Experimental Demonstration of Optics Using Easily Obtainable and Low Cost materials

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Contents of presentation

I) One day workshop on optics for children
(held on July 25, in Fukui by our NPO)

II) Simple direct-vision spectroscope

III) Water lens microscope

If high school students have no experience seeing these kind of basic experiments, please show them. Physics should be learned through experiments, not through books!

My assertion

Chapter .1

One day workshop on optics for children

Workshop in old house(150y old)

Very **dark**

Wide wooden floor

Wide earthen floor

One Day Workshop for Children

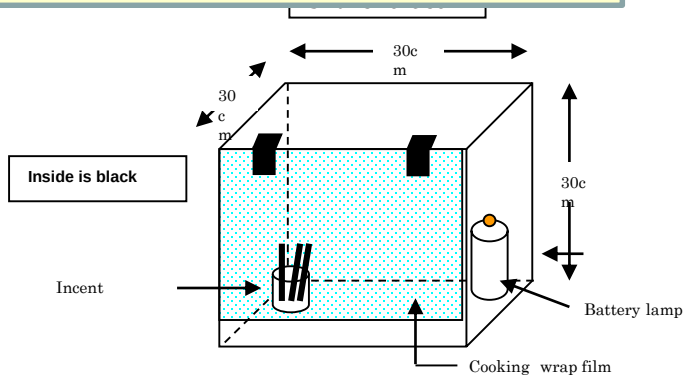
Old people help this workshop as volunteer

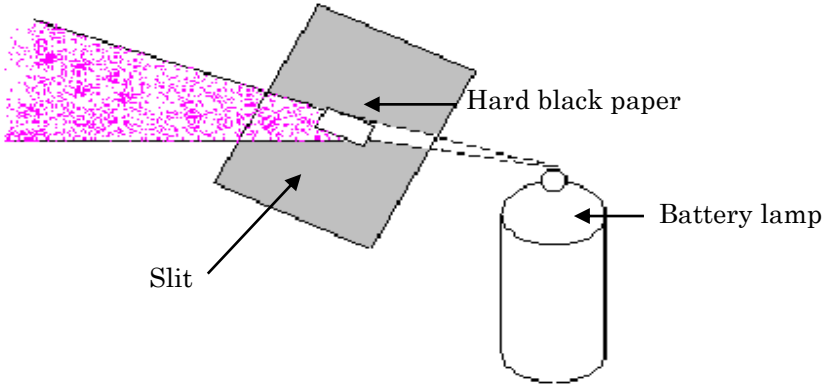
- Contents
- 1) Experiments using big smoke box
- 2) Experiments using laser light
- 3) Experiments using sun light (I)
- 4) Experiments of reflection and dispersion
- 5)Experiments using sun light (II)Spectrum
- 6) Experiments of big pin-hole camera
- 7) Construction of big pin-hole camera

Small smoke box

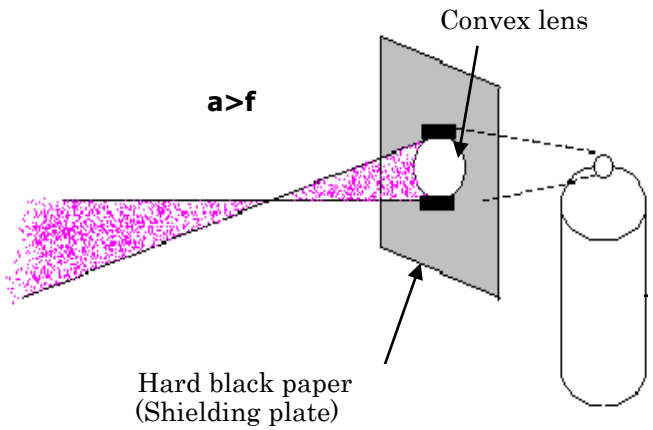
Very effective to learn optics.
Just see, then understand

In regular workshop, we use small smoke box and a battery lamp





In a small smokes box



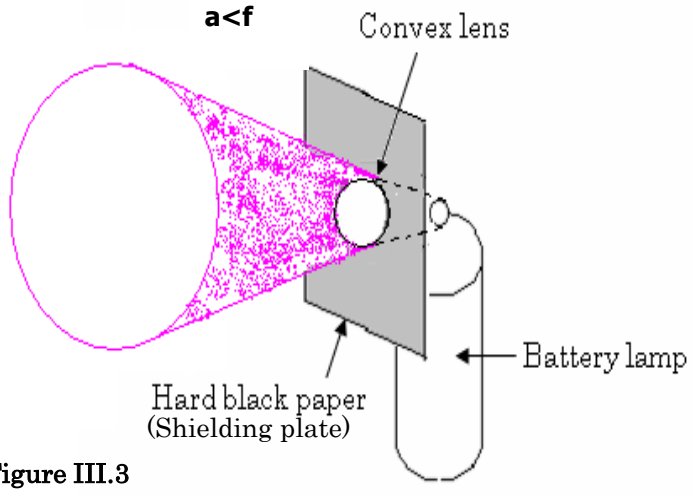
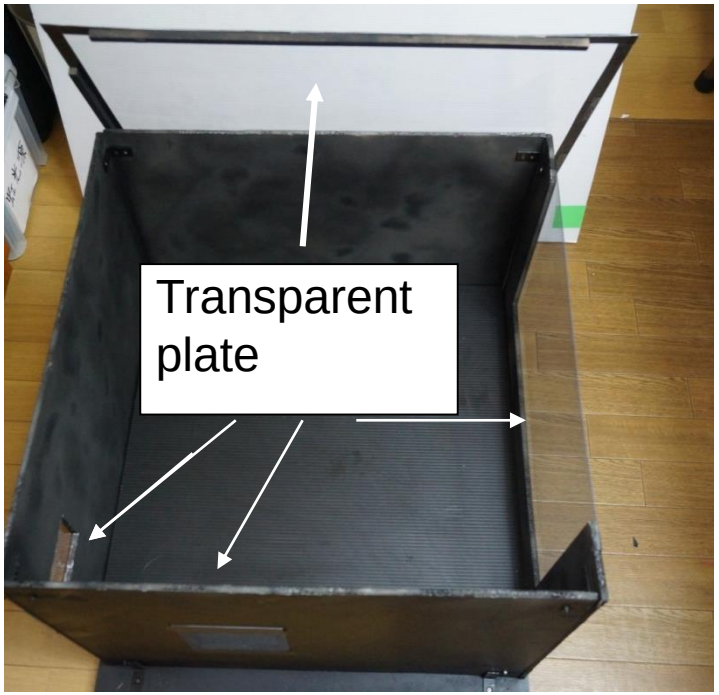


Figure III.3

Big smoke box



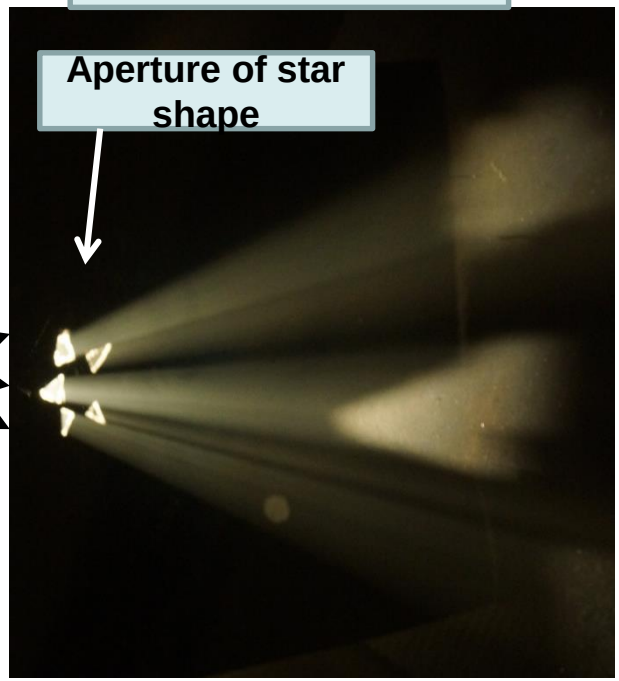
Size: 57 x 57 x 45 cm

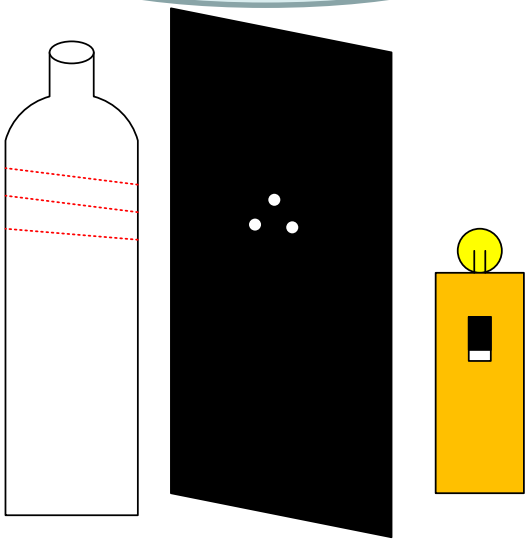
Fill smoke of stick incense to see the light ray.

Light directivity

Point light source:

Car's head light(12V, 55W)

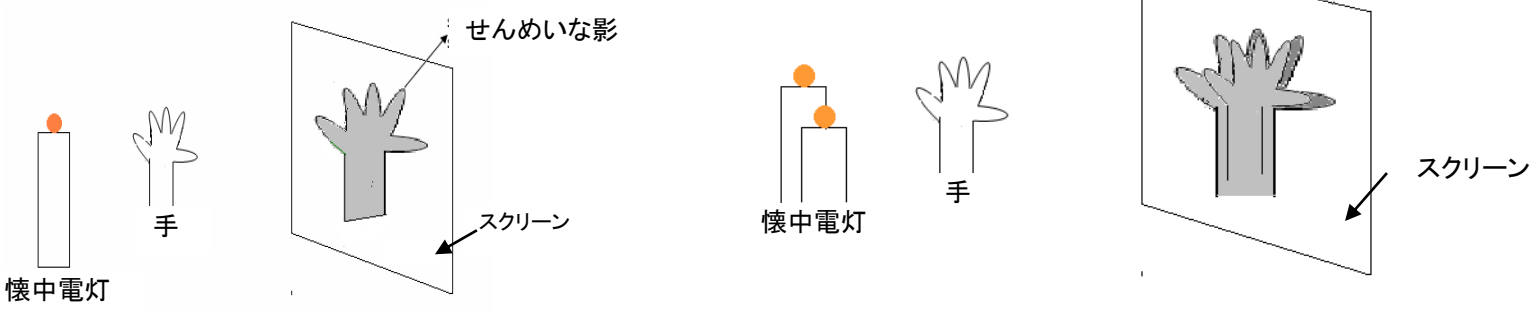




See the light scattering in the direction to which light propagates

Shadow

Shadow also shows the evidence of the light directivity



How change, when we use light source with wide area?

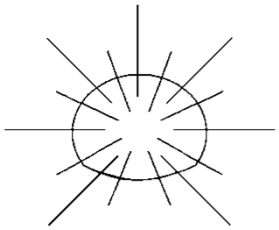


Image of light directivity

Carefully see the shadow, Where is light source?

Enlargement using light directivity

Question for high school students

What percentage of high school students can give right answer?

Pulse X ray

a

Near point source

Mesh

Battery lamp

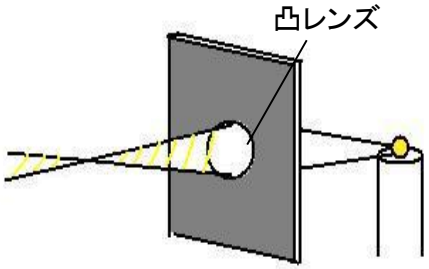
d

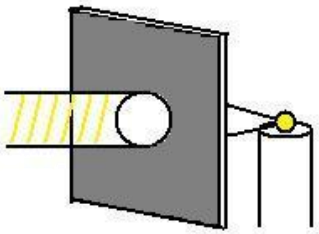
d'

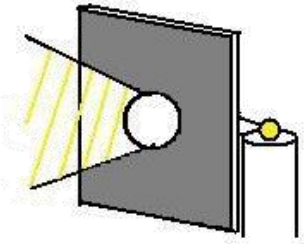
b

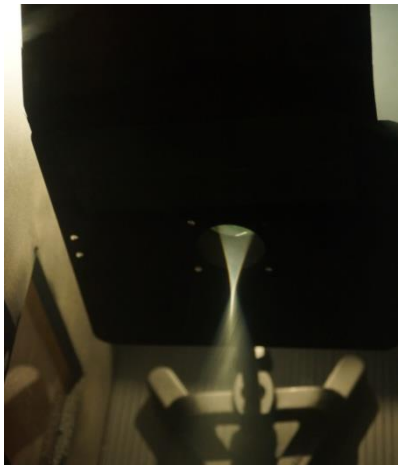
d' = (d x b)/ d (application of similarity)

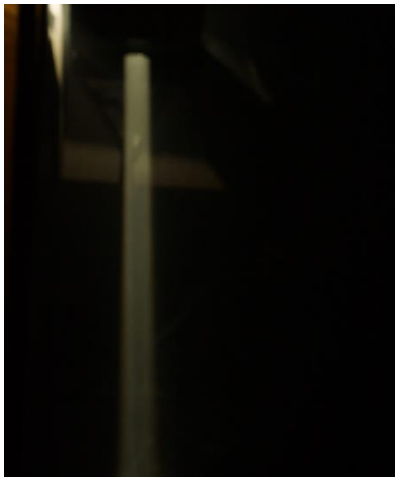
Convex lens





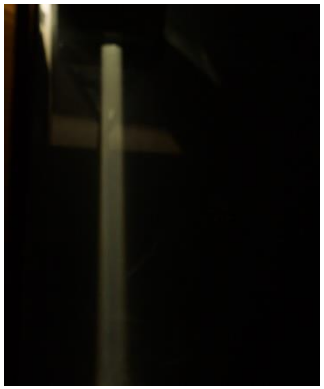






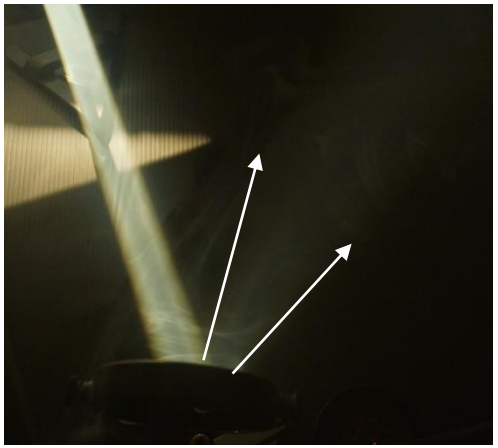
using Big smoke box

Convex and concave mirror



Parallel beam

for concave mirror

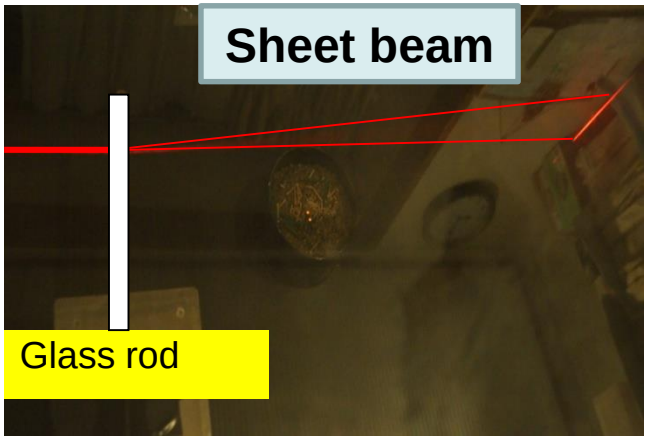


for convex mirror

using Big smoke box

Laser light

Directivity of laser light

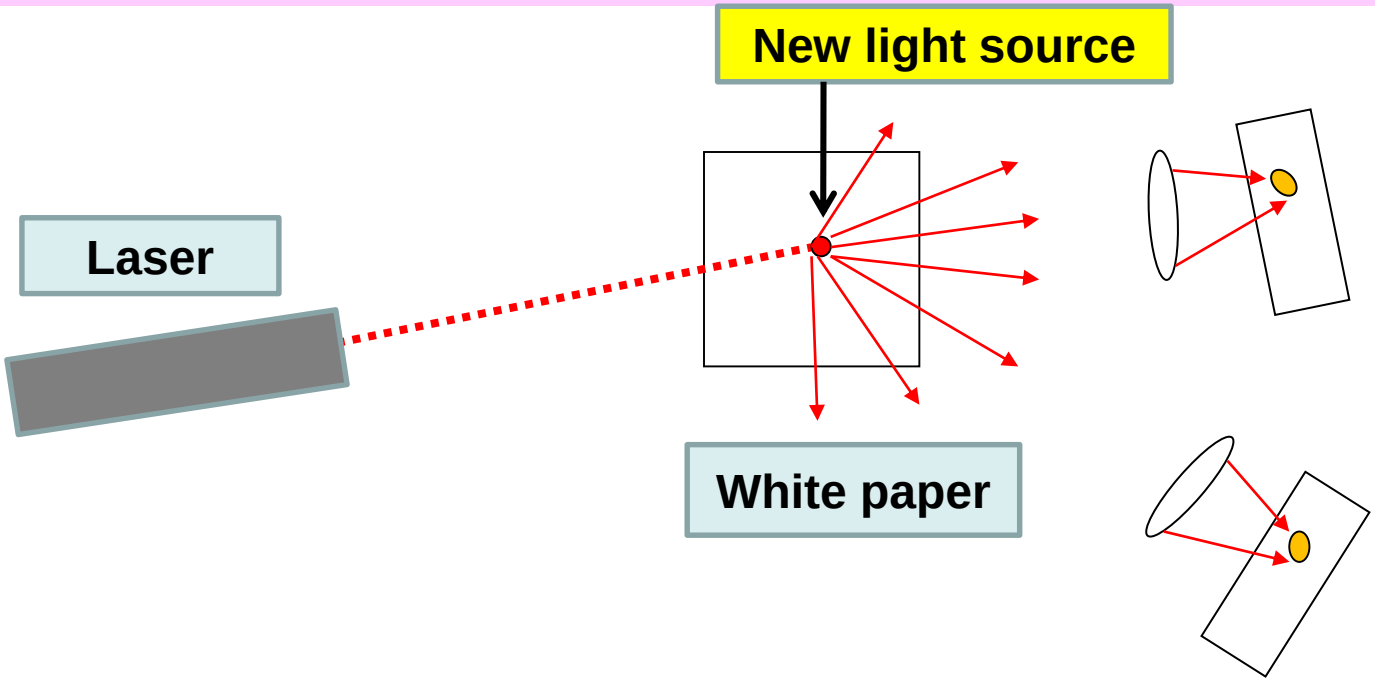


Application of sheet beam

- 1) Draw a slight line on irregular surface
- 2) Cross sectional observation of eddy

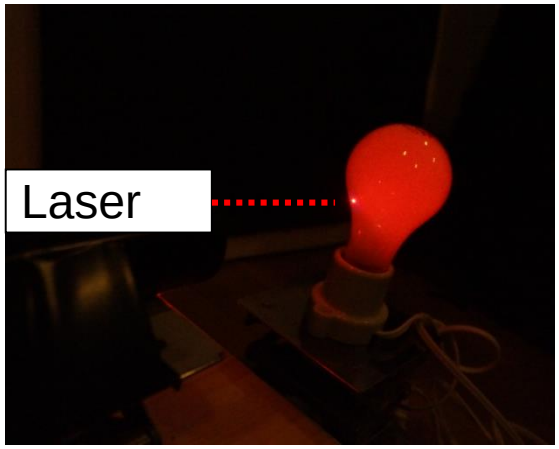
In big smoke box

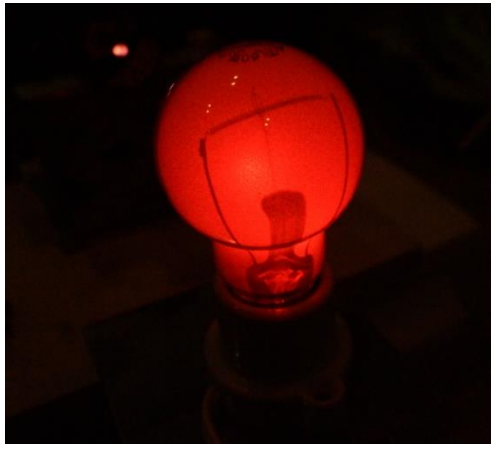
Point light source made by laser light



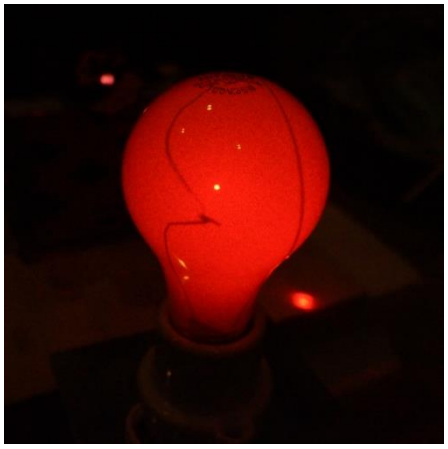
Very simple, but important to get the concept of laser light and ordinary light

Can see inside of bulb?





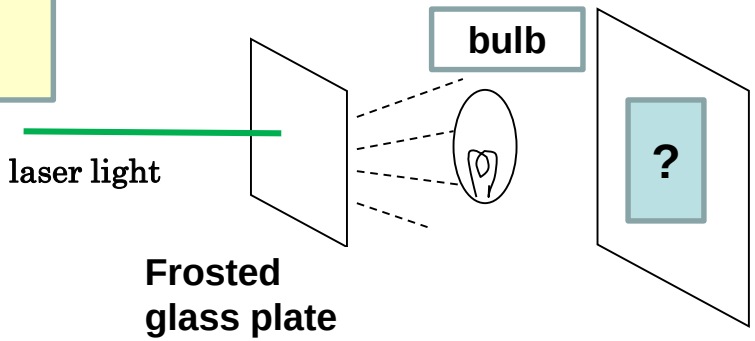
Panasonic



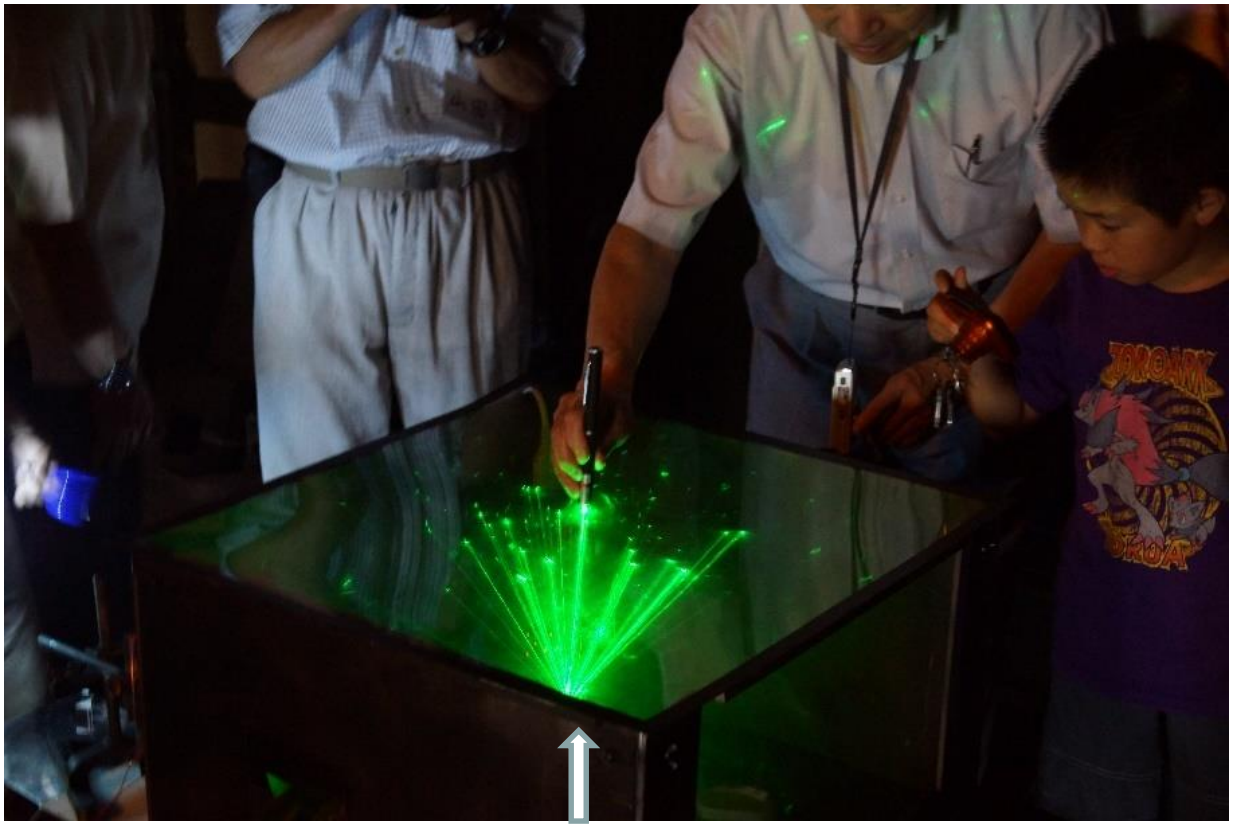
Hitachi

What percentage of high school students can give right answer?

This Phe. relates to Coherence of laser light?



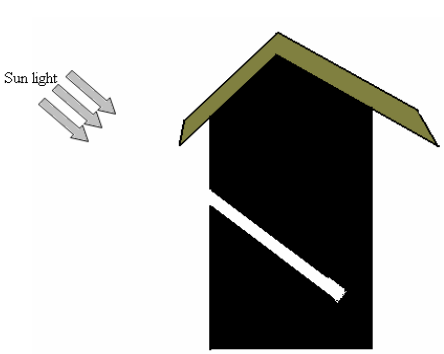
Attraction for children!

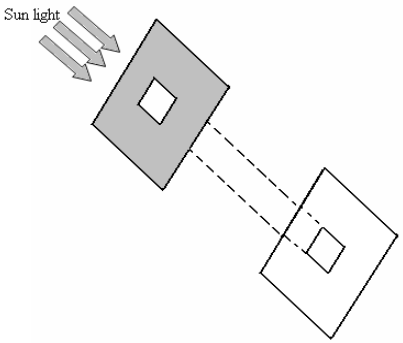


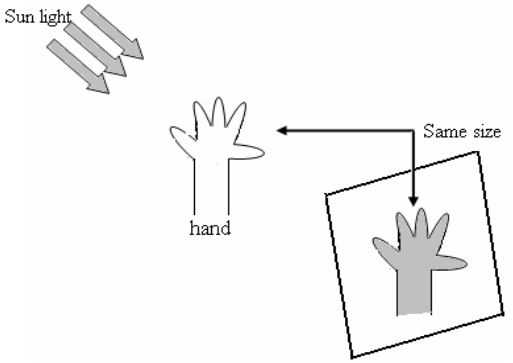
Jewel of diamond

Experiments using sun light (I)

Ask children how to know sun light is parallel beam?

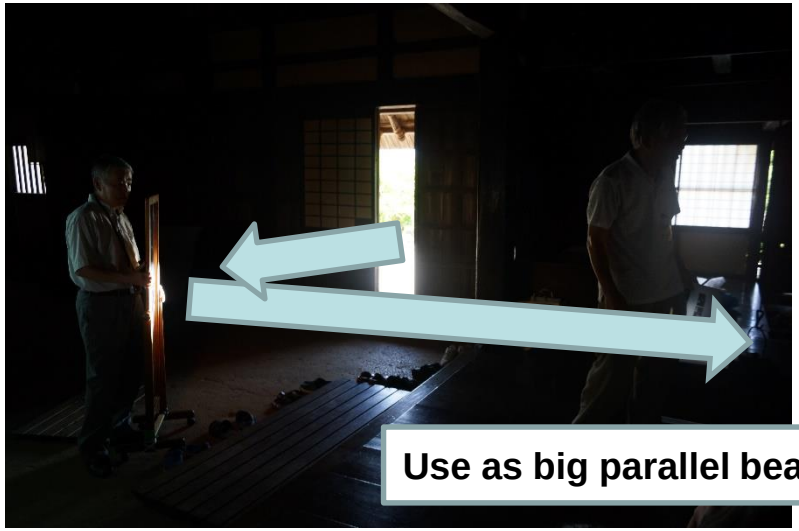






Big parallel beam for optics

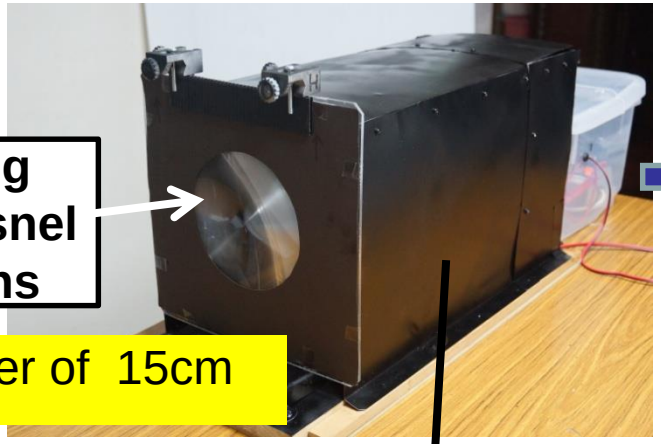
Drive sun light Using big mirrors



Use as big parallel beam

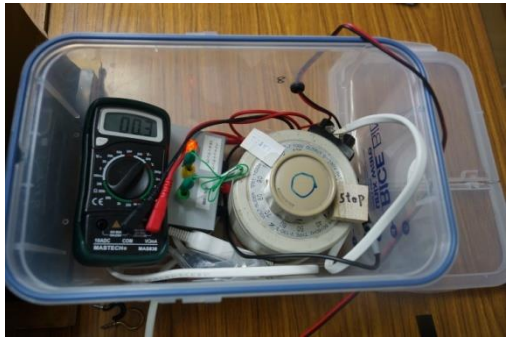
Tropical countries have much advantages to use sun light; There is sun light almost every day . (free charge)

Home made big parallel beam

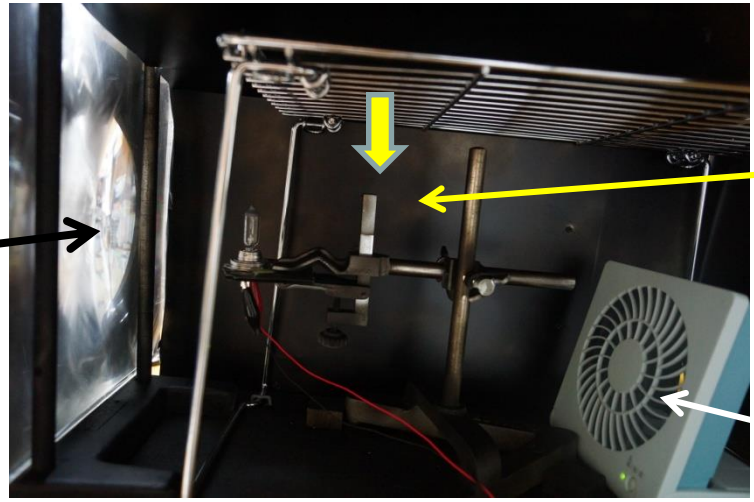


Big Fresnel lens

Diameter of 15cm



Power transformer



Big Fresnel lens

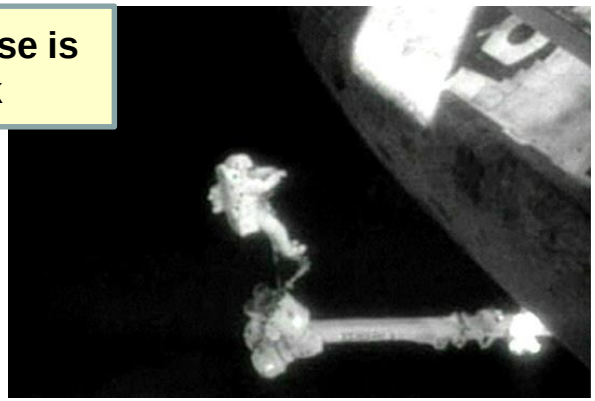
Head light for car: 12V, 55W (20US&)

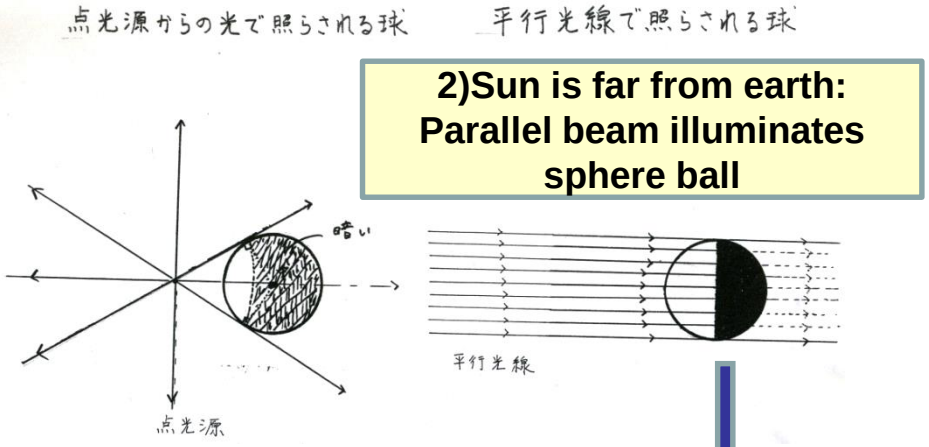
Fan

Wax and wane of moon

Earth science → **Optics problem**

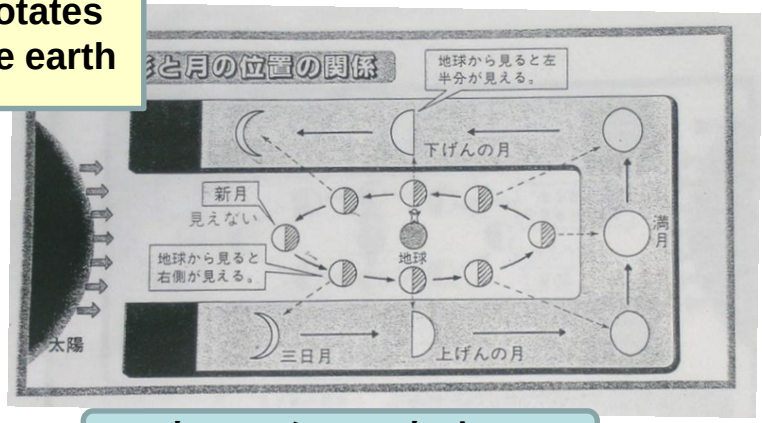
1)Universe is dark





2)Sun is far from earth: Parallel beam illuminates sphere ball

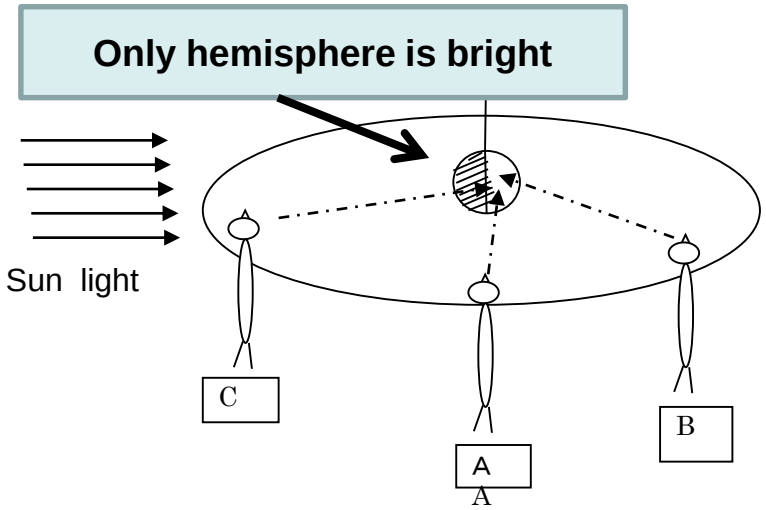
3)Moon rotates around the earth



ウエックス、ウオン

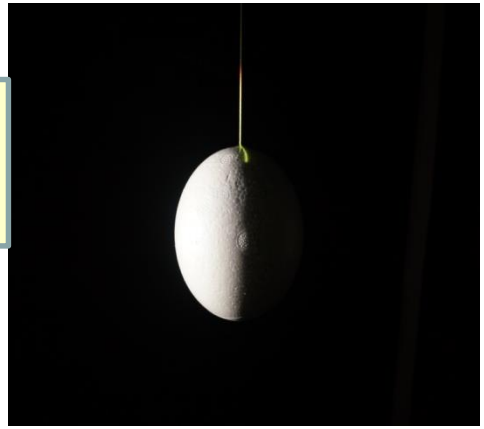
Hemi-sphere ball

Direct demonstration to explain wax and wane of moon



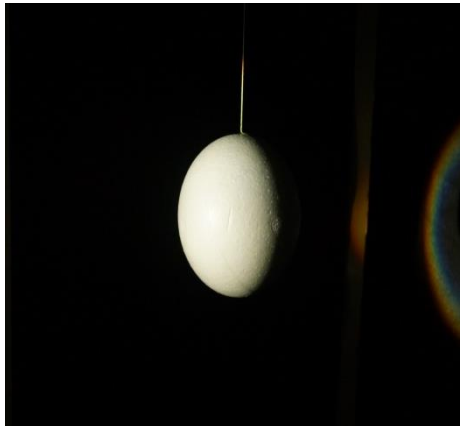
Children turn around

Suspended ball



from A

from B

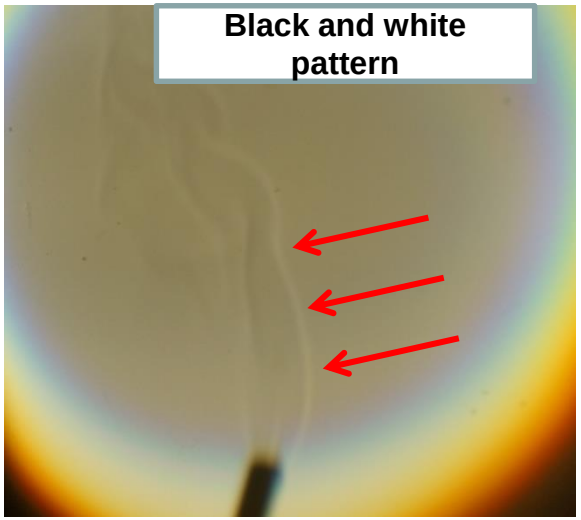


from C

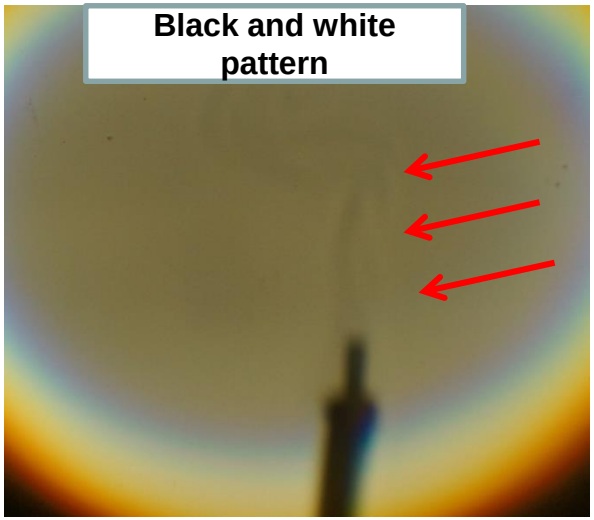
half moon

crescent moon

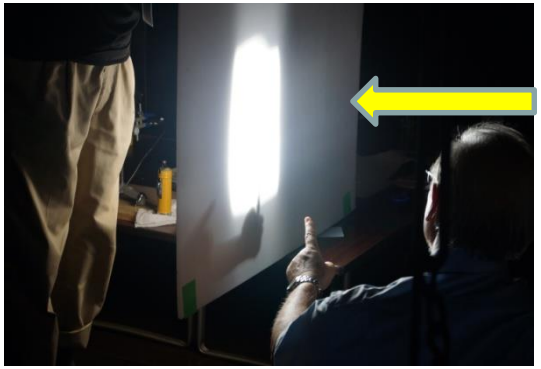
Demonstration of shimmer of hot air

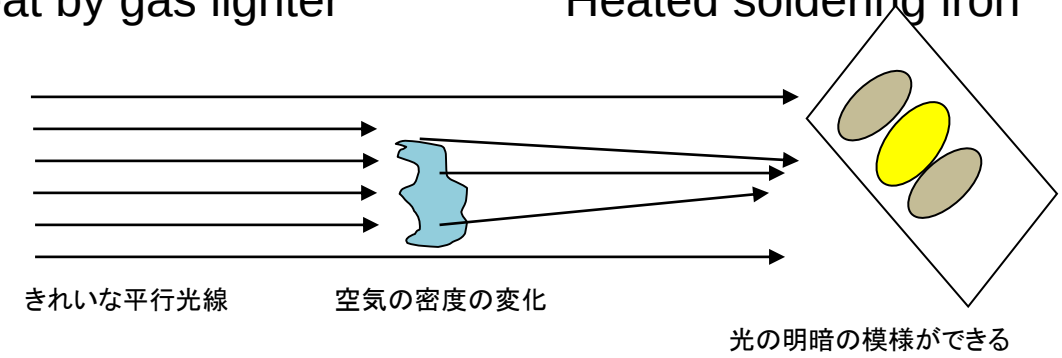


Heat by gas lighter



Heated soldering iron



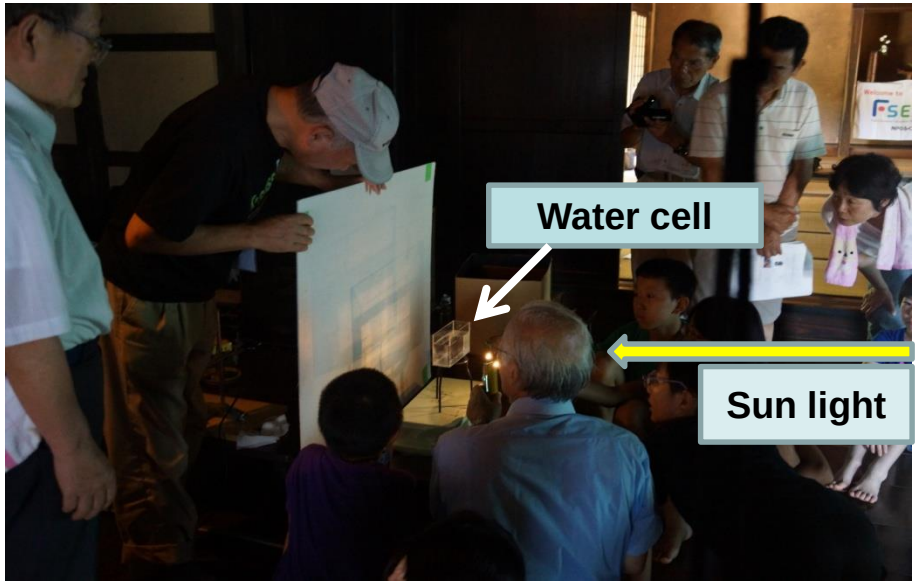


We can see this only for parallel beam and light ray from a point source

Mixing process of water and alcohol

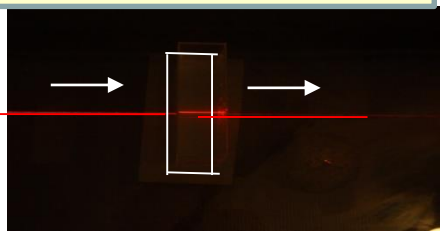
Alcohol is poured into water

Irregular pattern



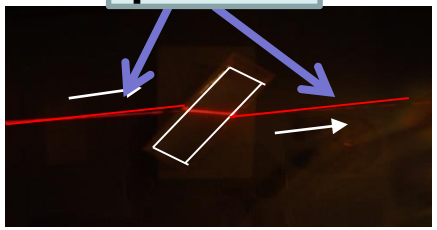
Refraction and dispersion of light in the smoke box

A little milk is added

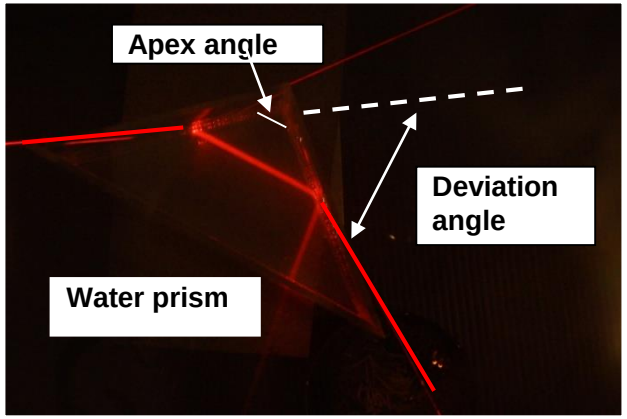


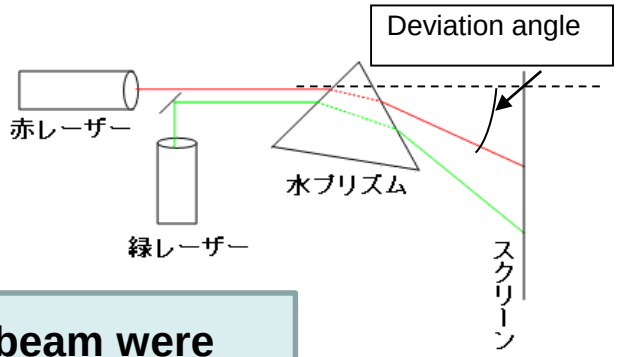
vertical

paralell

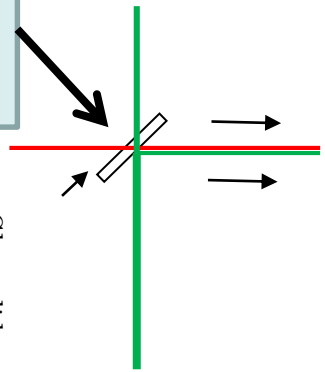


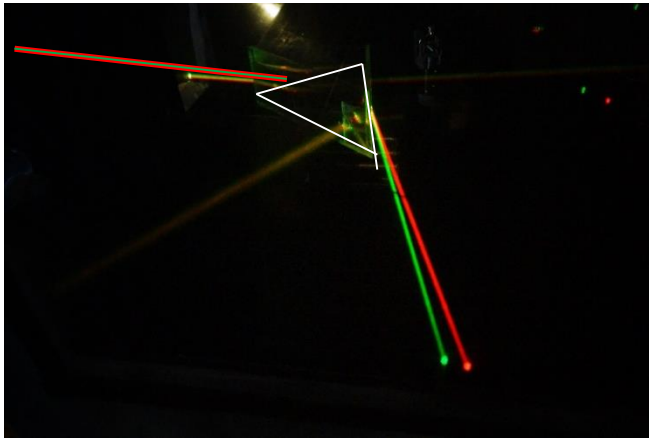
inclining





Two laser beam were coincided to be one beam using a slide glass

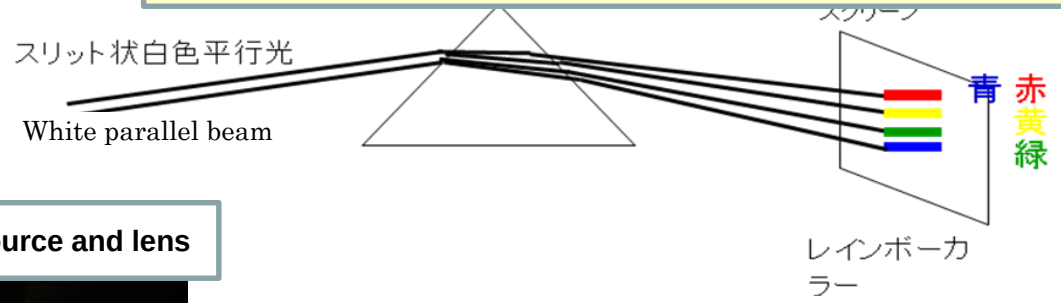




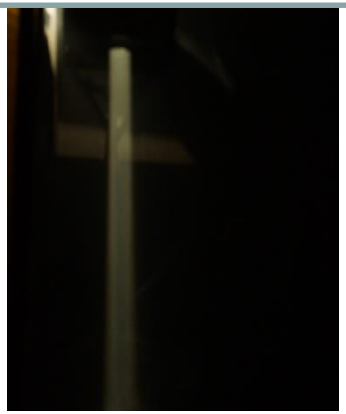
Demonstration in the big smoke box

Color dispersion in the smoke box

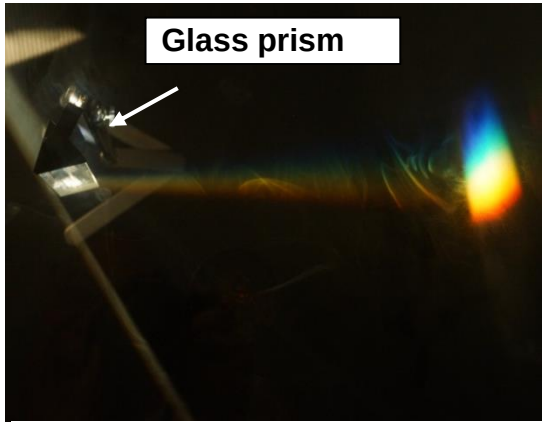
In the text book, but actually ,little students see!



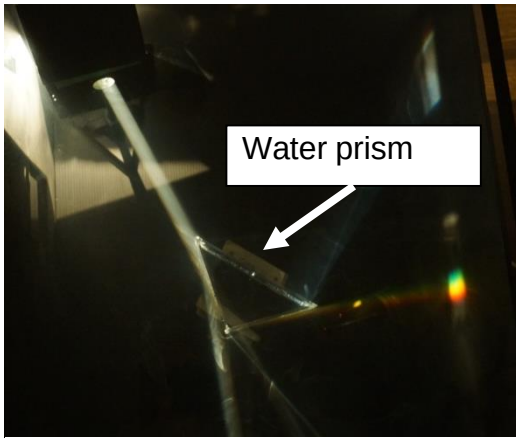
Bright point source and lens



White parallel beam



for glass prism

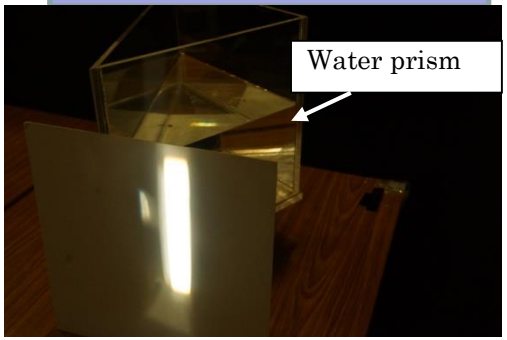


for water prism

Basic exp. can be done in the big smoke box

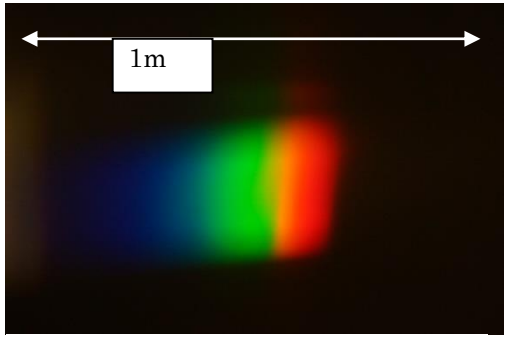
Color dispersion using sun light

Big water prism



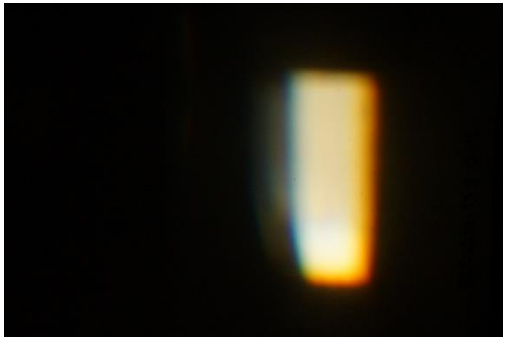
One side: 30cm
height: 25cm

Aquarium ok!



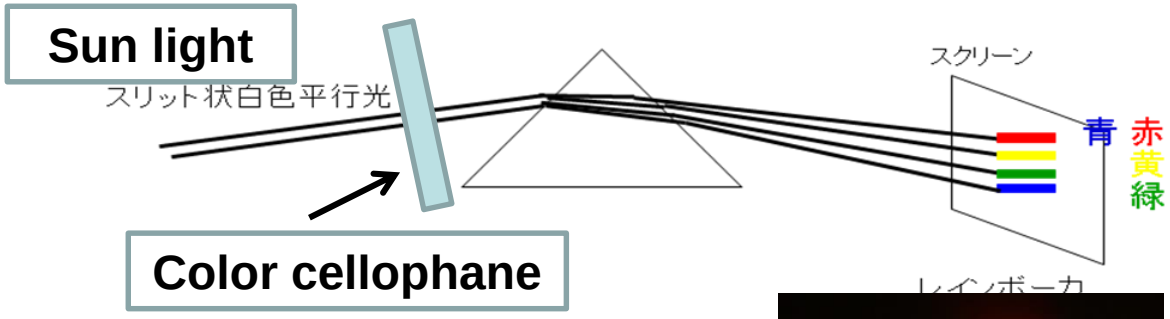
Spectrum of sunlight

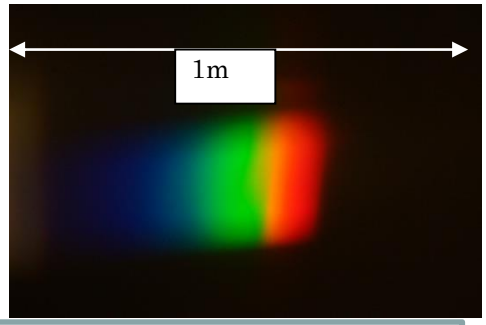
For 90 degree



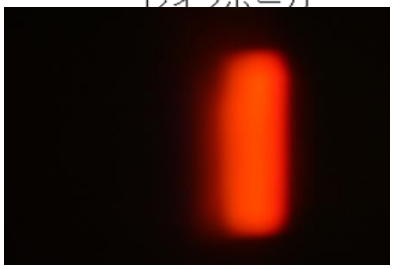
For 60 degree

Color and Absorption

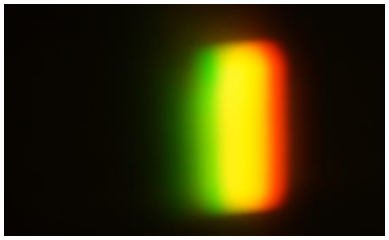




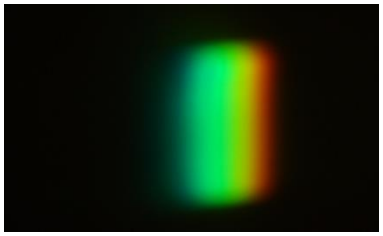
without cellophane



red cellophane

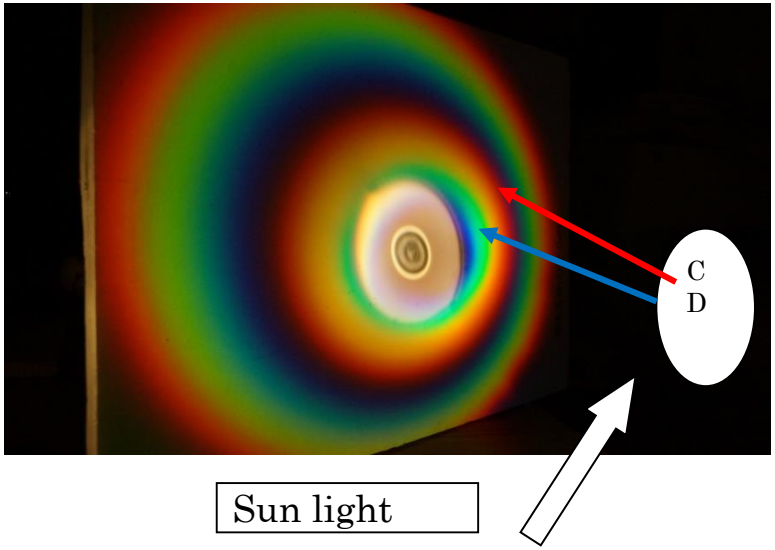


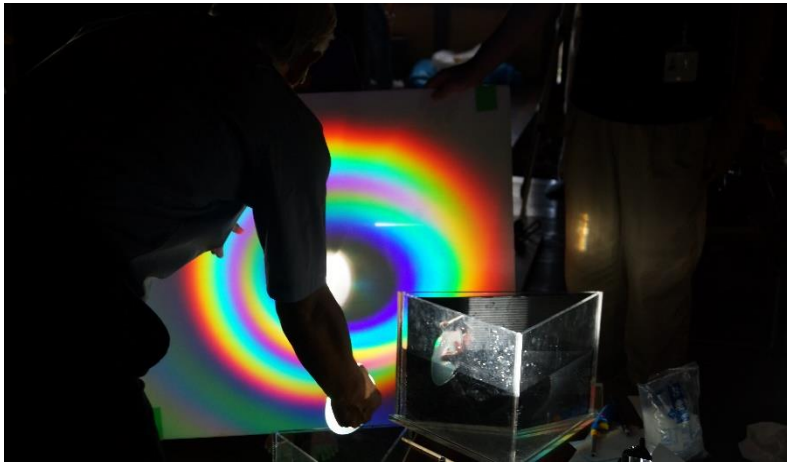
yelow cellophane



green cellophane

Rainbow color due to CD grating





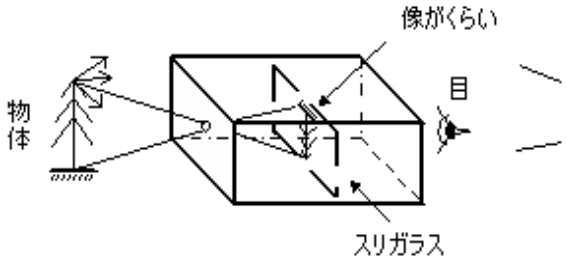
In a dark room, impressive demonstration can be made using sun light

Rainbow experiments?

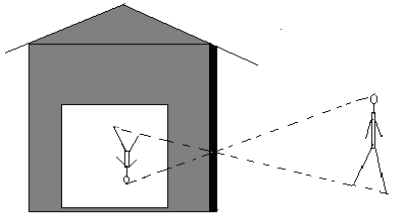
Very interesting topics , but eliminated because of lack of time

Big pin-hole camera

Application of light directivity



Usually in a small box



As dark box

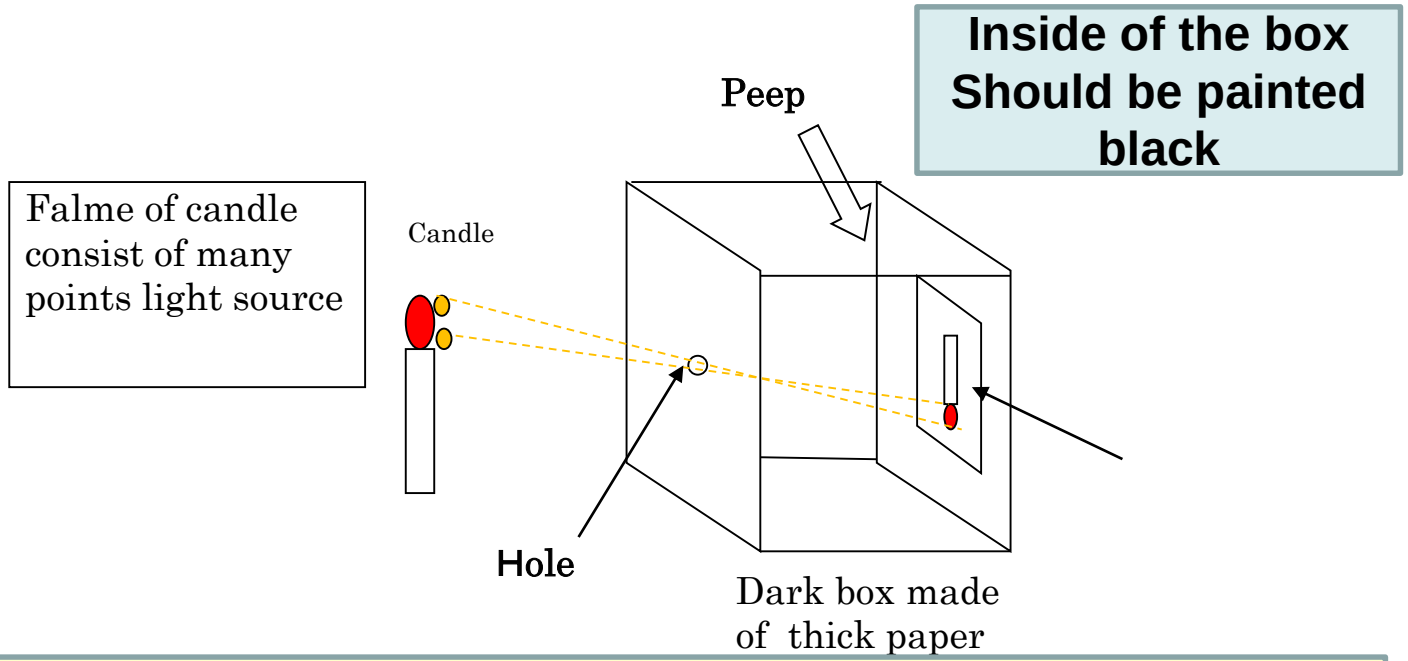
Door of old house

Outside of house

Moving car is much better

On a screen

Home work for children

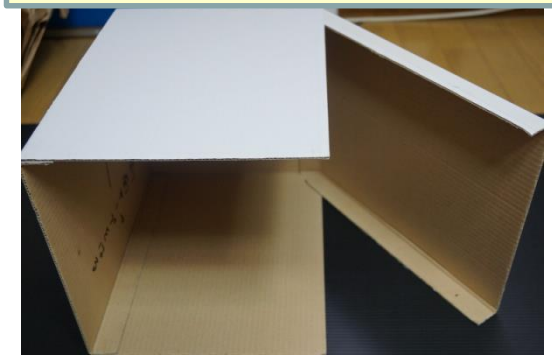


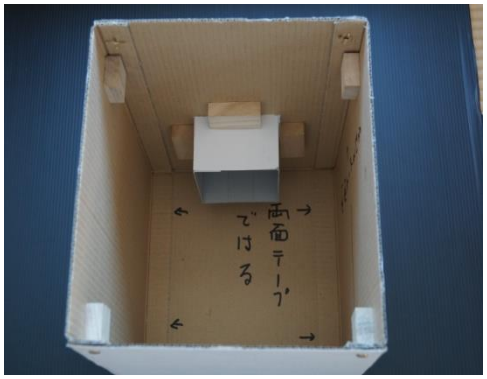
In order to improve the ability of logical thinking, try to do these basic experiments .

Changeable conditions: hole size, number of candle, height of candle, distance between candle and hole, distance between hole and white paper, number of hole, shape of the hole

Construction of big pin-hole camera

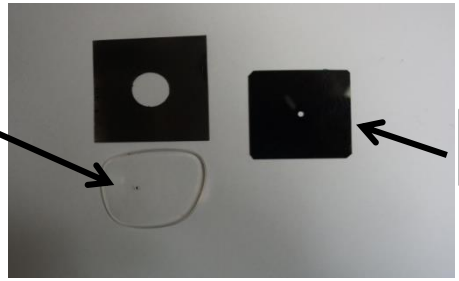
One children made one, and bring back





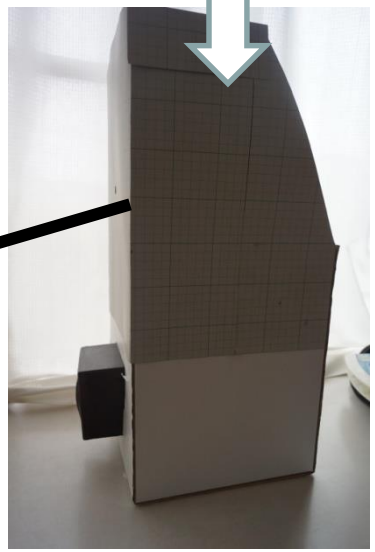
Paint black

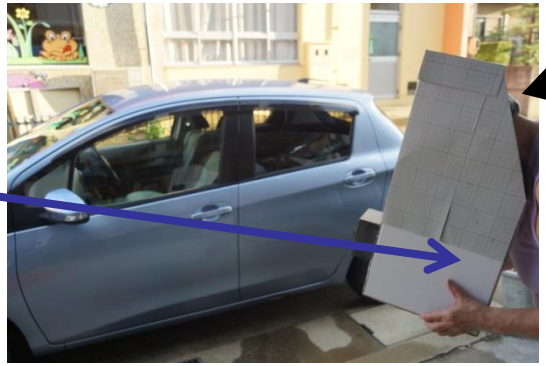
Old man's lens
(+ 3.0)

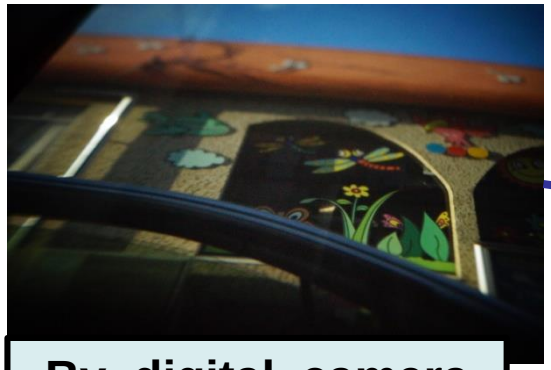


2mm φ pin-hole

Peep



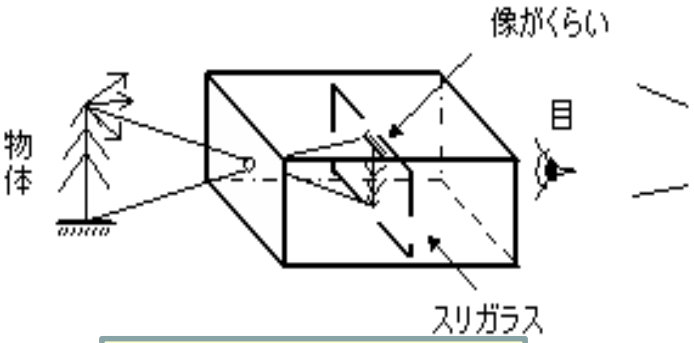




By digital camera

Comparison of camera

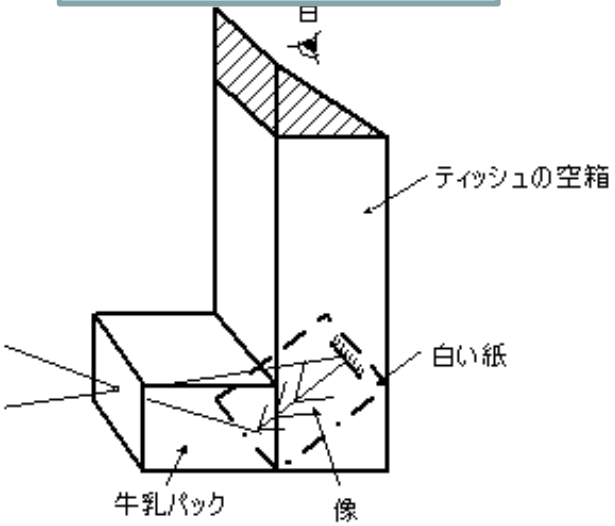
Commercial type



Weak points

- We are forced to see the lens- hole
- image is dark.

Our type



Good point

Clear and bright image

Chapter .2

Simple direct-vision spectroscope

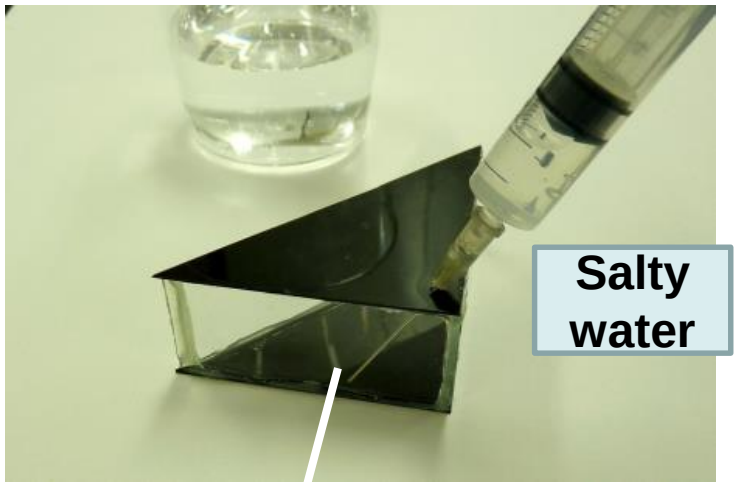
Various types of direct-vision spectroscope

Commercial direct – vision spectroscope
~ 300 US$

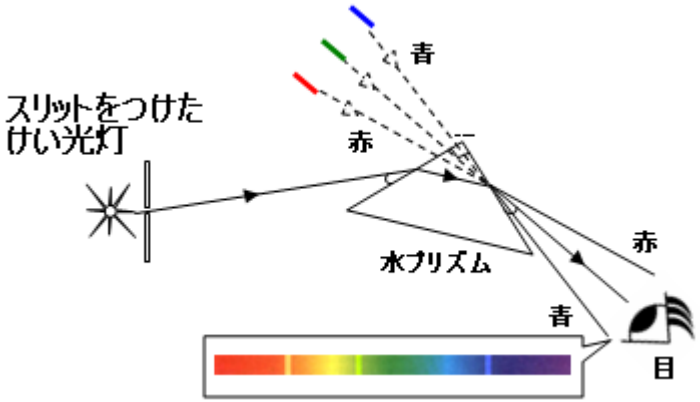
Simple direct-vision spectroscope

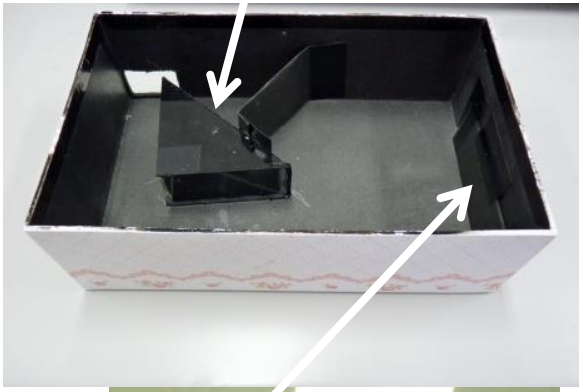
three types
1) water prism ----insufficient resolution -→ 95 degree prism type
2) using film grating ----→ a little dark
3) using CD grating ---- good but one problem→ improved type

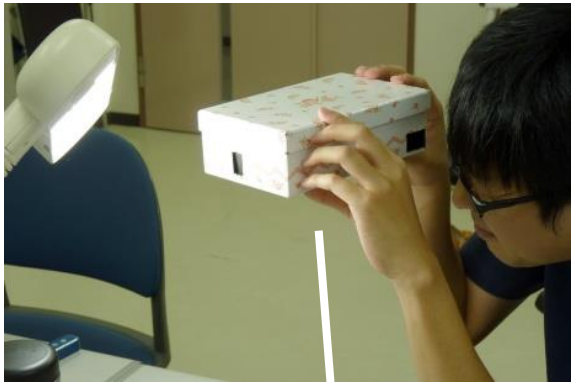
Water prism

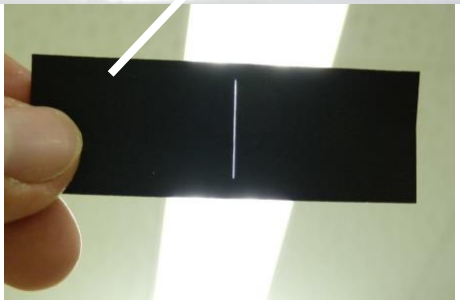


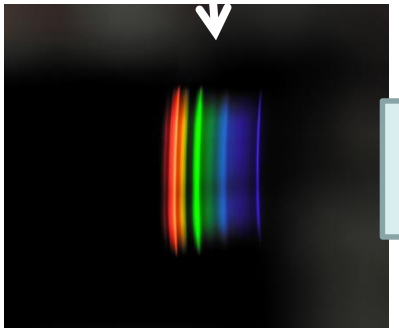
Salty water







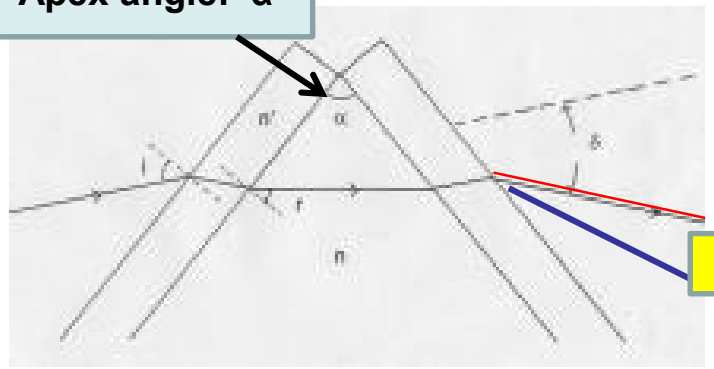




Less resolution

Improved water prism

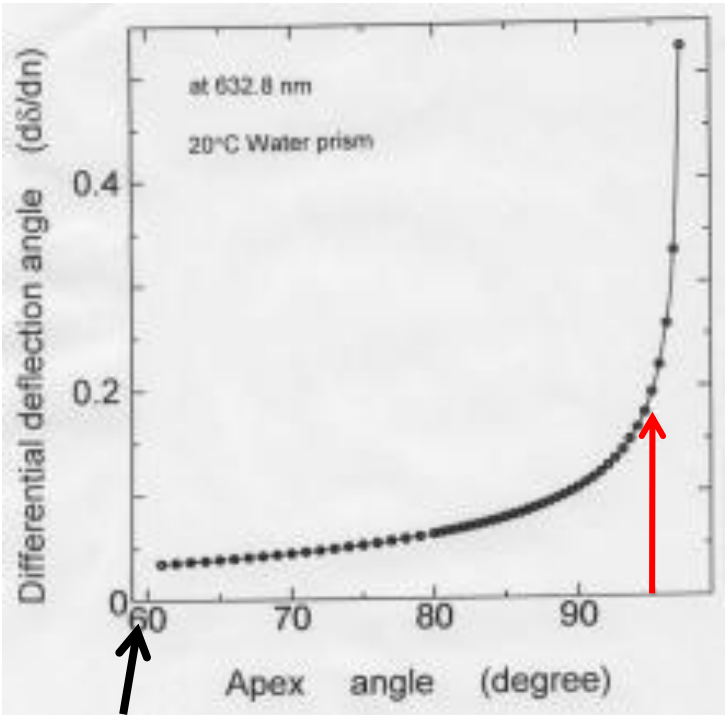
Apex angle: α



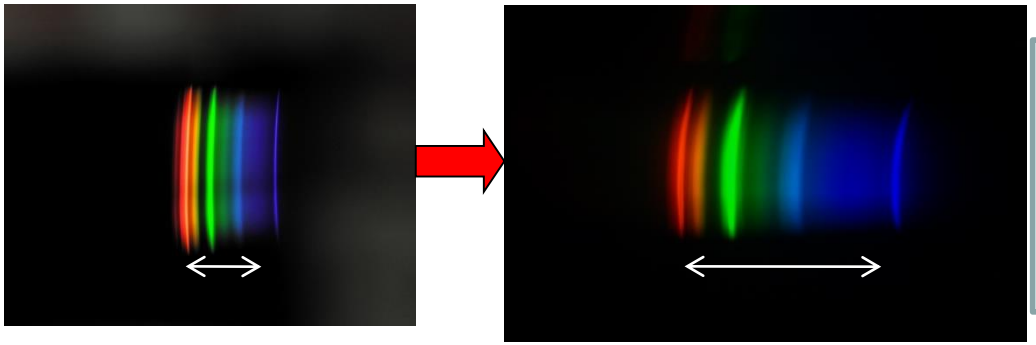
dδ

$$\frac{d\delta}{dn} = \frac{2\sin(\alpha/2)}{(n')^2\cos\left[\frac{1}{2}(\alpha+\delta)\right]}$$

We published in Journal of Indonesia Physical Society in 2003



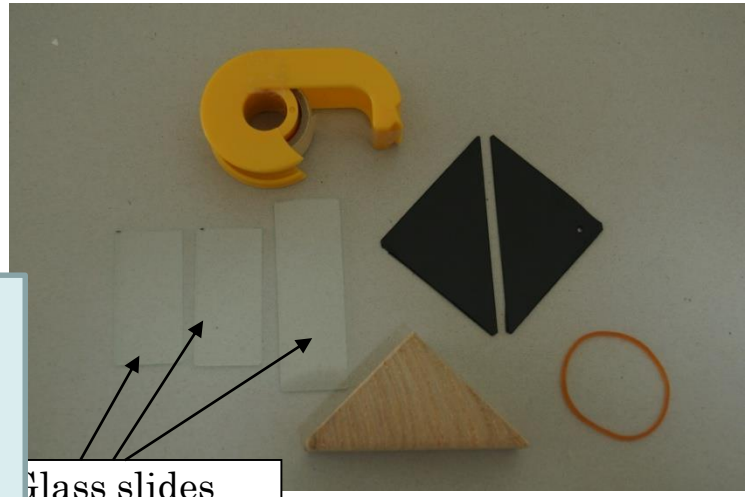
dn is the refractive index difference between red light and blue light

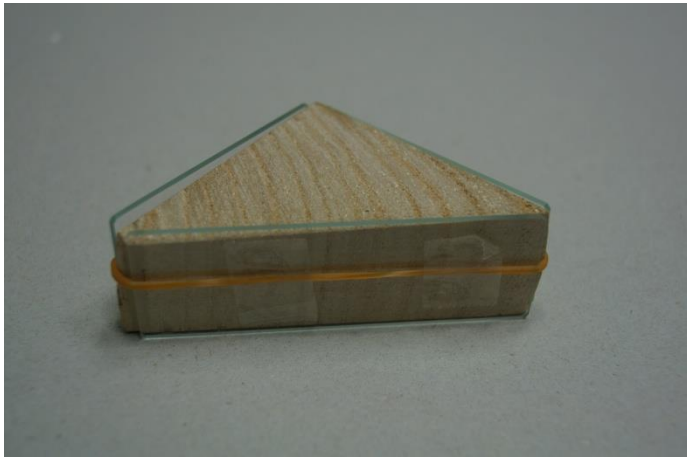


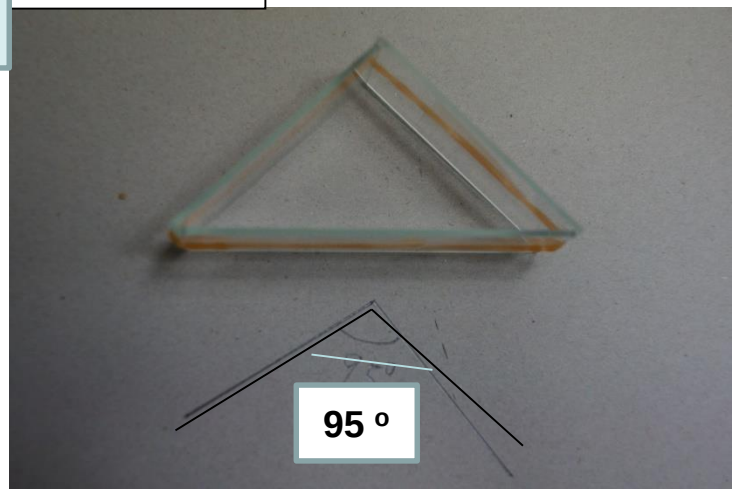
Attention:
Total reflection
→Control by salt concentration

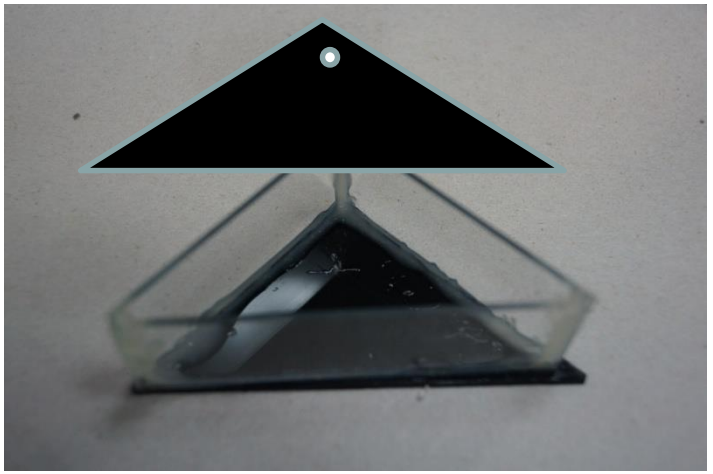
How to construct 95 degree water prism

Length of 75, 53, 51 mm



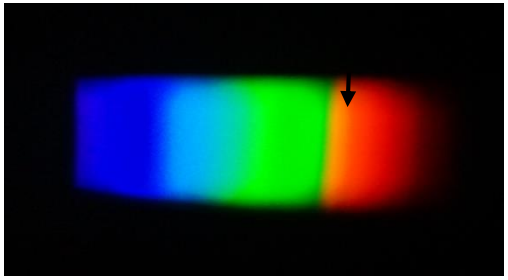




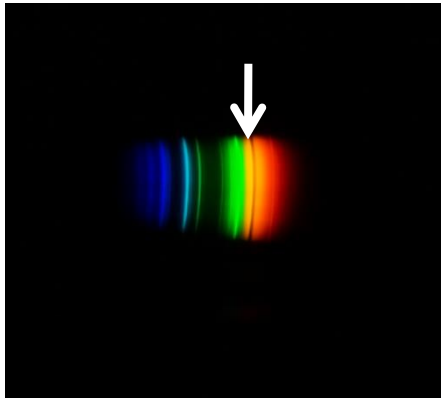


Student's activity using the CD spectroscope

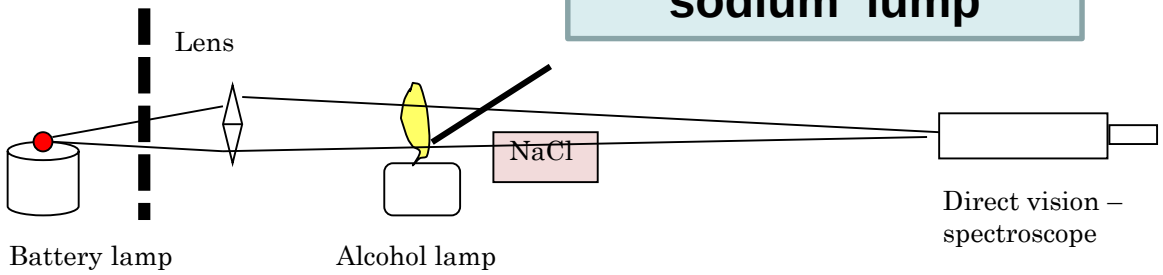
Every high school students should construct by themselves

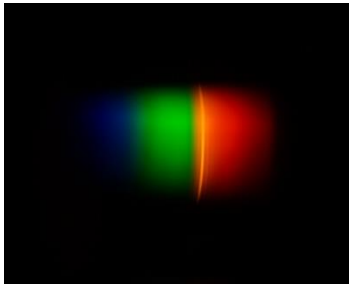


Sun light spectrum: Fraunhofer's line



High pressure sodium lump



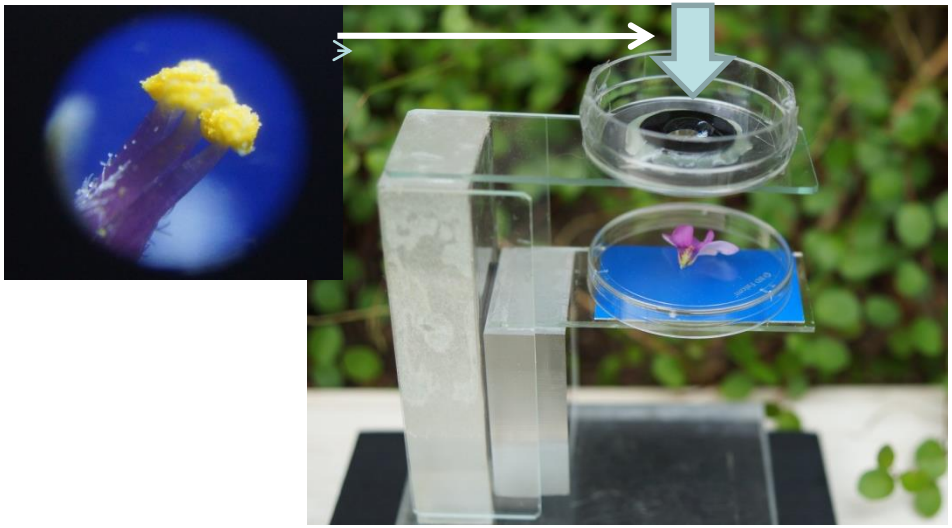


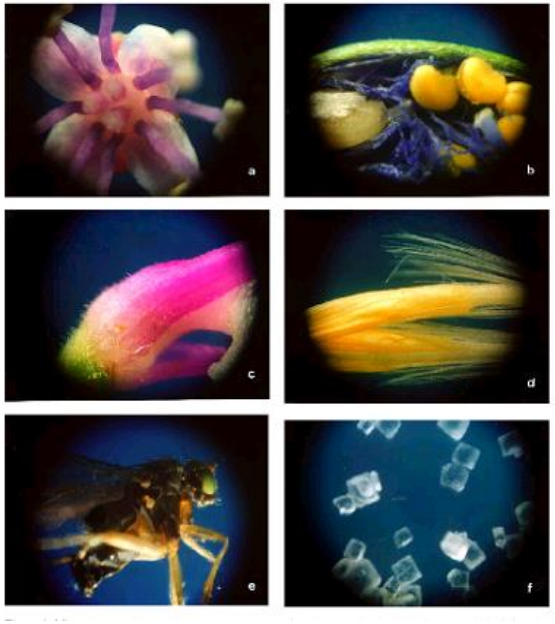
Simple exp. for Atomic Absorption Spectroscopy

Chapter .3

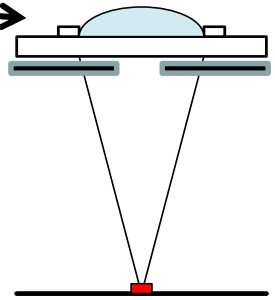
Water lens microscope

Water lens microscope

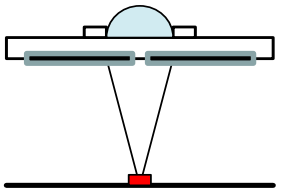




Screw ring



Low magnification



High magnification

Front cover

of Physics Education, 2001

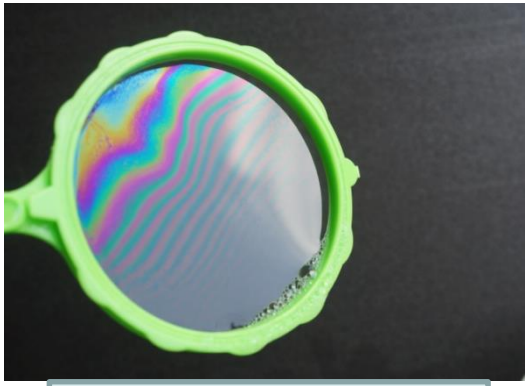
Magnification ~10 to 40

Children should repeat exp. for more than five hours, if cannot, no hope

End

Color of soap bubble

No fringe, no color



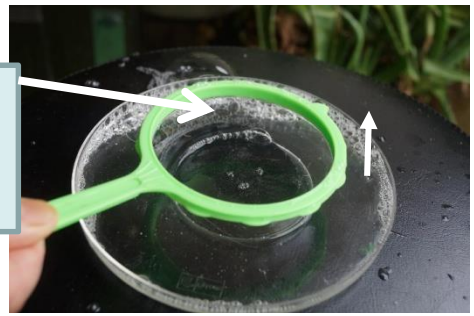
Fringe appear

Upper, no color

Lay a glass slide on another, due to the sandwiched air space

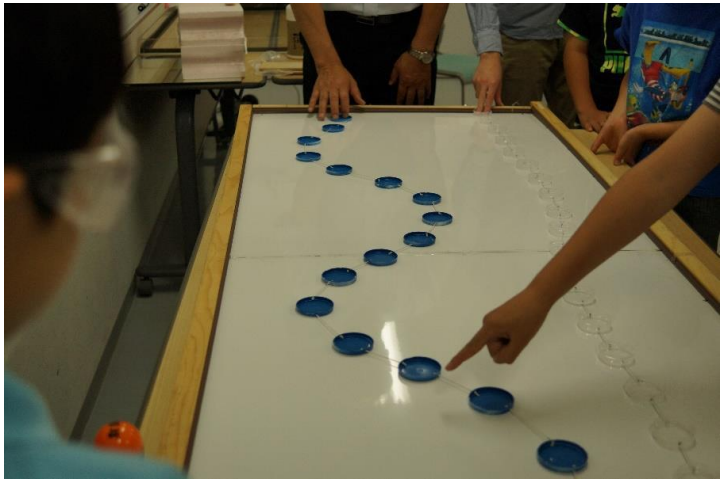
Very big soap babble

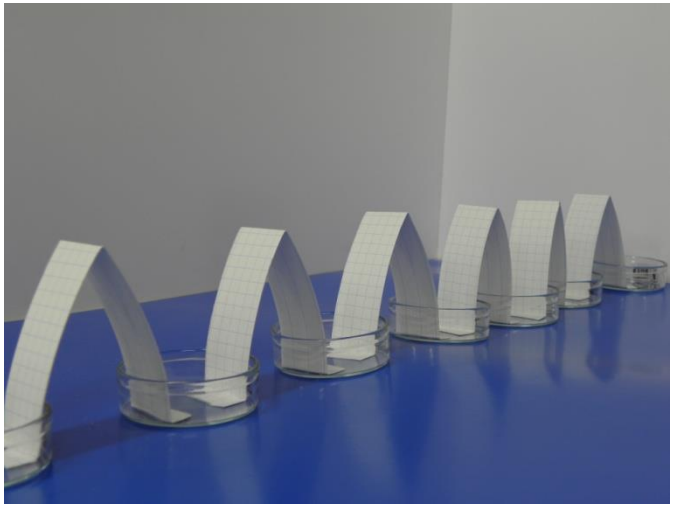
Cylindrical membrane



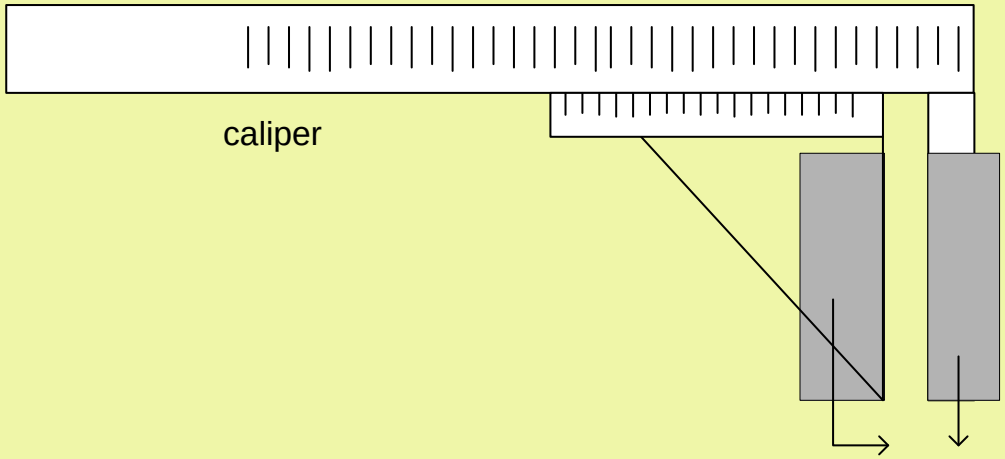
表面張力が働き、底の方が縮み、つい

Wave demonstration





Diffraction Pattern Using a Caliper (Jangka Sorong)

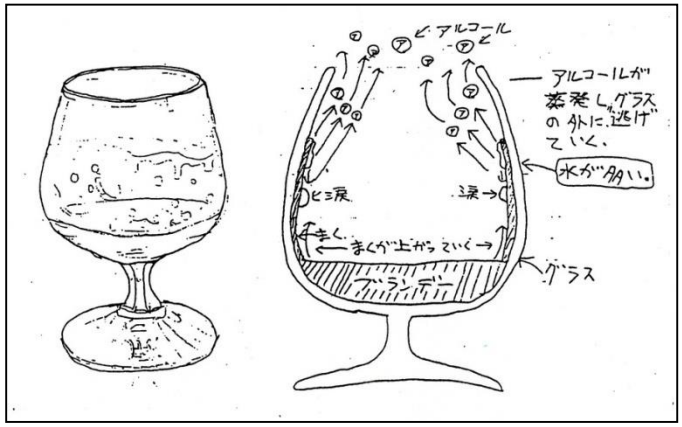


Variable Single Slit is very expensive

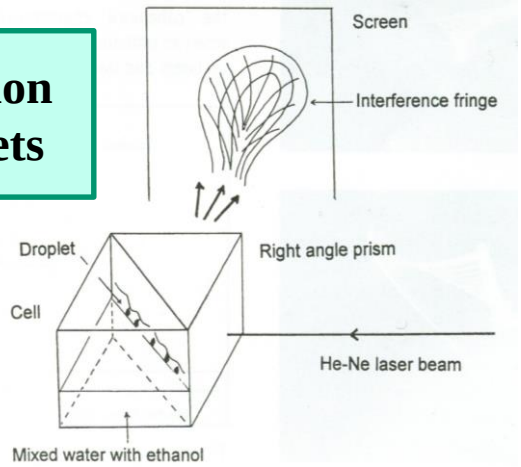
wide single slit

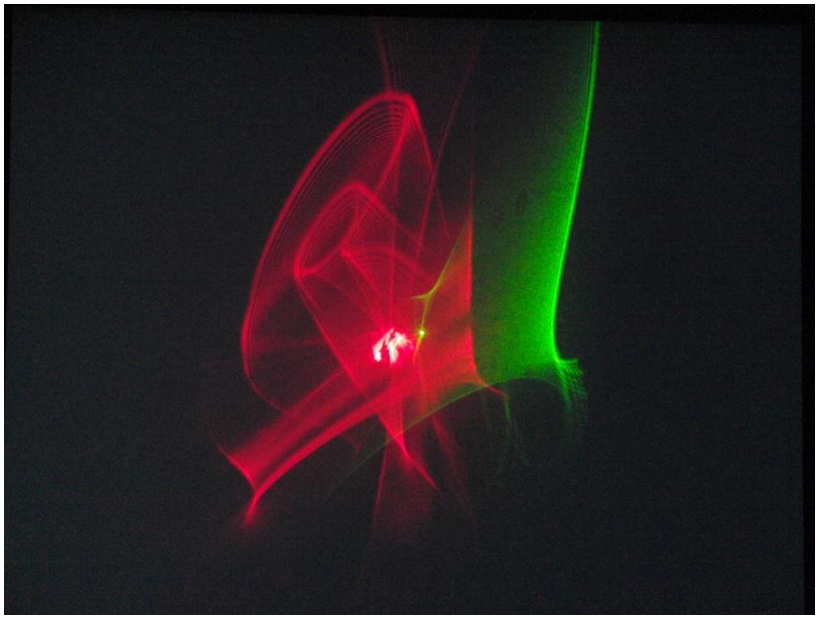
narrow single slit

Dancing fringe



Lens action of droplets





Move with time