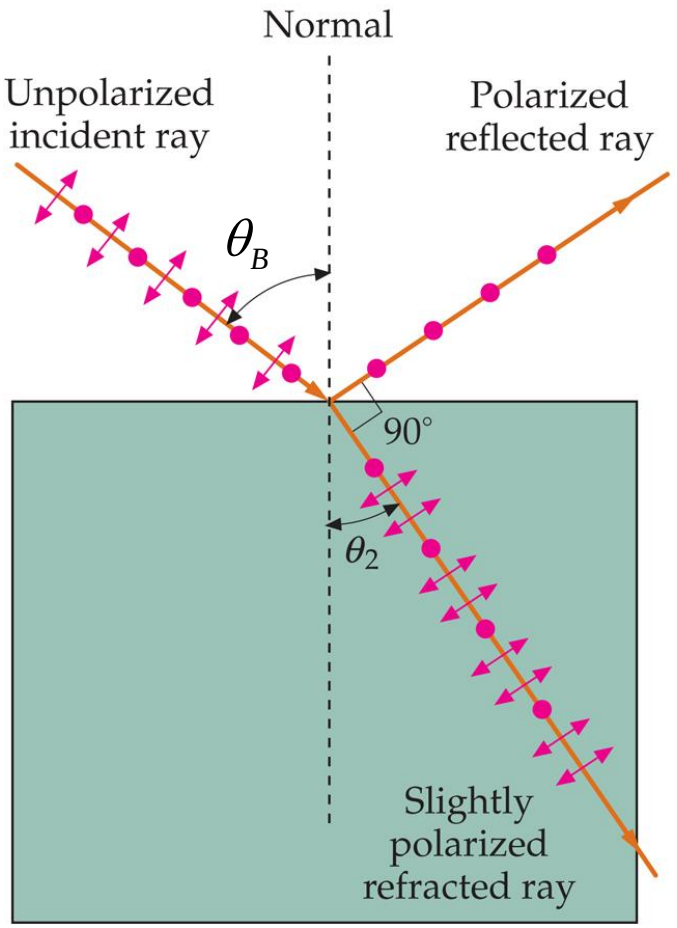
Brewster Angle

Unpolarized light becomes polarized upon reflection

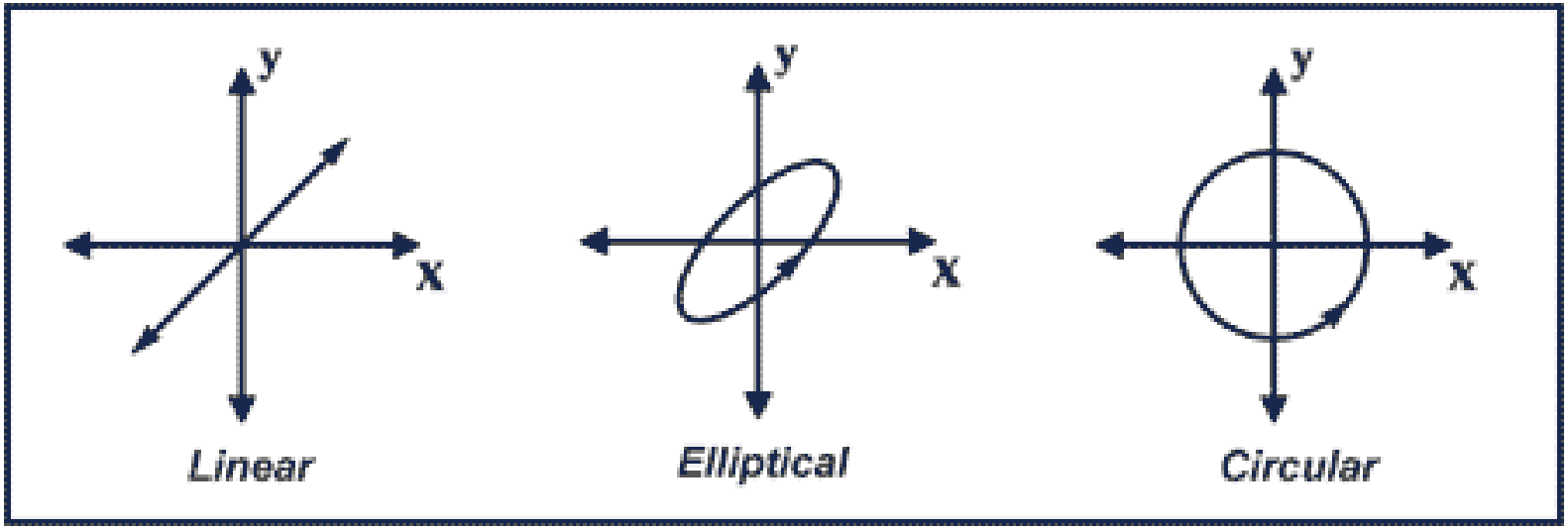
$$n_1 \sin\theta_B = n_2 \sin\theta_2$$

$$n_1 \sin\theta_B = n_2 \cos\theta_B$$

$$\tan\theta_B = {}^{n_2}\!/_{n_1}$$



Reflection of polarization parallel to surface (perpendicular to plane of incidence)


y
x
Linear
y
x
Elliptical
y
x
Circular