Dr. Murty's

By Dr. Murty Mantravadi
(previously Dr. M.V.R.K. Murty)

With help from his friends: Tom Godfrey, Susan Raffensperger, Walter Clark, Dennis Rose, Reddy Chirra, Gary Fisher, Murali Mantravadi, et.al.

OPTRICKS: Tricks and simple experiments you can do in Optics

FOR YOUNG READERS

● Your own built-in magnifier

DO you know that you have your own magnifier and can commission it any time you want? Of course you have to work a little hard — to the point of tears — for it, but the thrill is worth the cry.

Before you start on the project, get a printed paper on which the printing is very fine with small letters. Spread it flat on the table and touch the paper with your nose-tip as shown in Fig. 1. What do you see? Nothing but a very blurred image of the print. But wait and have patience.

Fig. 1

If you wait for about one or two minutes in the same posture without blinking, you will collect a tear drop in each eye and it will form into an almost hemispherical drop and will literally hang from your eyeball. This is shown

Fig. 2

in Fig. 2. You can actually feel the formation of the tear drops and you should be careful not to blink, otherwise you will have to start all over again.

As the tear starts to form, you begin to see the fine print a little less blurred and finally, at the correct moment, the fine print appears very clear and highly magnified. This is the moment you have been waiting for.

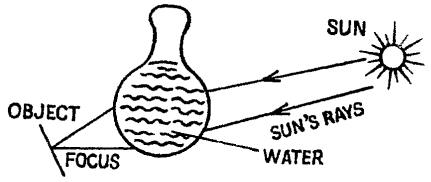
Can you estimate the magnification obtained? How do you proceed to make a calculation for the magnification?

● A burning-glass with a fused electric bulb

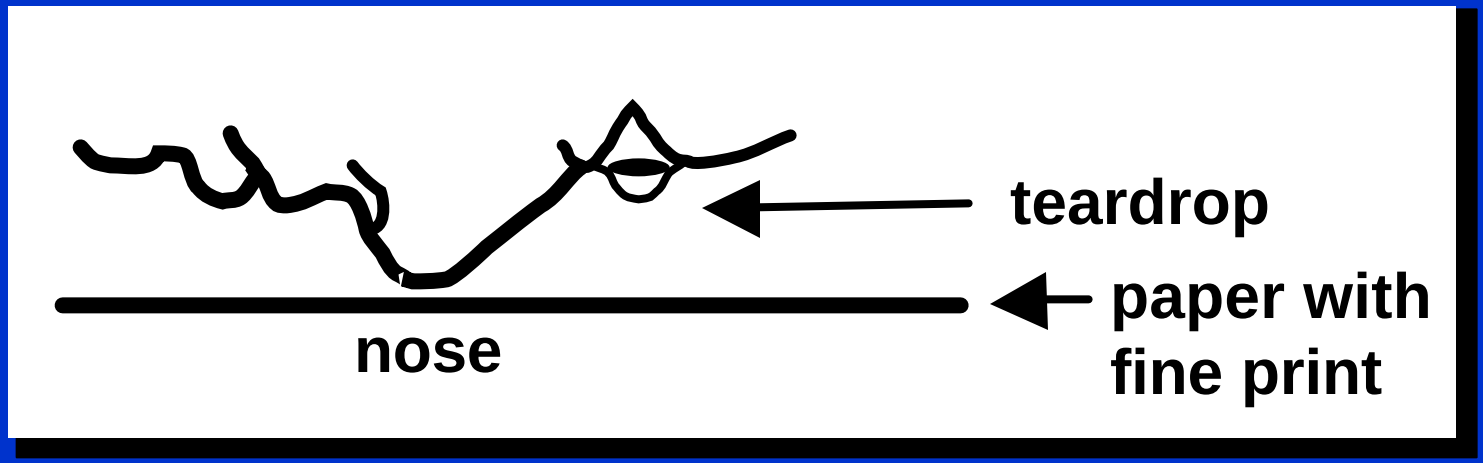
WOULD you like to make a burning-glass that will burn pieces of paper when you focus sunlight through it? Next time you have a fused electric bulb, don't throw it away. Instead, carefully remove the metal cap and the glass rod which holds the filament. If you cannot do it properly, any trader dealing in sheet glass will be able to mark a line on the glass bulb with a diamond point. Then by heating the bulb along this line with a small candle flame, you will be able to get a clean bulb without anything inside. It is preferable to use a clear bulb rather than a frosted one.

After cleaning the inside and the outside, fill the bulb with clear water. Make sure that the outside of the bulb is dry and without any spots. Now you are ready for your burning tricks. Take several pieces of coloured paper, cloth, etc. You will be able to focus the sunlight by means of the water-filled bulb on these articles. This is shown in Fig. 3.

Fig. 3



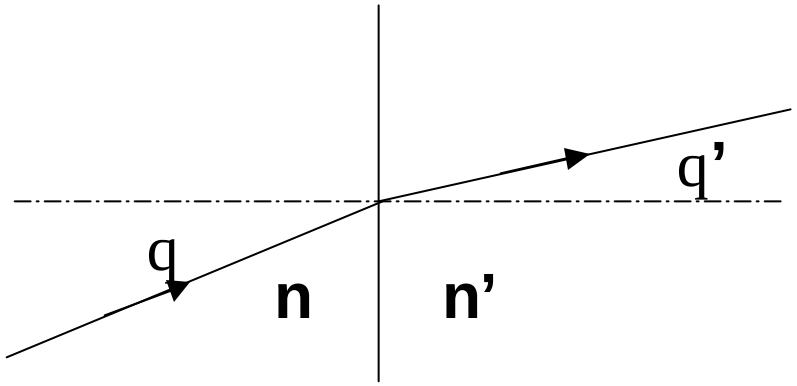
Your Own Built-In Magnifier



Raindrops Make Rainbows

From http://acept.la.asu.edu/

Snell's Law



$n \sin q = n' \sin q'$

where n = refractive index
(n =1 for air, 1.33 for water)
and
q = angle of incidence
q' = angle of refraction

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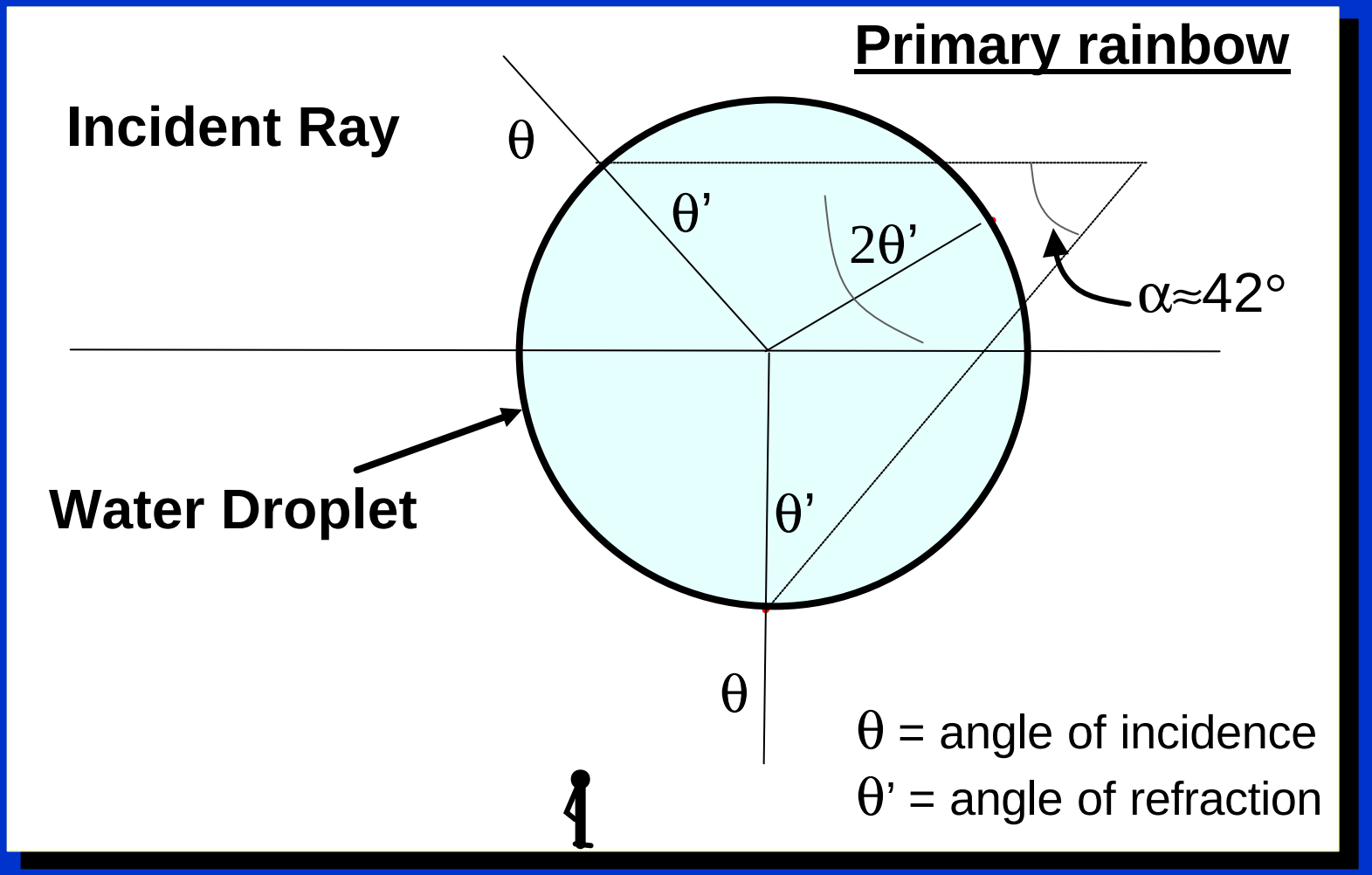

From an article by Dr. Murty on www.armchair.com

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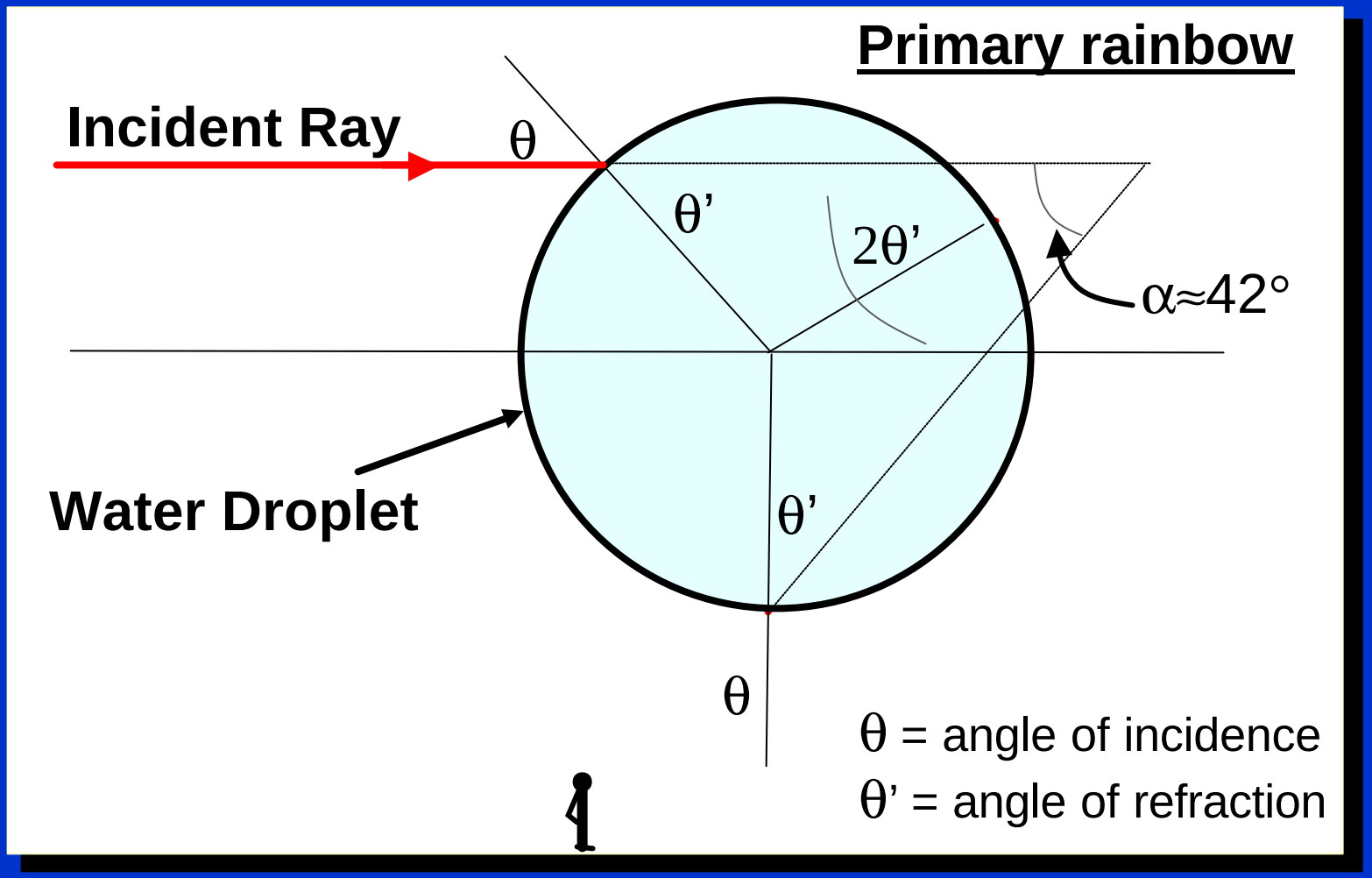

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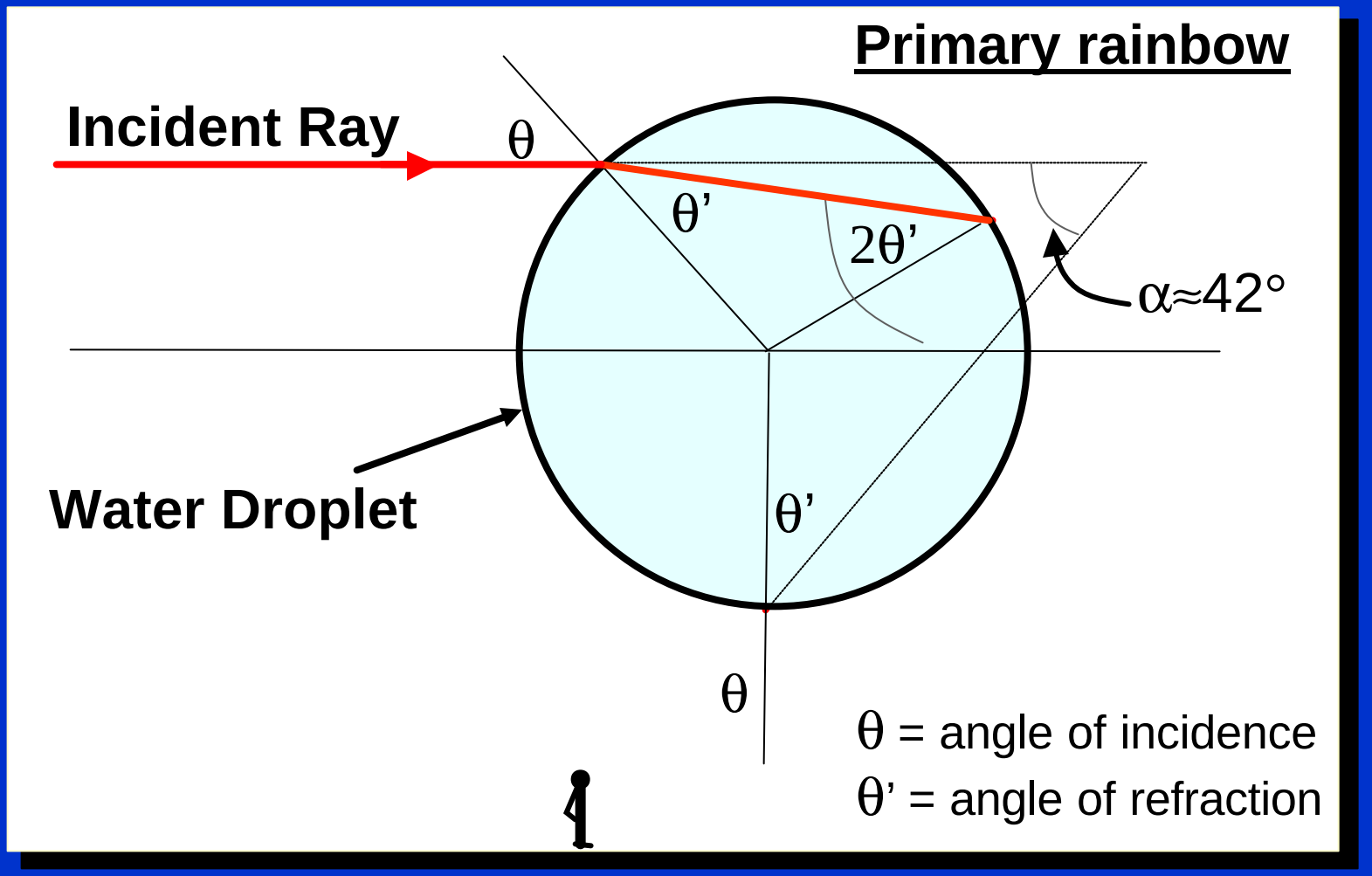

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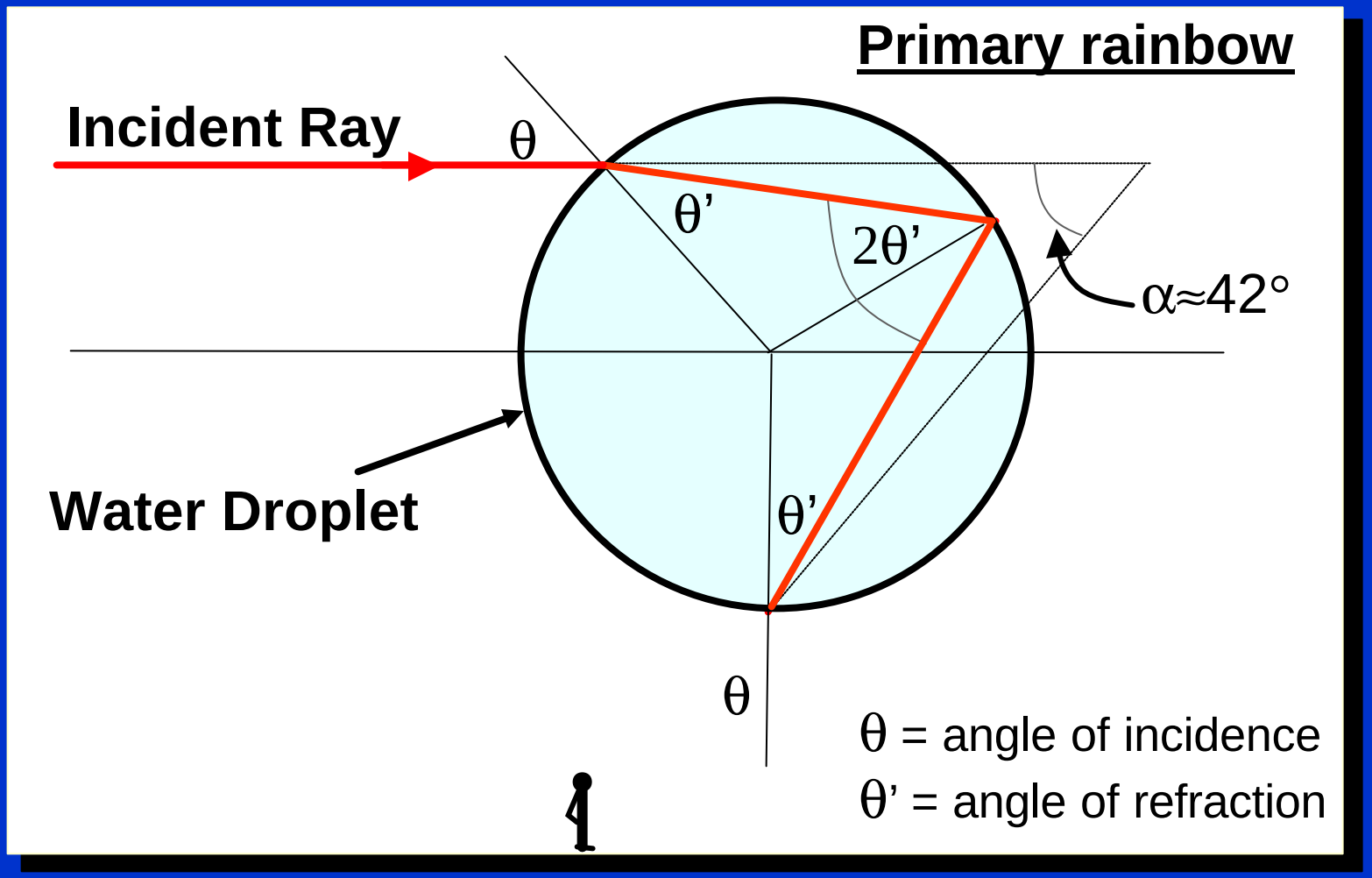

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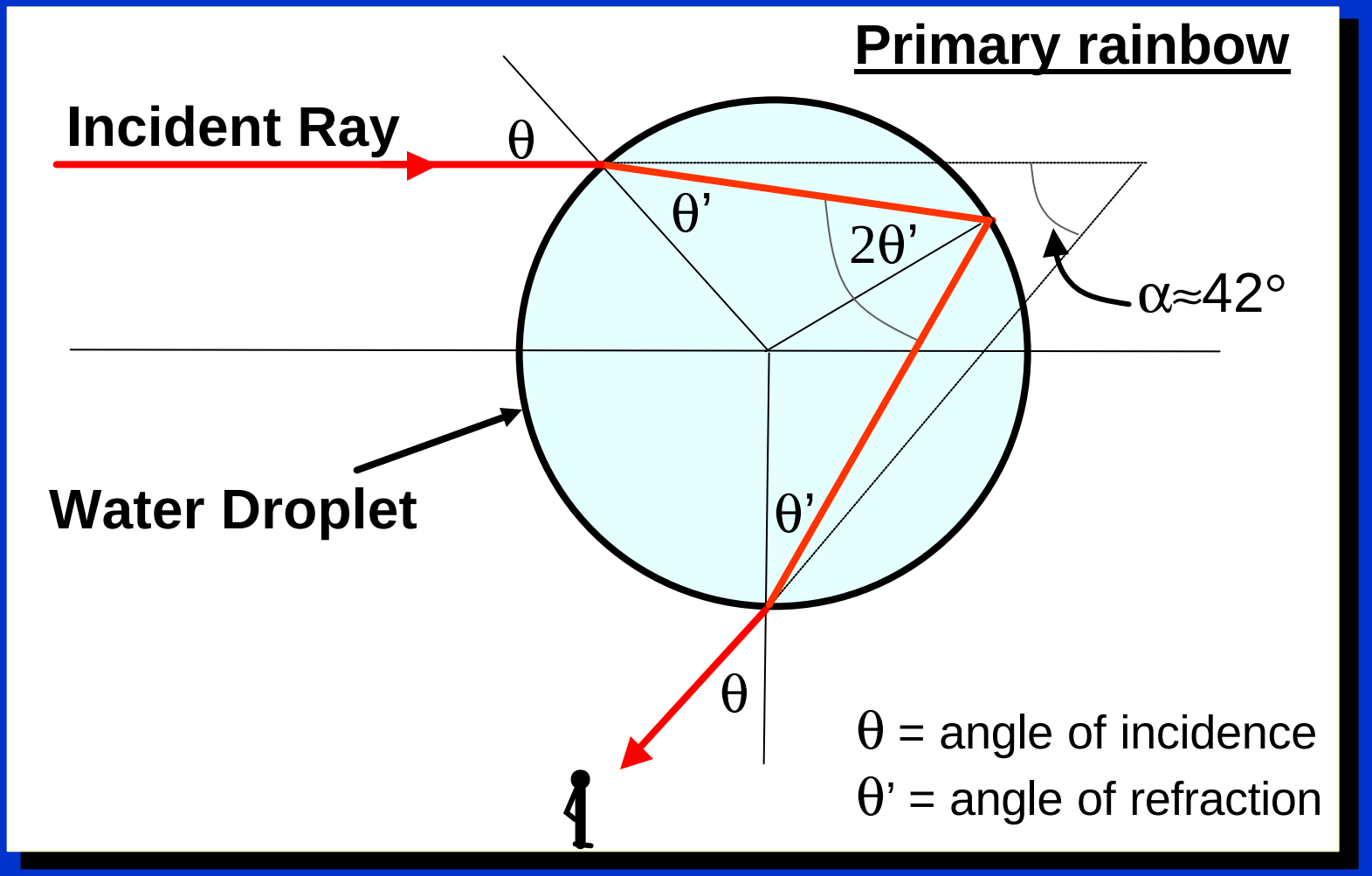

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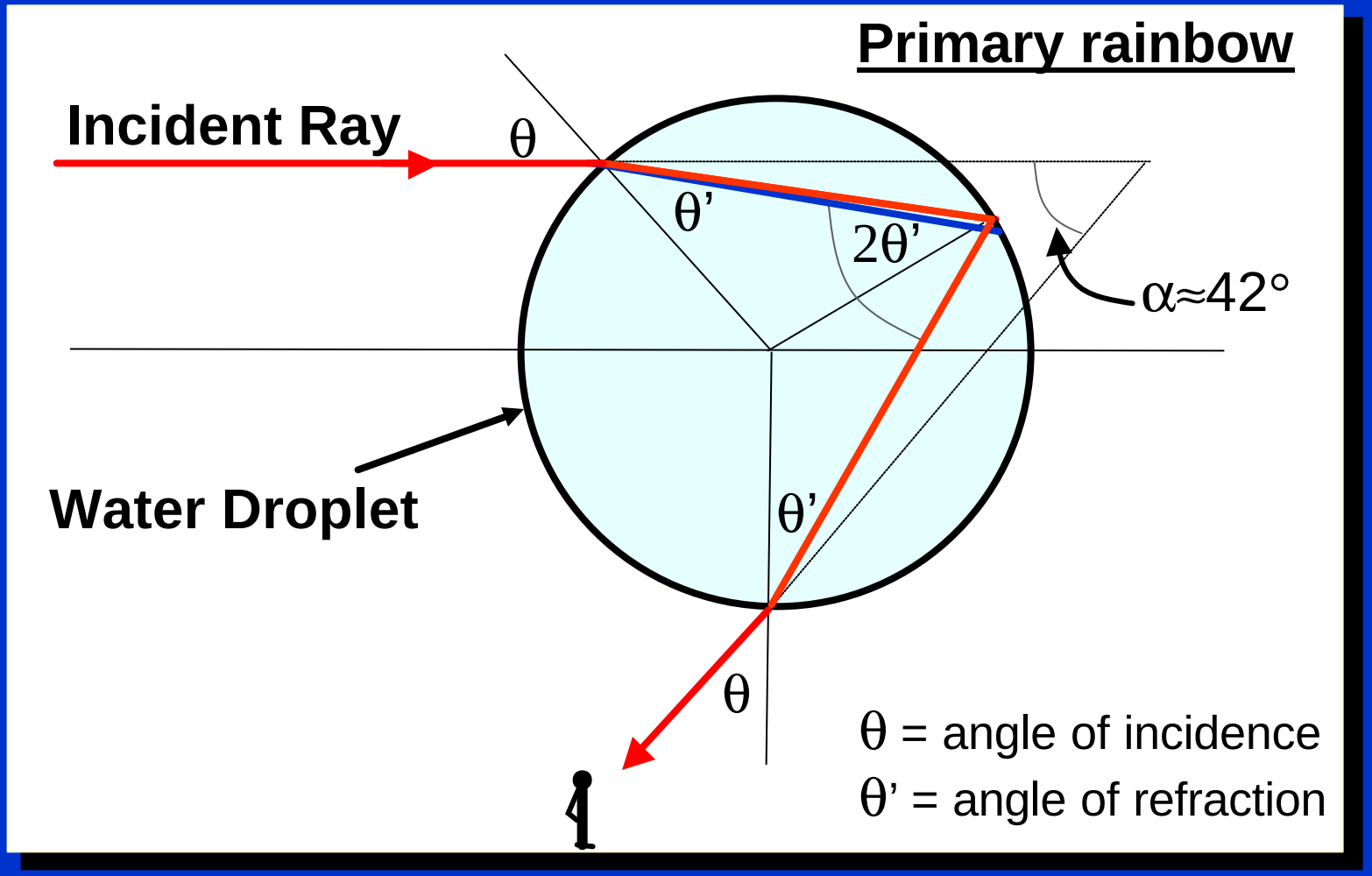

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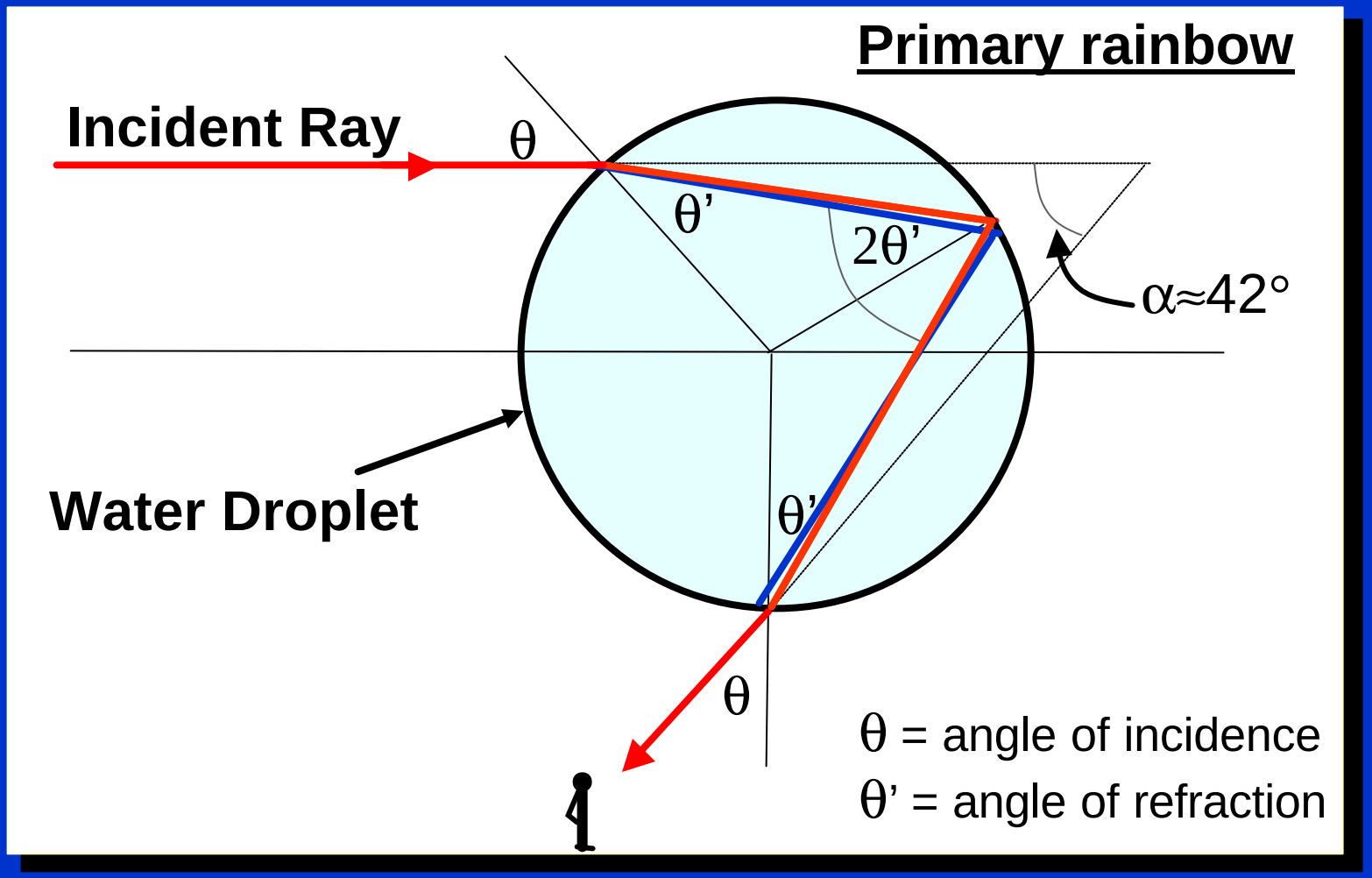

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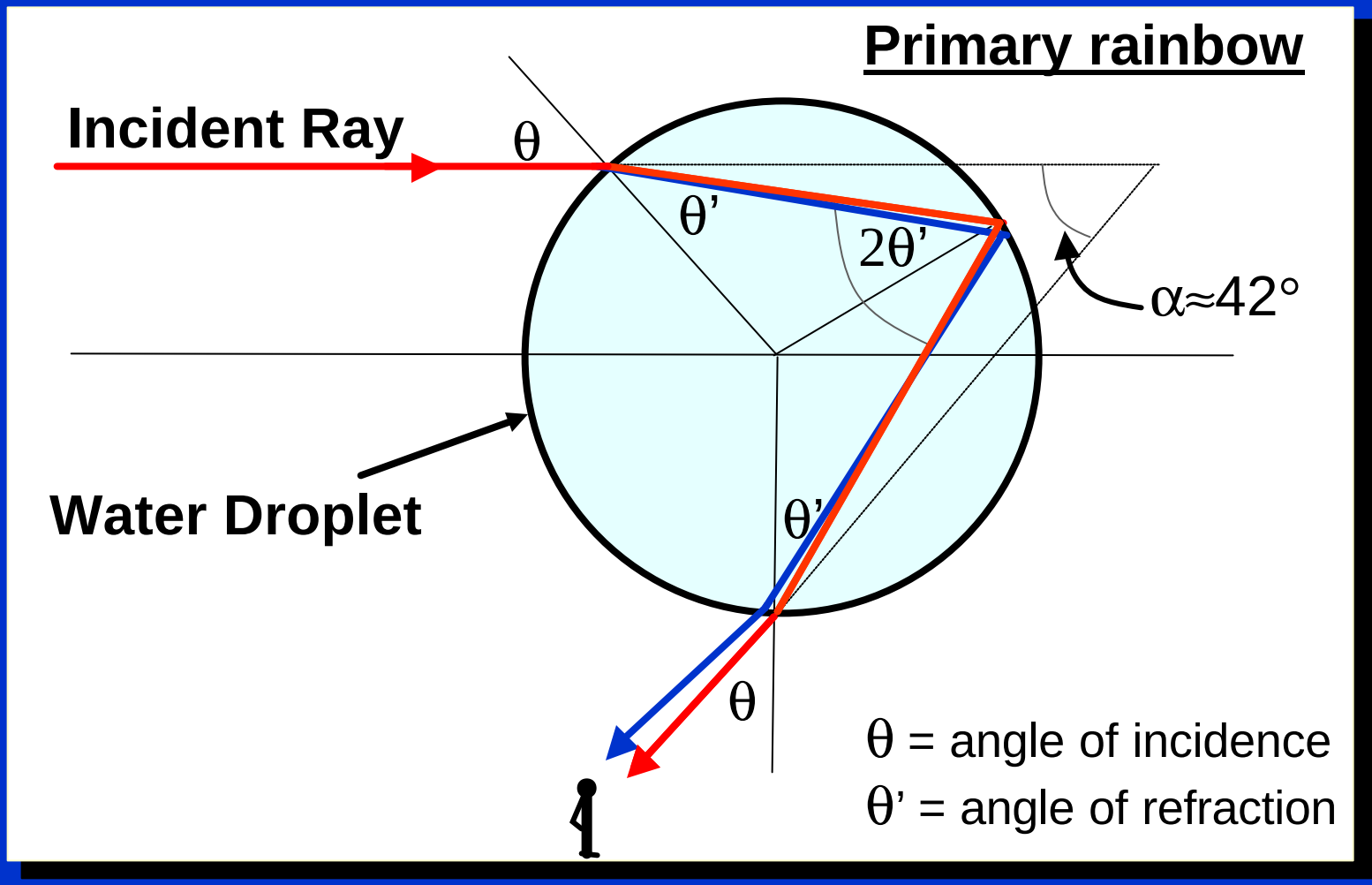

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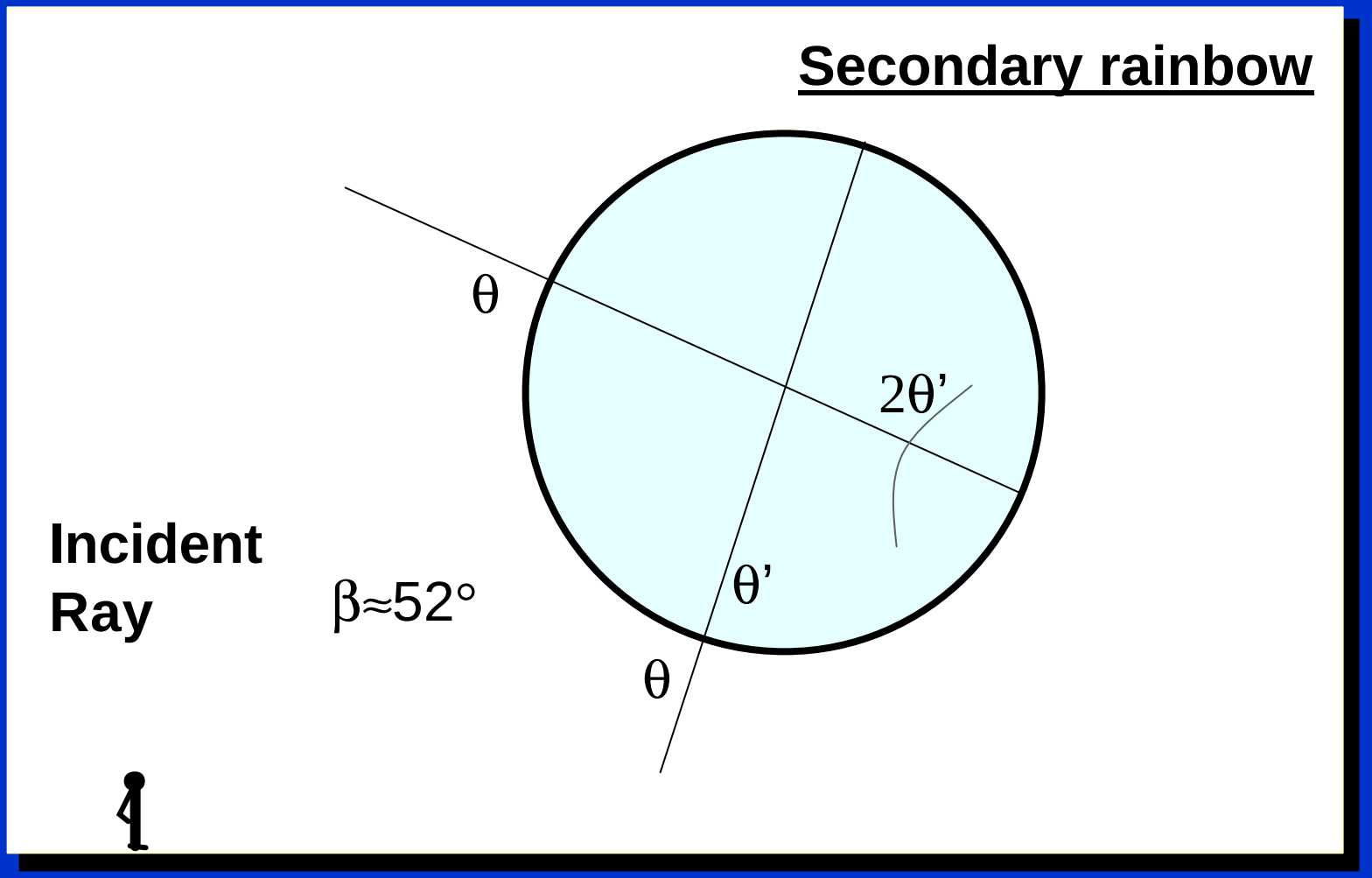

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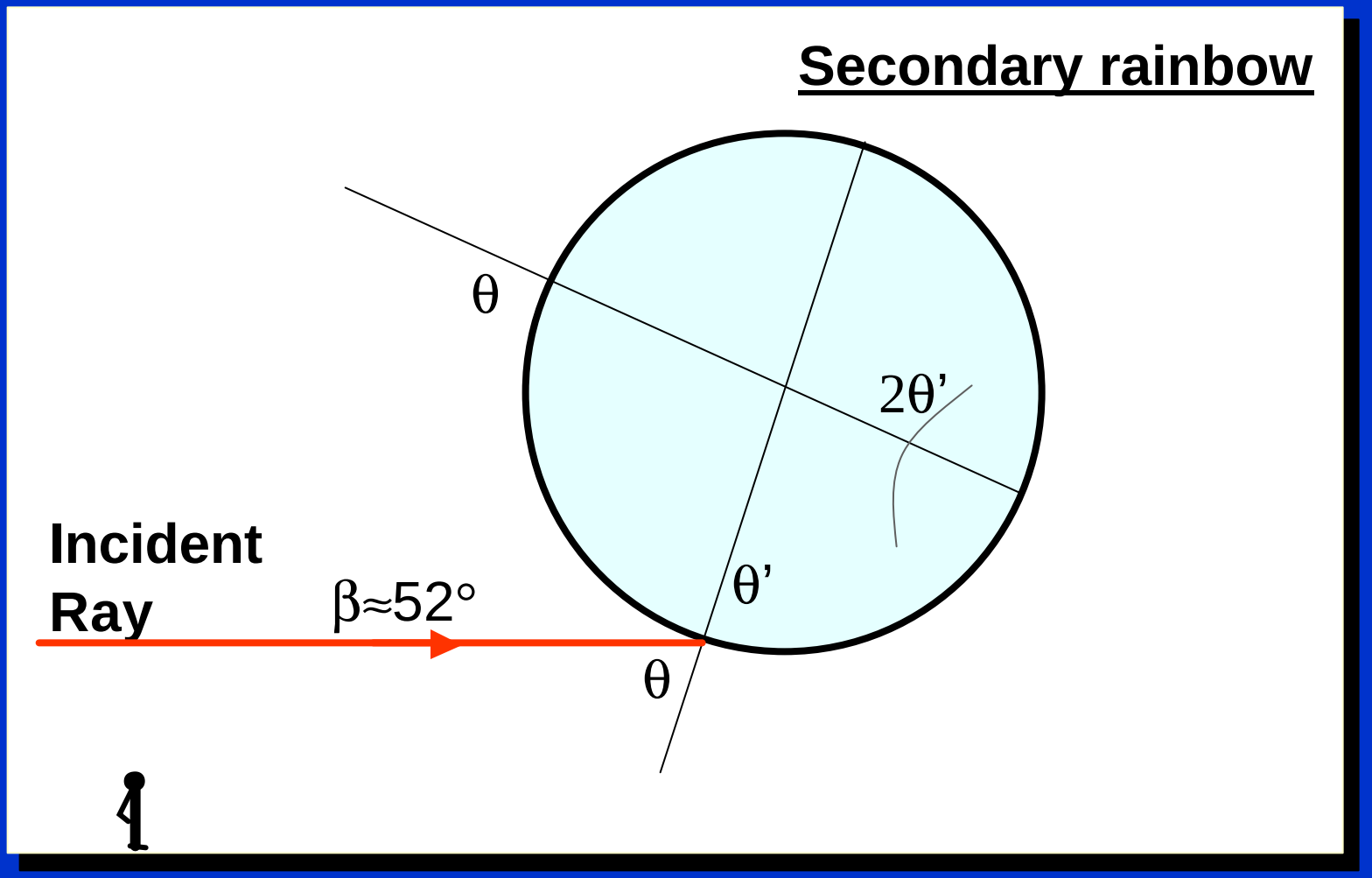

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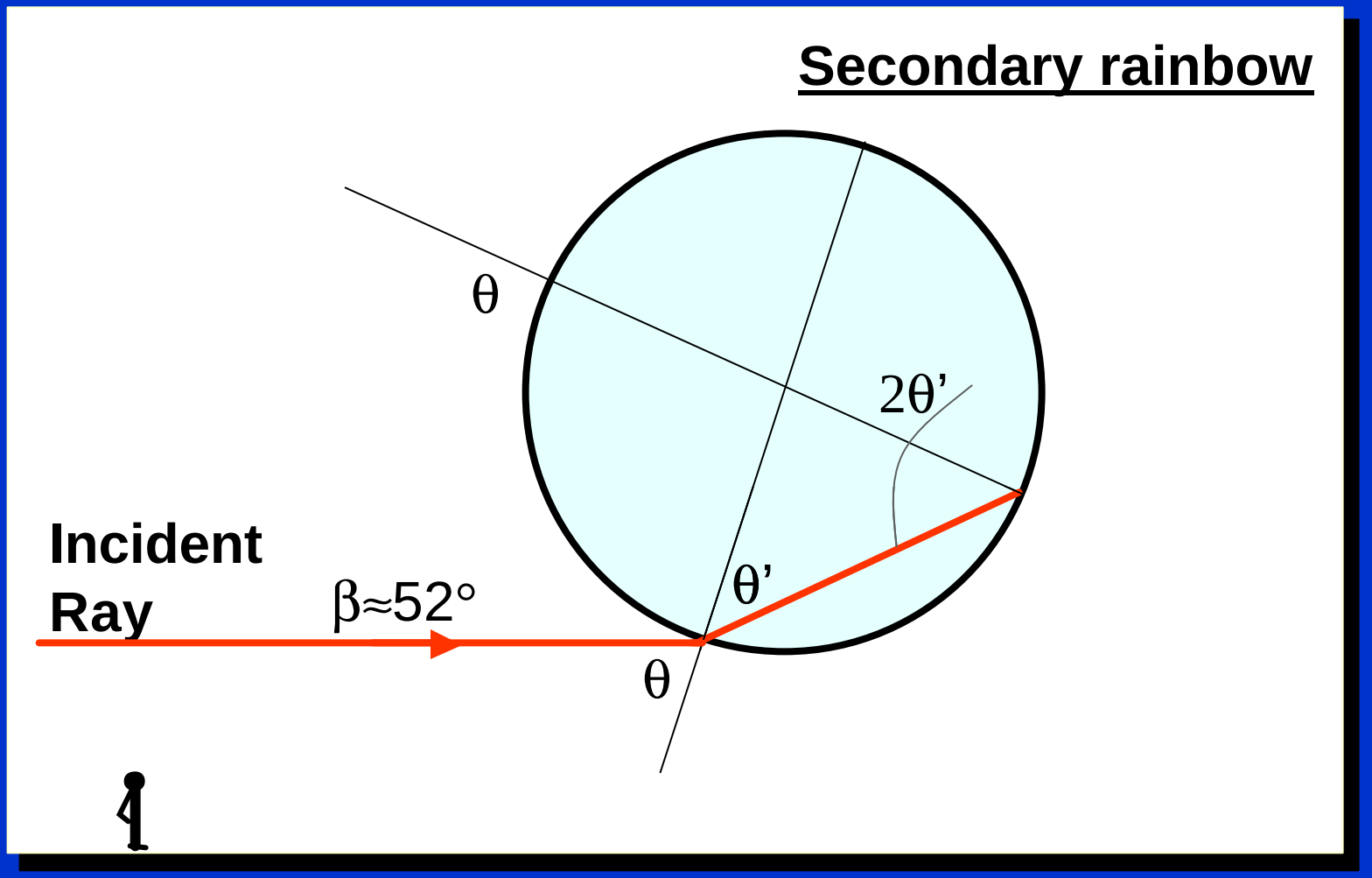

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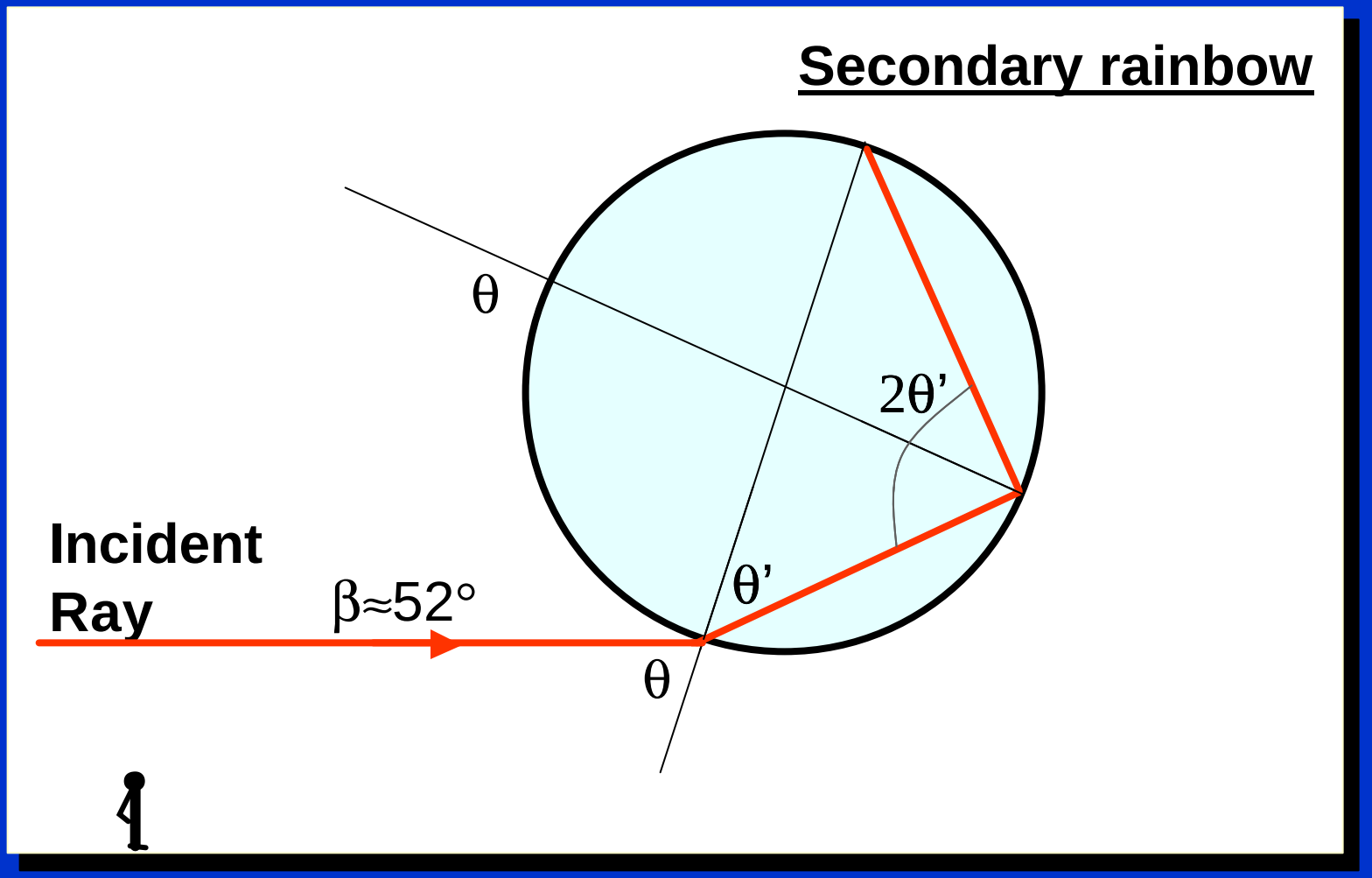

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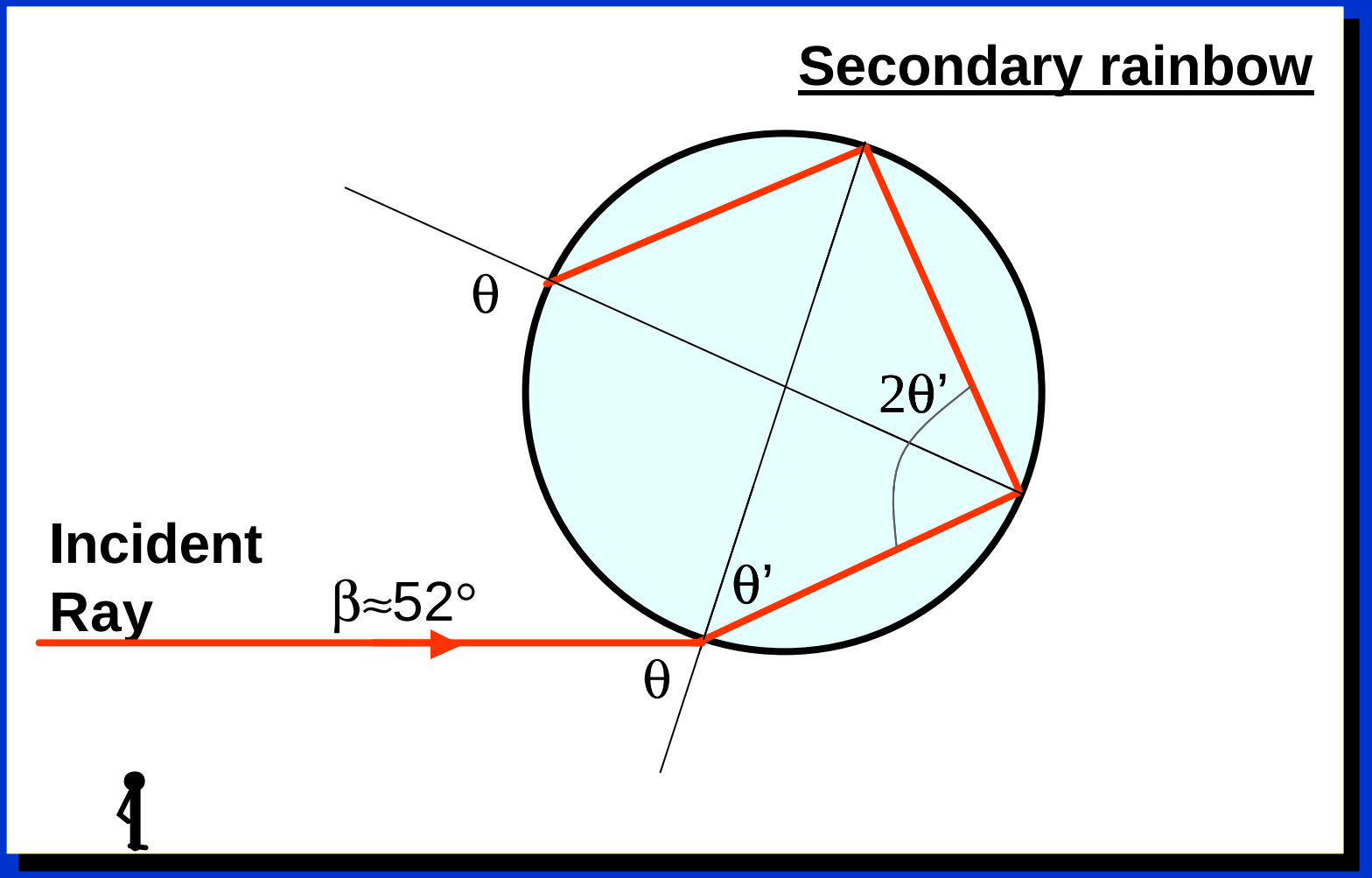

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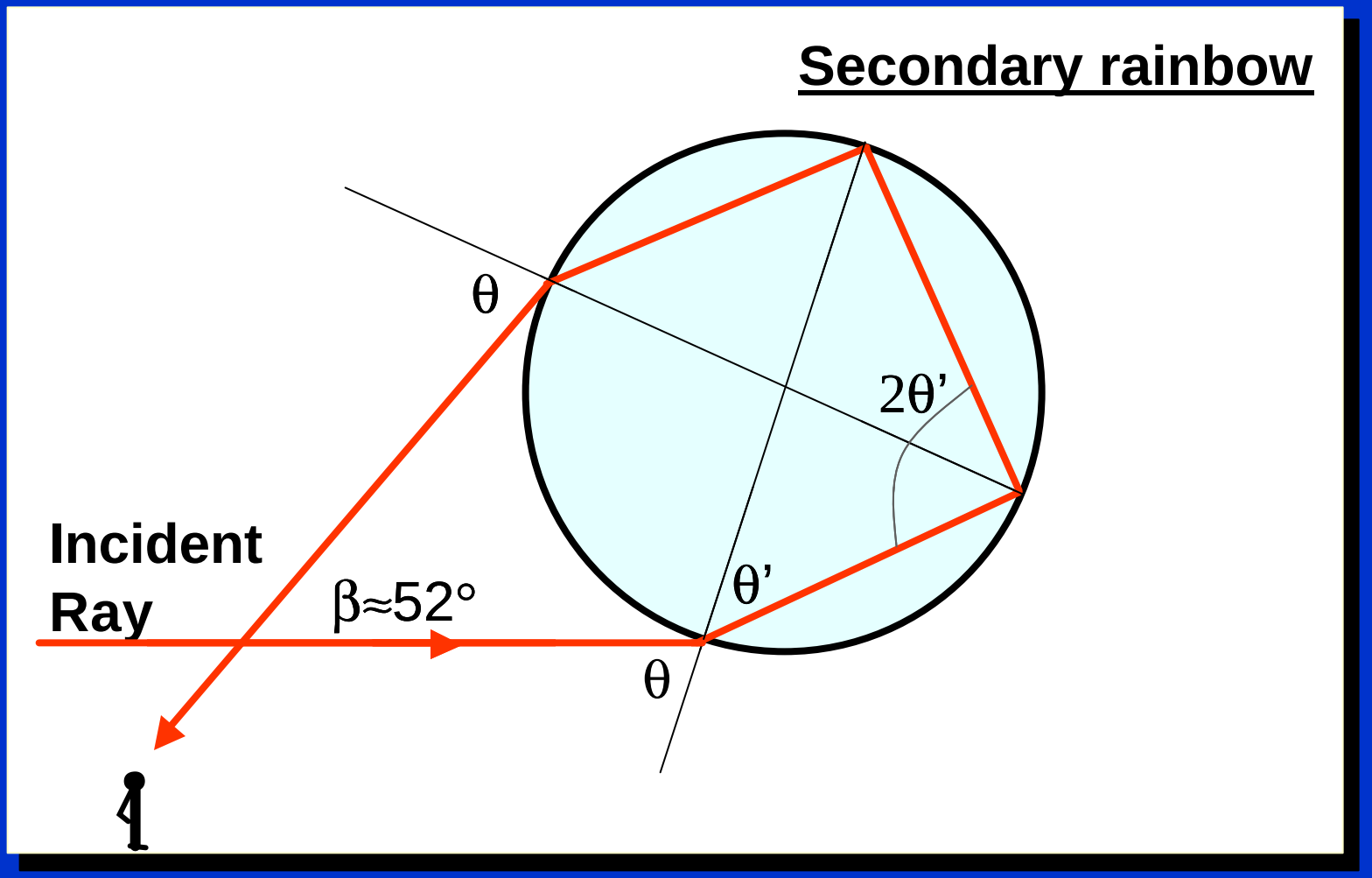

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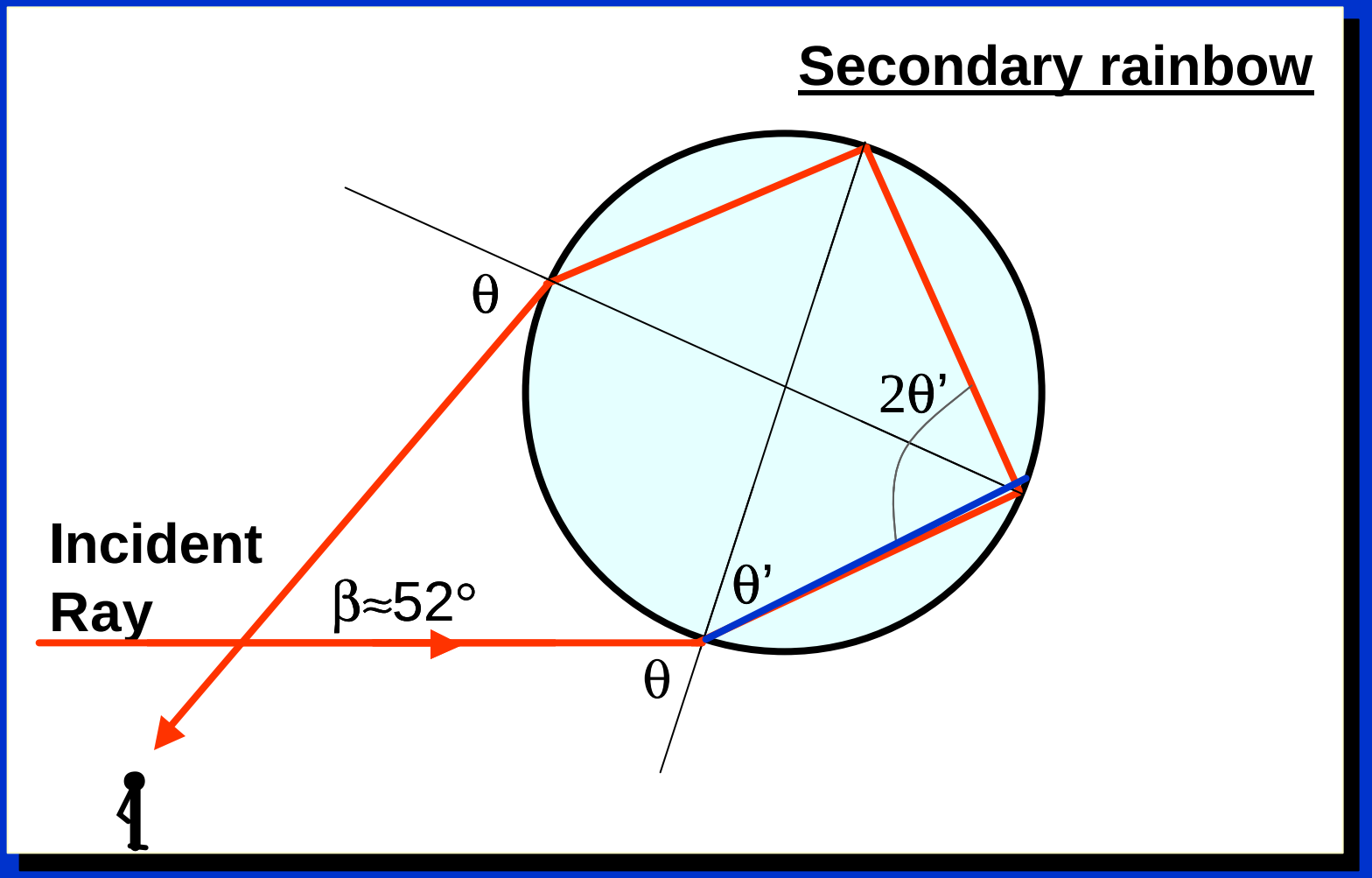

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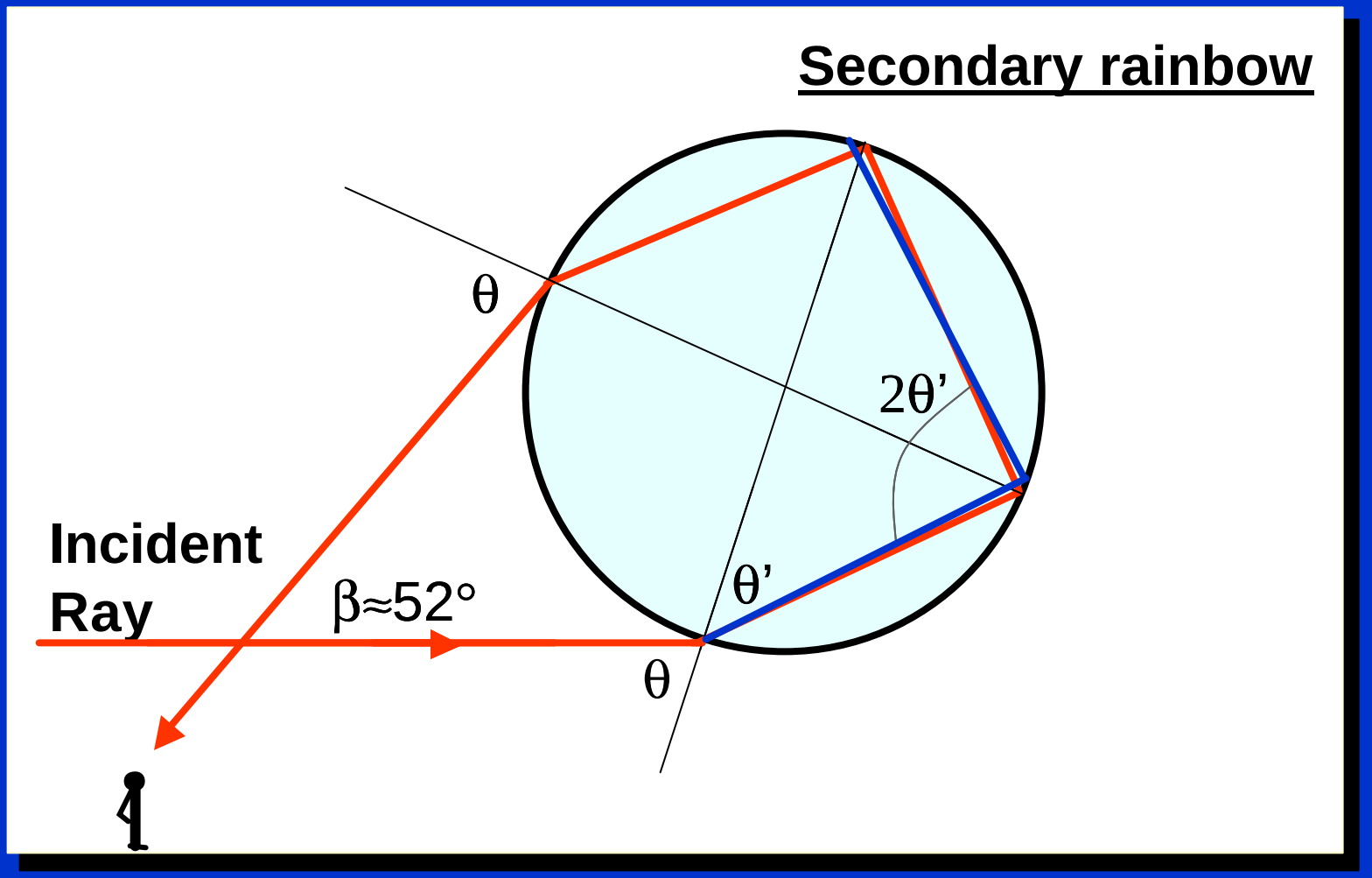

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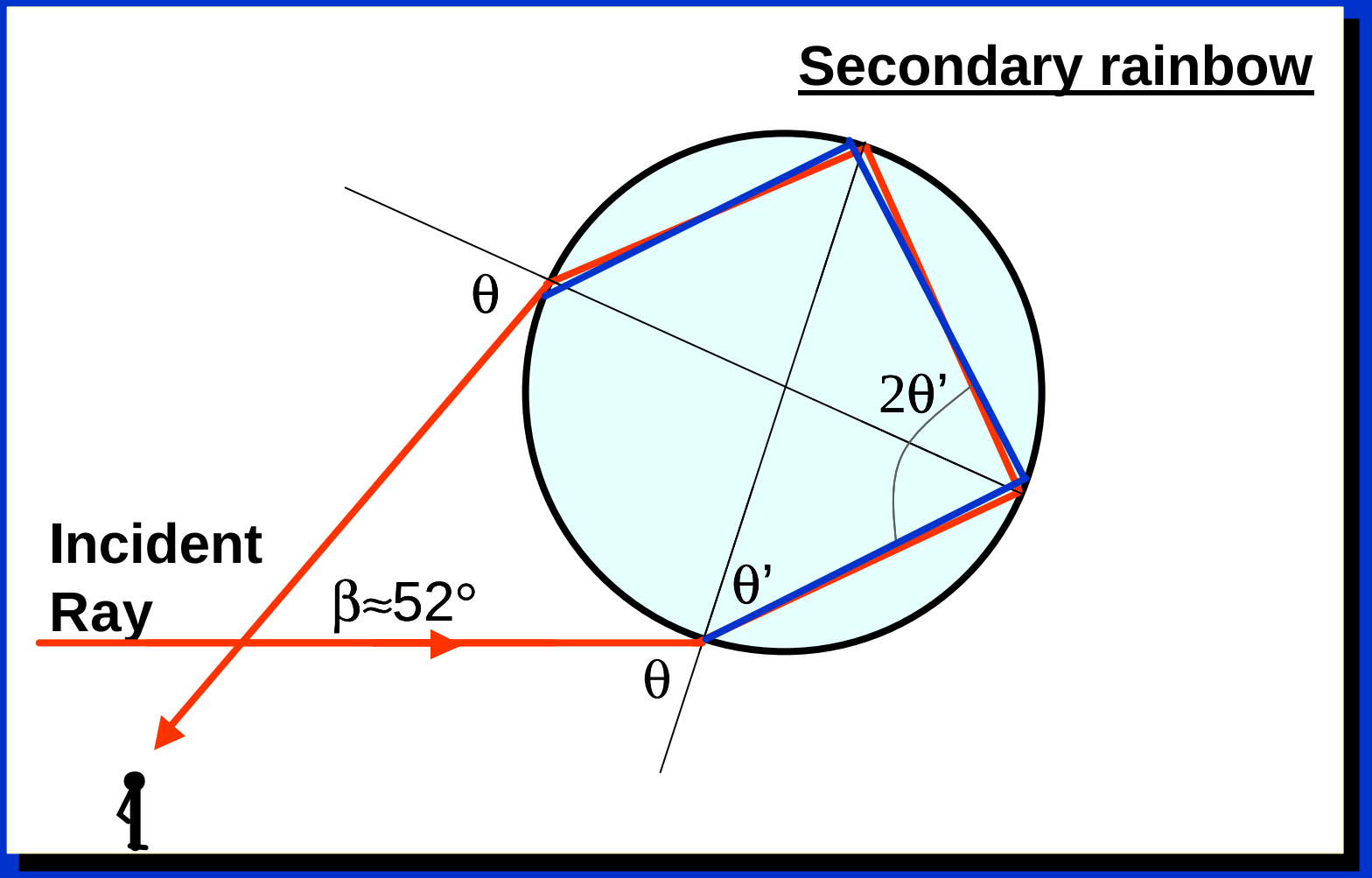

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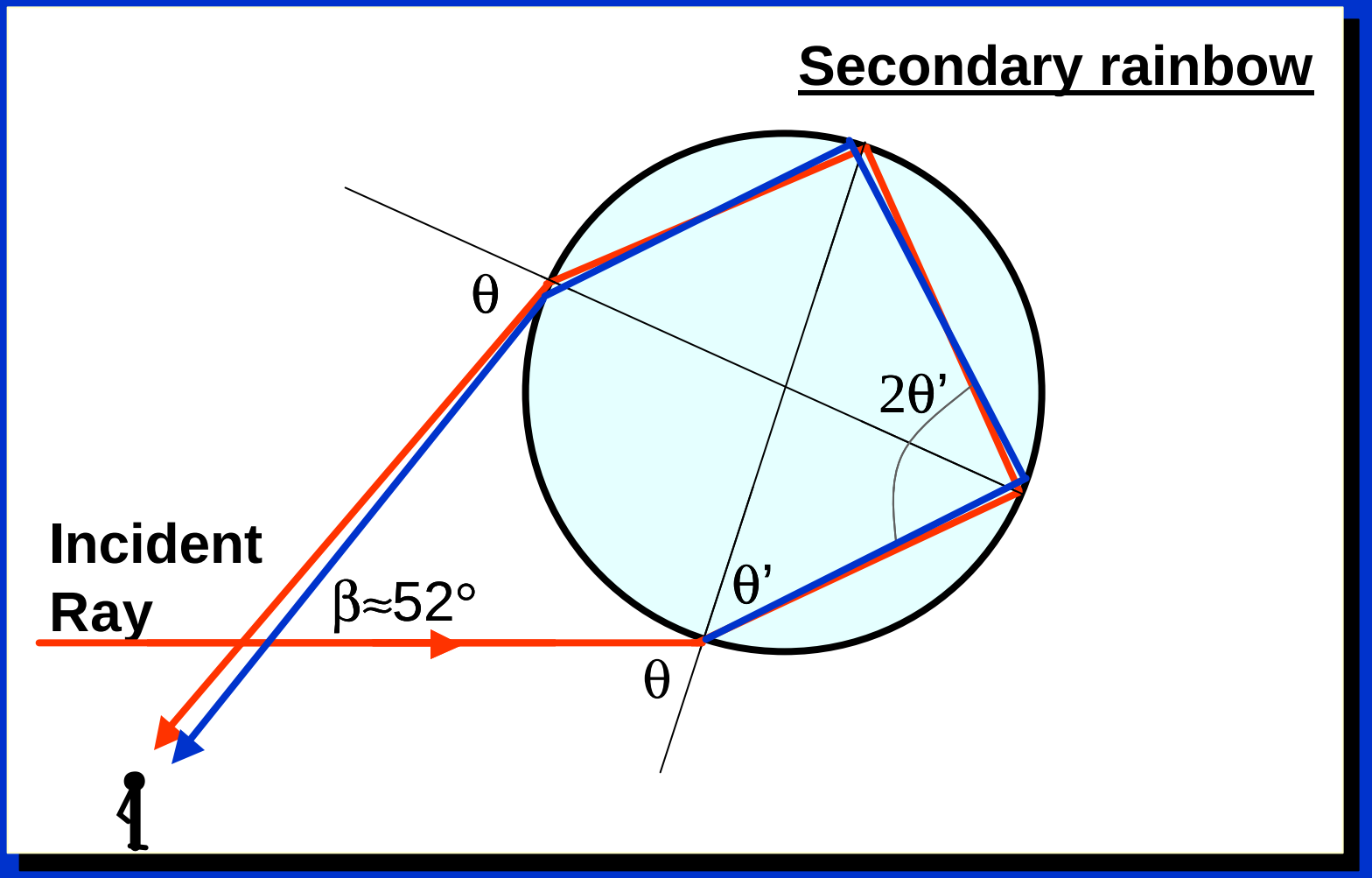

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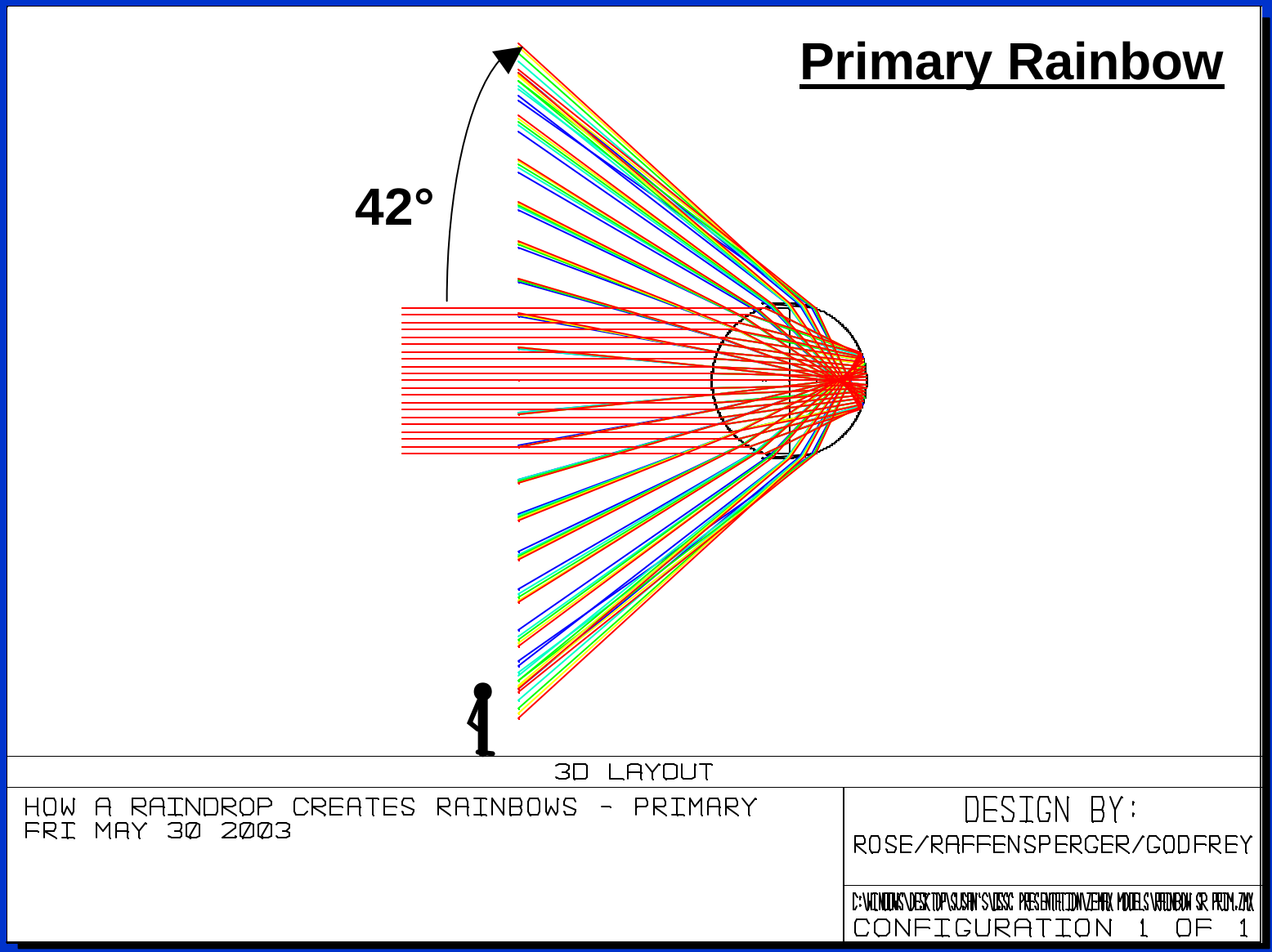

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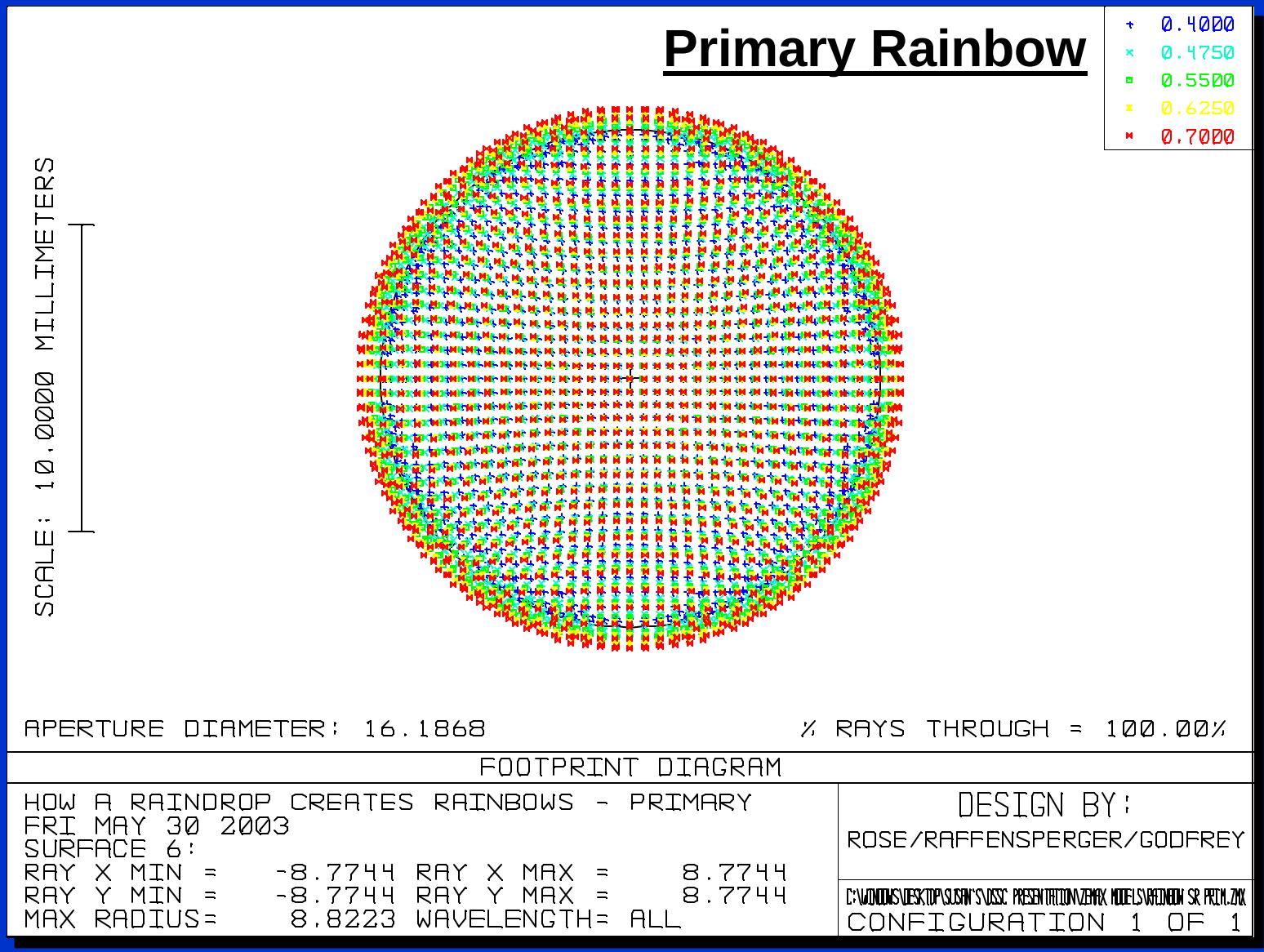

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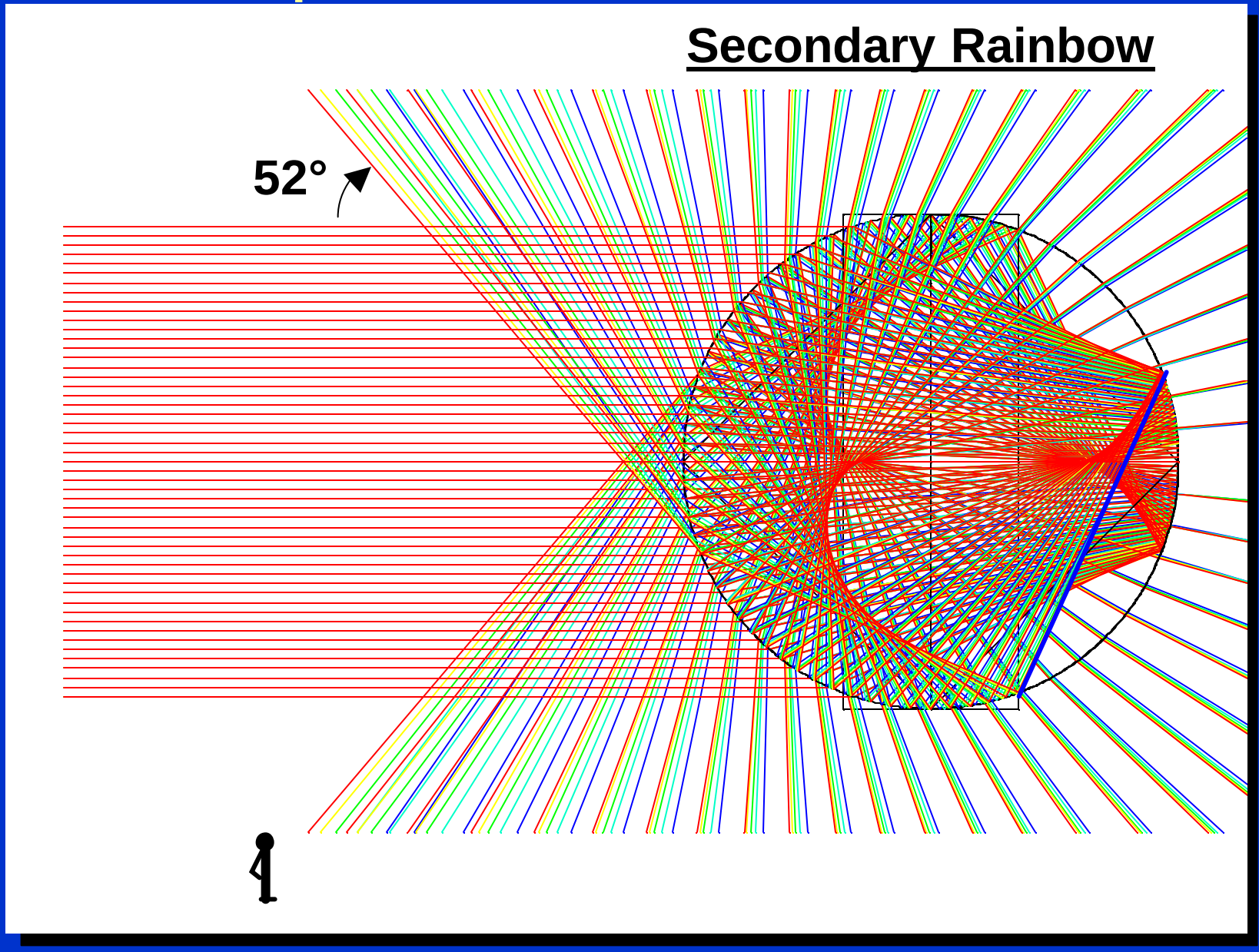

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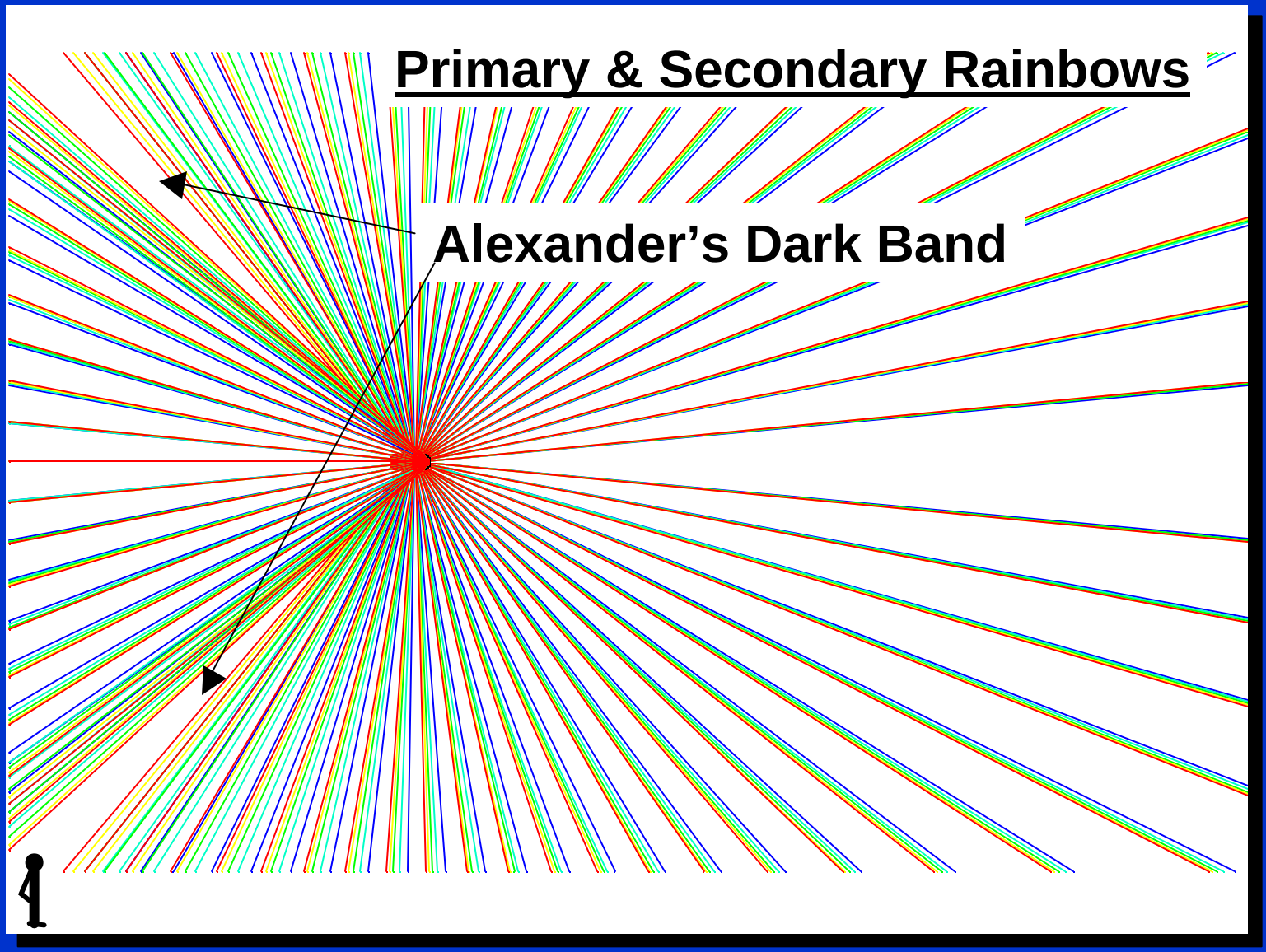

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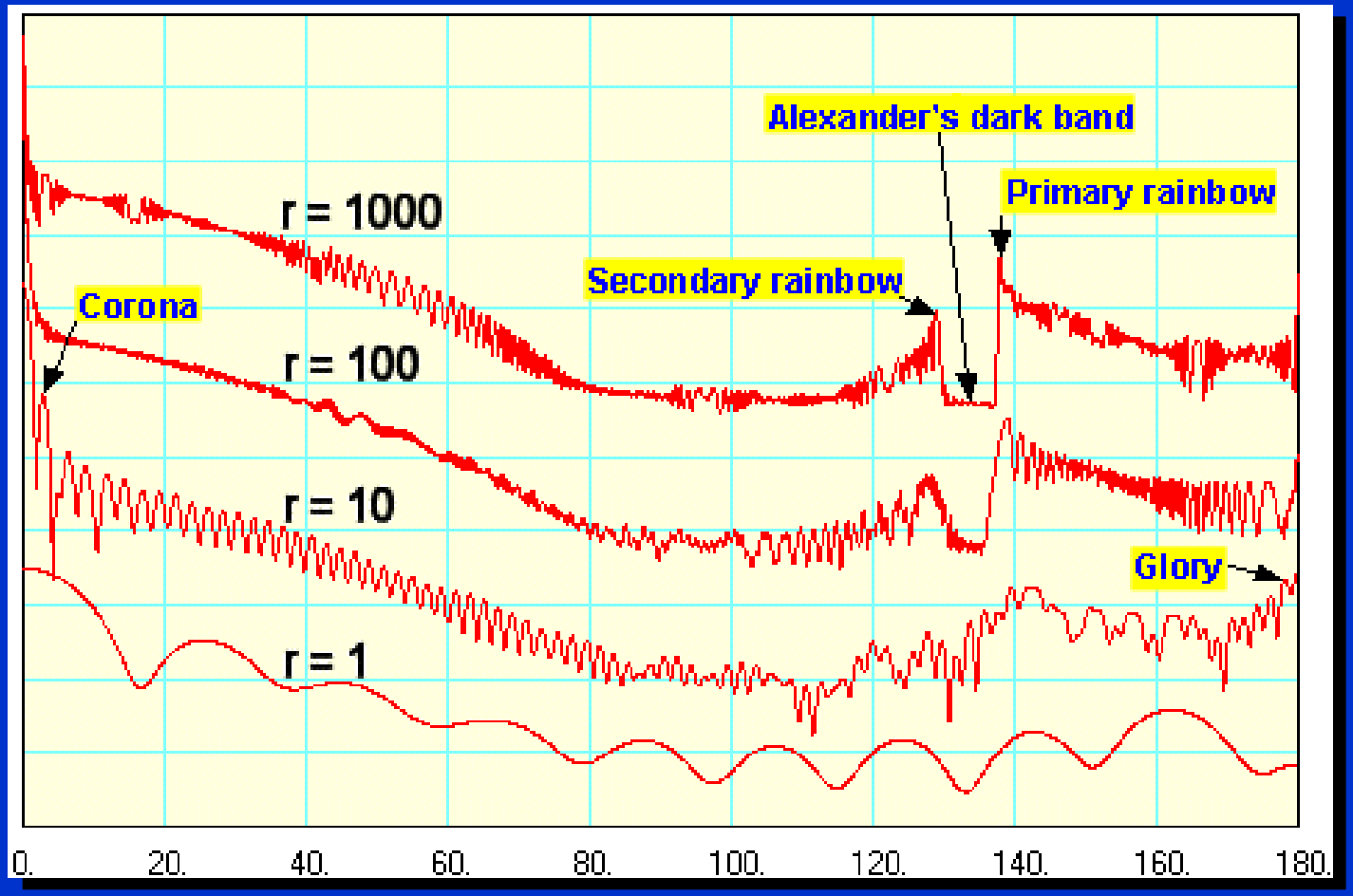
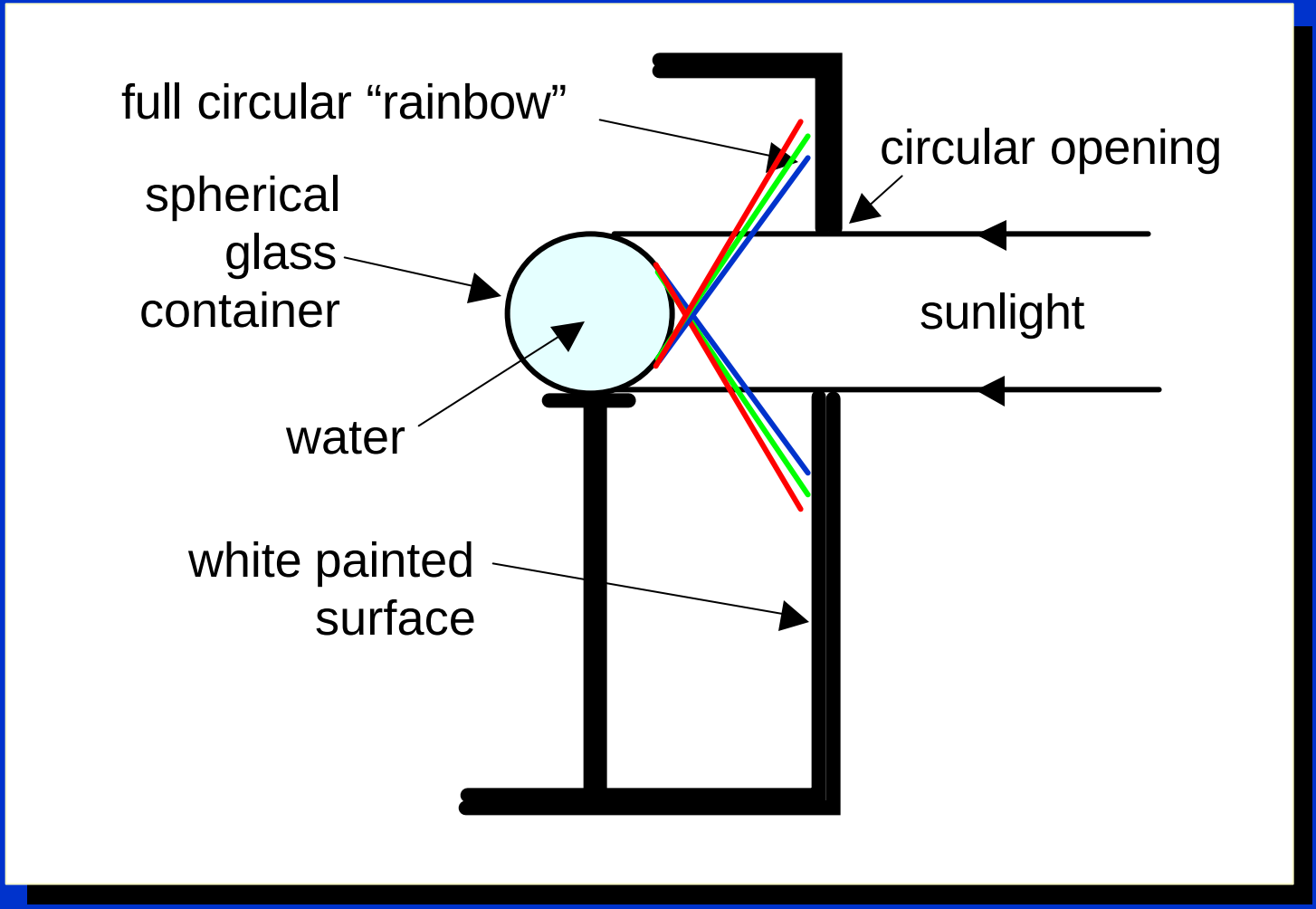
Mie theory for unpolarized red light (λ = 0.65 μm) by water drops of radius r.



From www.philiplaven.com

Homemade Rainbow



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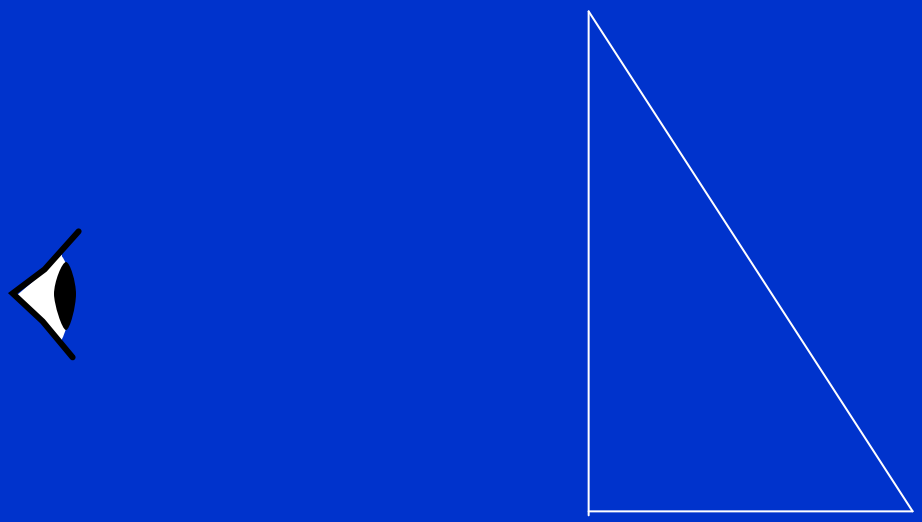
Visual (Pin) Ray Tracing



prism

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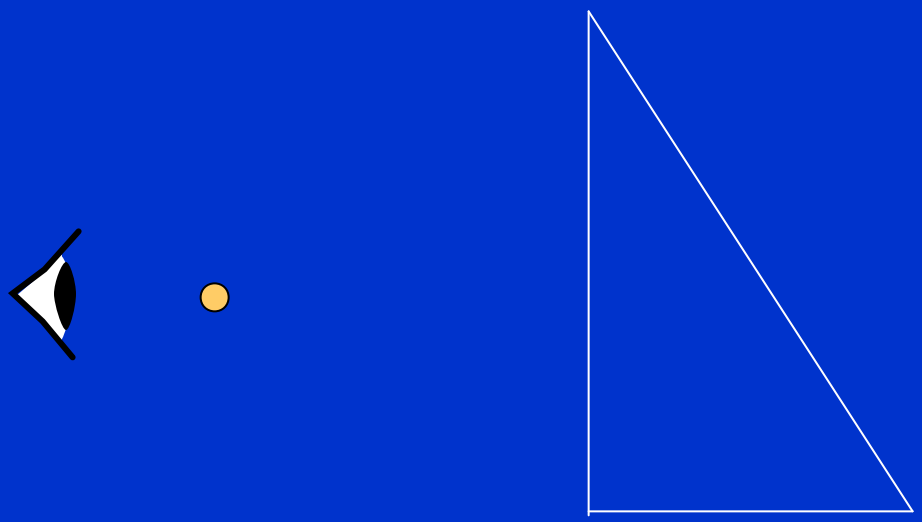

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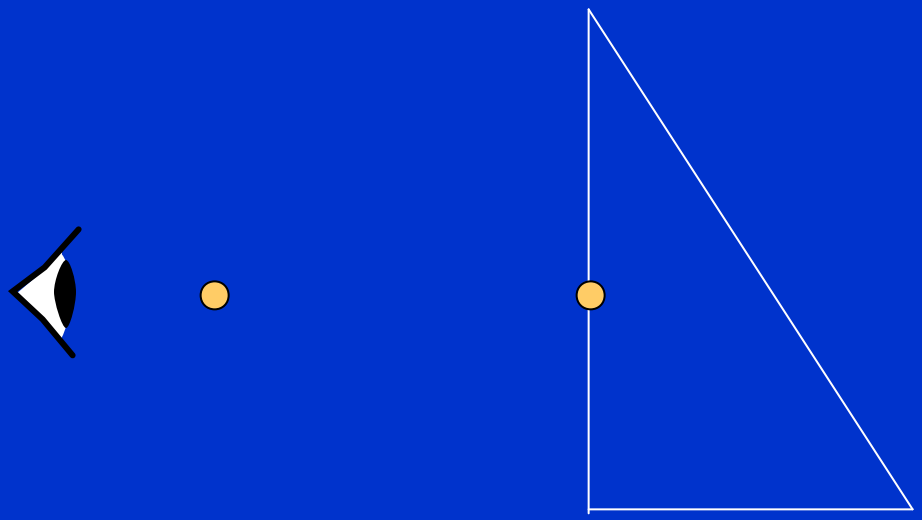

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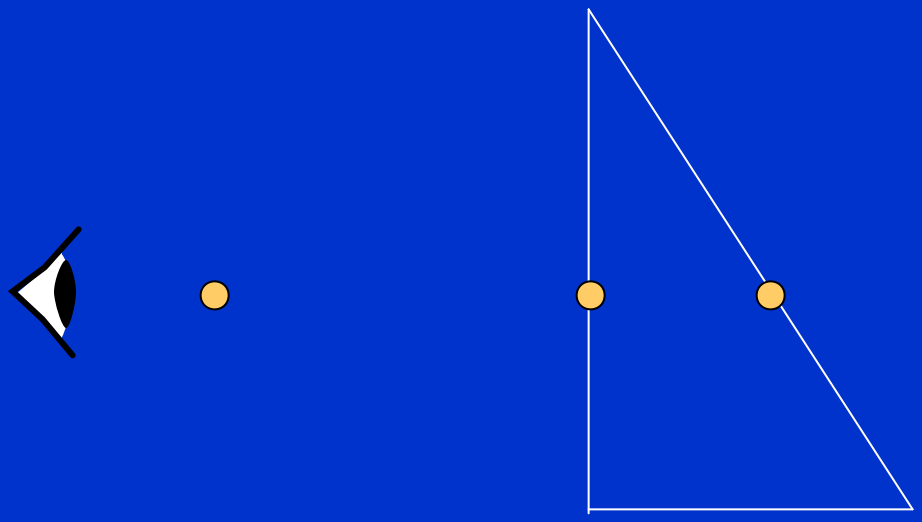

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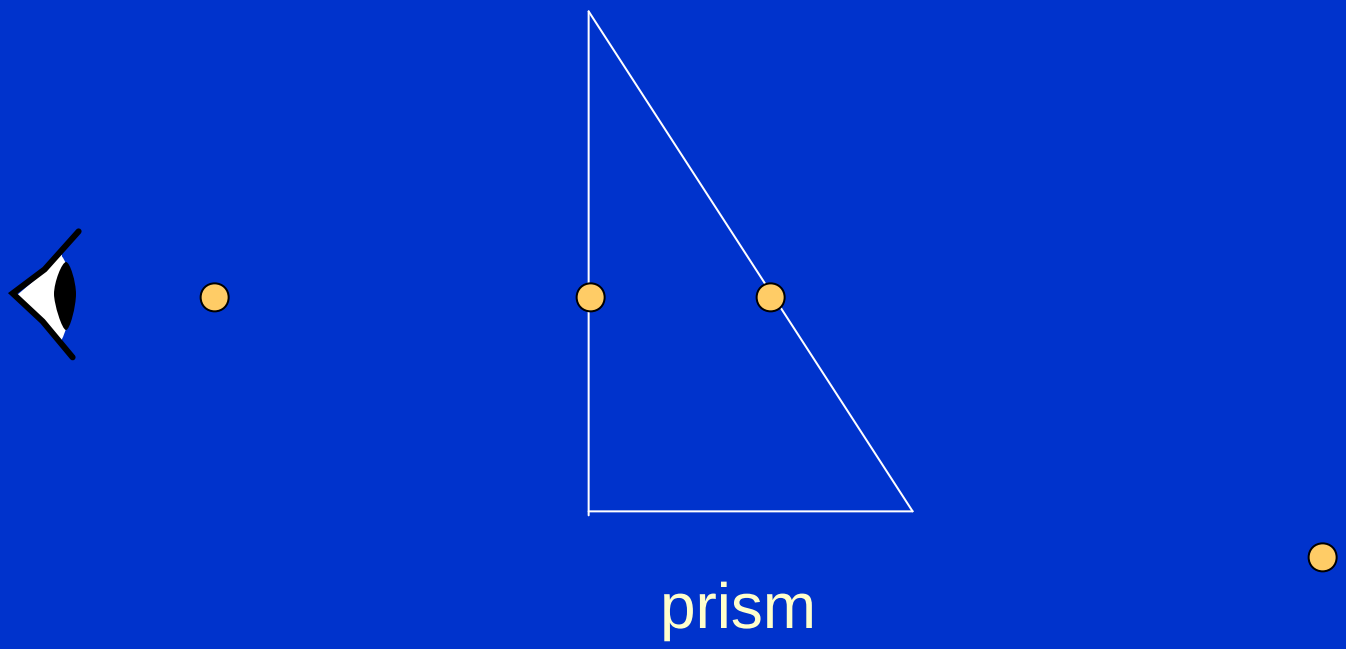

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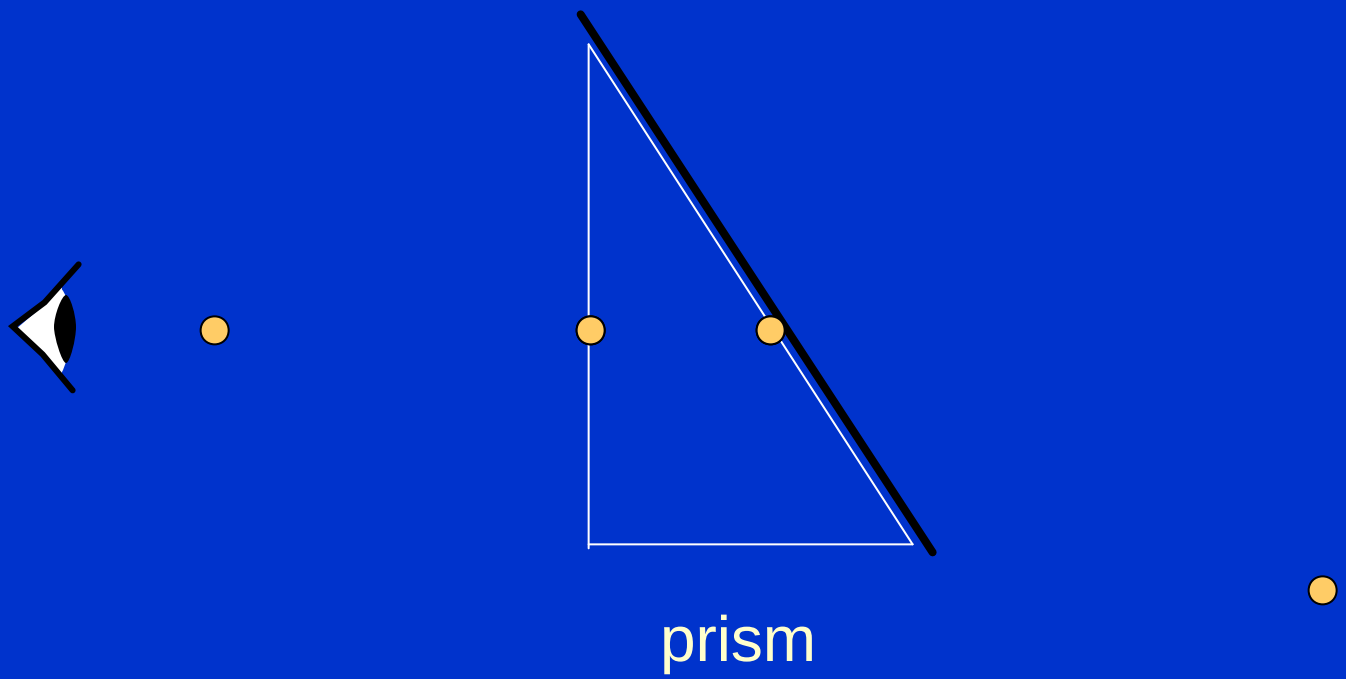

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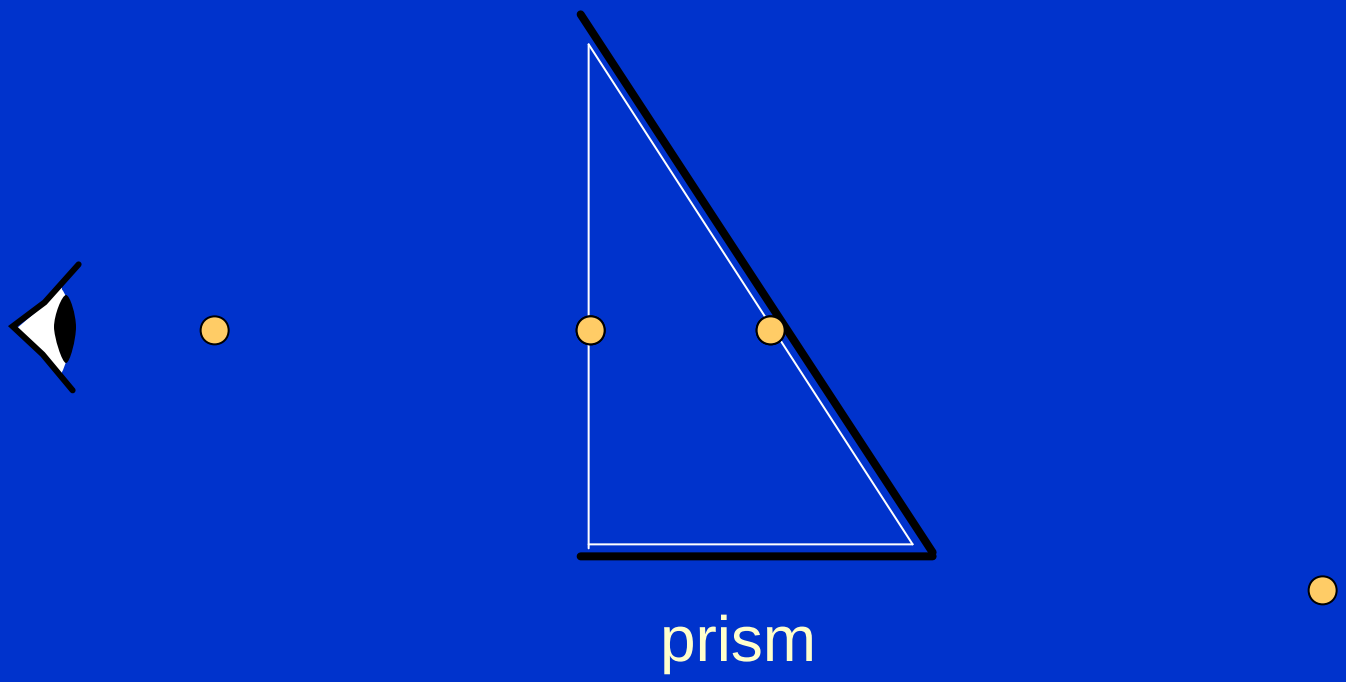

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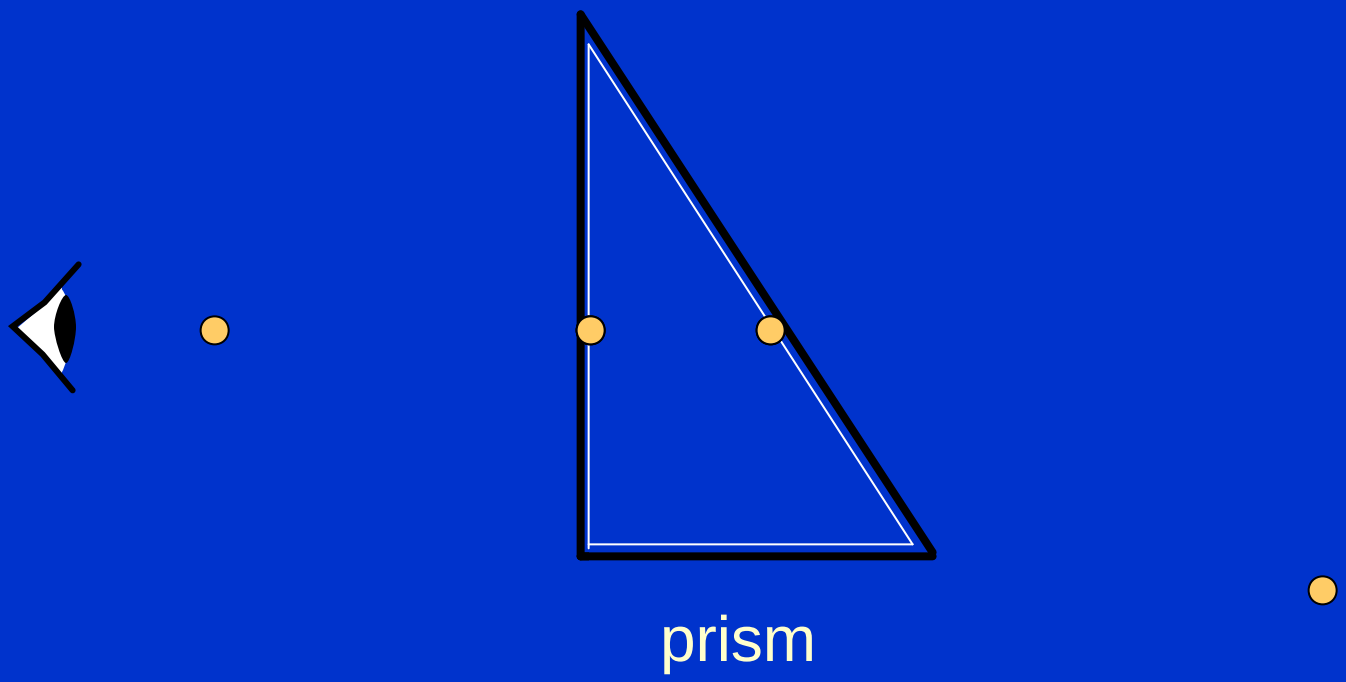

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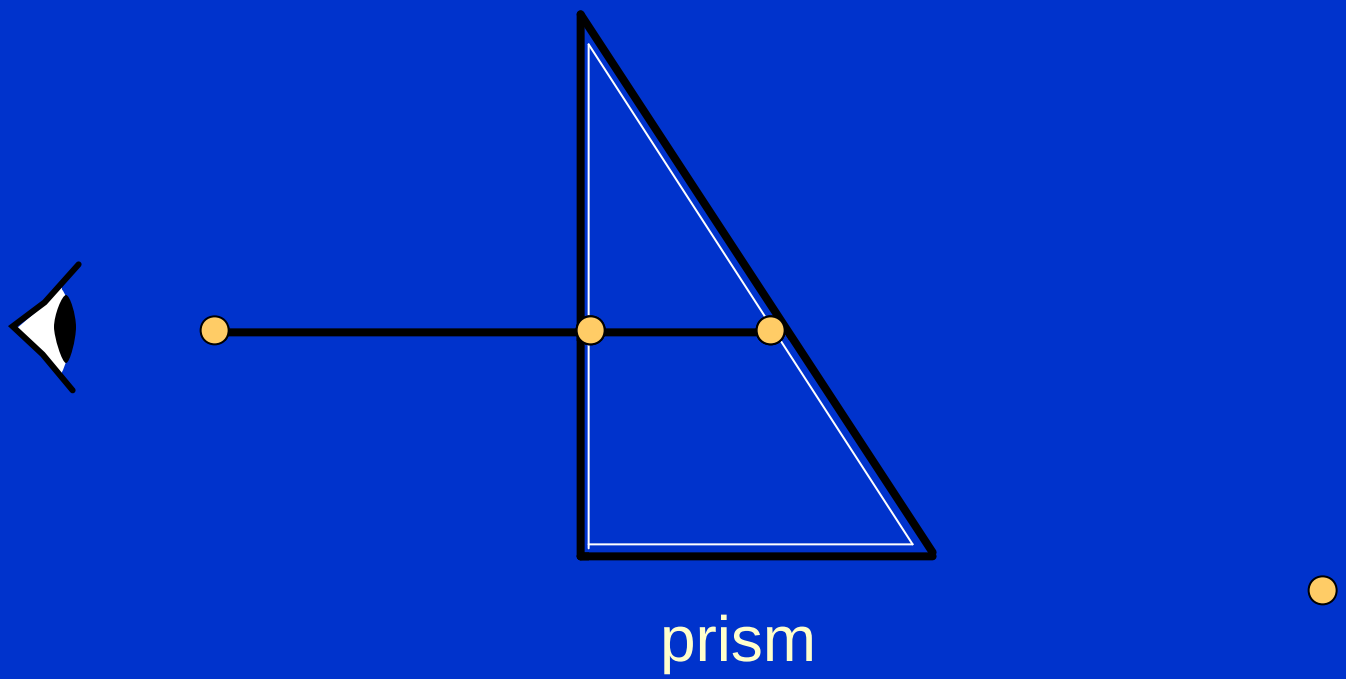

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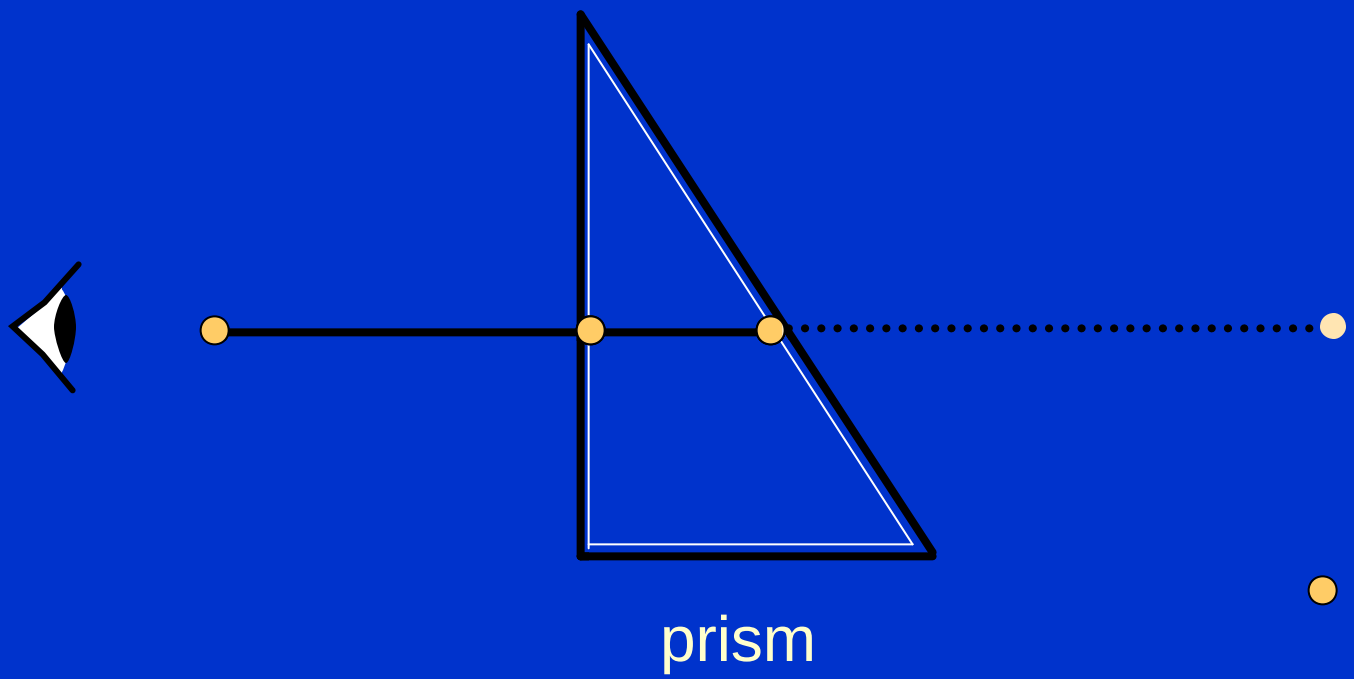

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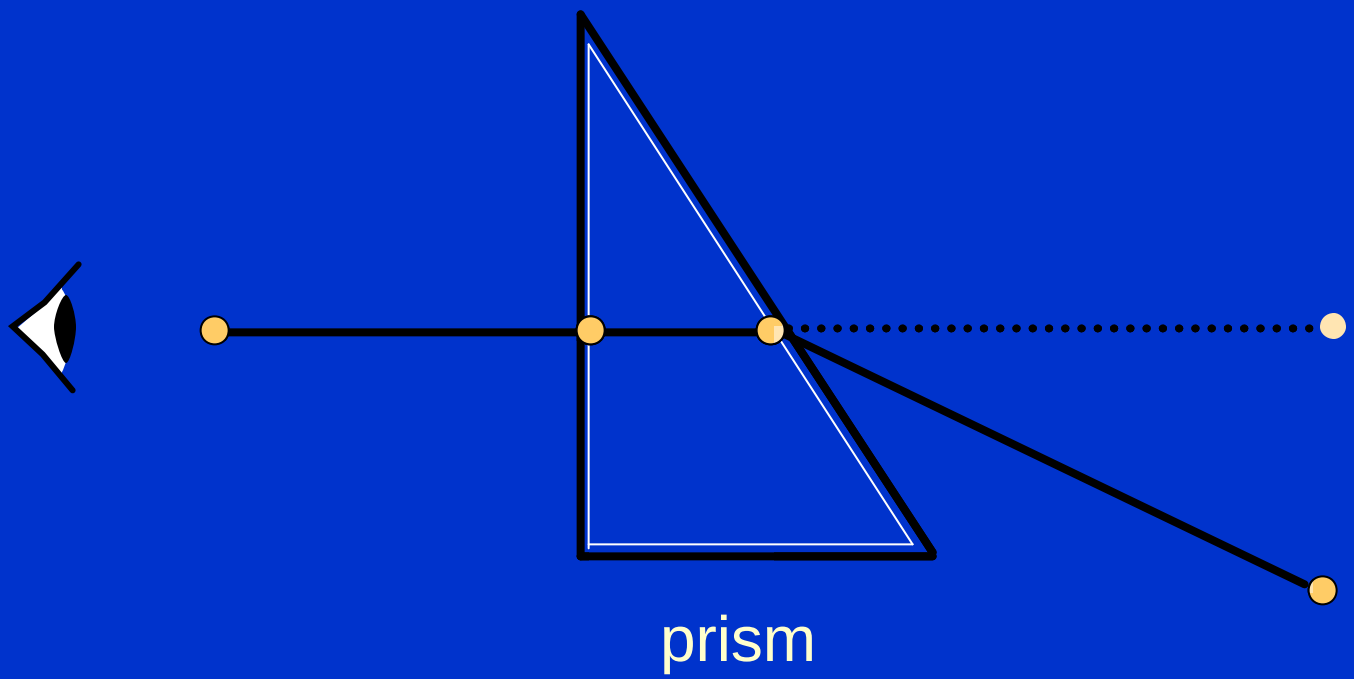

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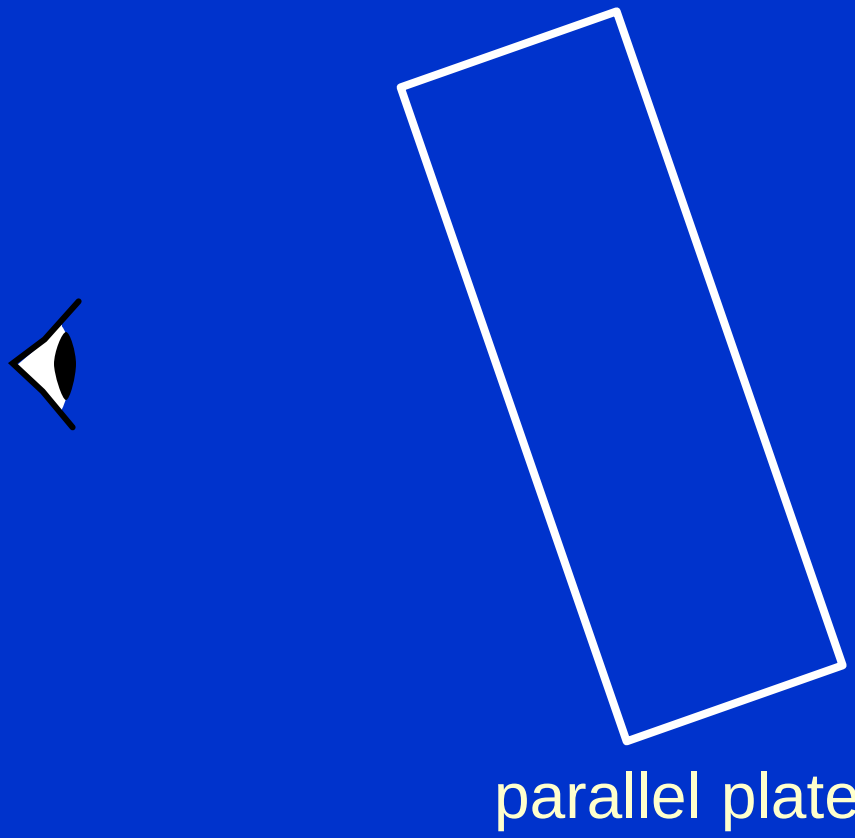

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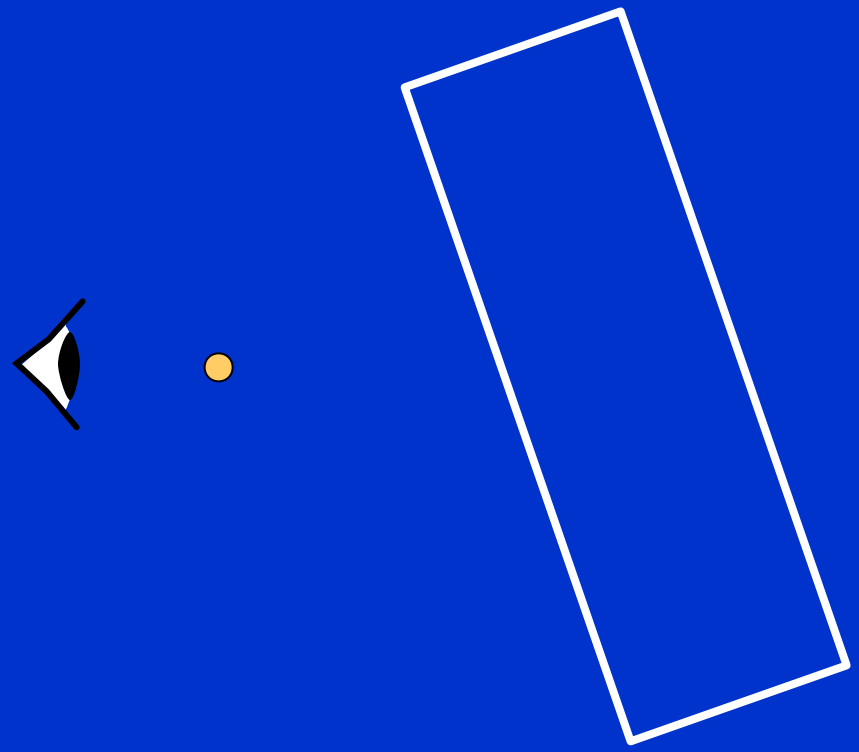

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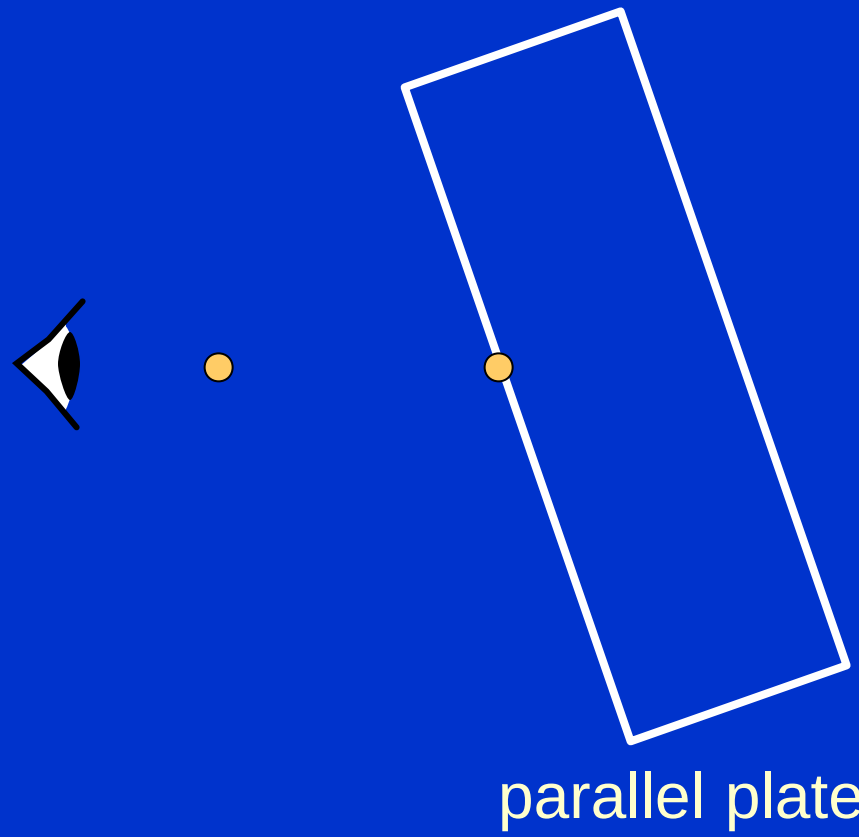

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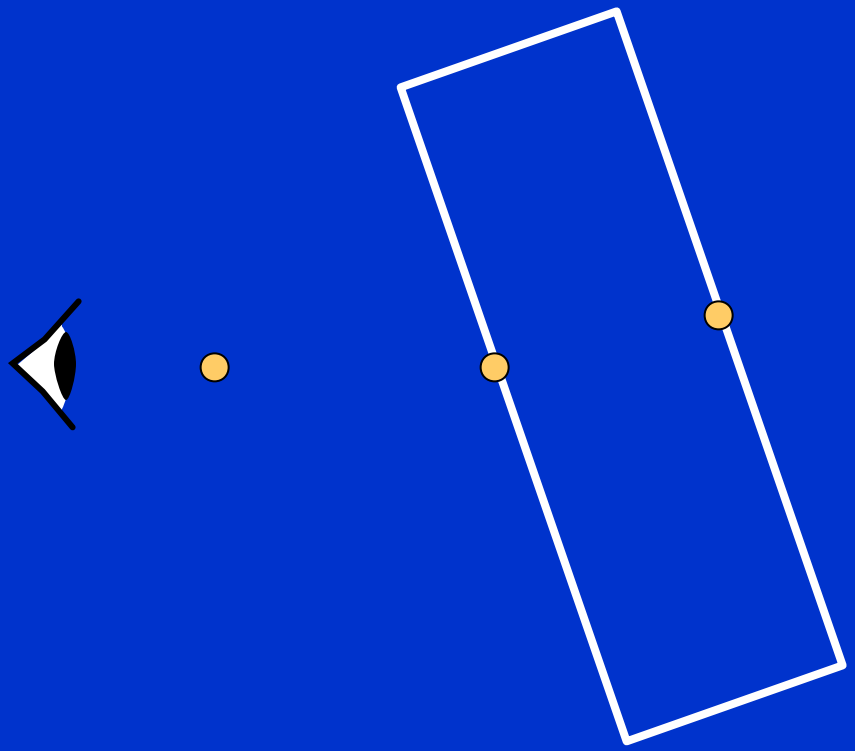

parallel plate

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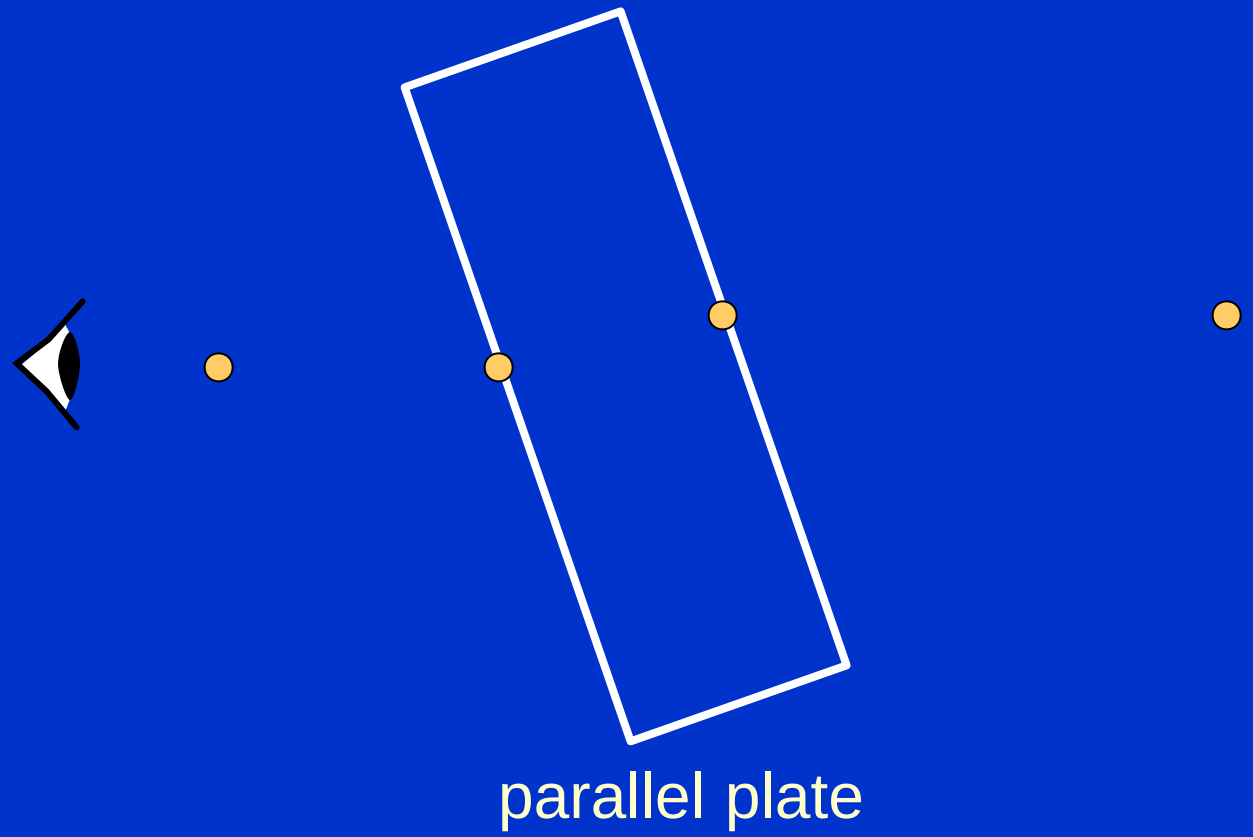

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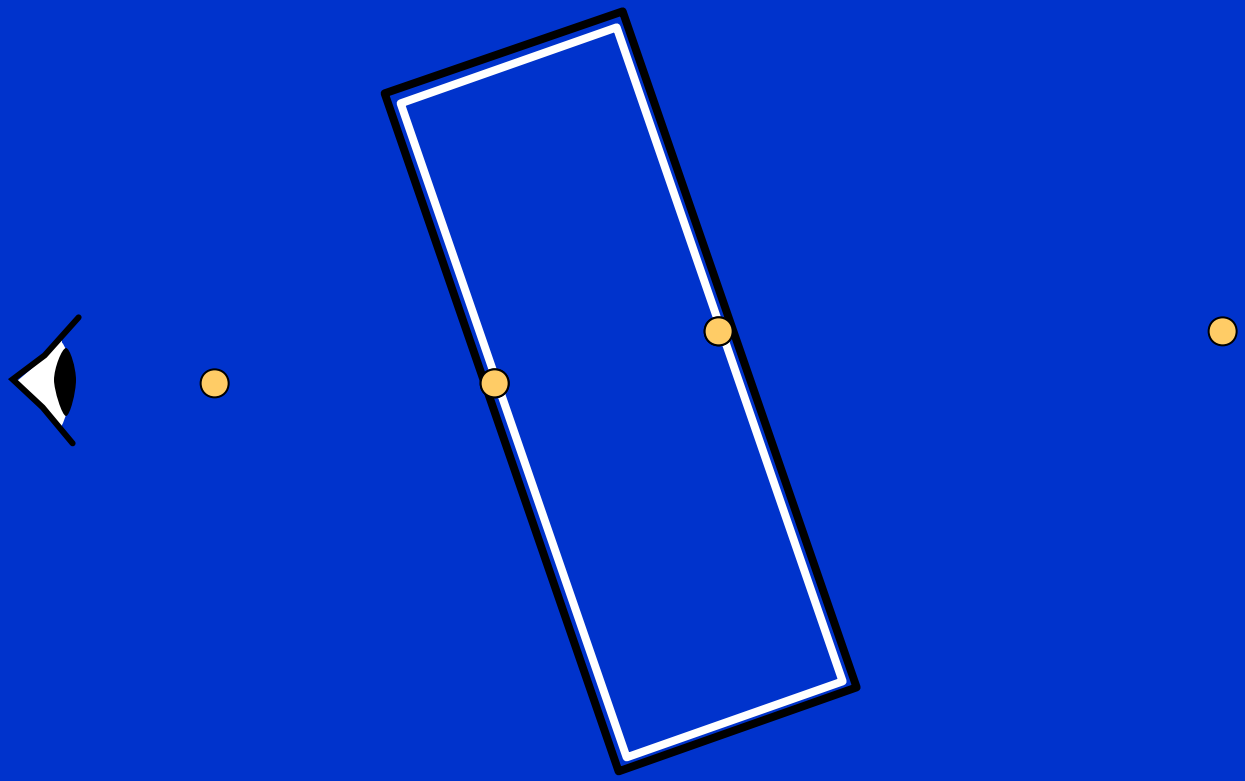

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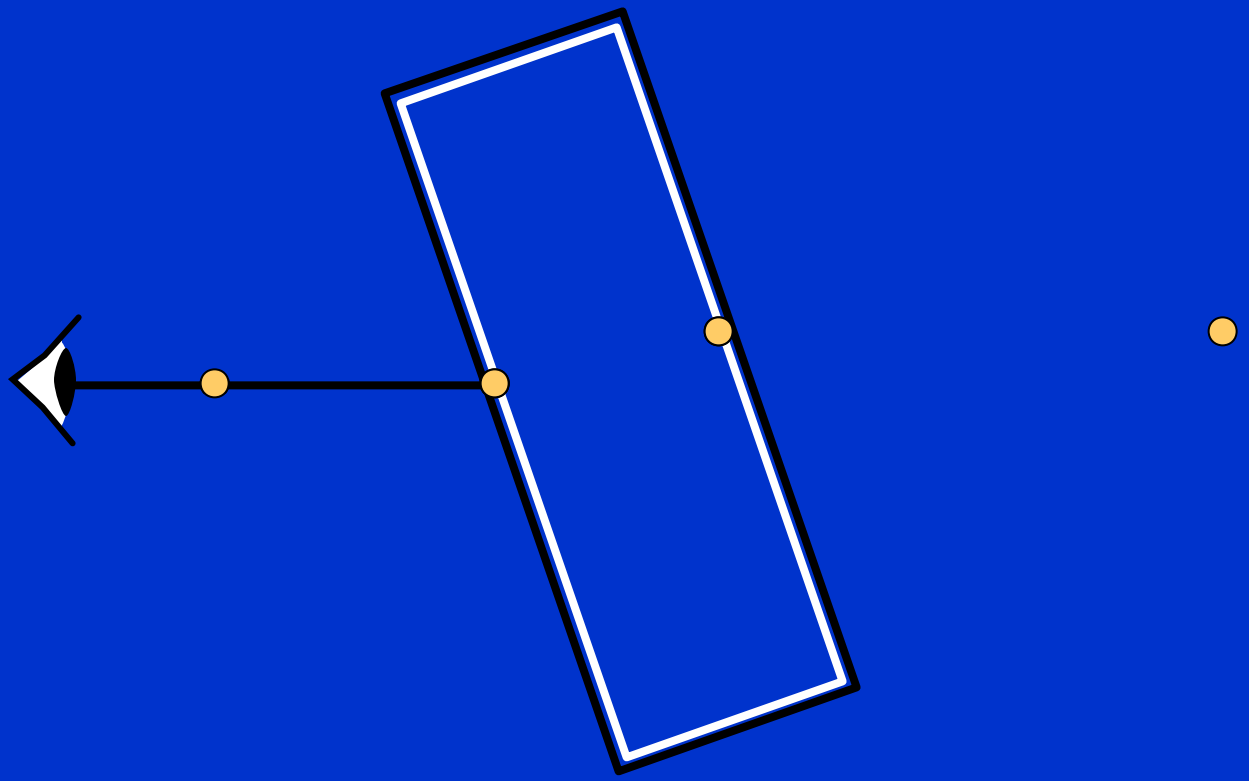

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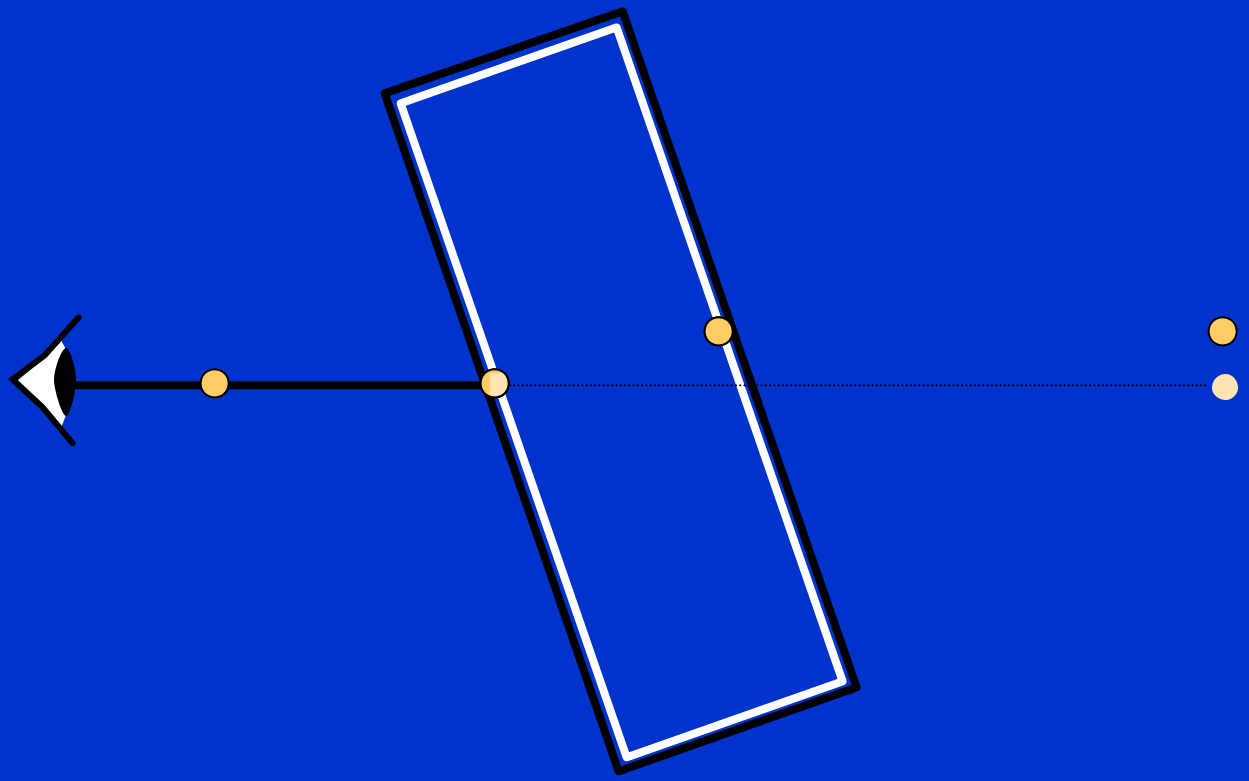

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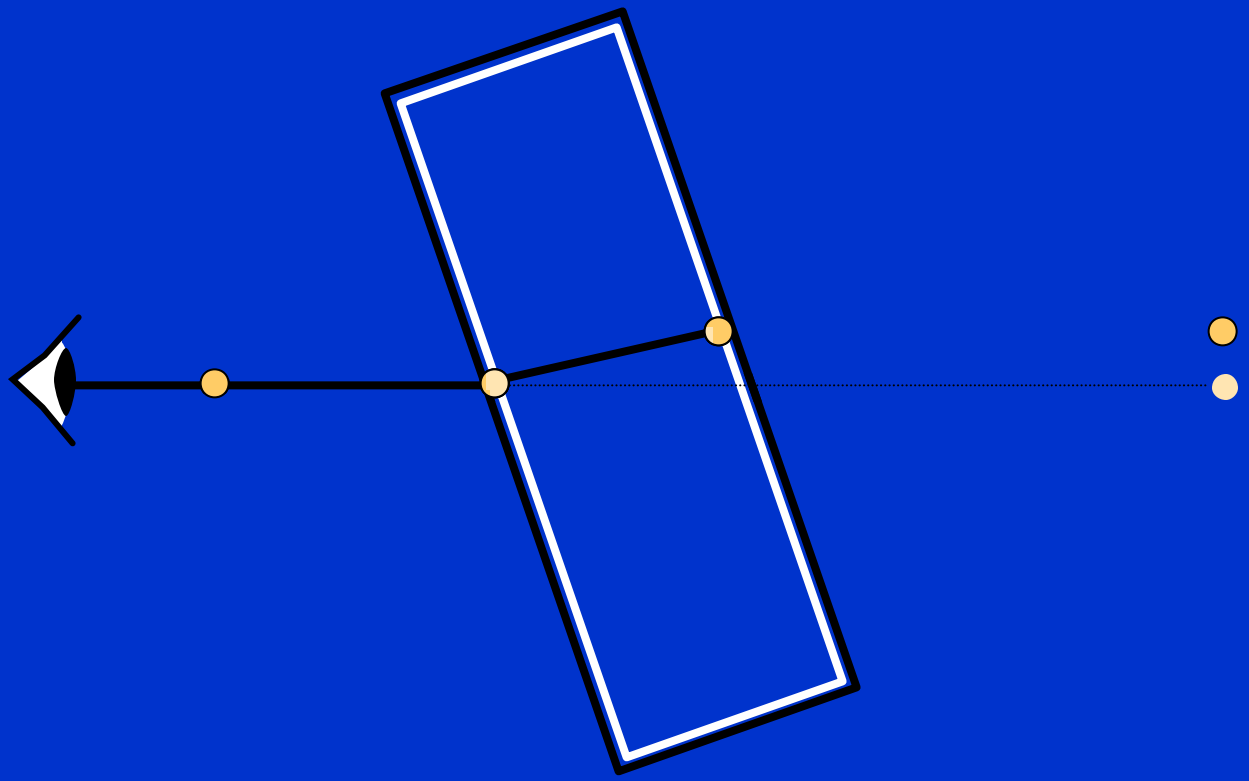

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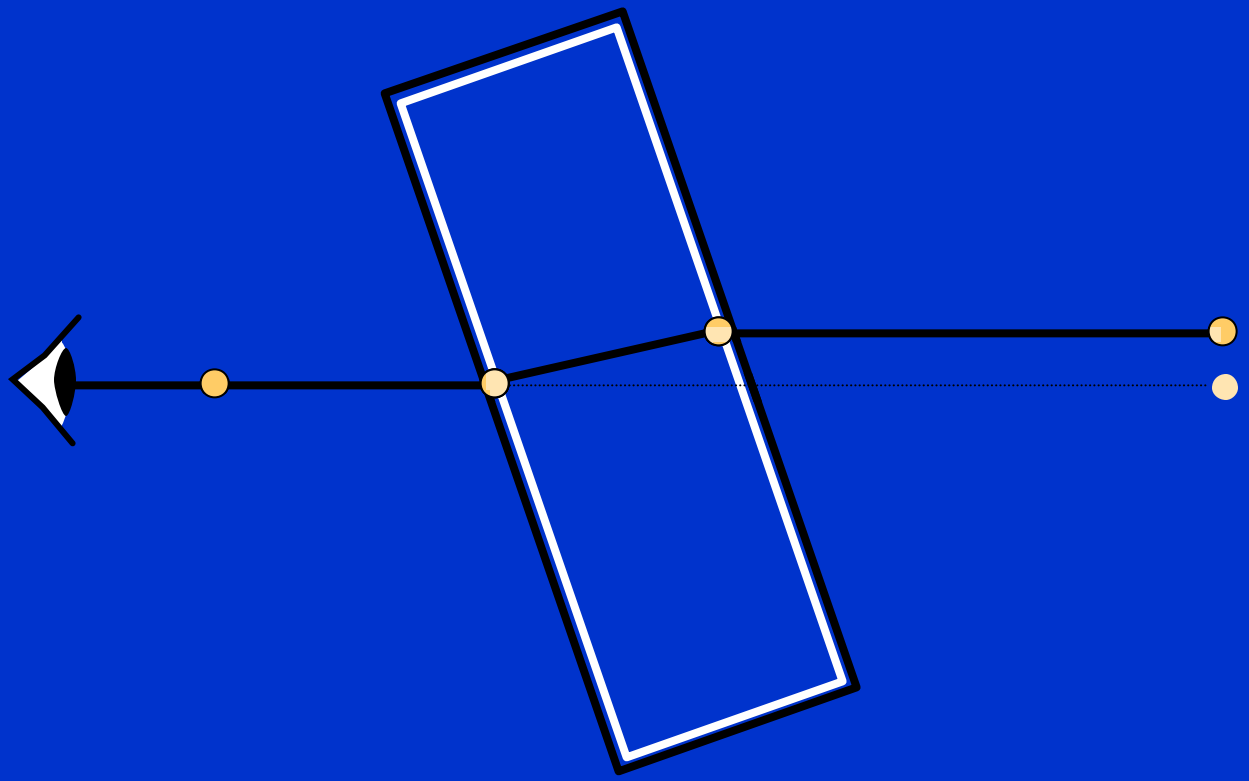

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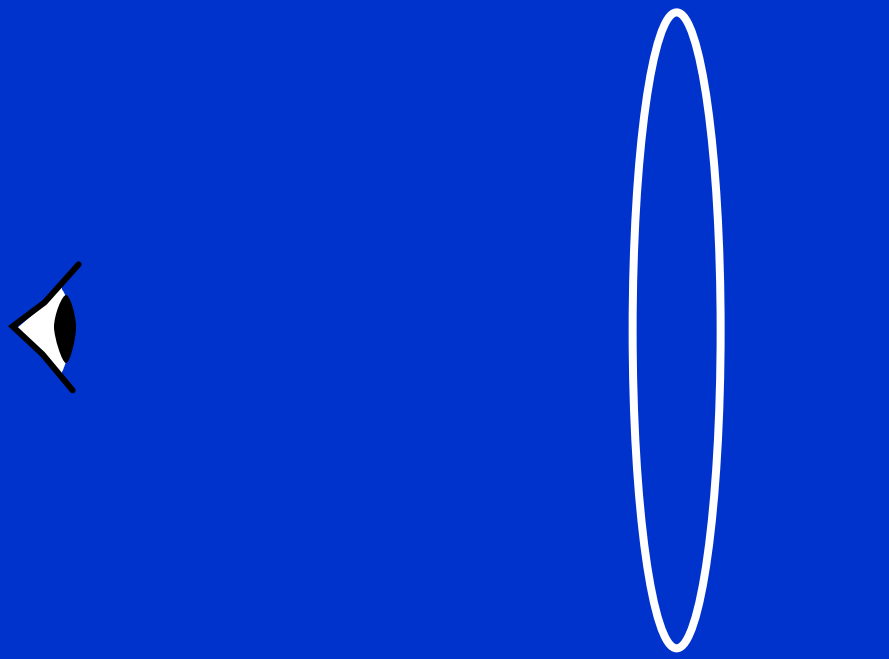

cylindrical lens

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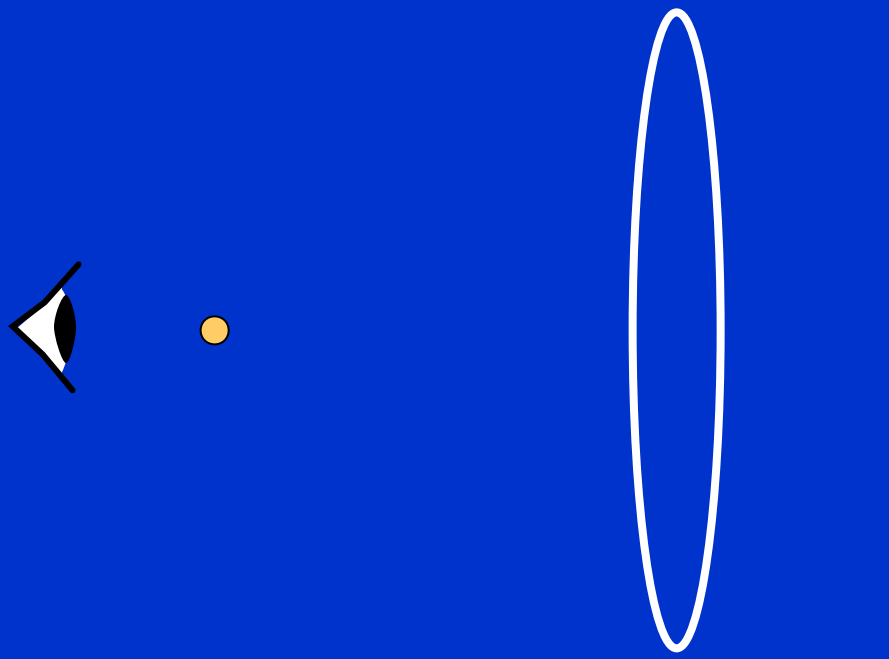

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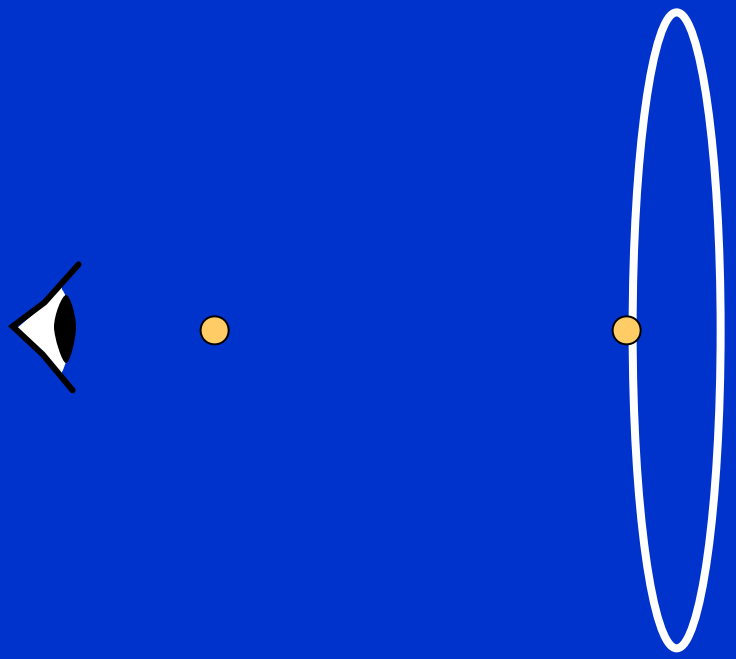

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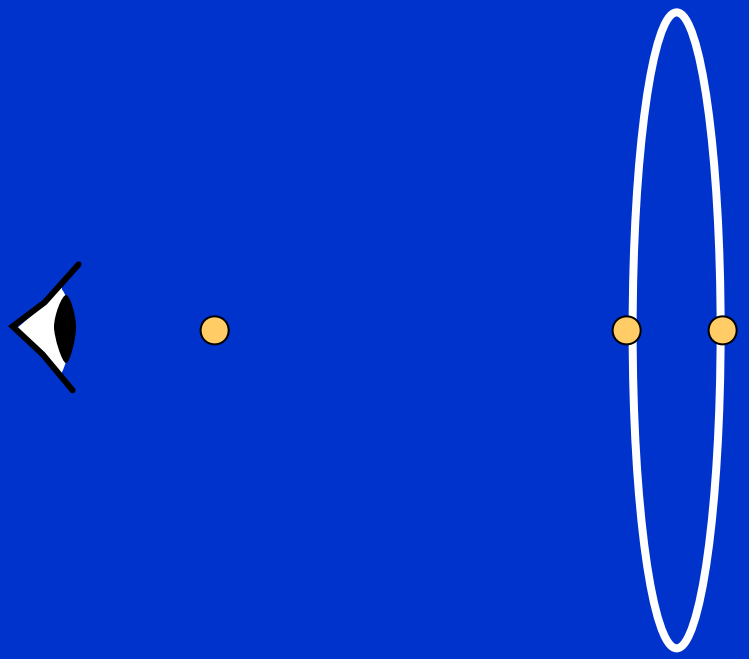

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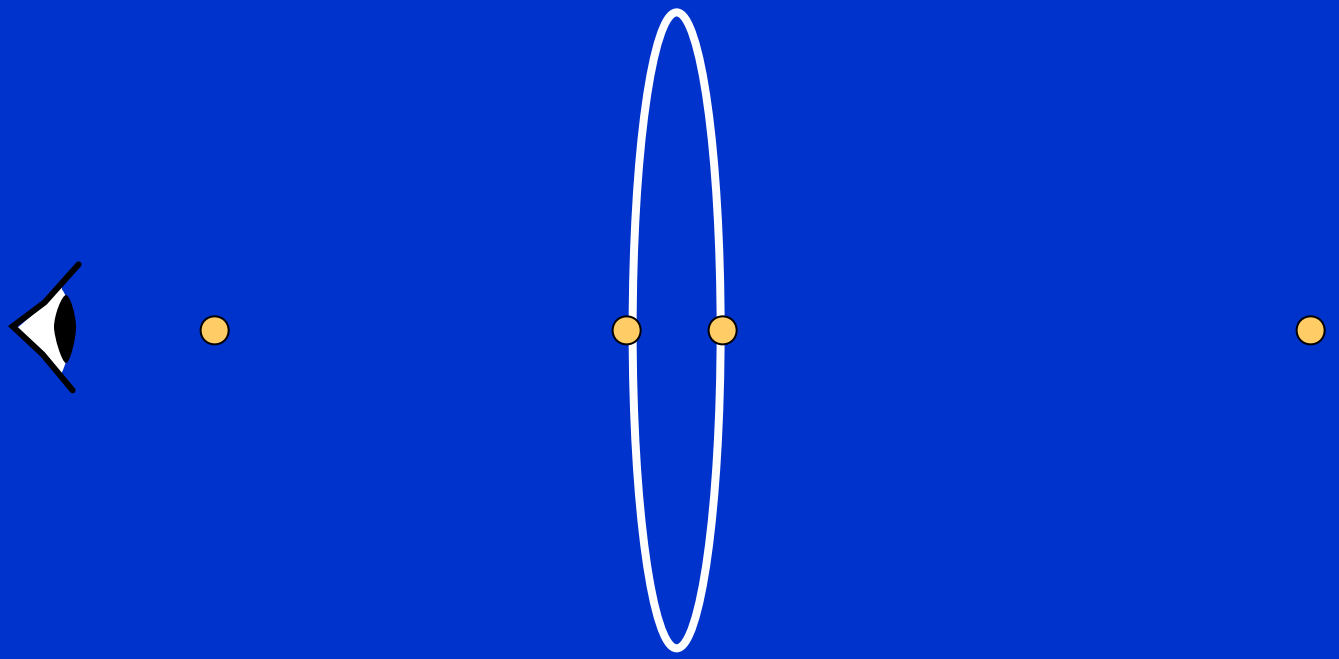
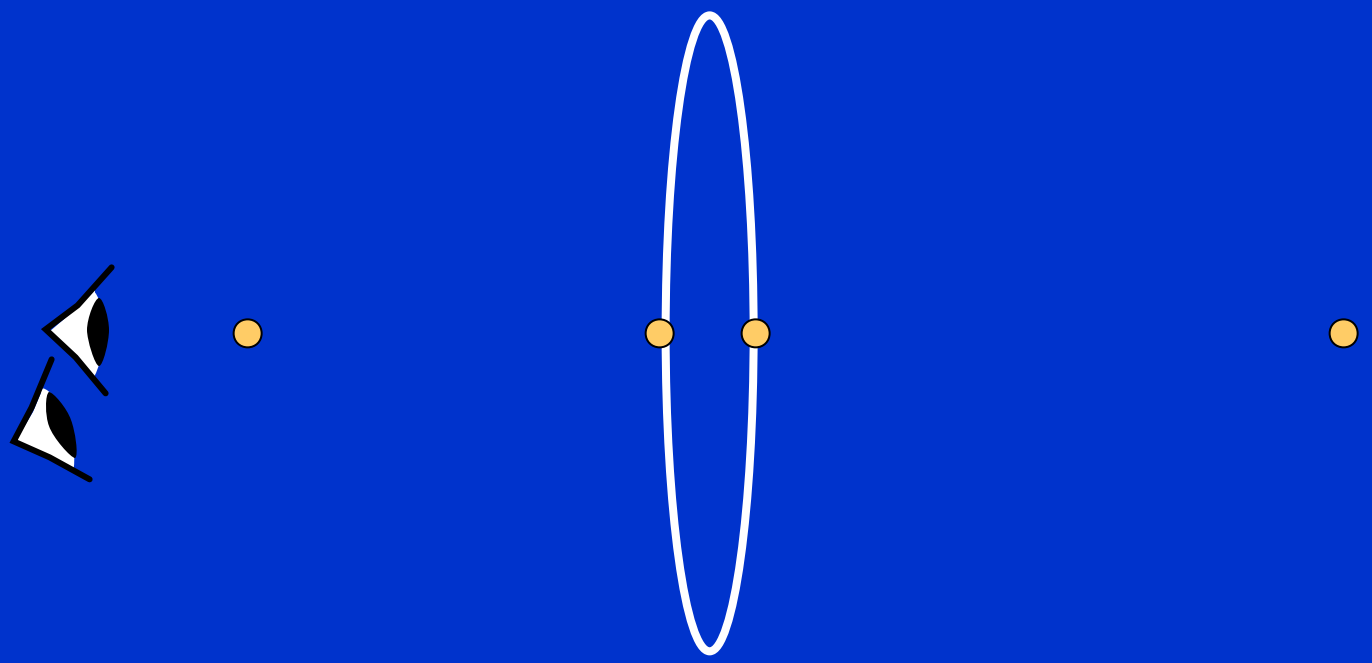


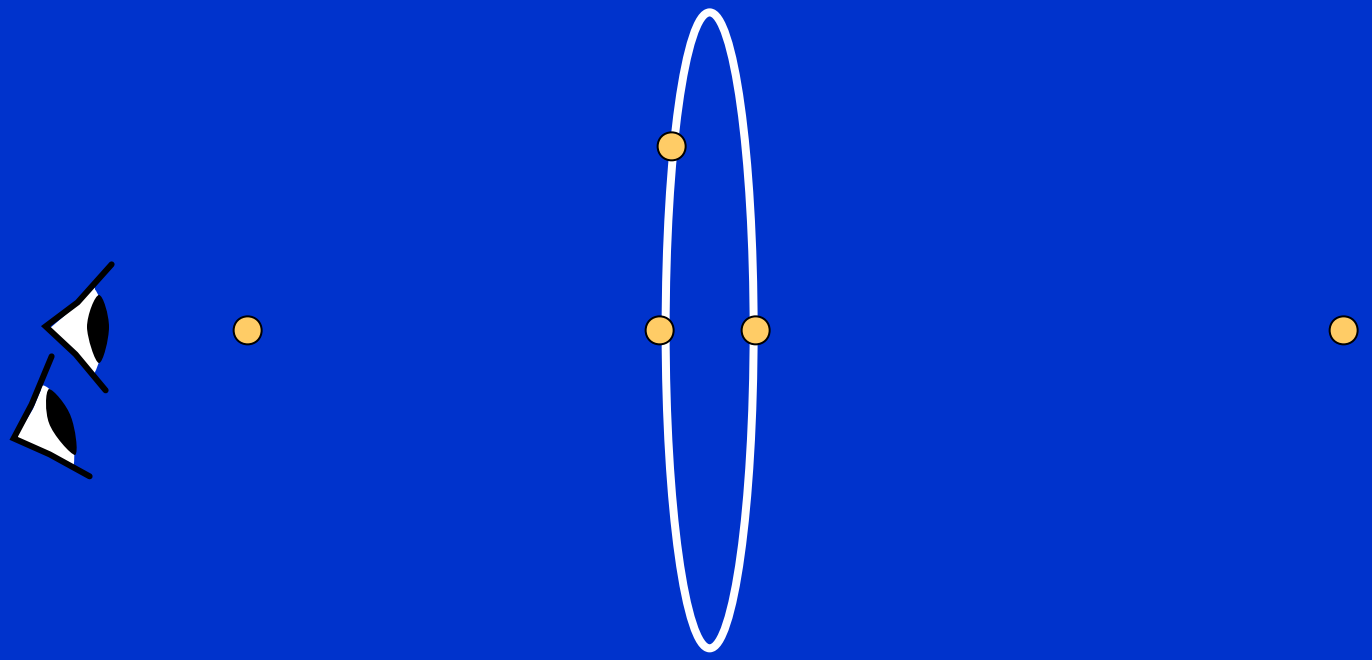
cylindrical lens

Visual (Pin) Ray Tracing



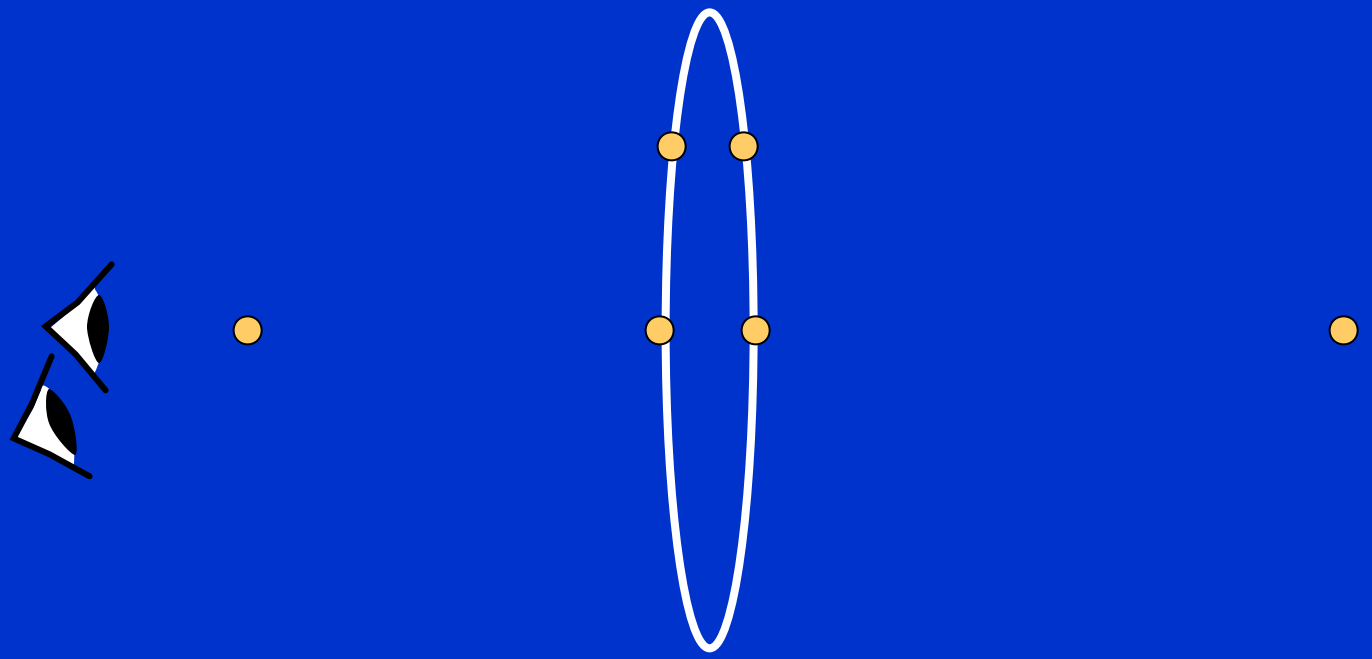
cylindrical lens

Visual (Pin) Ray Tracing



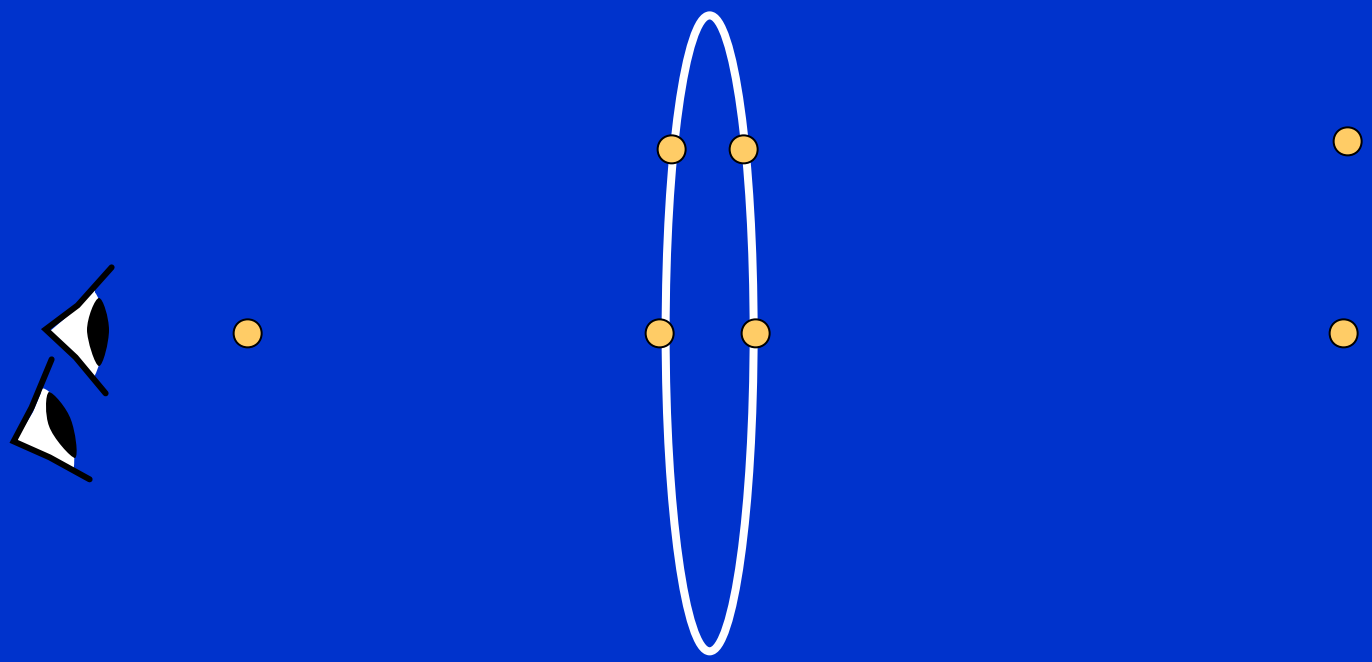
cylindrical lens

Visual (Pin) Ray Tracing



cylindrical lens

Visual (Pin) Ray Tracing



cylindrical lens

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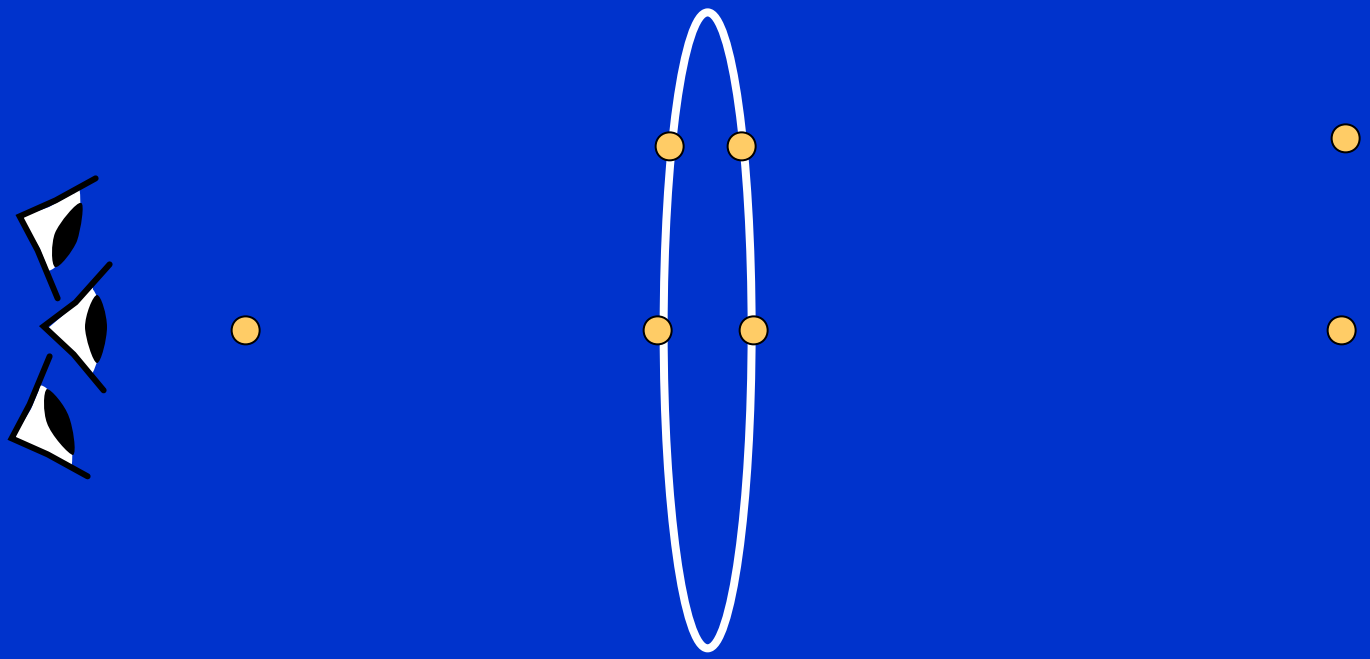

cylindrical lens

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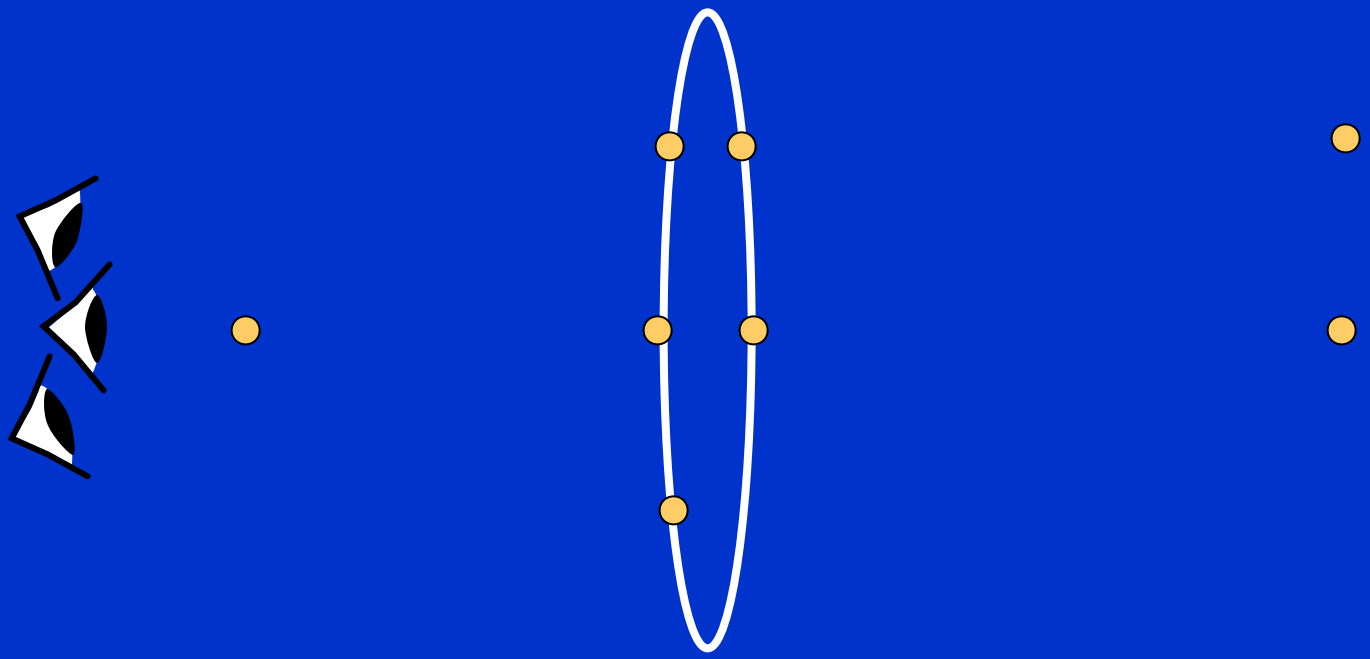

cylindrical lens

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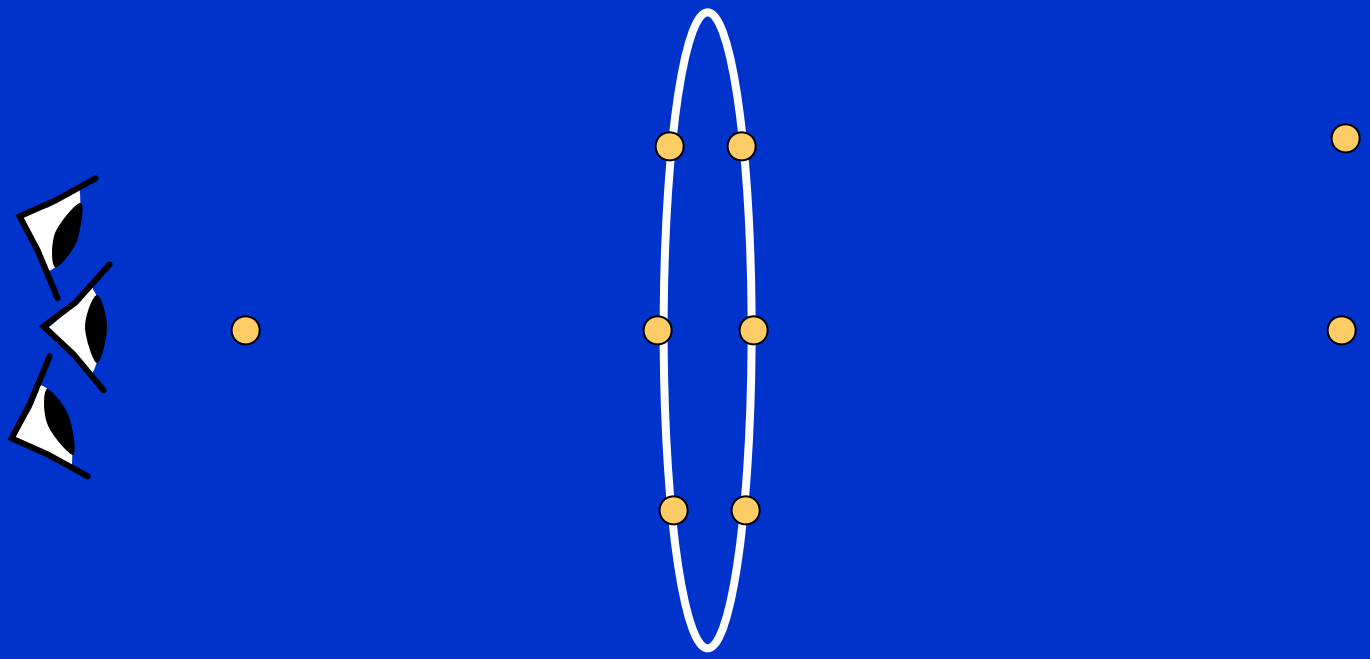

cylindrical lens

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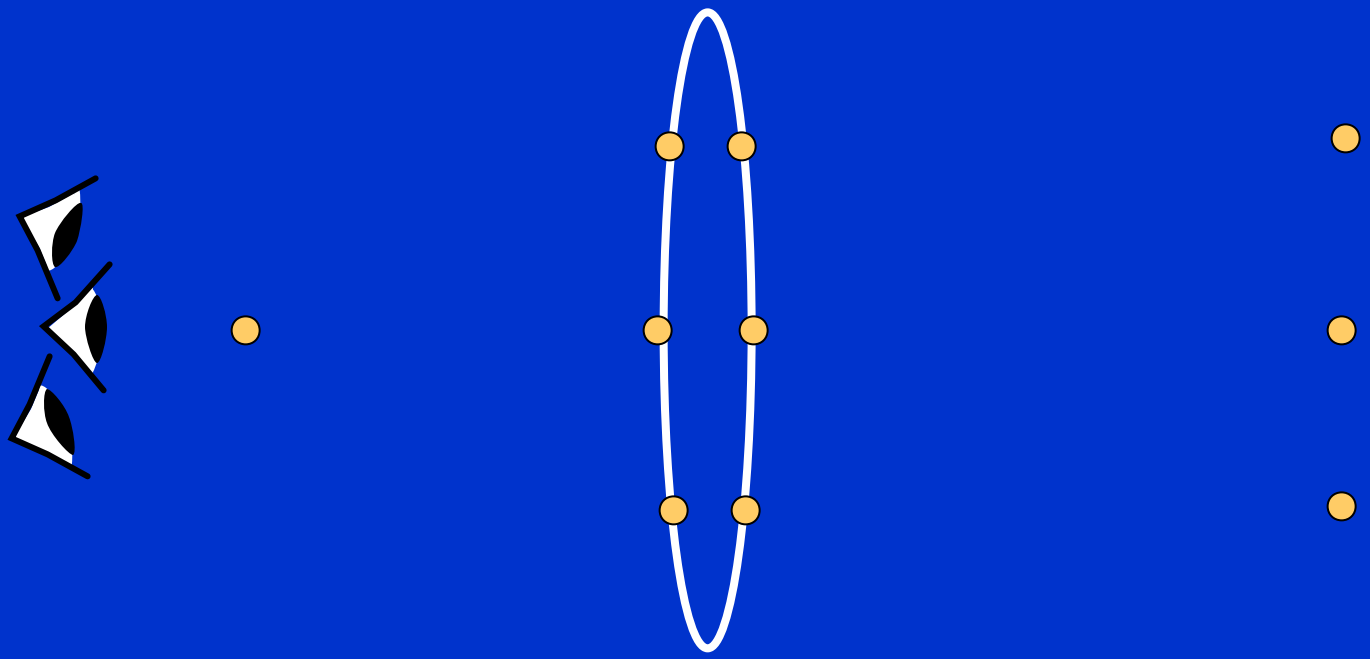
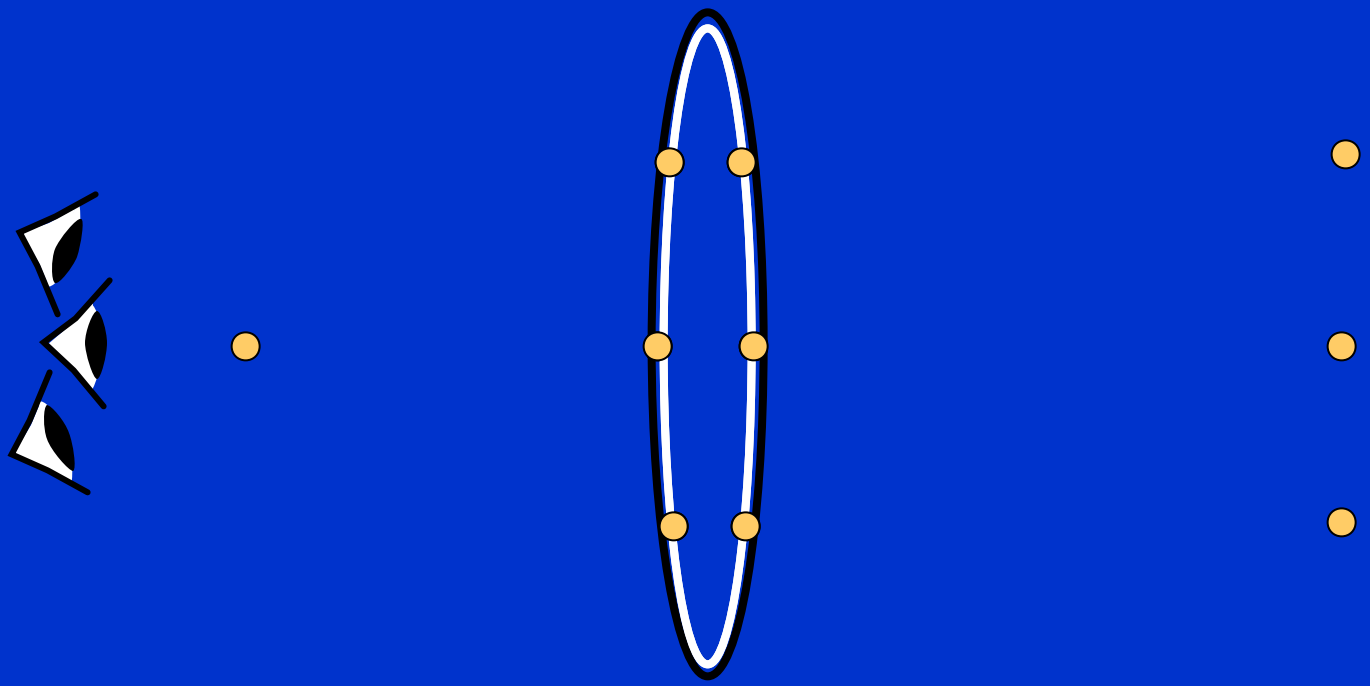


cylindrical lens

Visual (Pin) Ray Tracing



cylindrical lens

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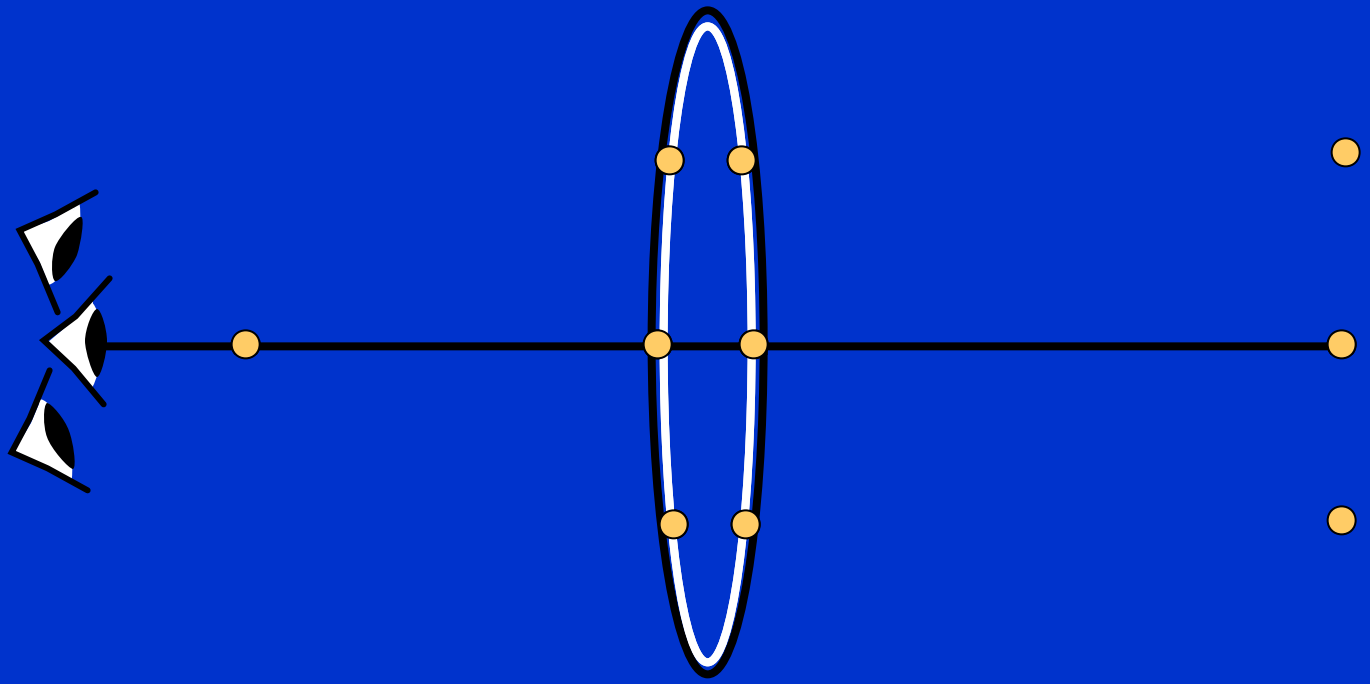
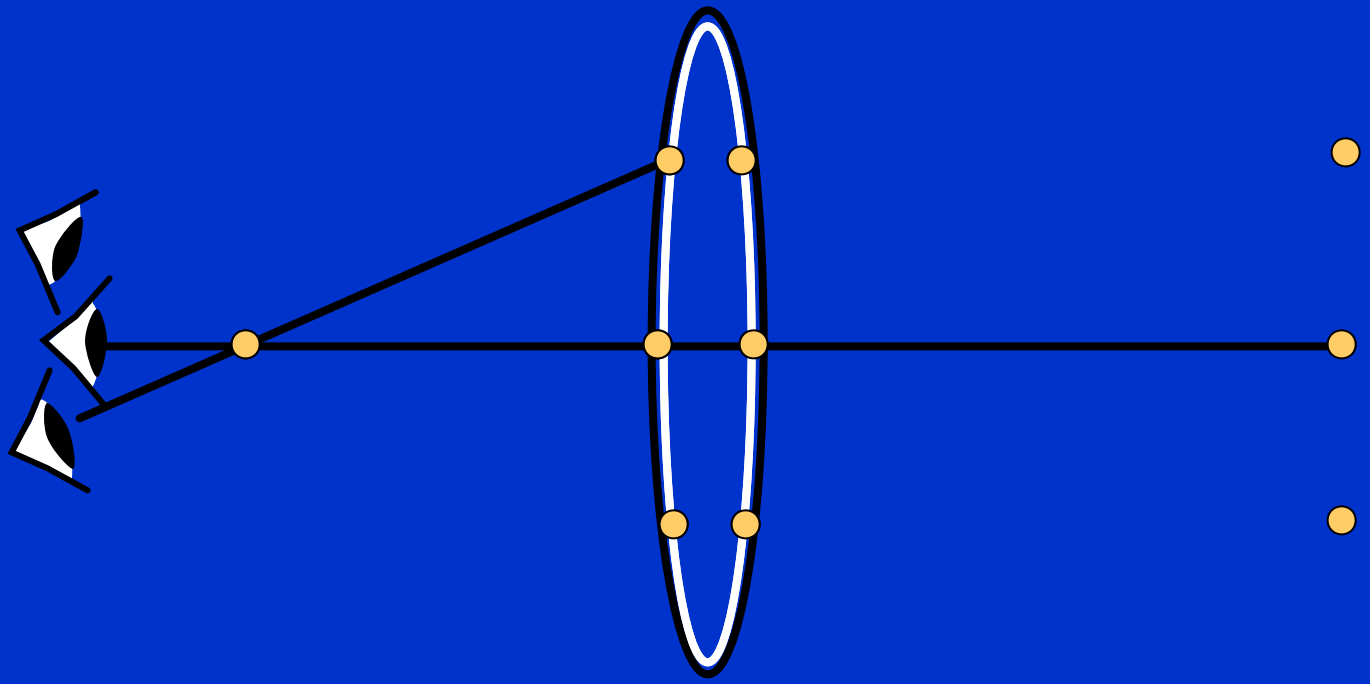


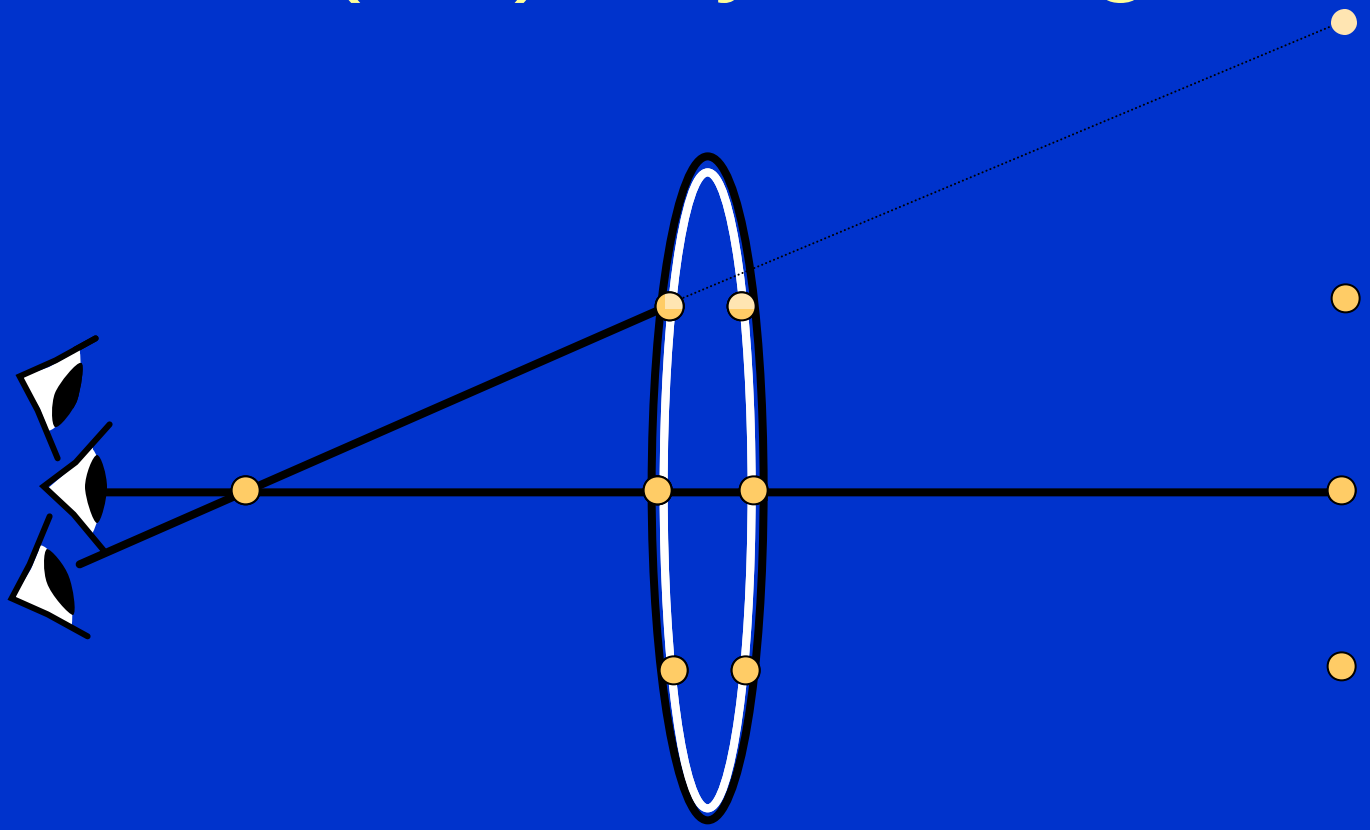
cylindrical lens

Visual (Pin) Ray Tracing



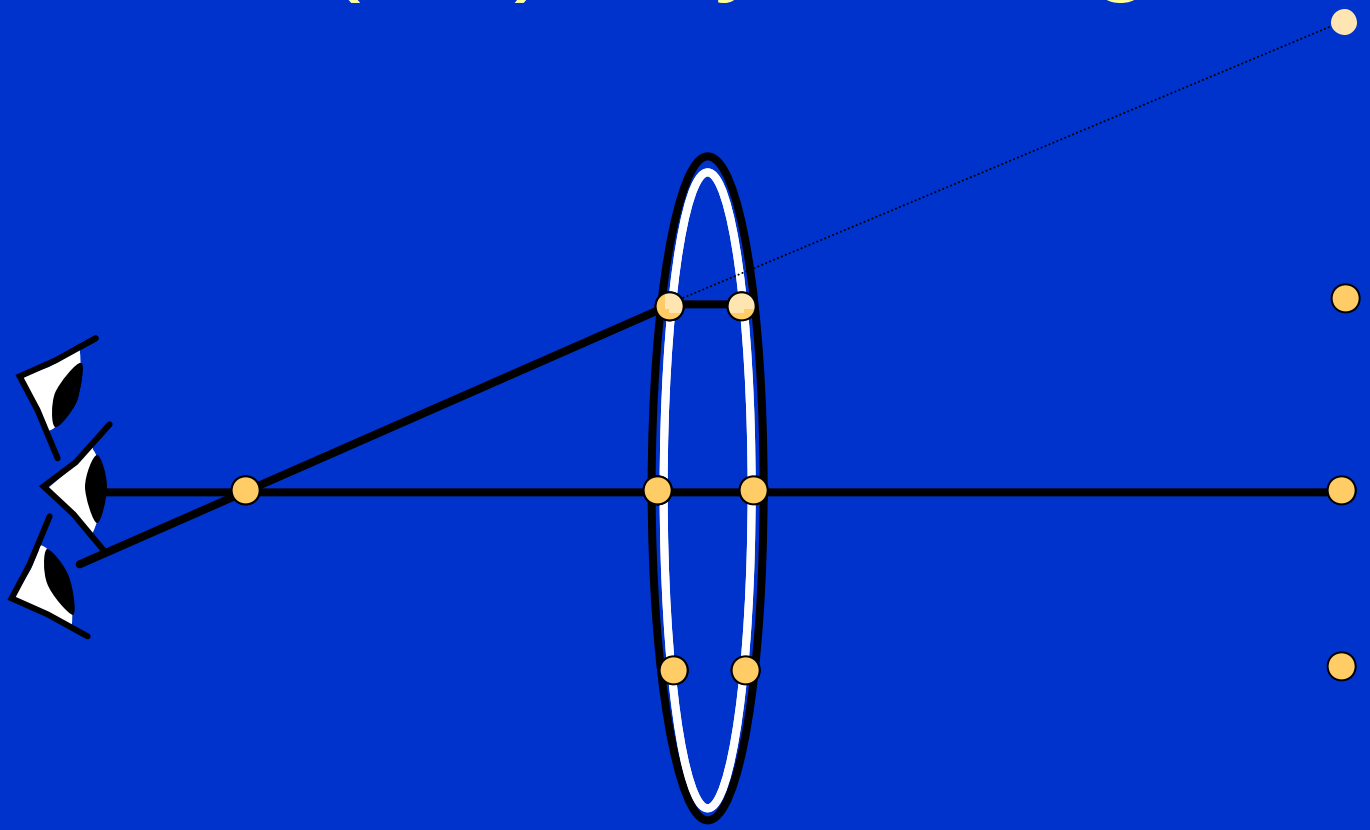
cylindrical lens

Visual (Pin) Ray Tracing



cylindrical lens

Visual (Pin) Ray Tracing



cylindrical lens

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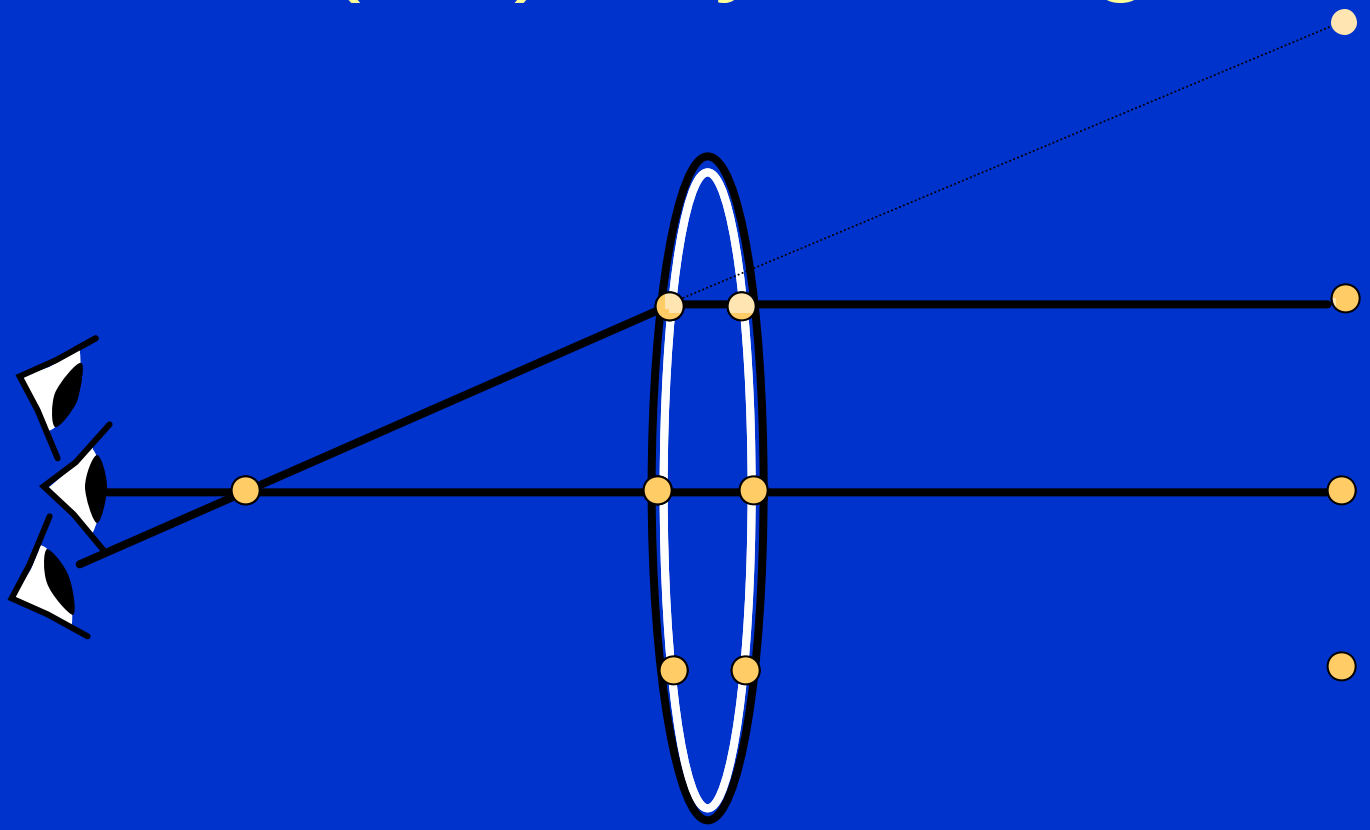
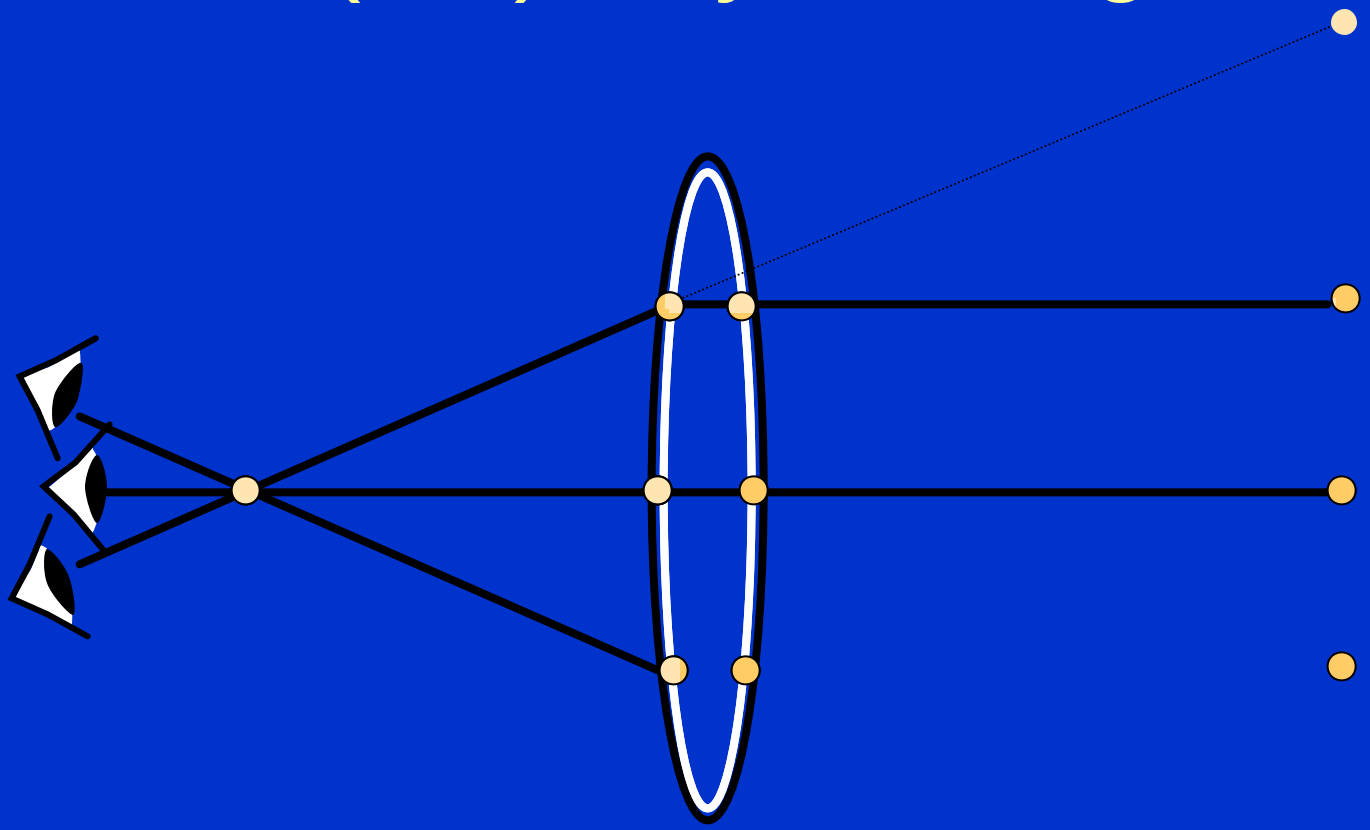


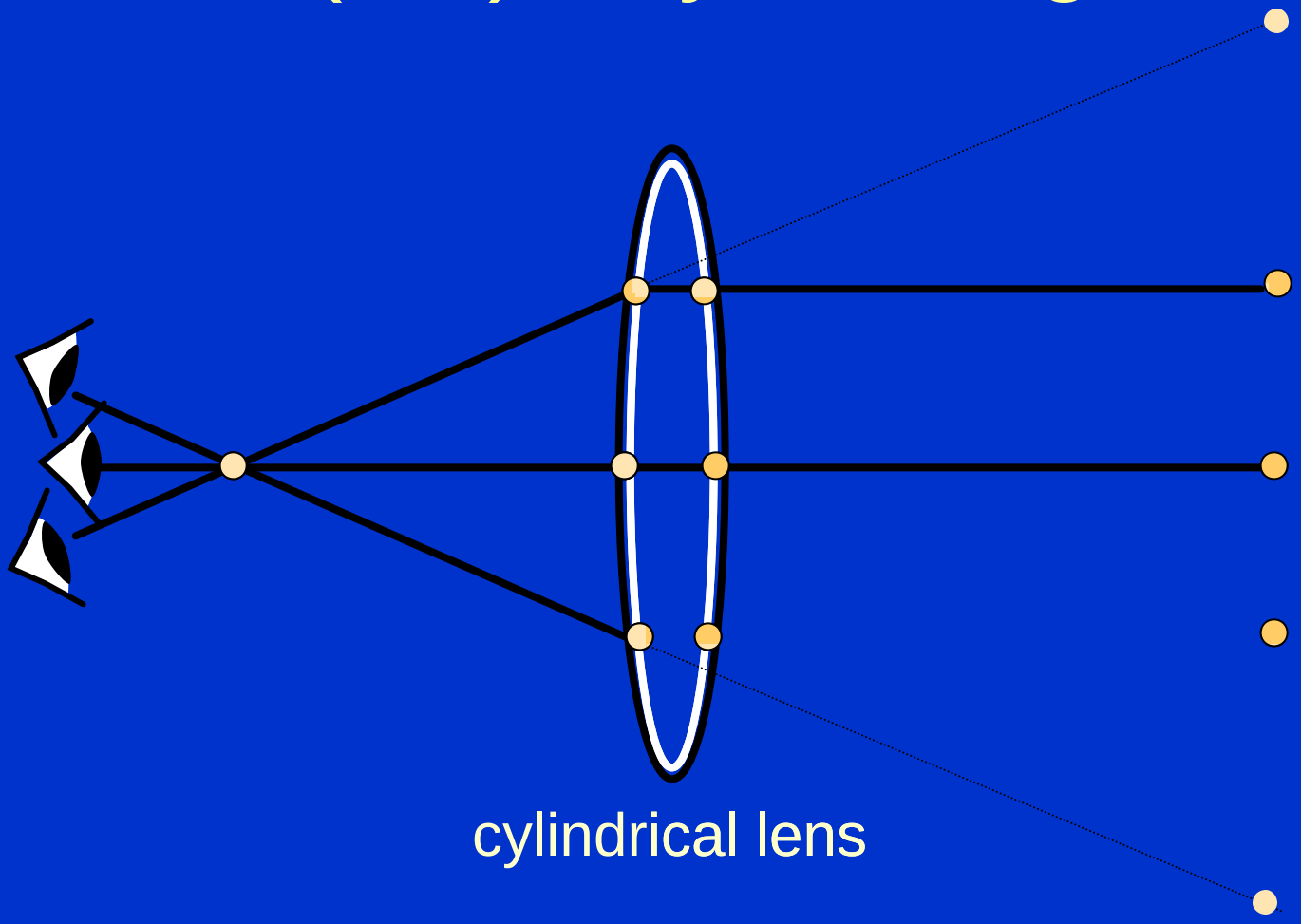
cylindrical lens

Visual (Pin) Ray Tracing



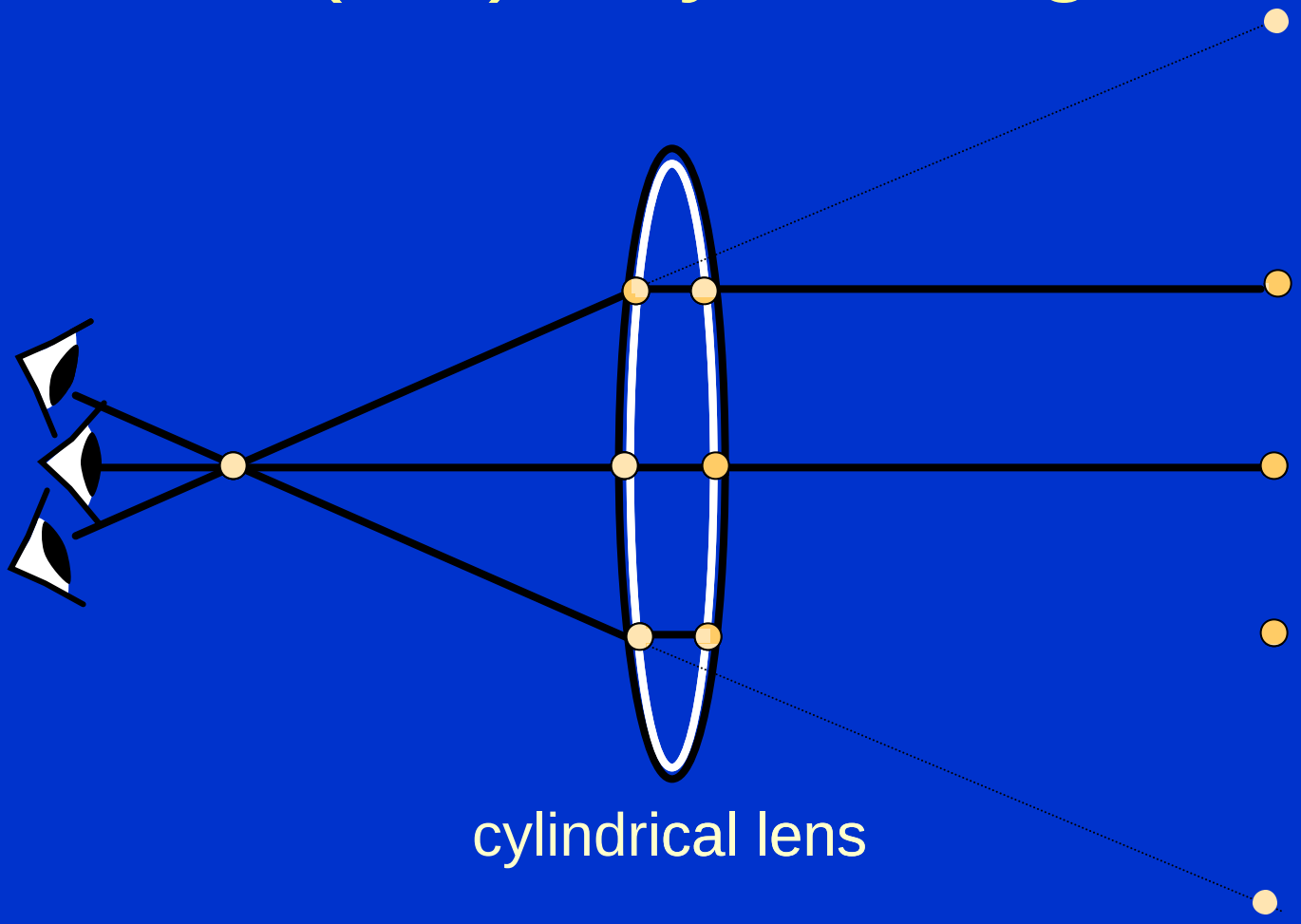
cylindrical lens

Visual (Pin) Ray Tracing



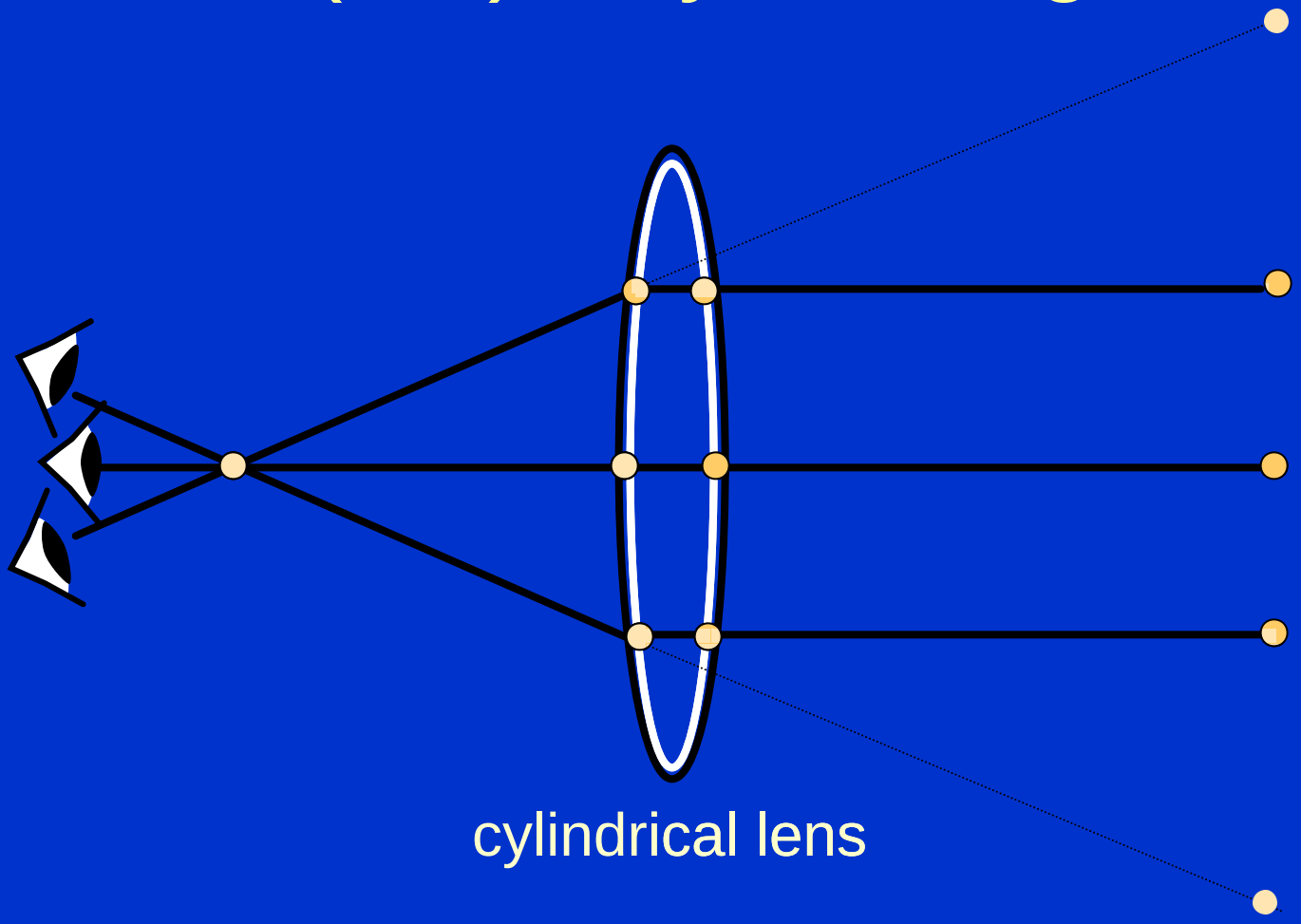
cylindrical lens

Visual (Pin) Ray Tracing



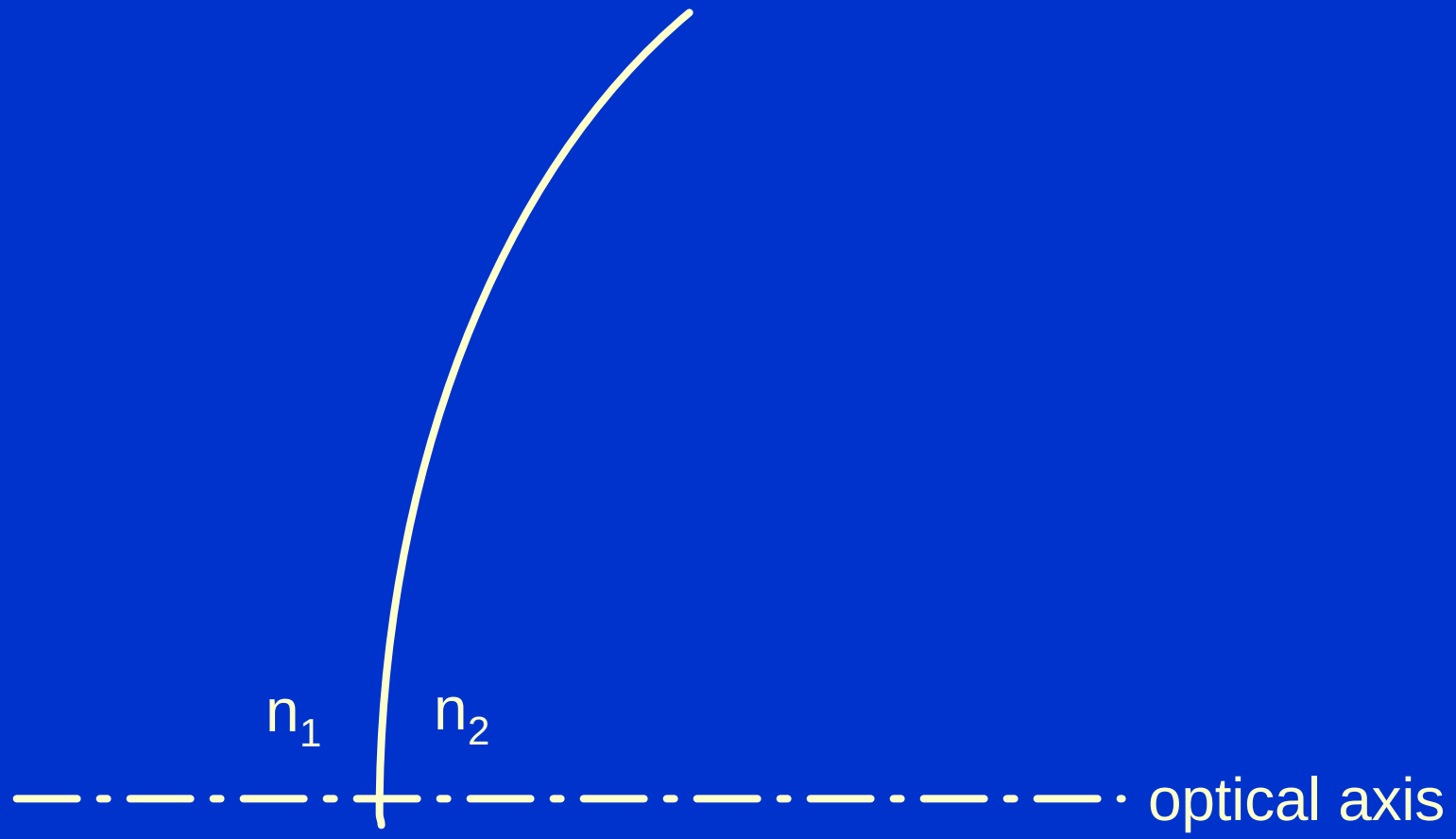
cylindrical lens

Visual (Pin) Ray Tracing



cylindrical lens

Graphical Ray Tracing



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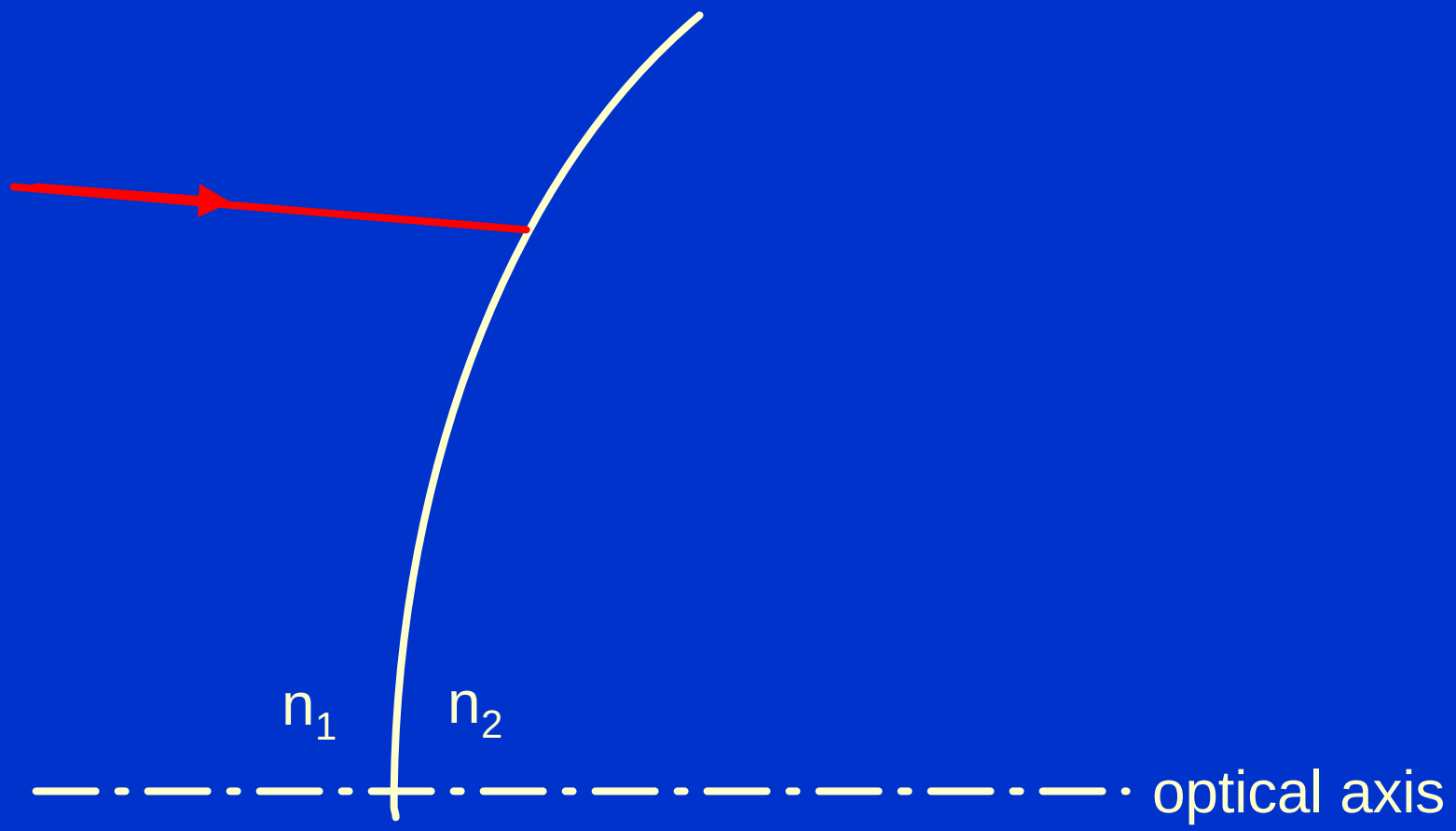

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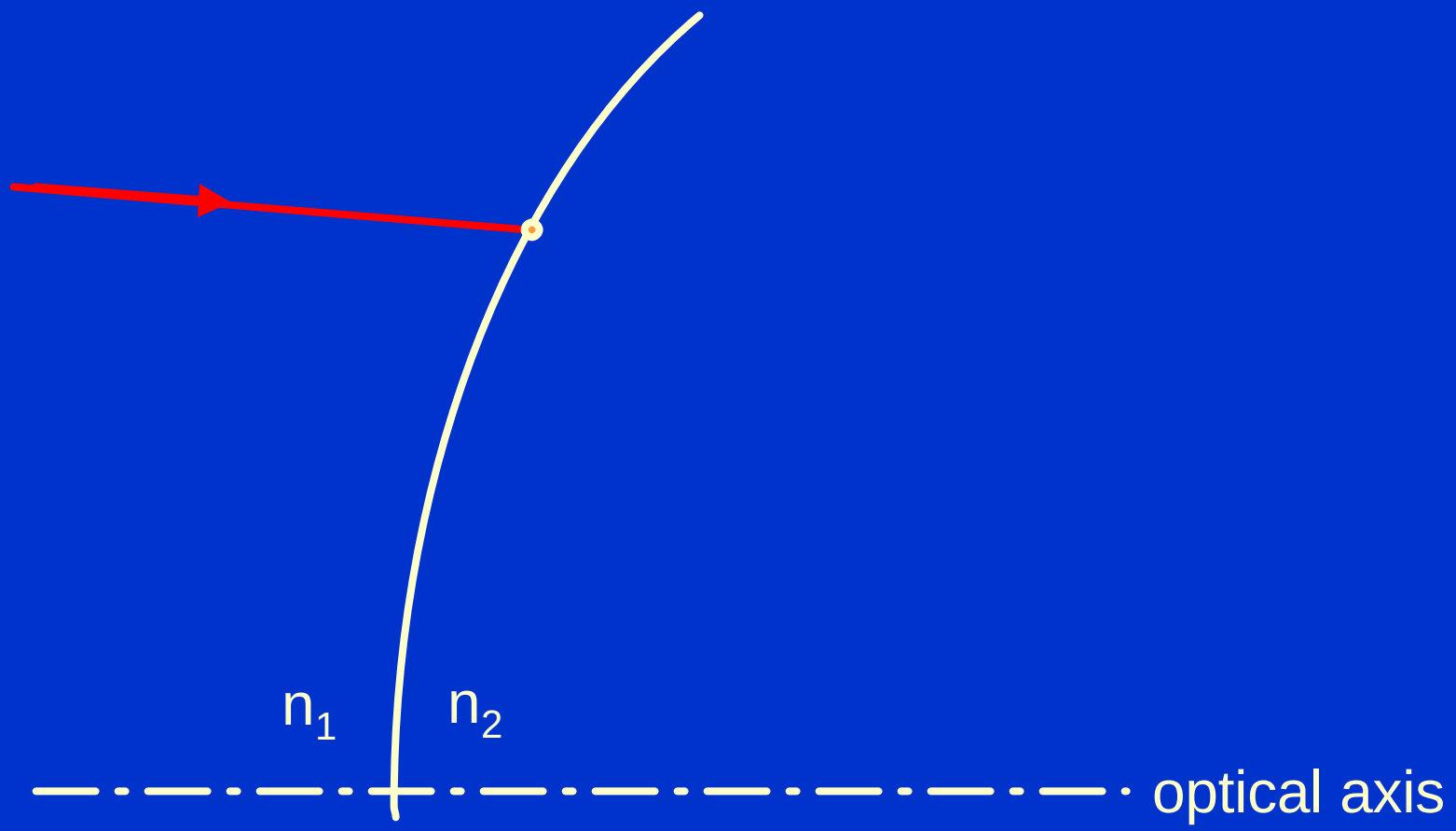

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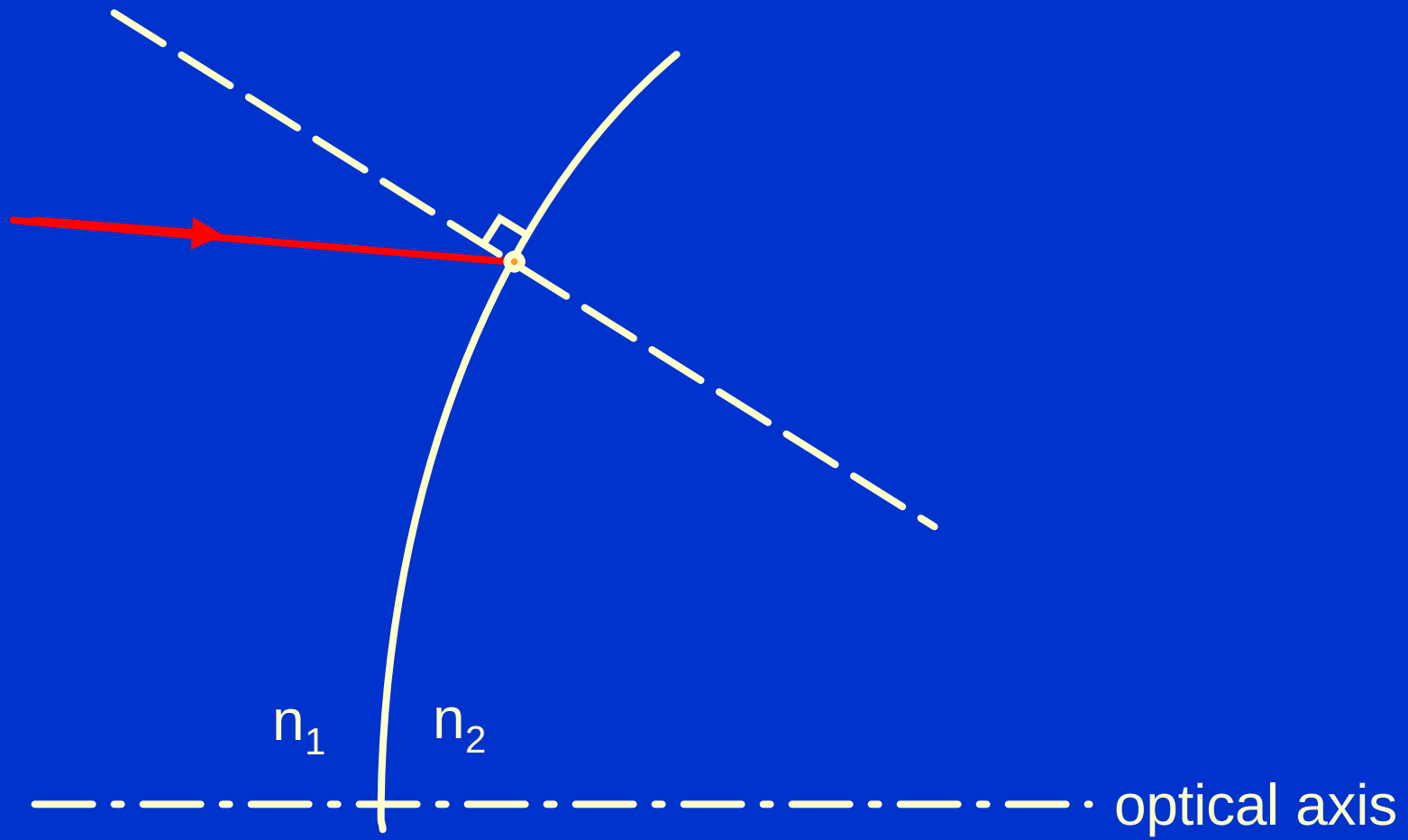

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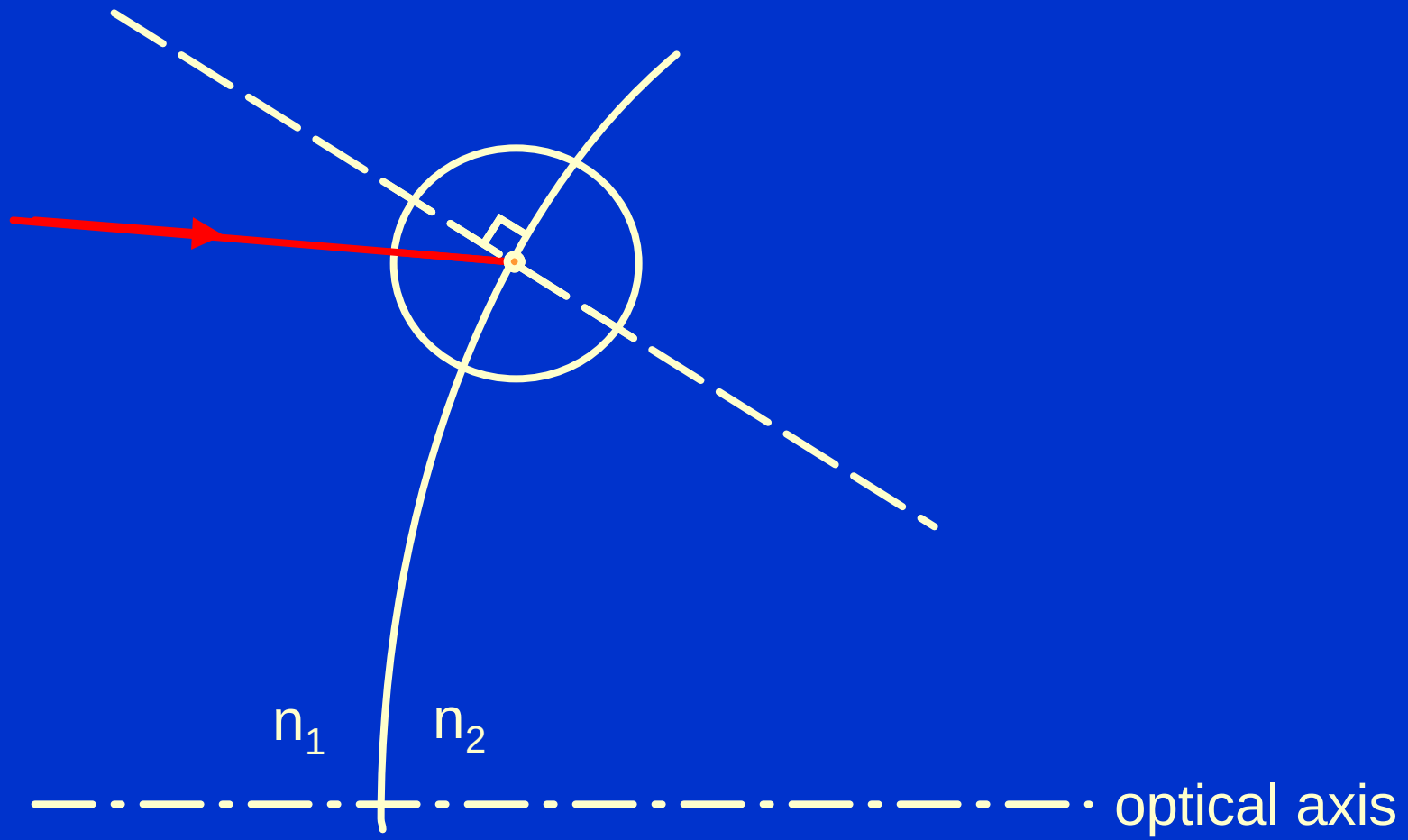

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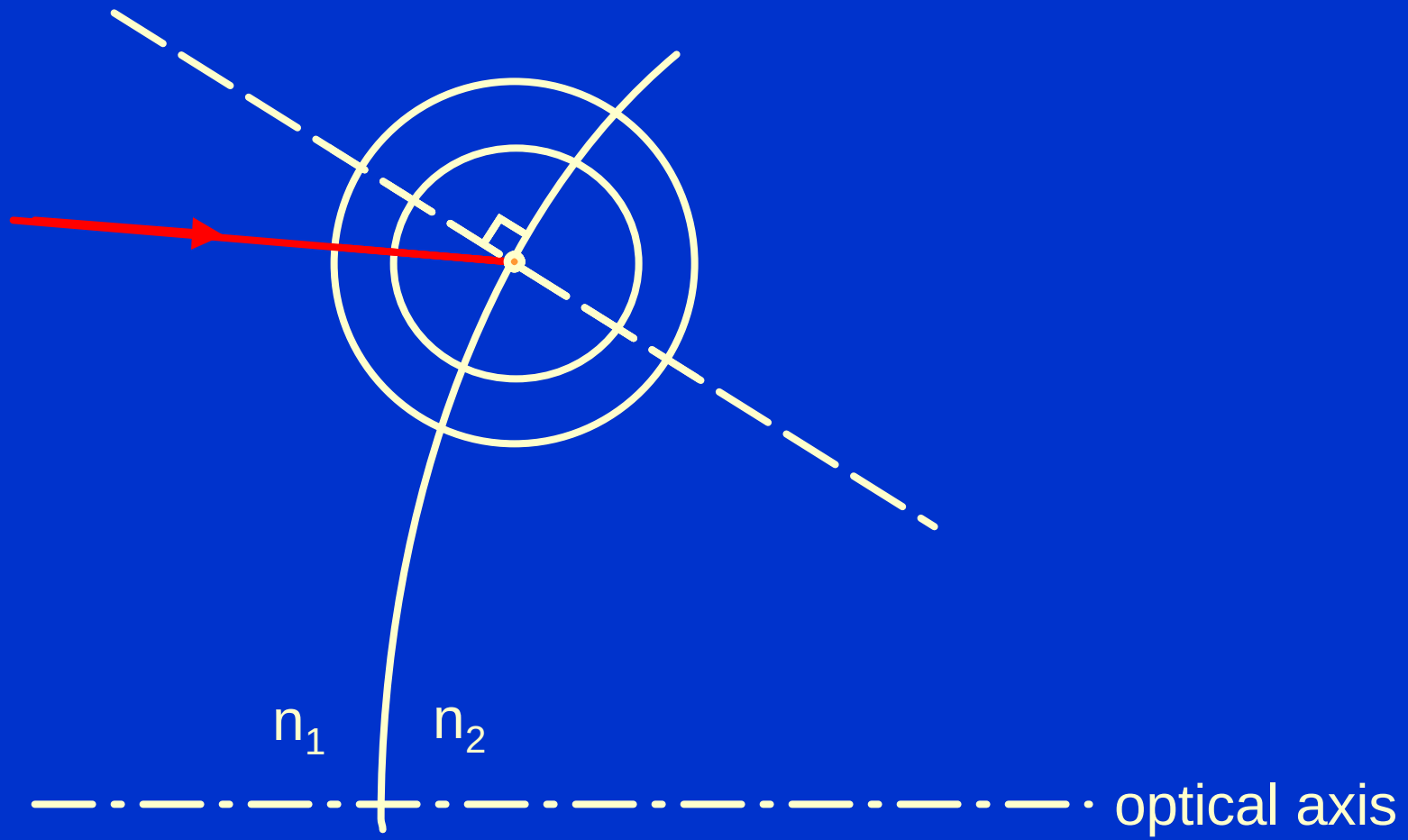

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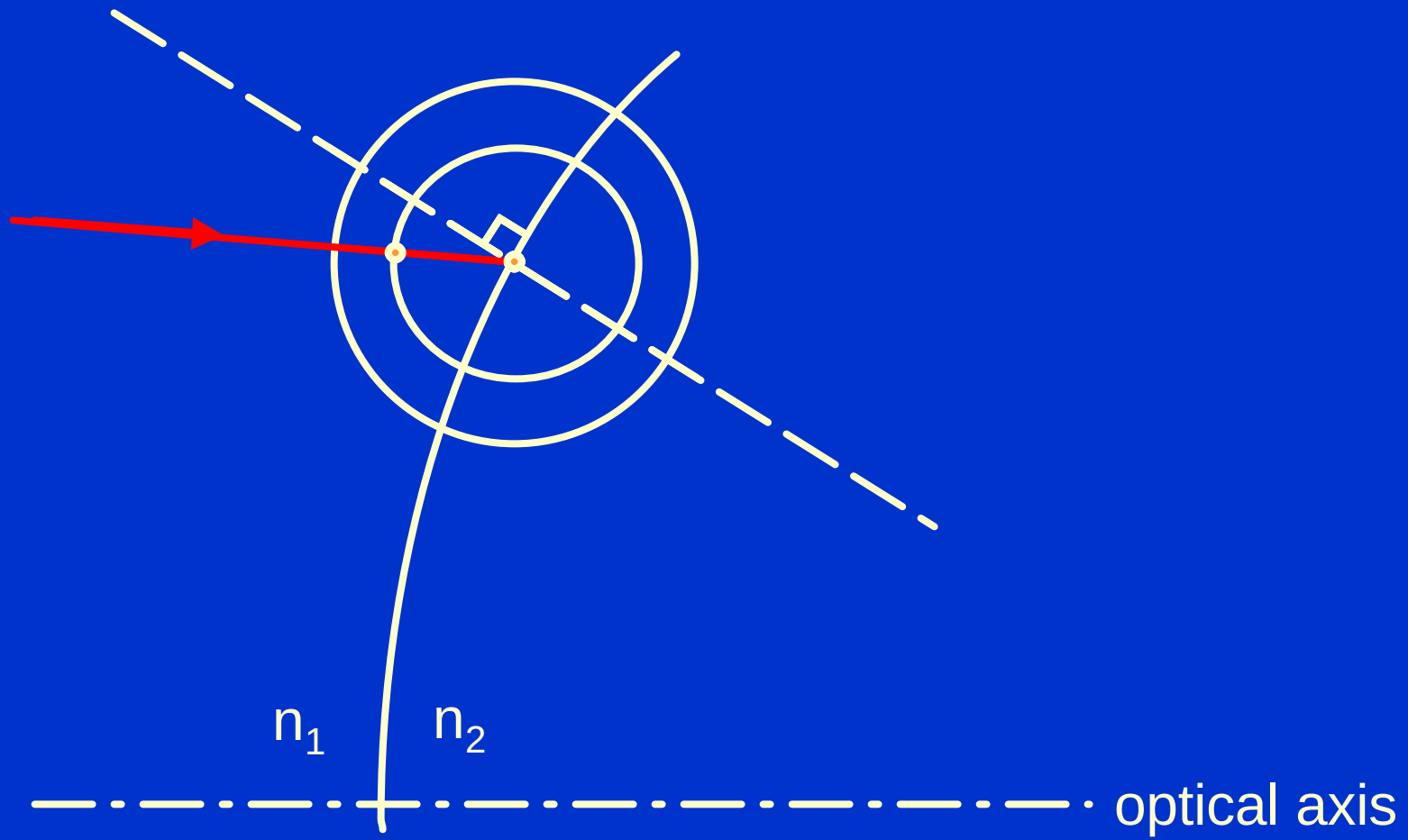

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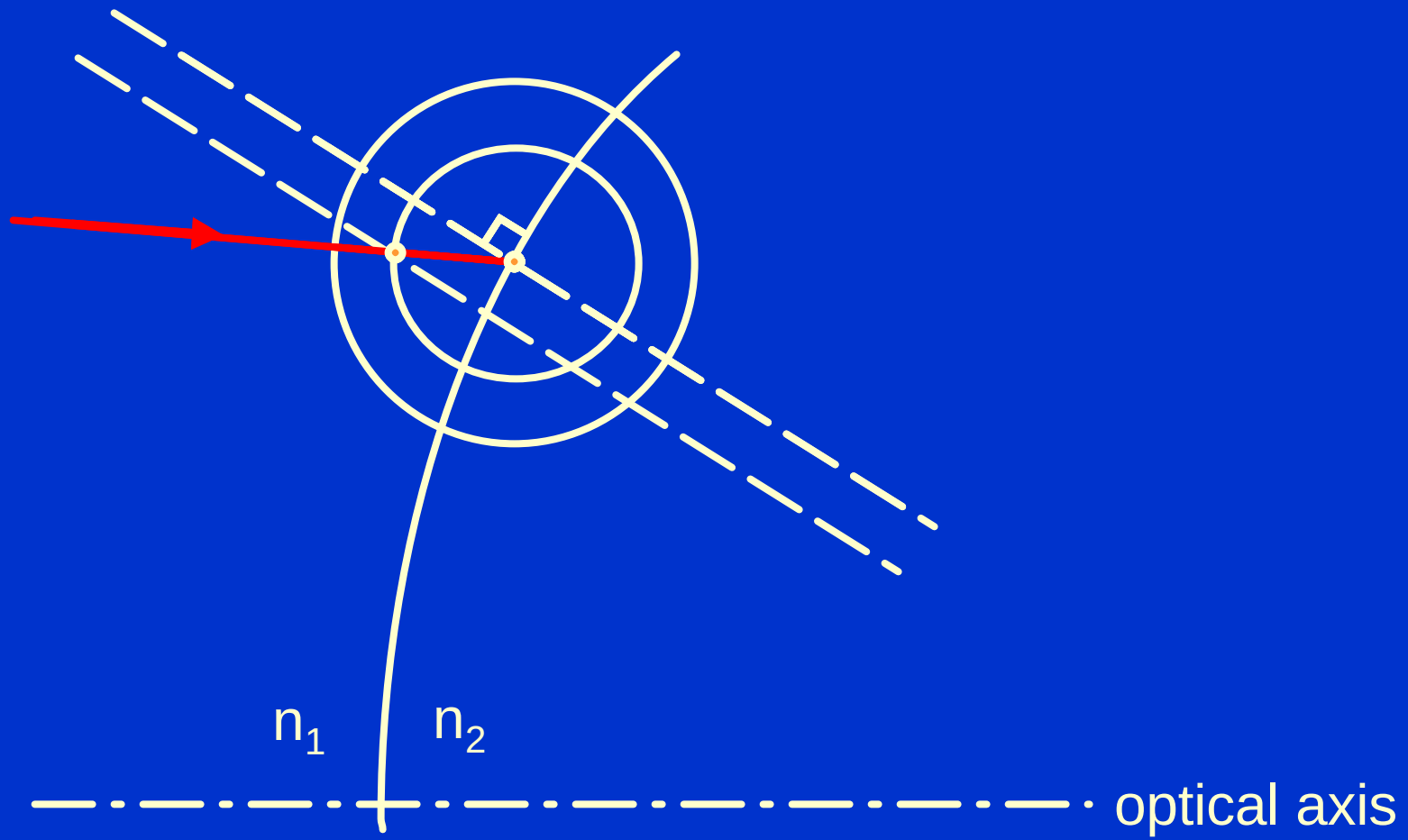

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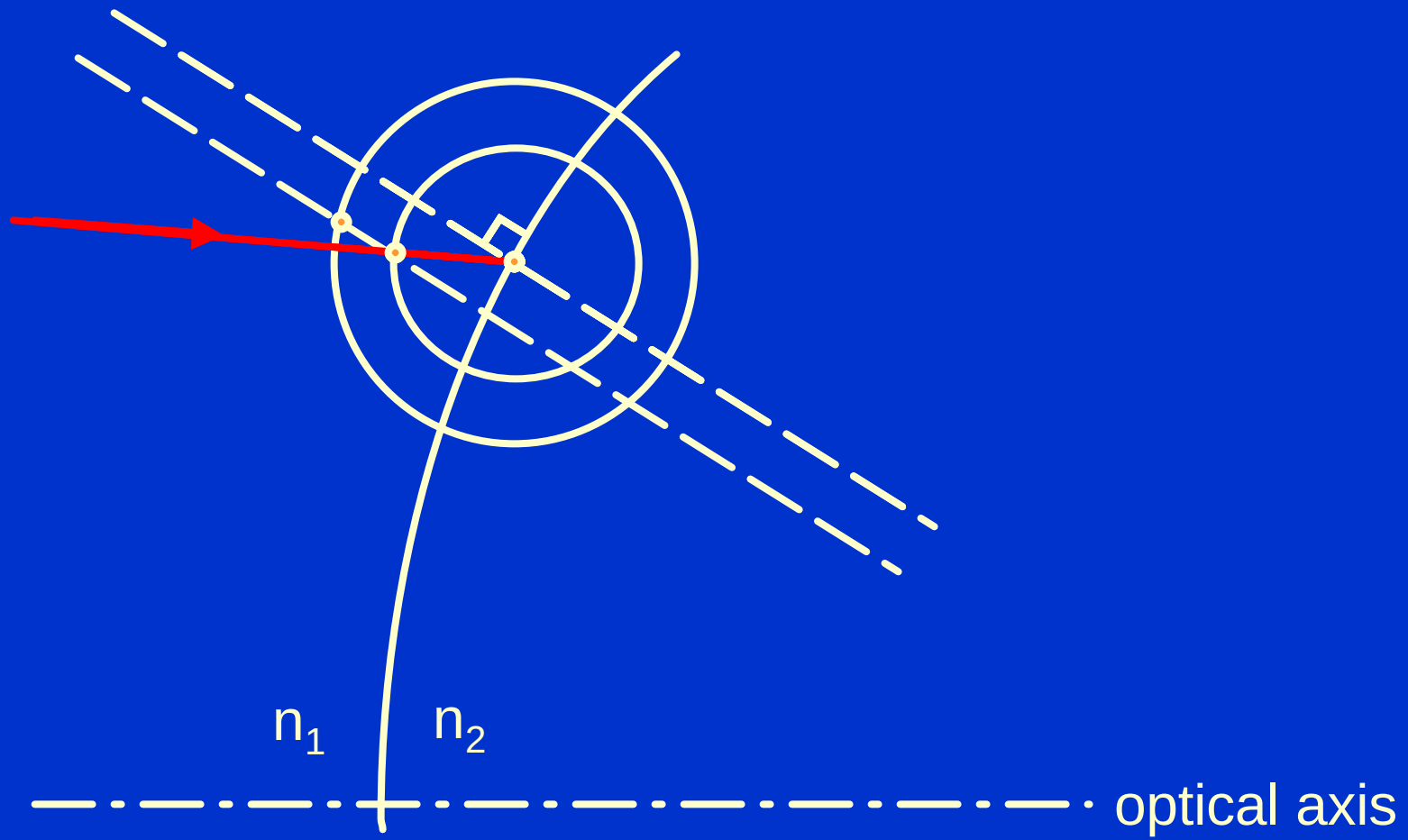

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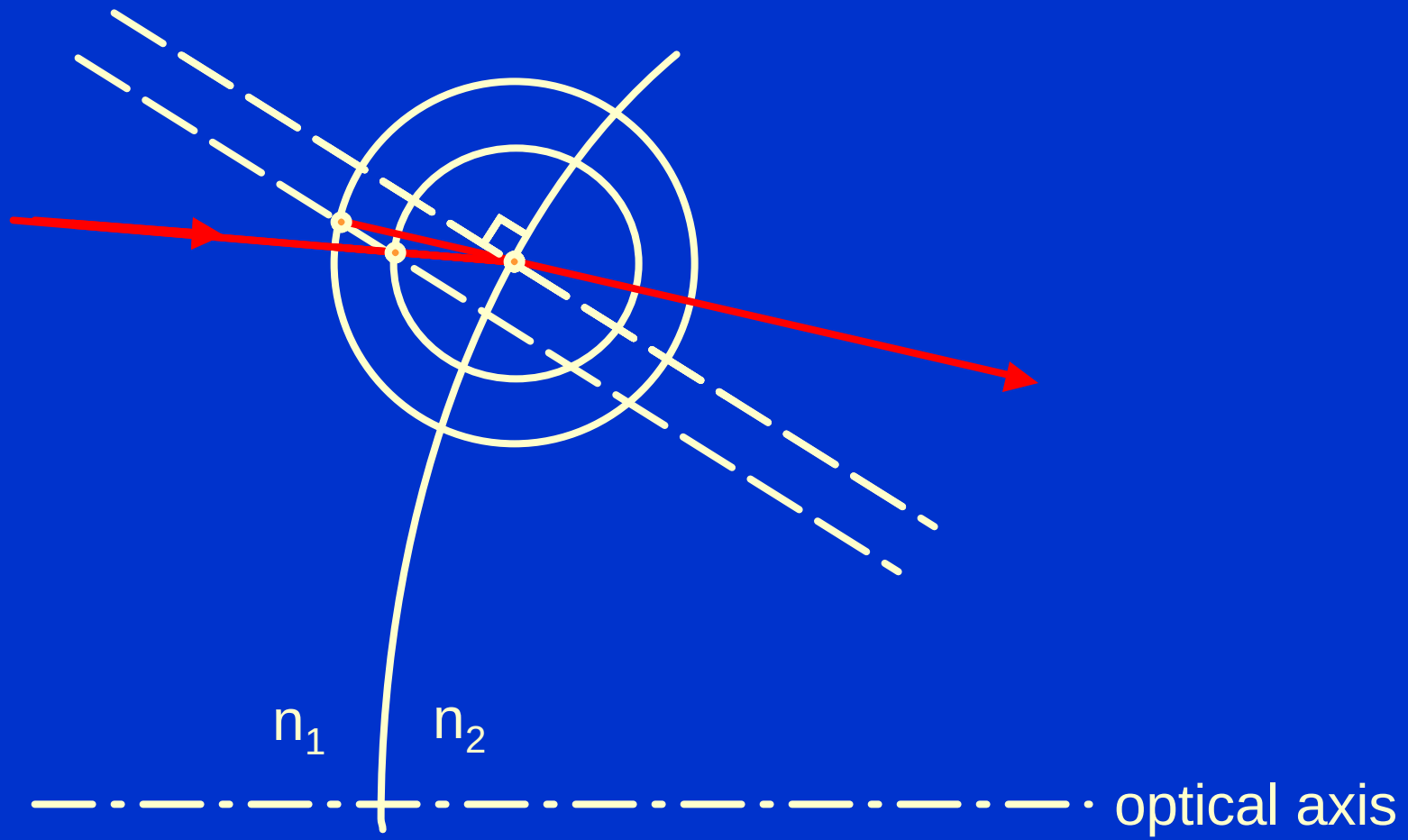
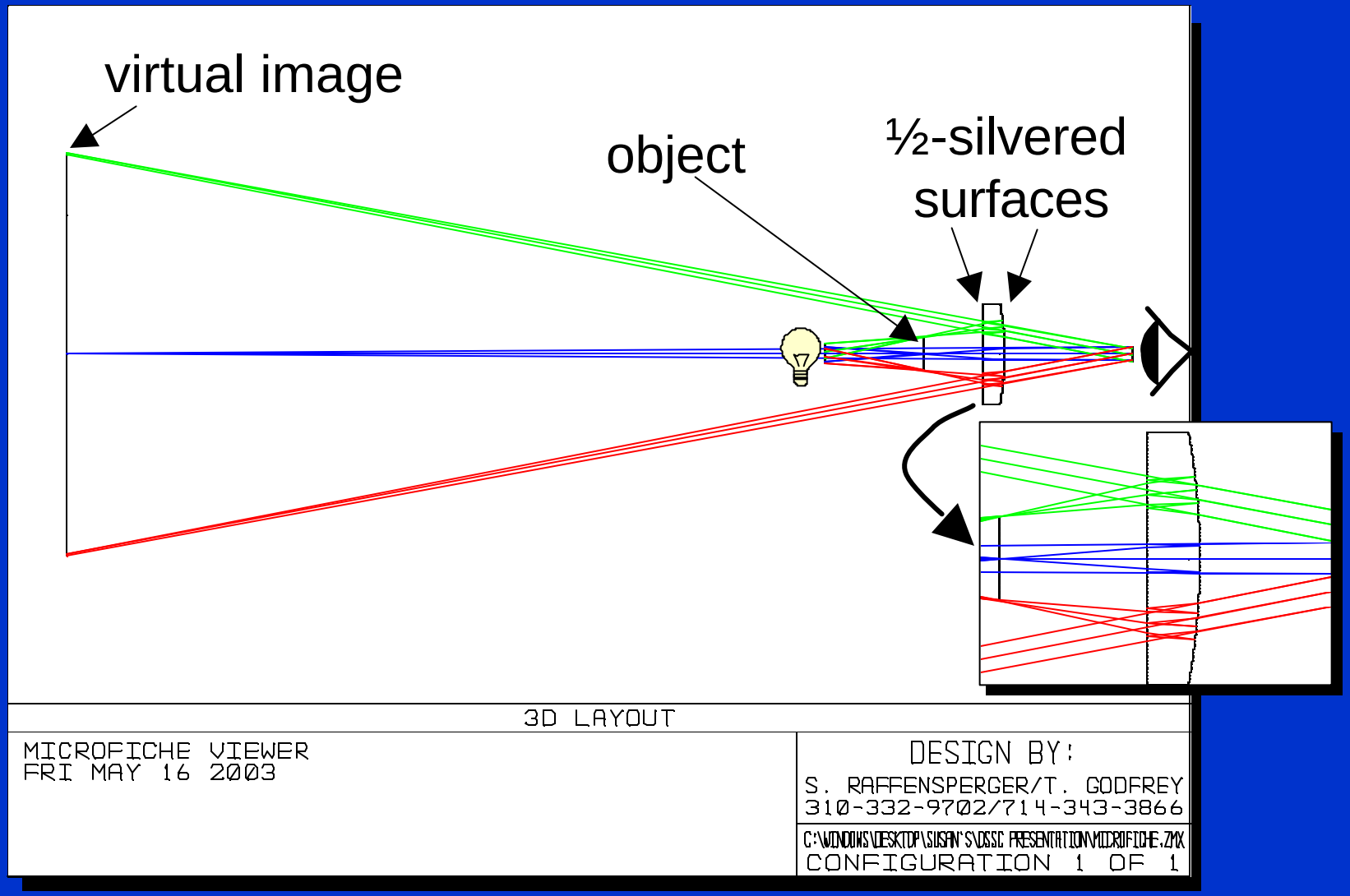
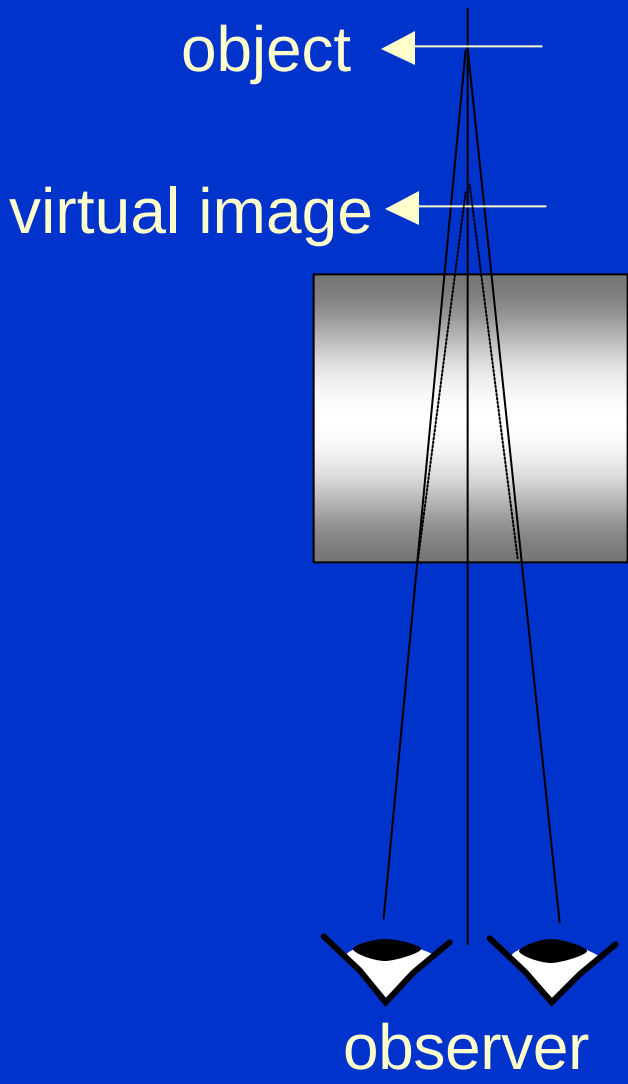


High-Power, Singlet Magnifier

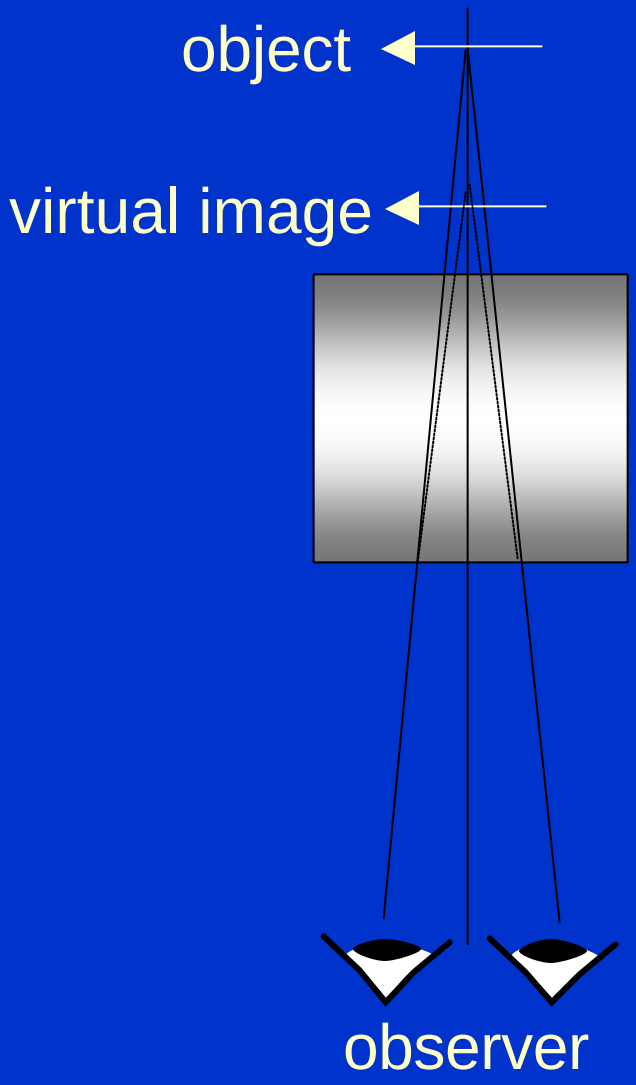


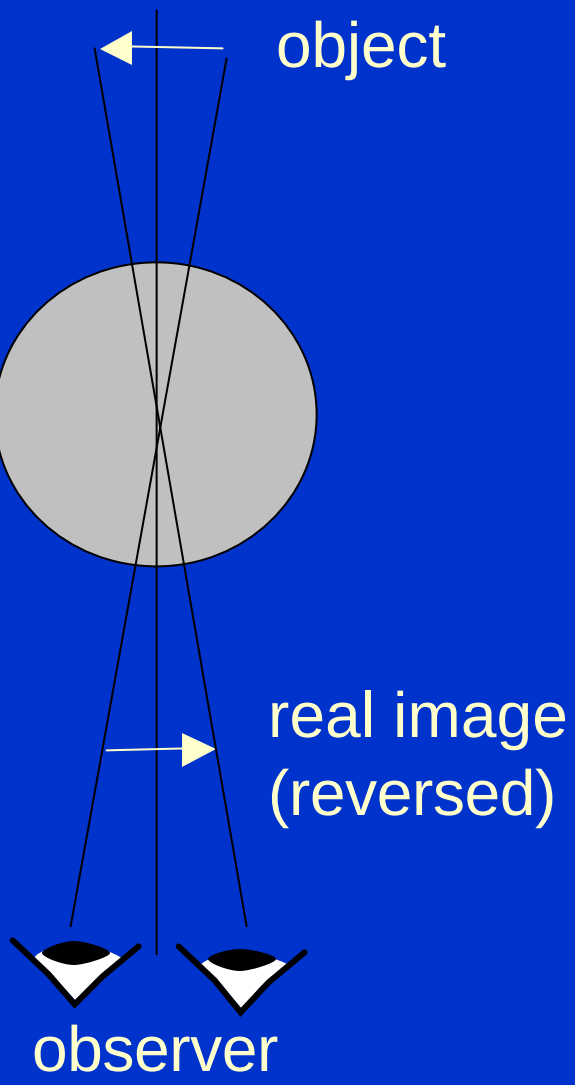
Cylindrical Lenses Make Real & Virtual Images

Cylindrical Lenses Make Real & Virtual Images

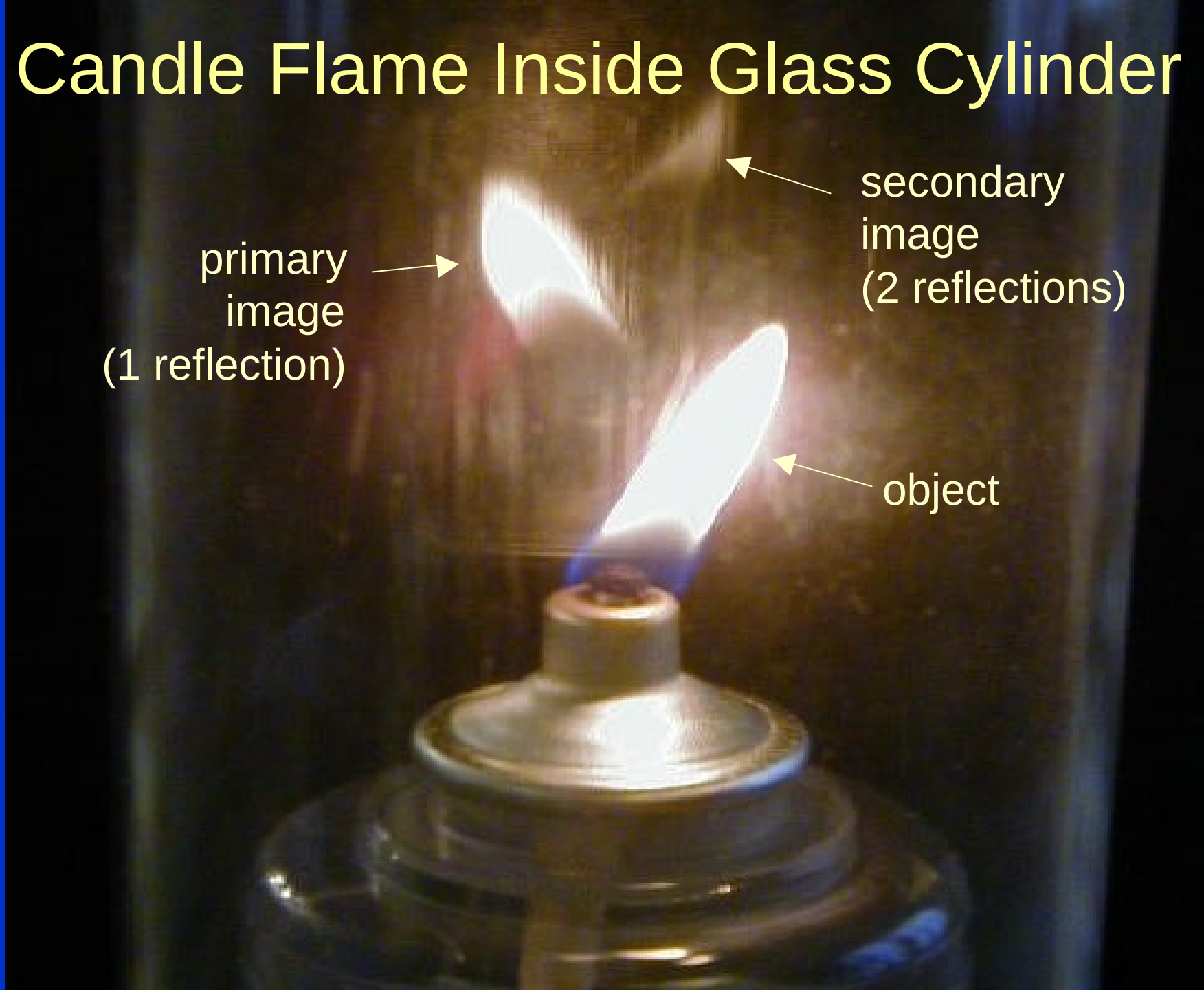


Cylindrical Lenses Make Real & Virtual Images



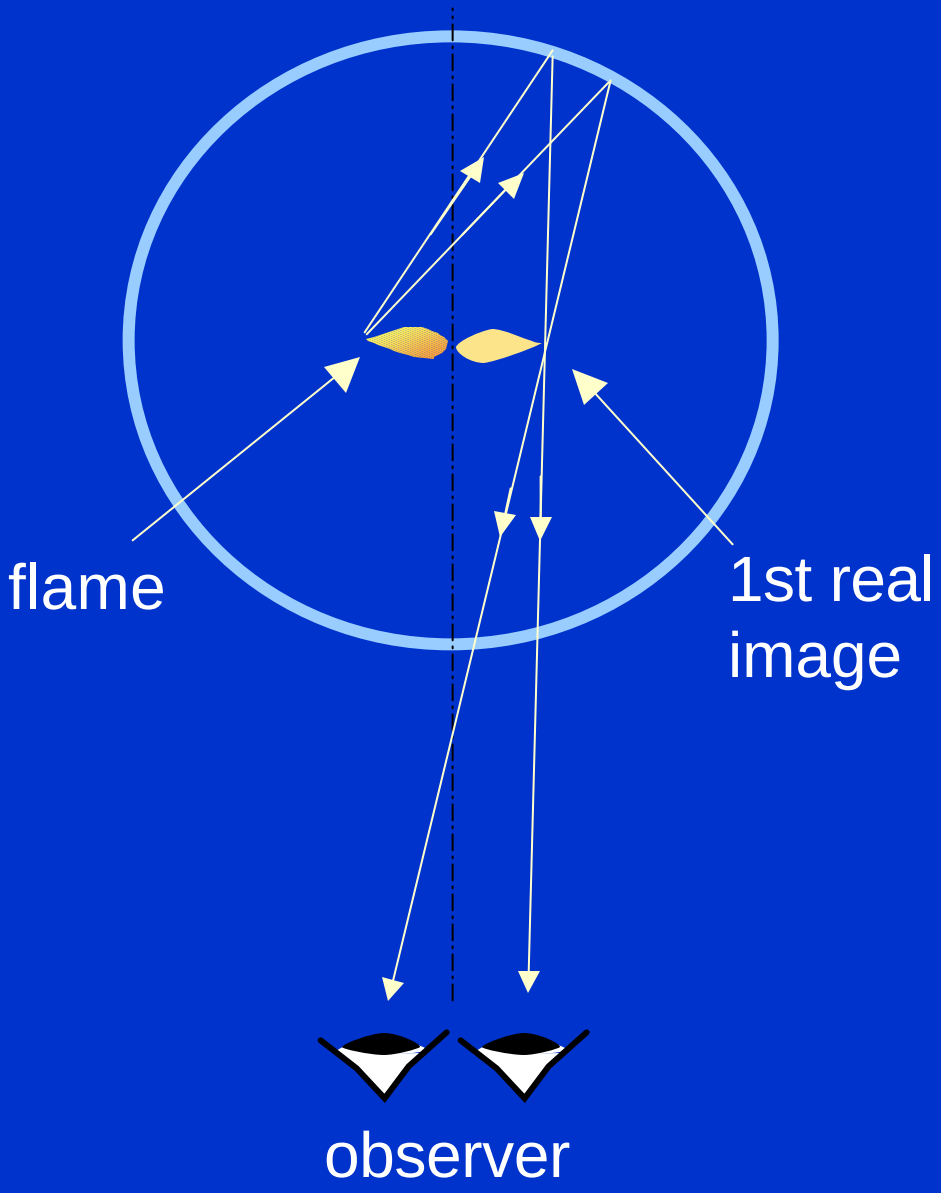


Candle Flame Inside Glass Cylinder

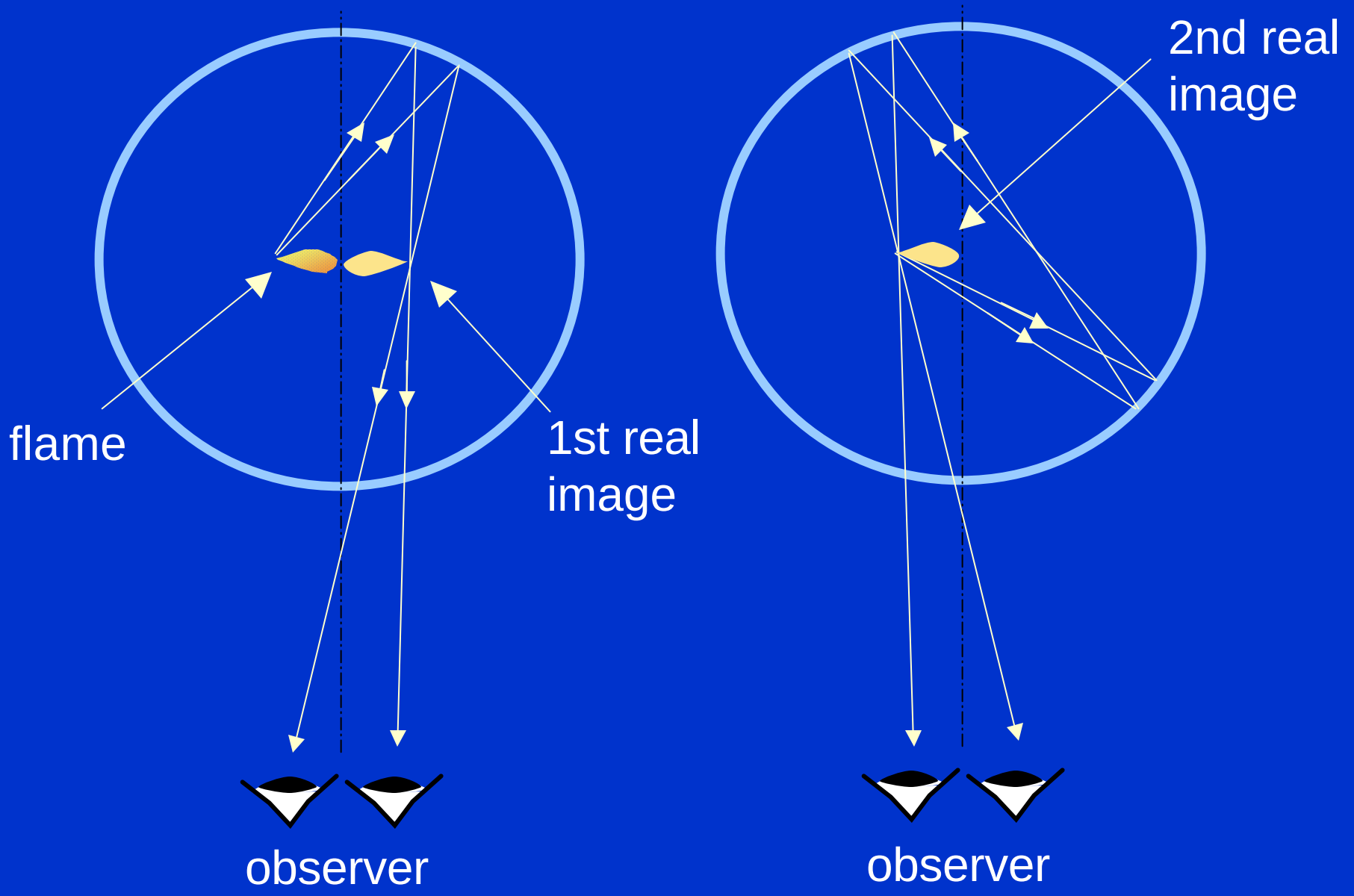


Candle Flame Inside Glass Cylinder

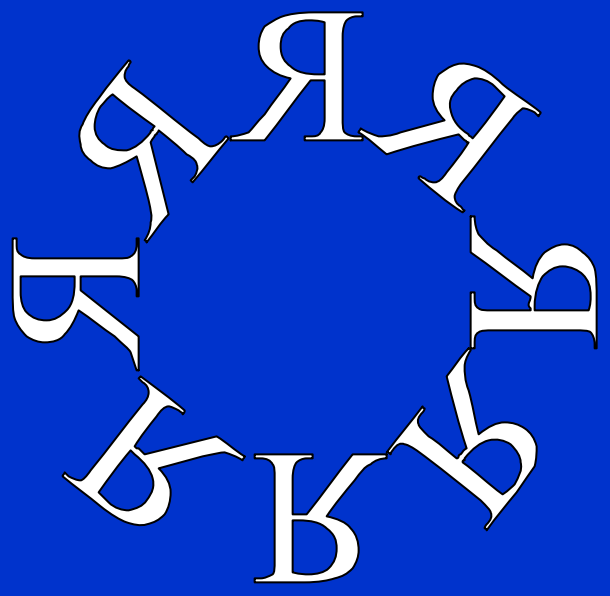
Candle Flame Inside Glass Cylinder



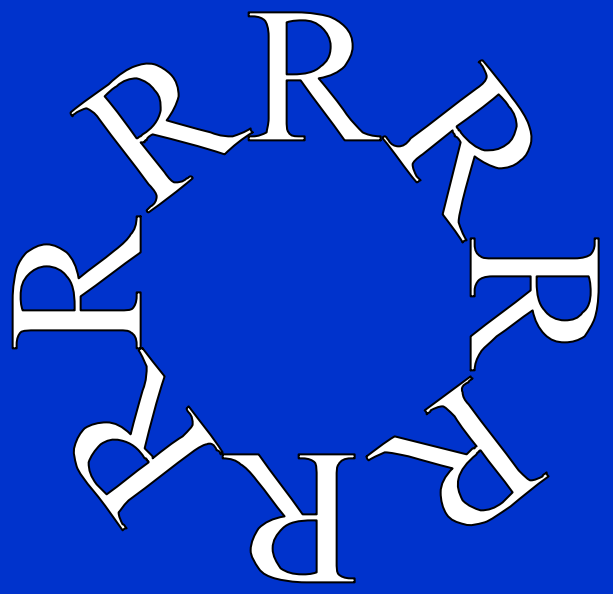
Candle Flame Inside Glass Cylinder



Right- and Left-Handed Images

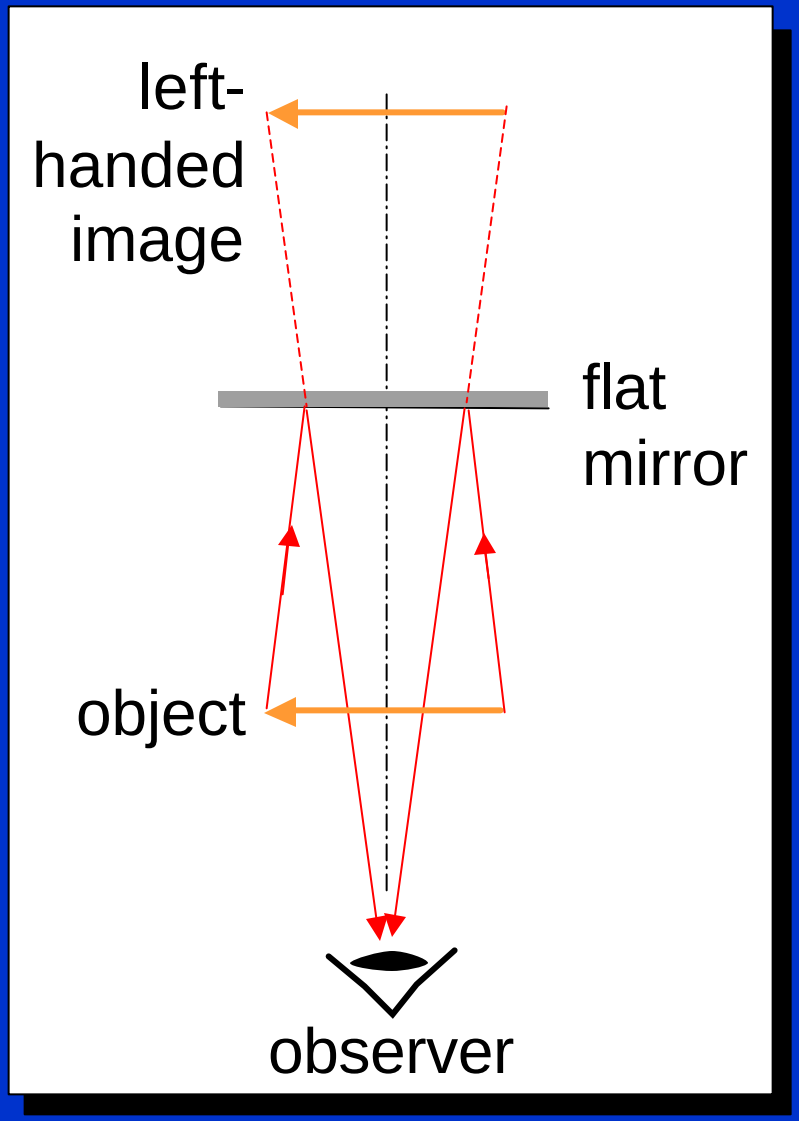


Left-Handed Images

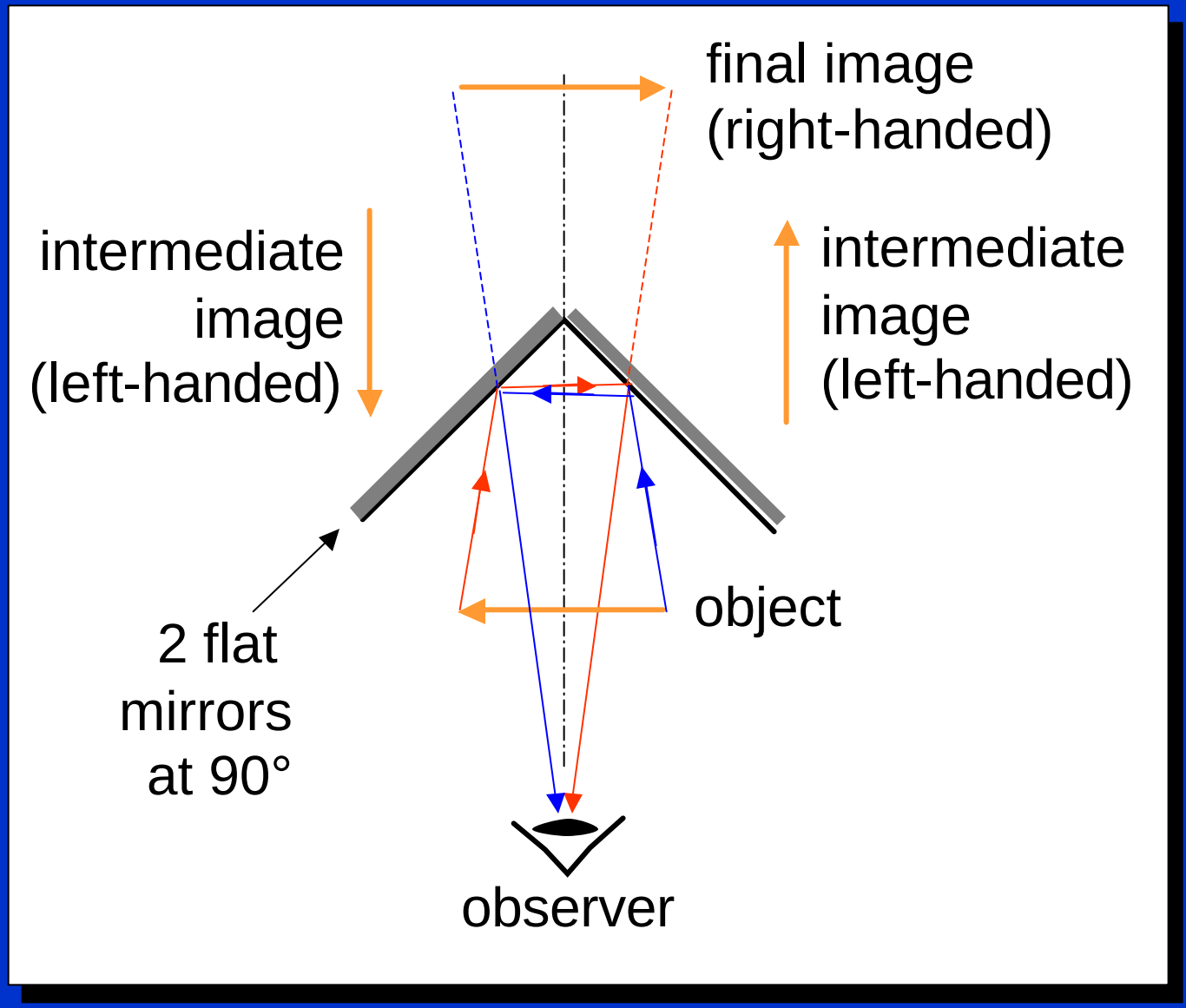


Right-Handed Images

Right- and Left-Handed Images



Right- and Left-Handed Images



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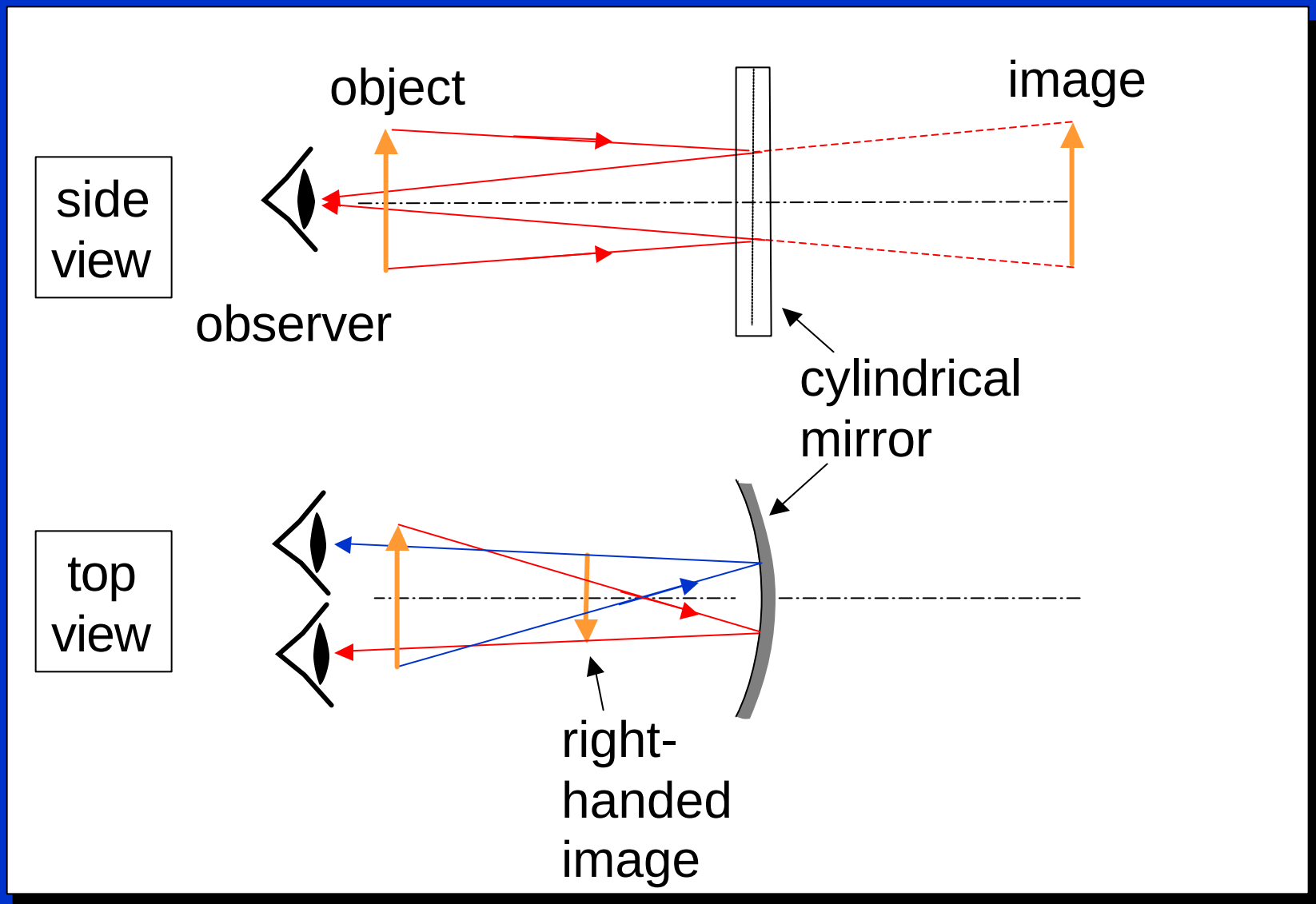

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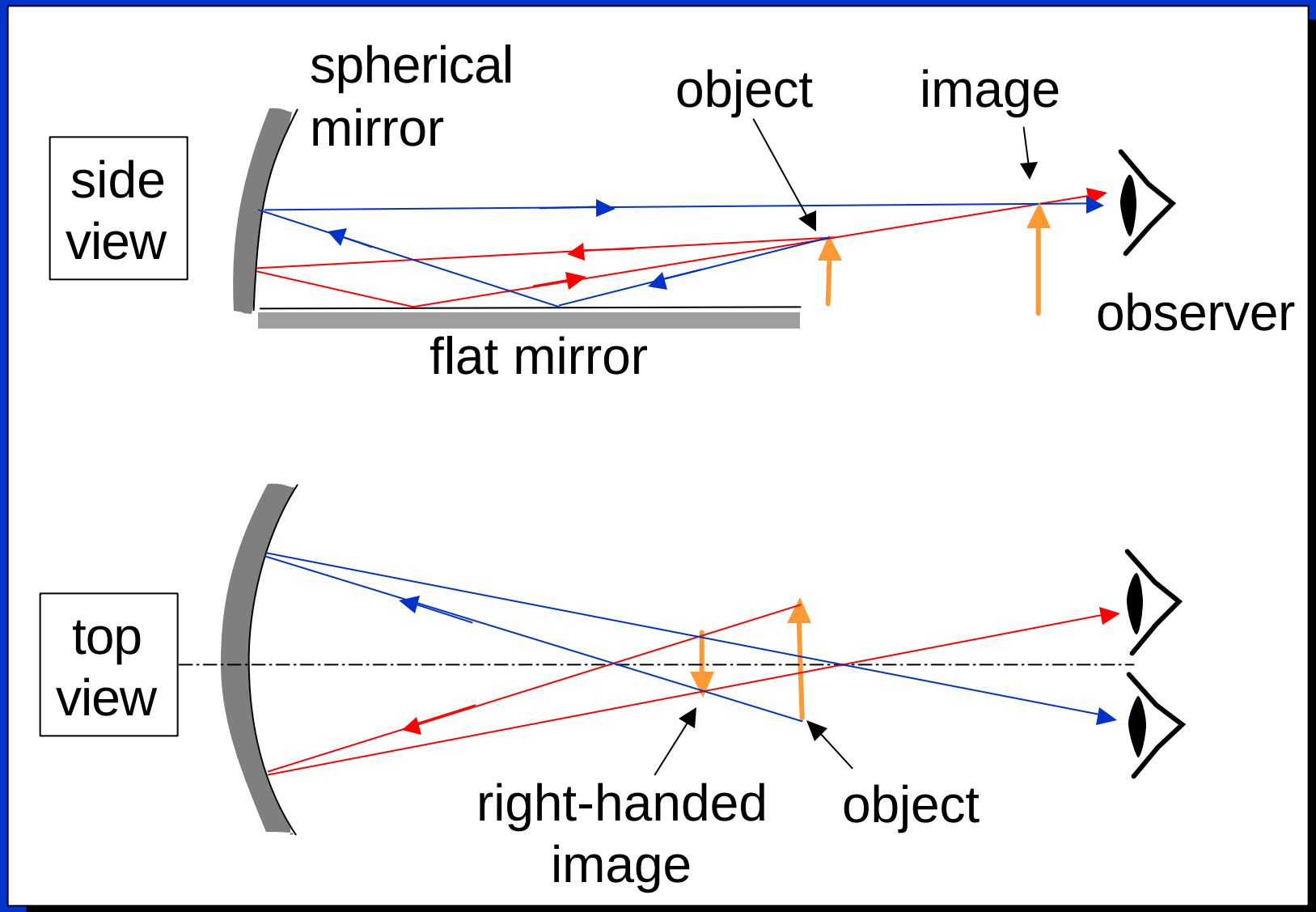
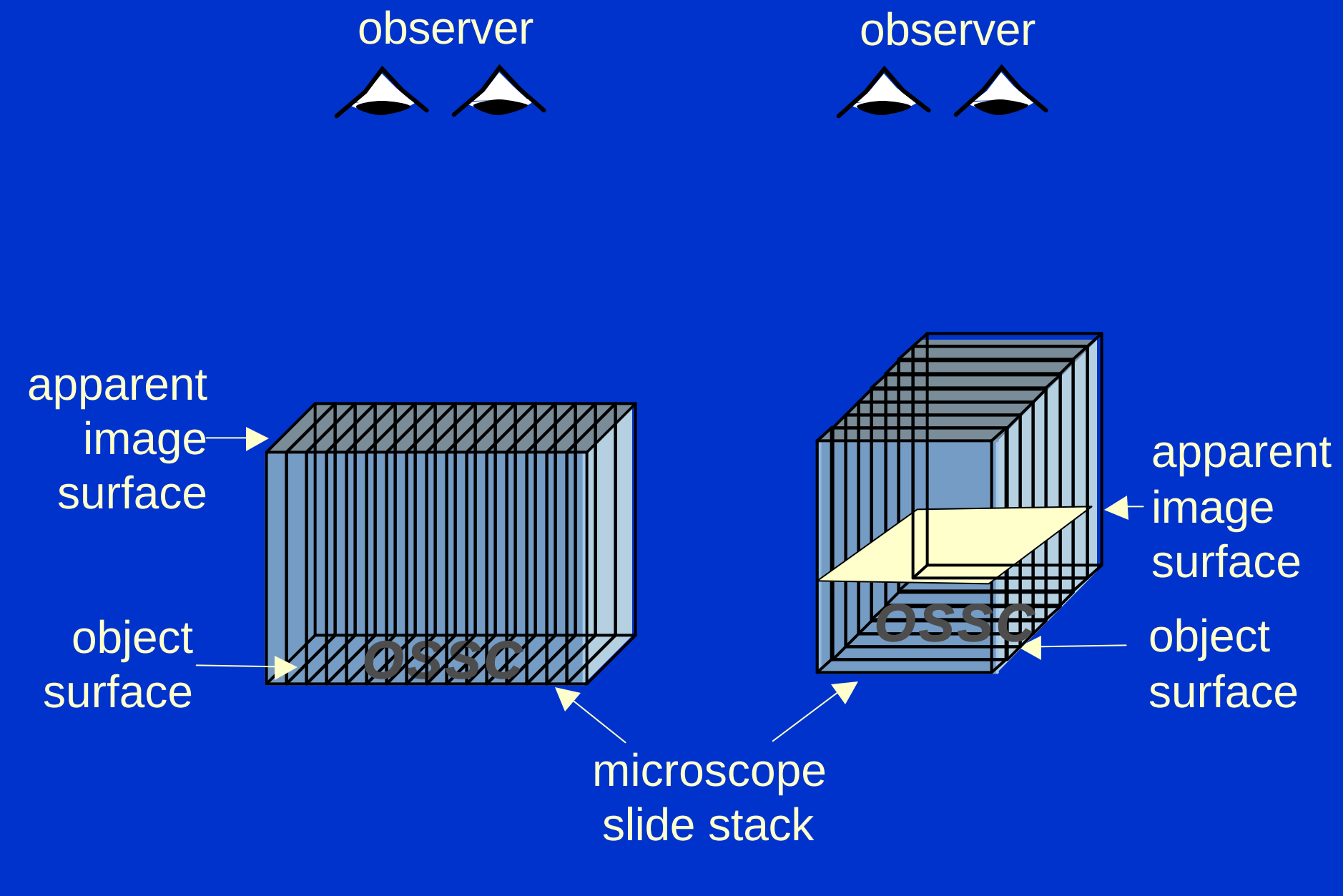
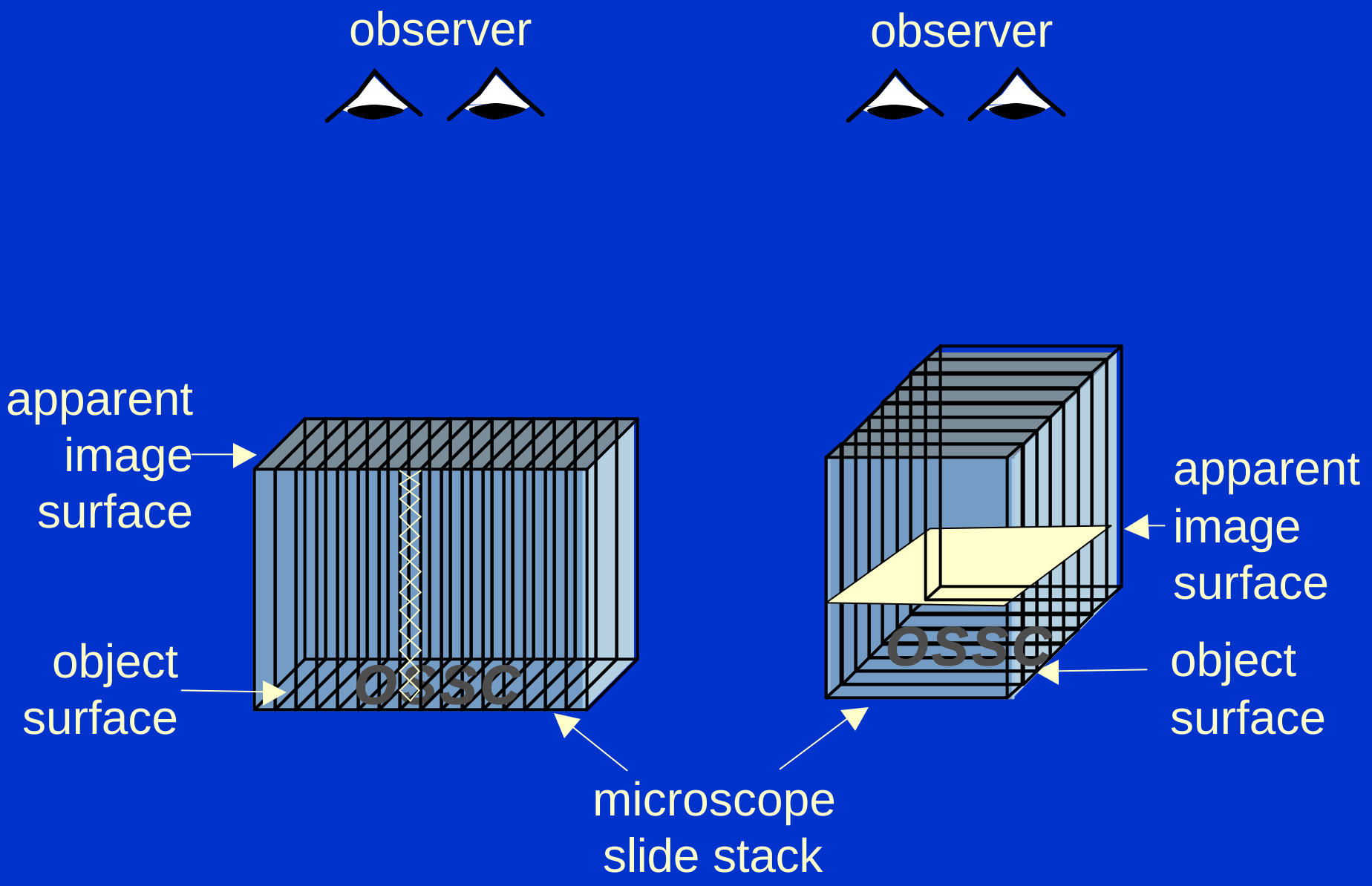


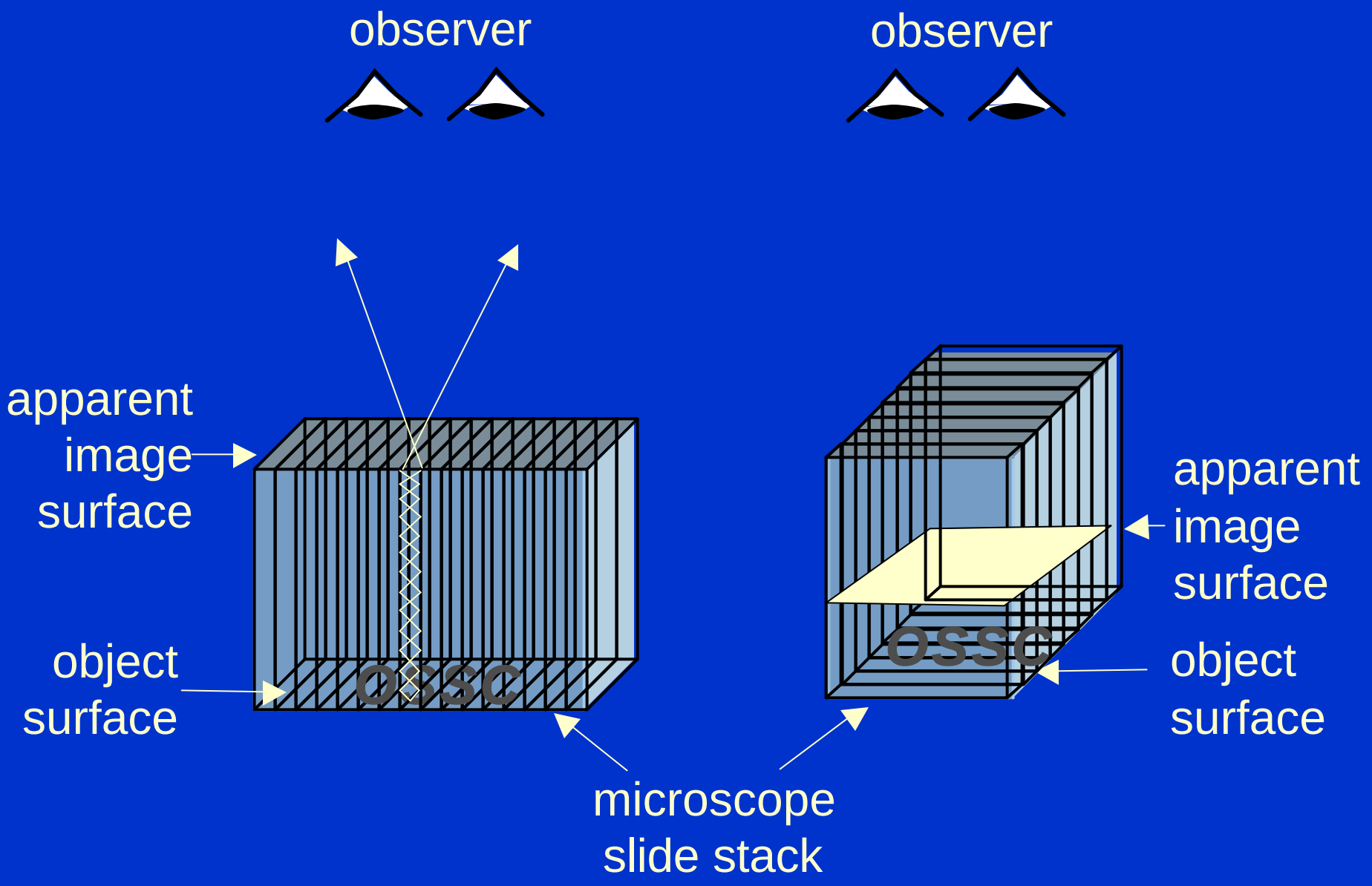
One-Dimensional Fiber Optics



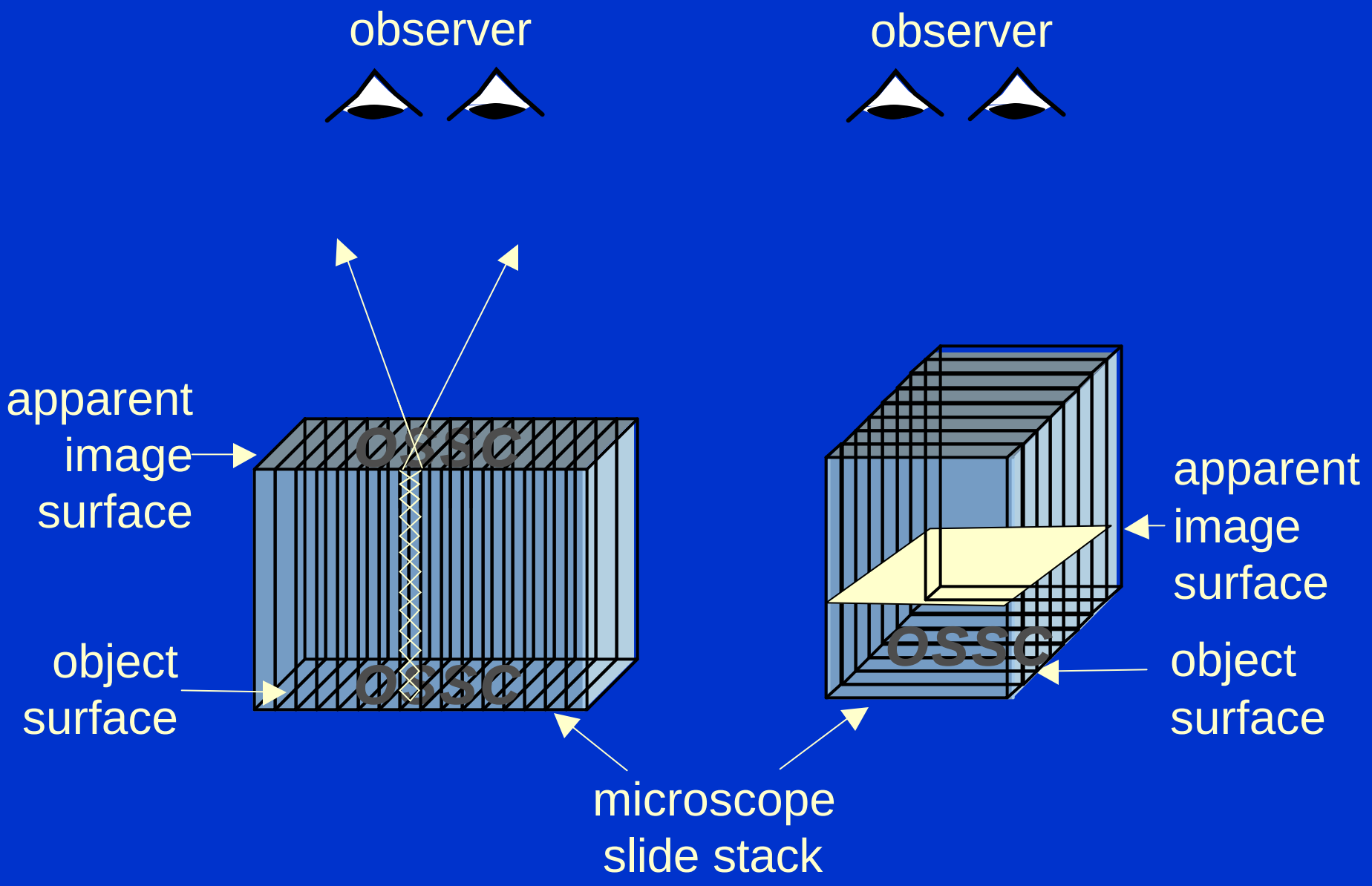
One-Dimensional Fiber Optics



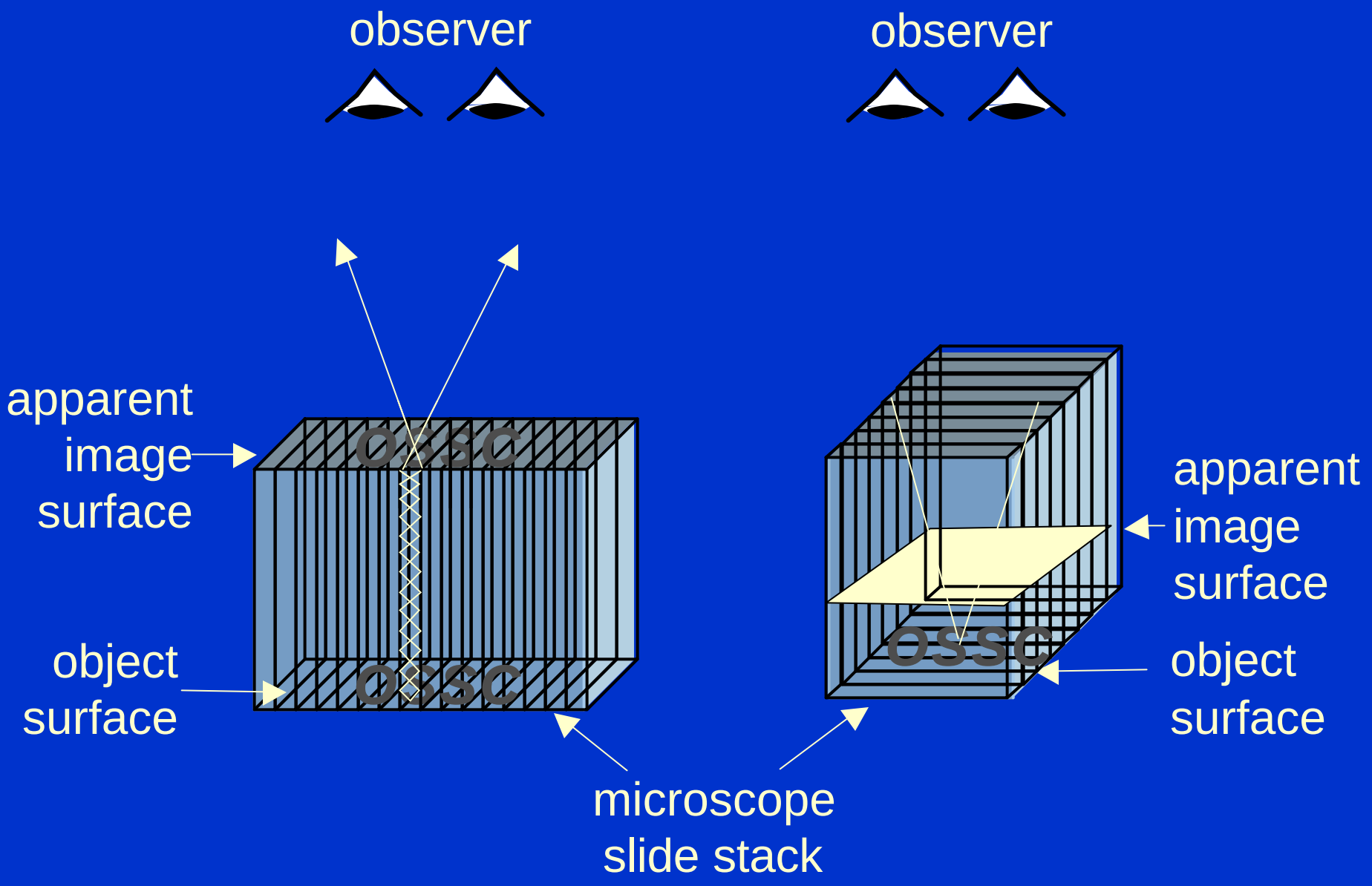
One-Dimensional Fiber Optics



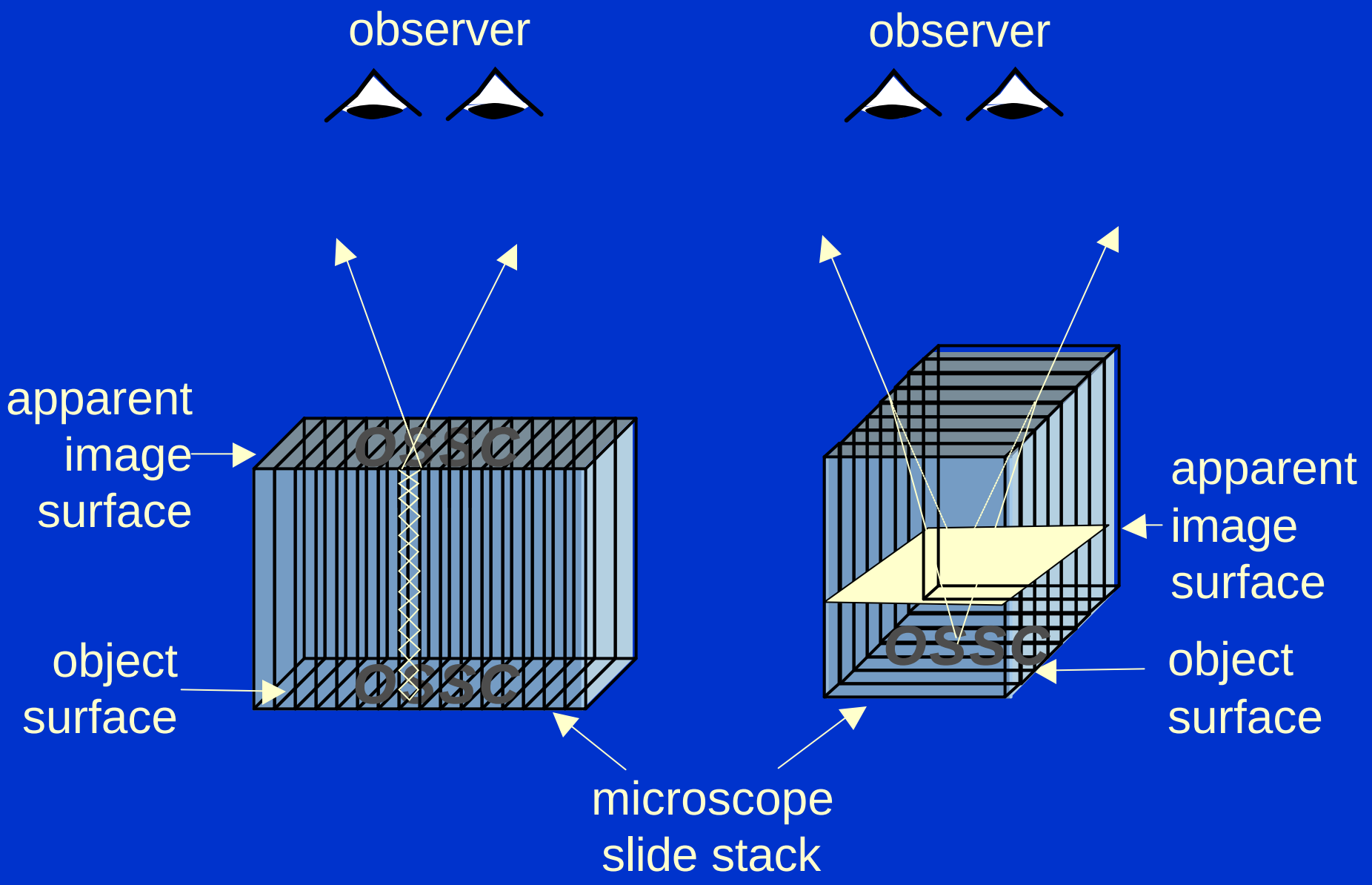
One-Dimensional Fiber Optics



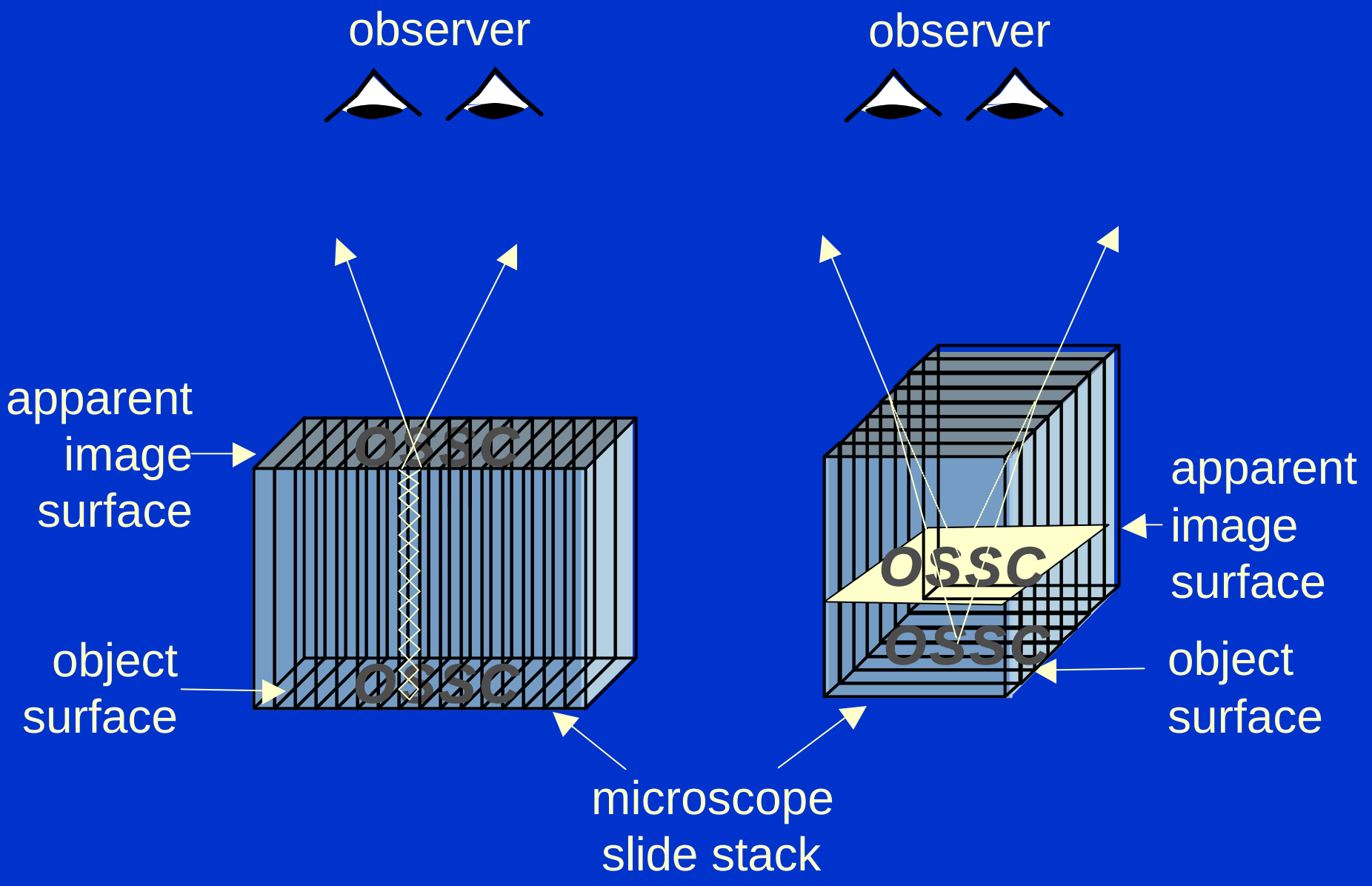
One-Dimensional Fiber Optics



One-Dimensional Fiber Optics



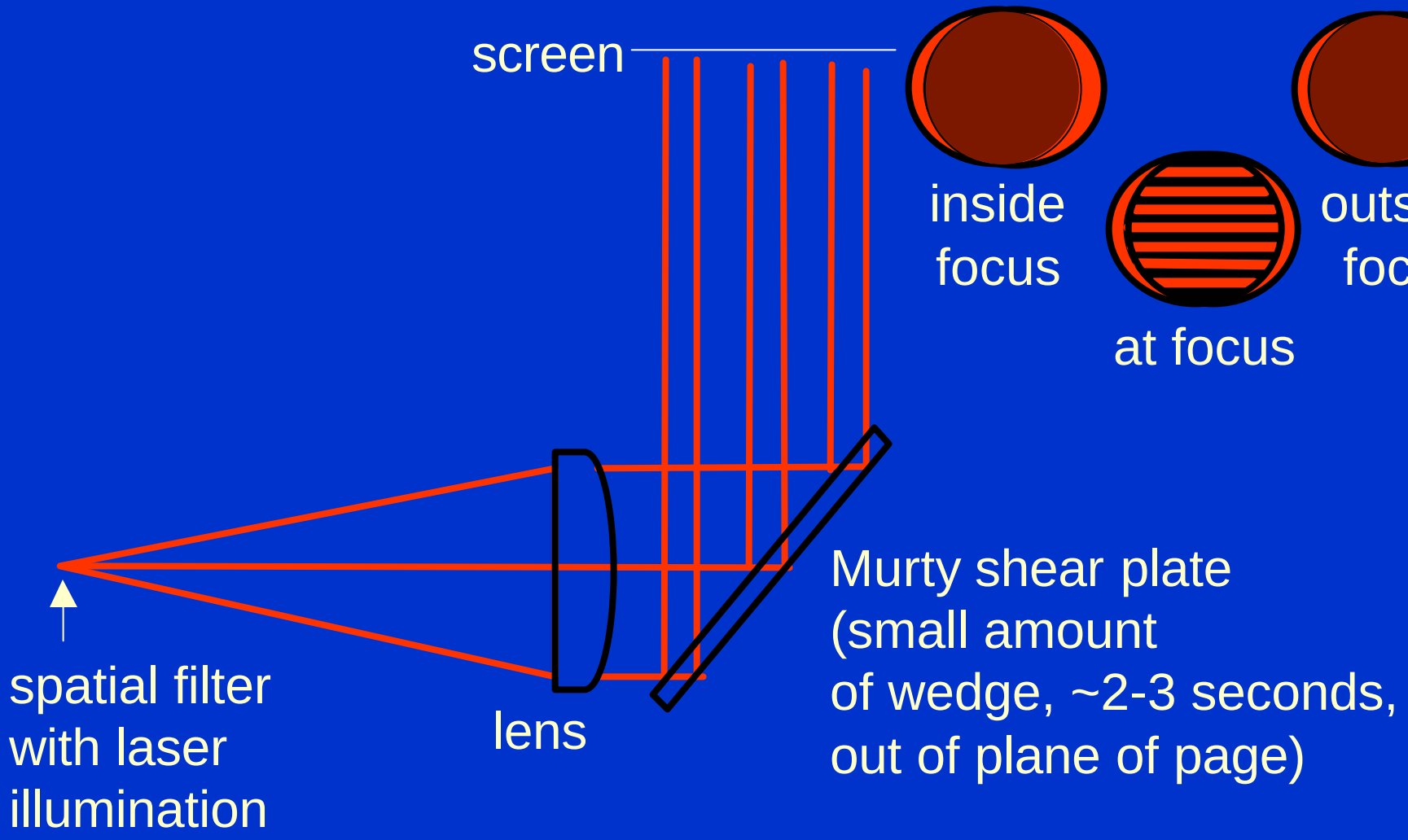
One-Dimensional Fiber Optics



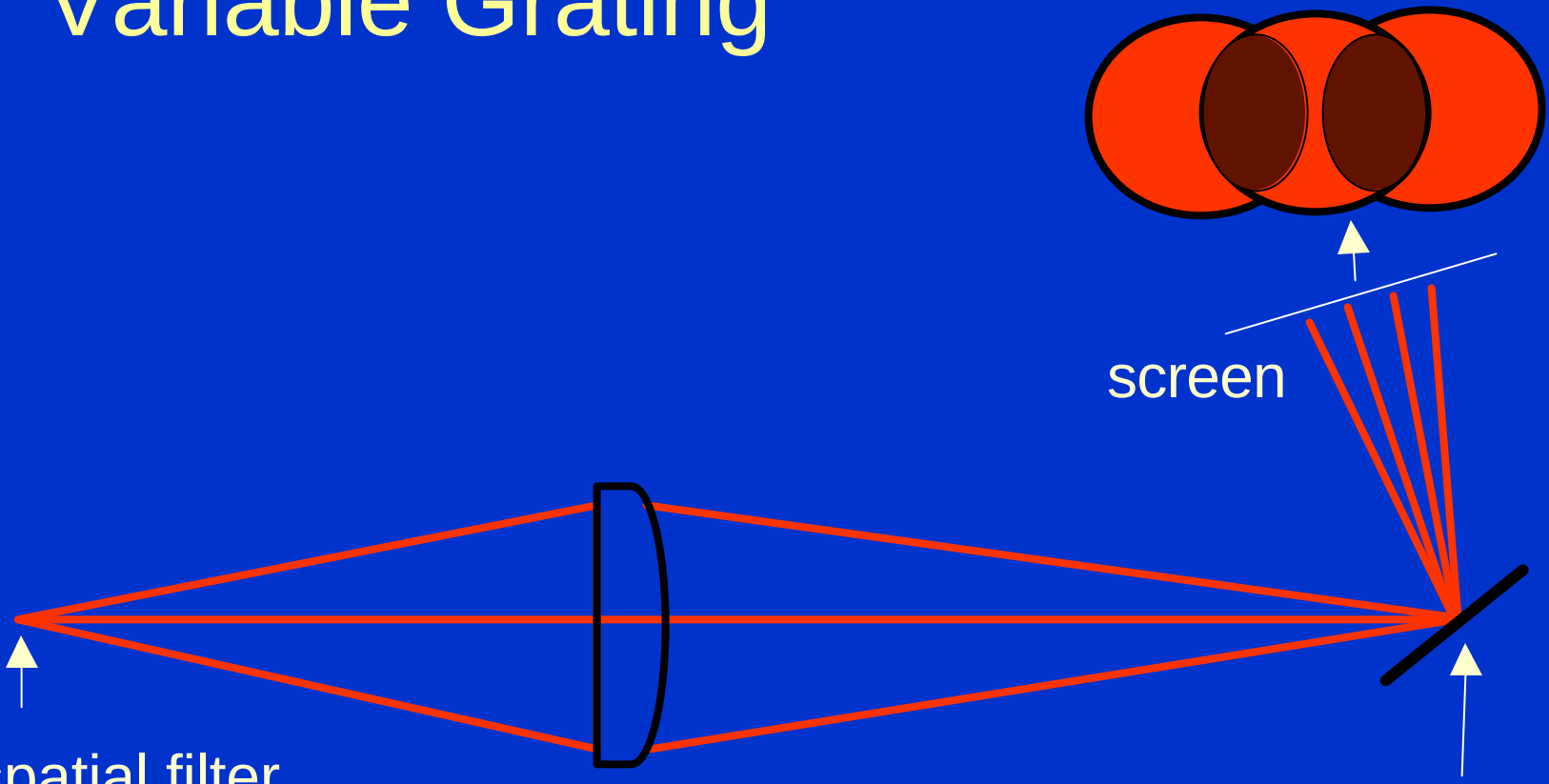
Ulexite: A Natural Fiber Bundle

- Also called “TV Rock”
- Forms in alkali salt flats where local water is rich with Boron, like around Boron, California
- Has silky white crystals that line up in one direction and transmit light like a fiber optic bundle

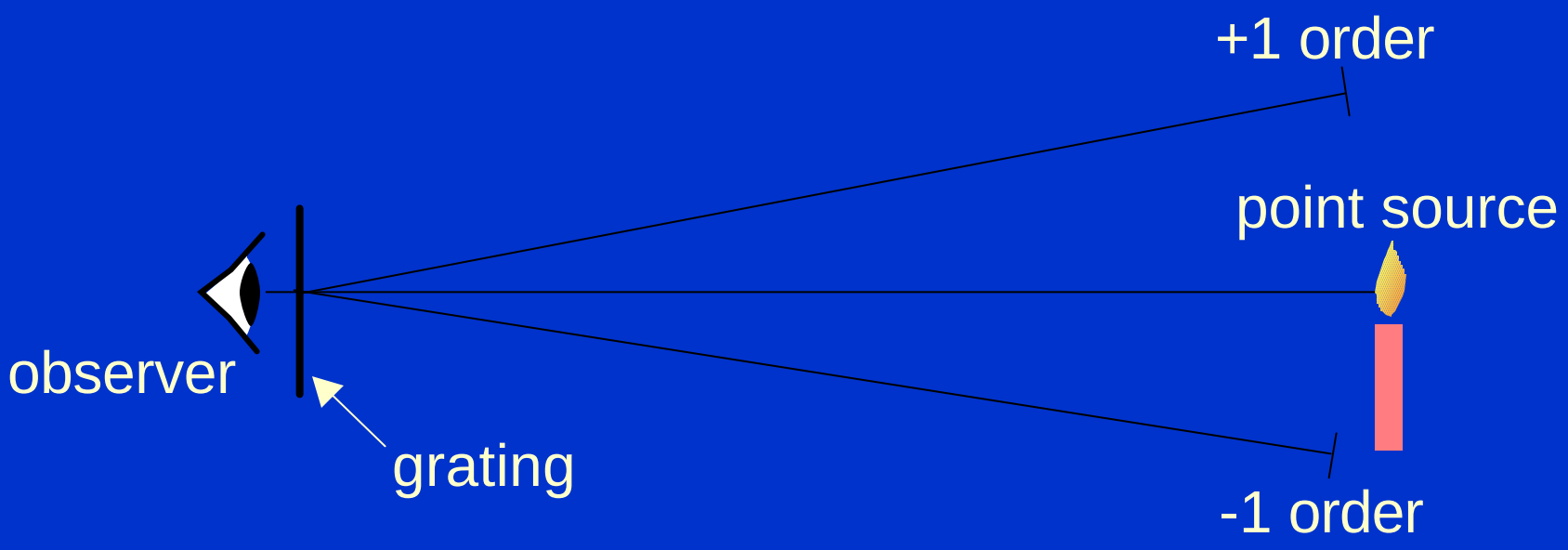
Murty Shearing Interferometer



Ronchi Interferometer with Variable Grating

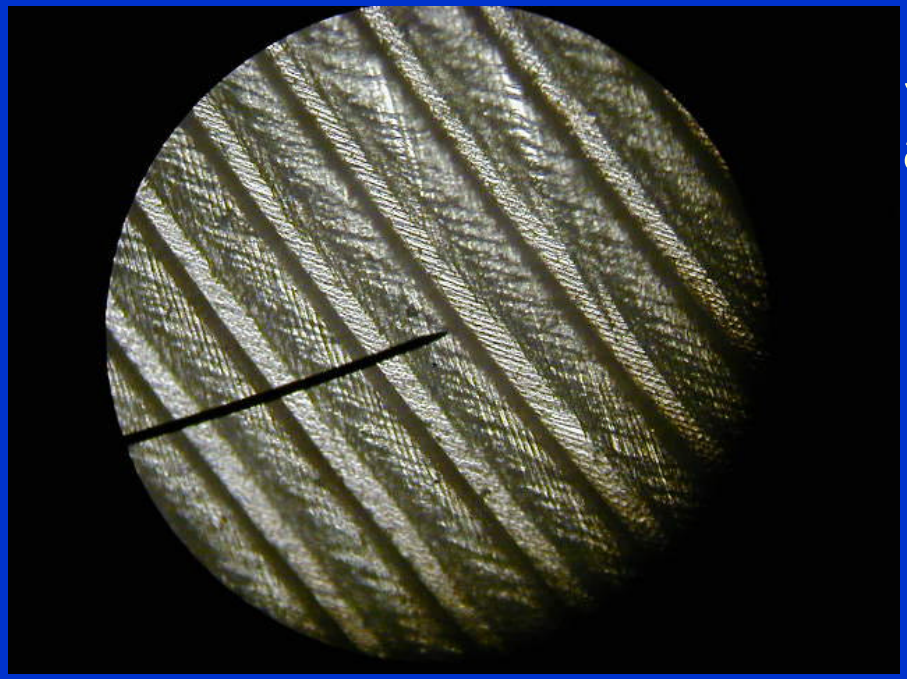


Observation of Spectra with Small Point Source



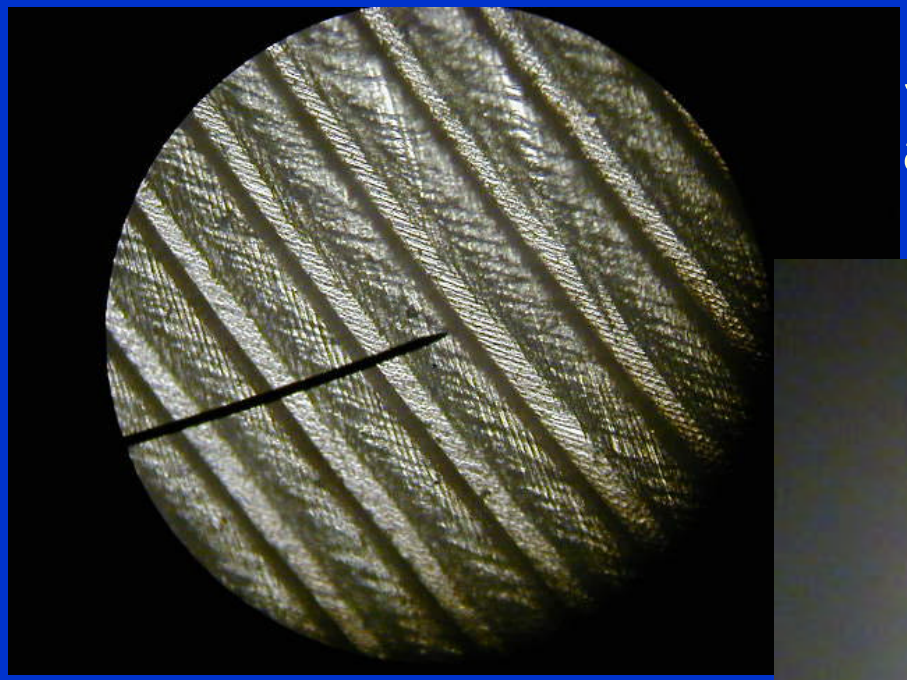
Feathers as Diffraction Gratings

Feathers as Diffraction Gratings



Sea gull feather
at 100x

Feathers as Diffraction Gratings



Sea gull feather
at 100x

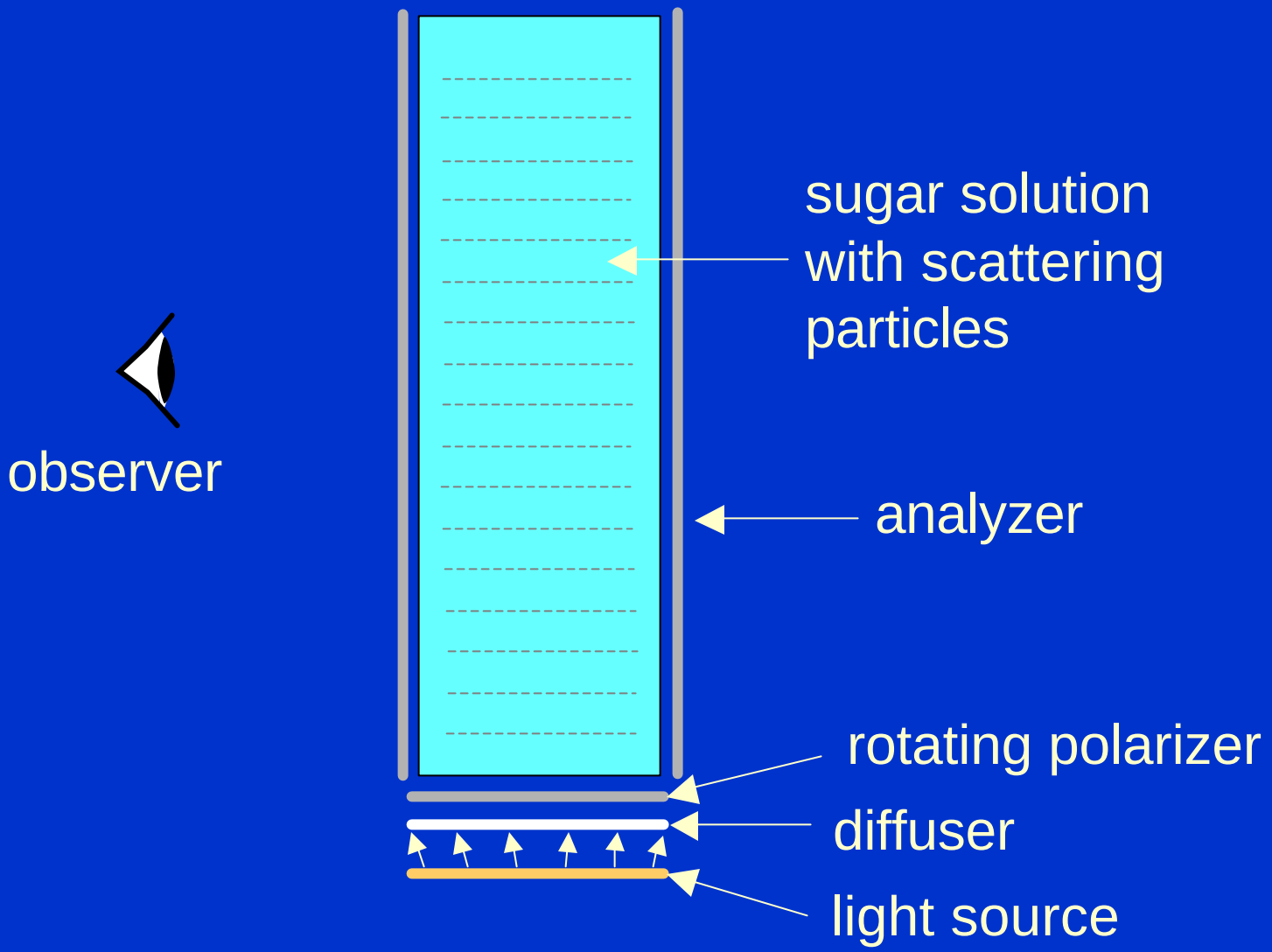
Point source
viewed through
feather

Optical Activity Demo “Barber Pole”

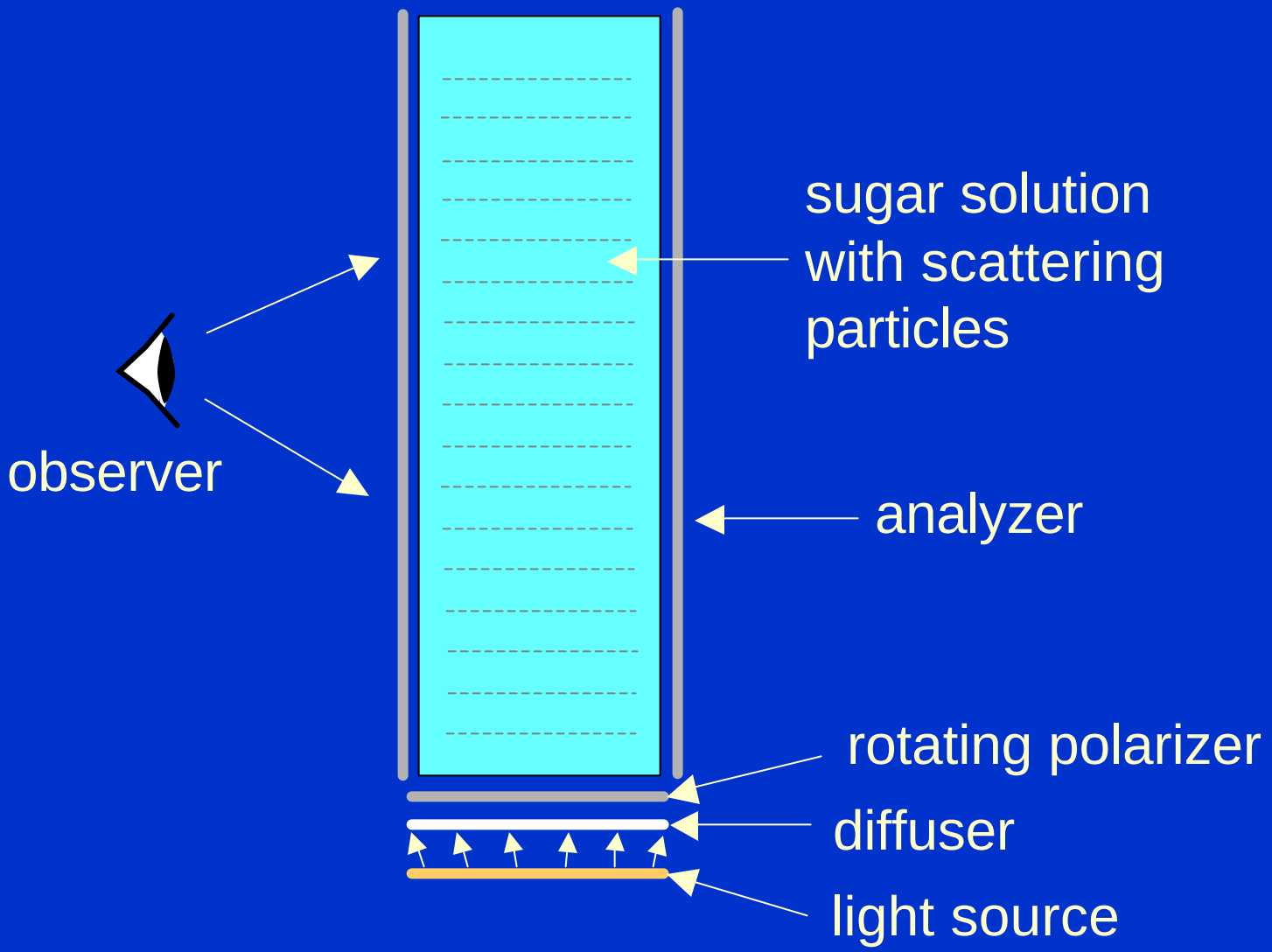
"Another very striking demonstration of optical activity and rotatary dispersion is achieved by passing plane-polarized light vertically into a clear solution of cane sugar contained in large glass tube. On observing the tube from the side with a Nicol prism, a very fine spiral arrangement of colors, somewhat like a barber-pole will be seen."

From Jenkins & White, Page 575

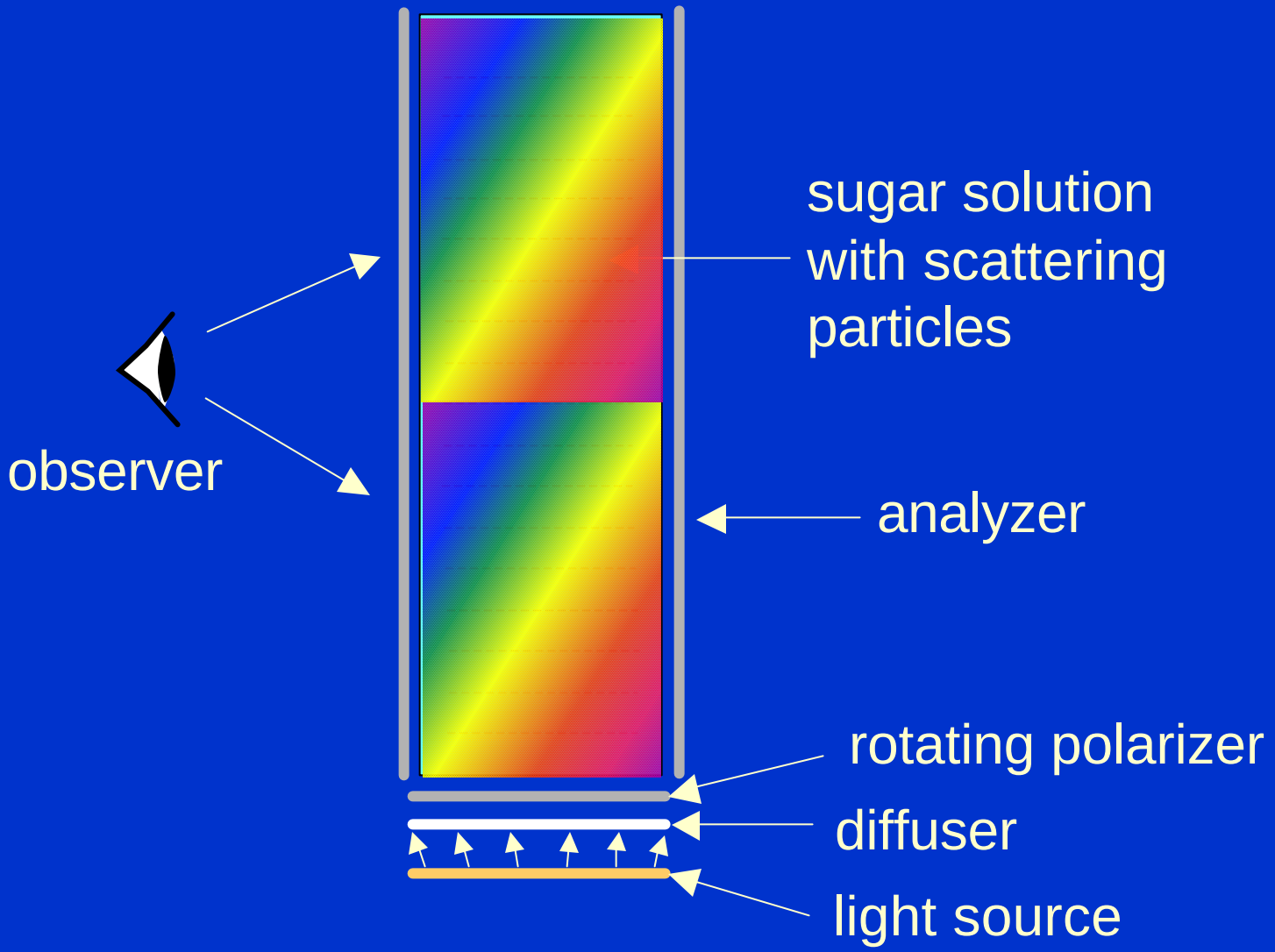
Optical Activity Demo “Barber Pole”



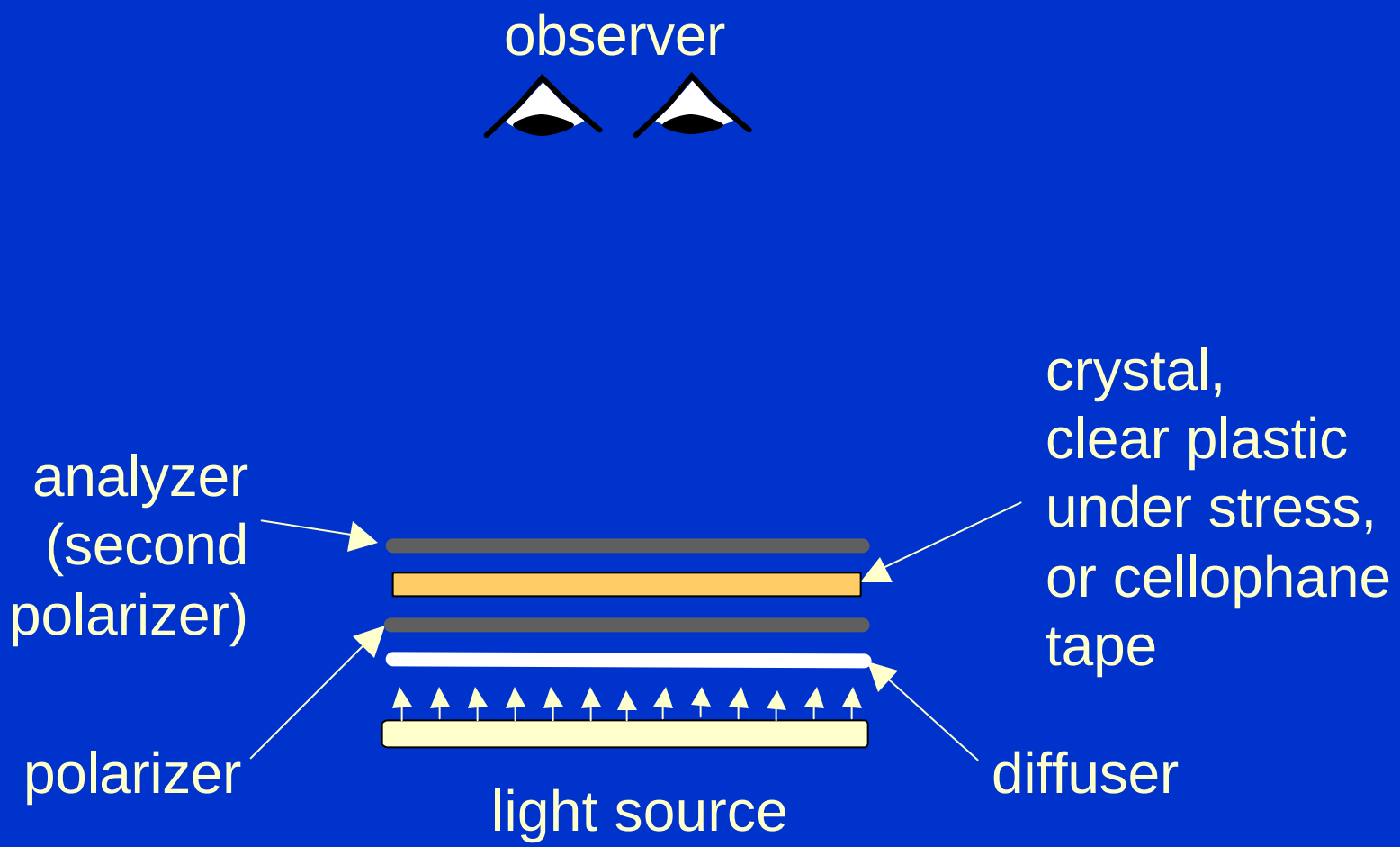
Optical Activity Demo “Barber Pole”



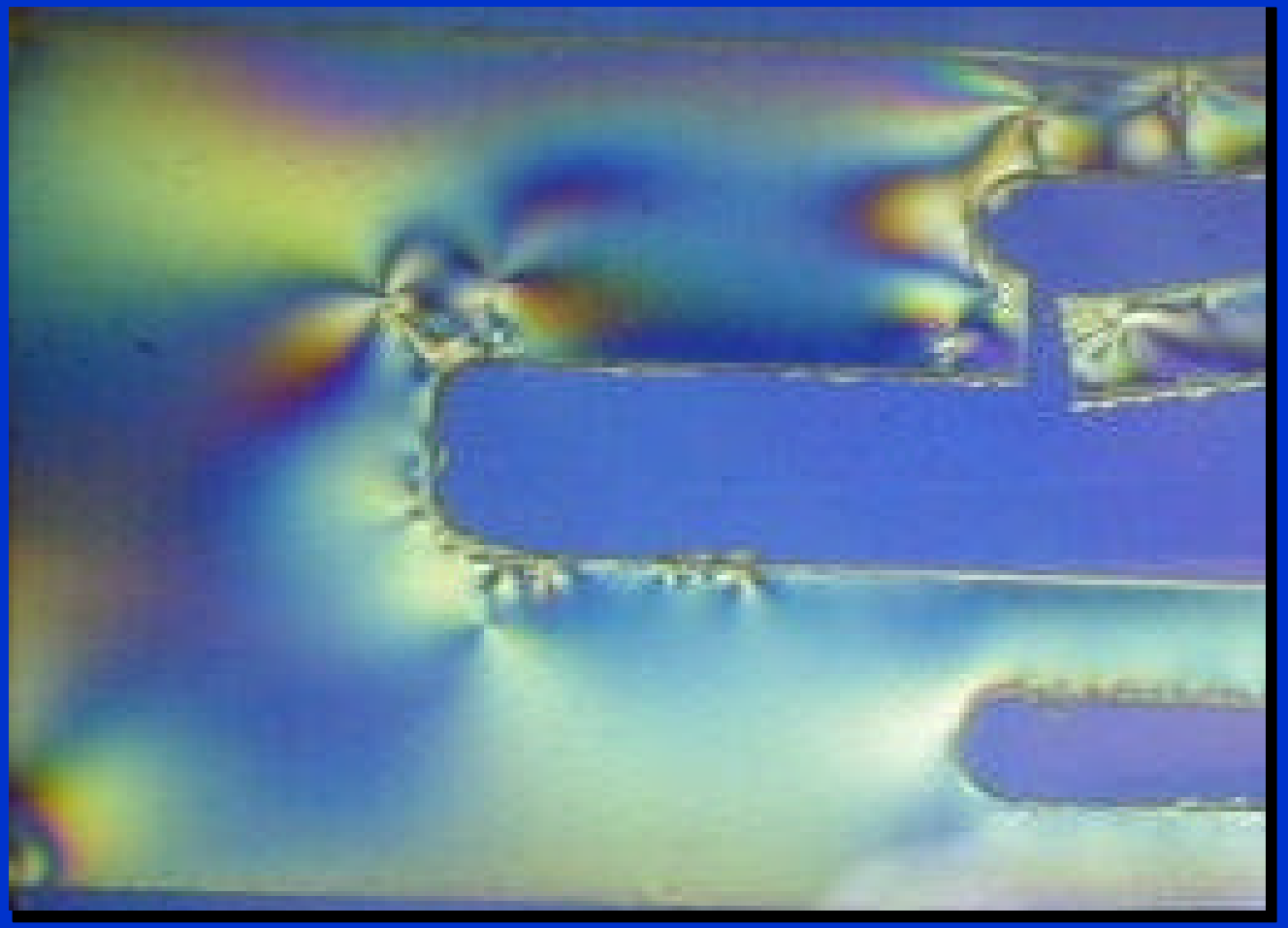
Optical Activity Demo “Barber Pole”



Birefringence Observation



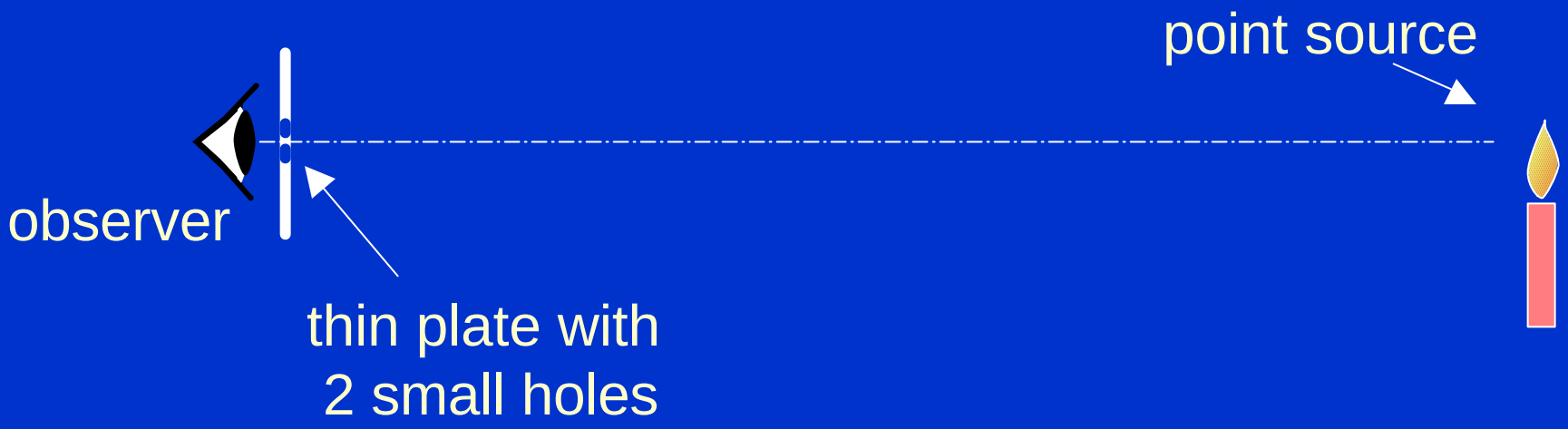
Birefringence Observation



This pattern produced by Gary Fisher

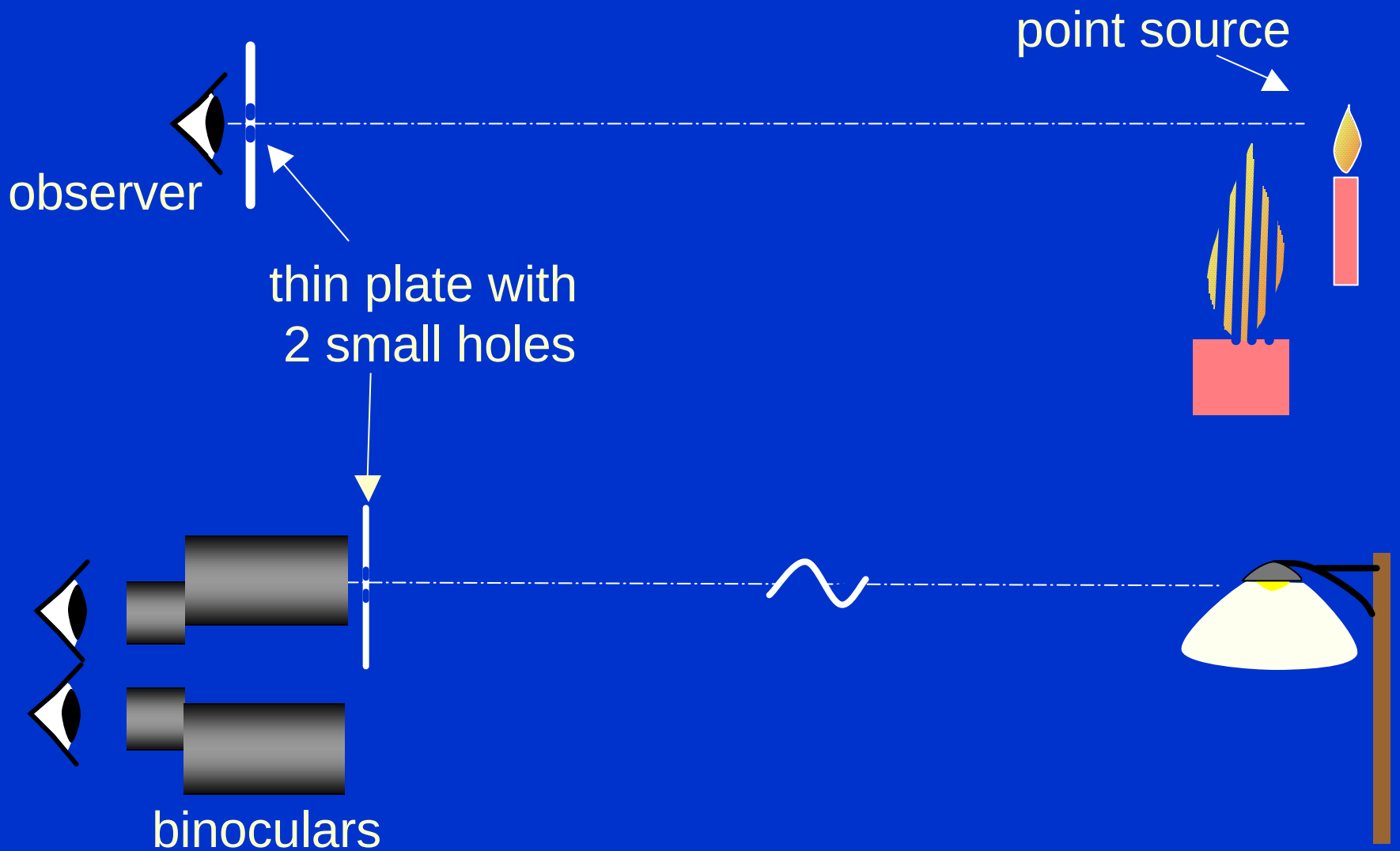
Young’s Two Pinhole Experiment

Young's Two Pinhole Experiment

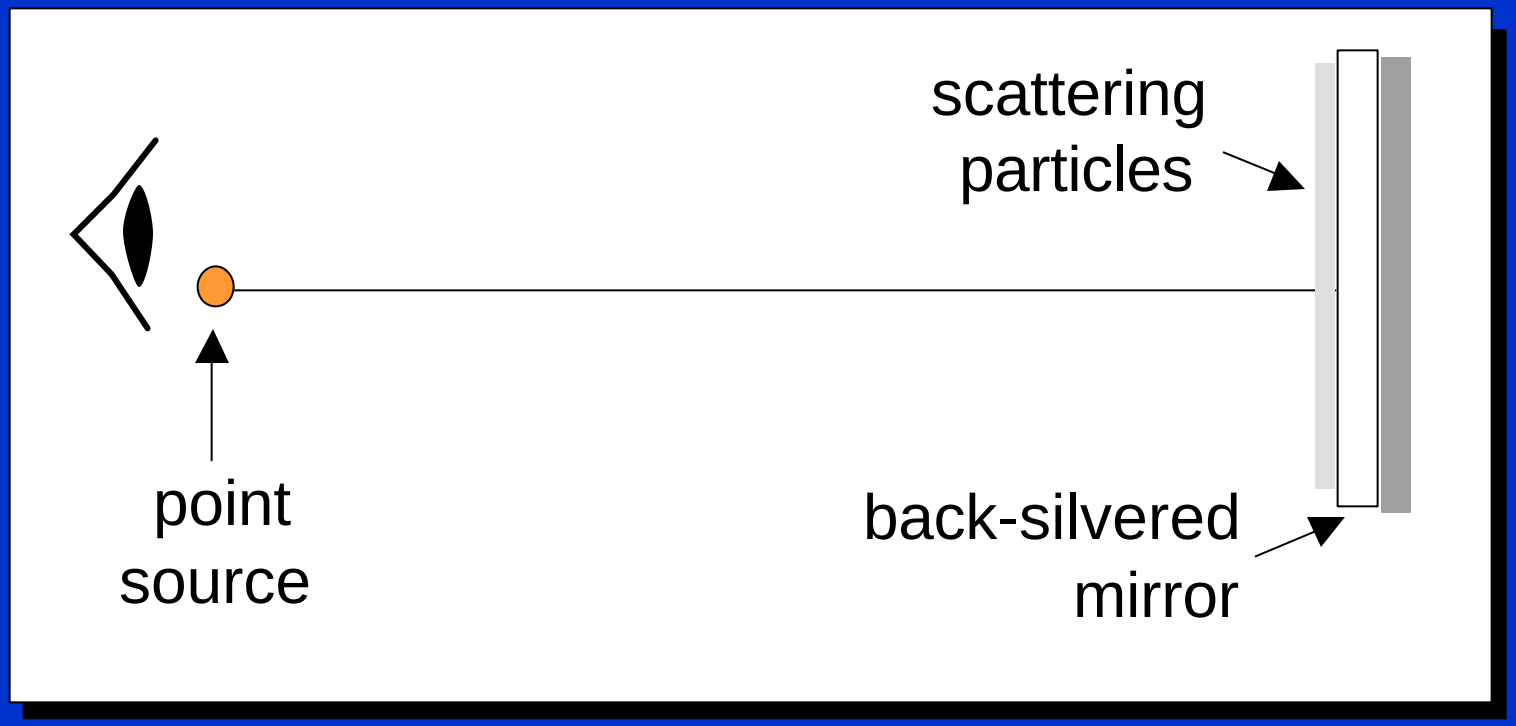


Young’s Two Pinhole Experiment

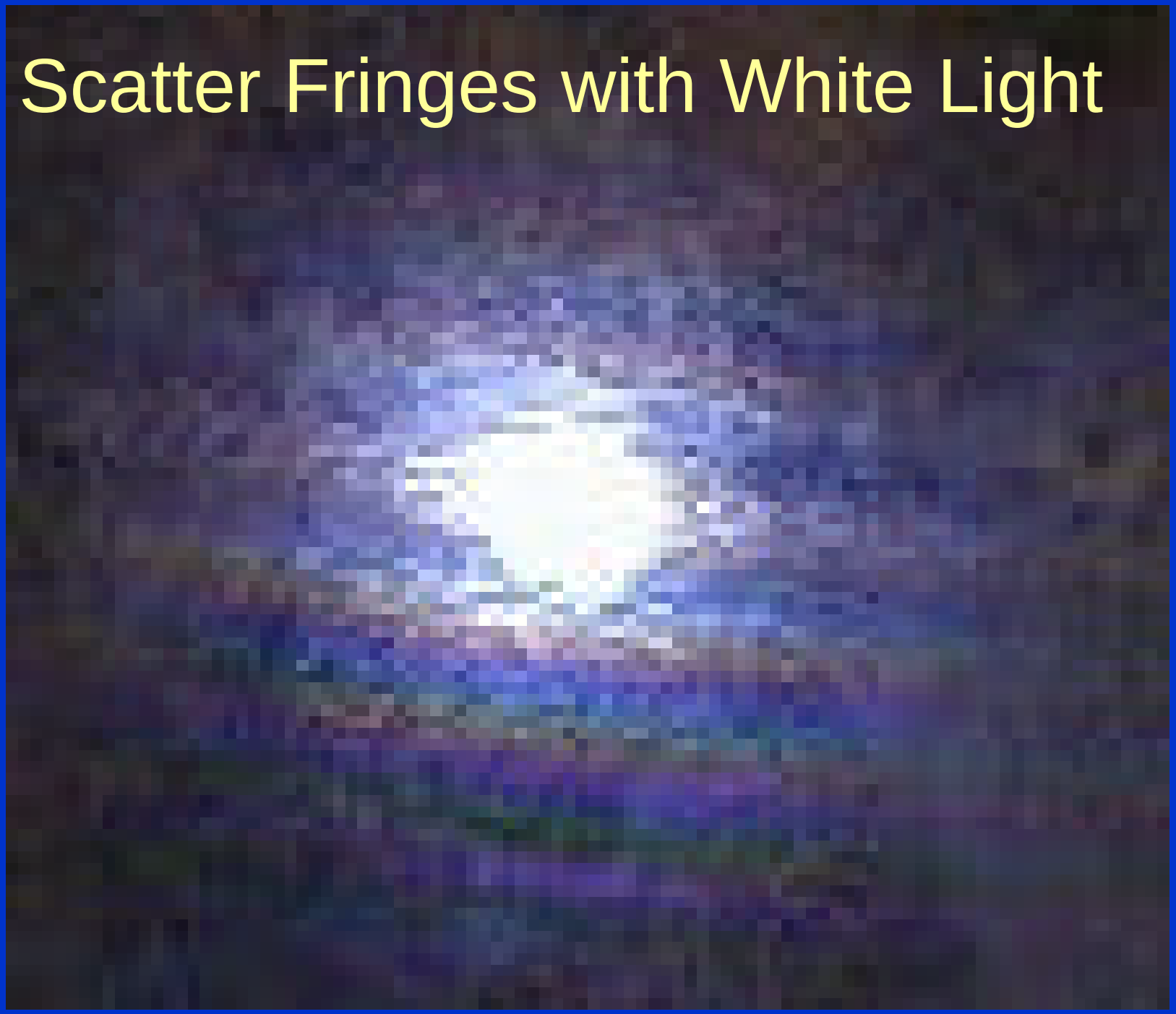
Young's Two Pinhole Experiment



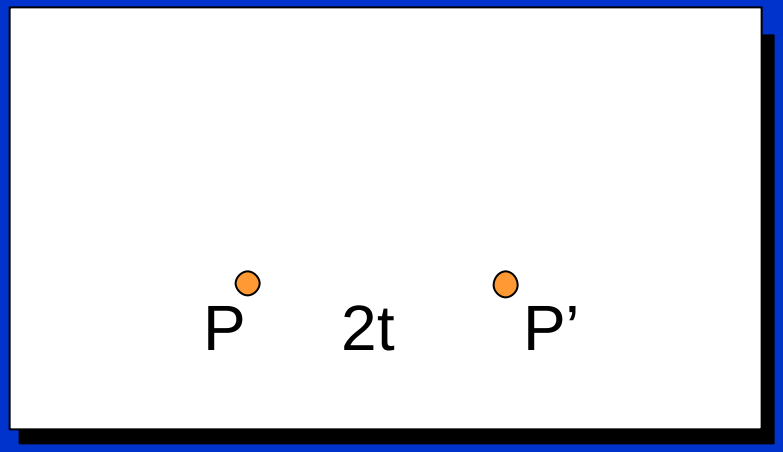
Scatter Fringes with White Light



Scatter Fringes with White Light

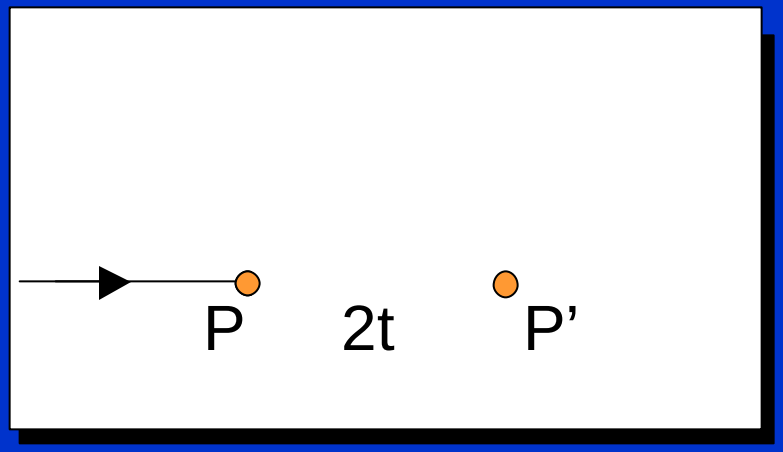


Scatter Fringes with White Light



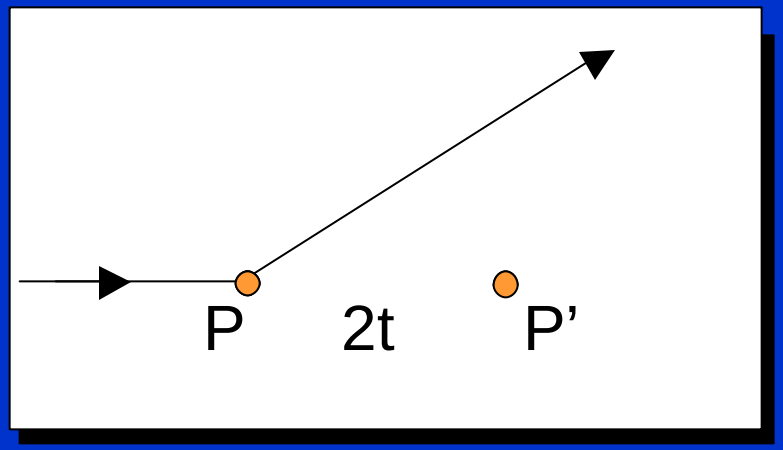
forward scatter

Scatter Fringes with White Light



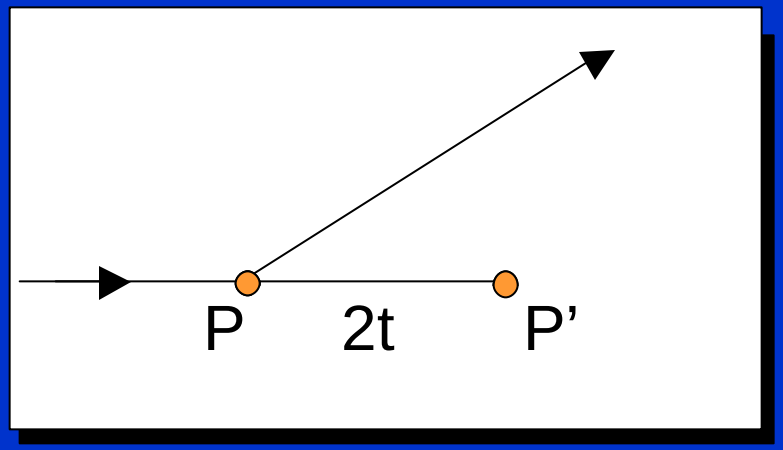
forward scatter

Scatter Fringes with White Light



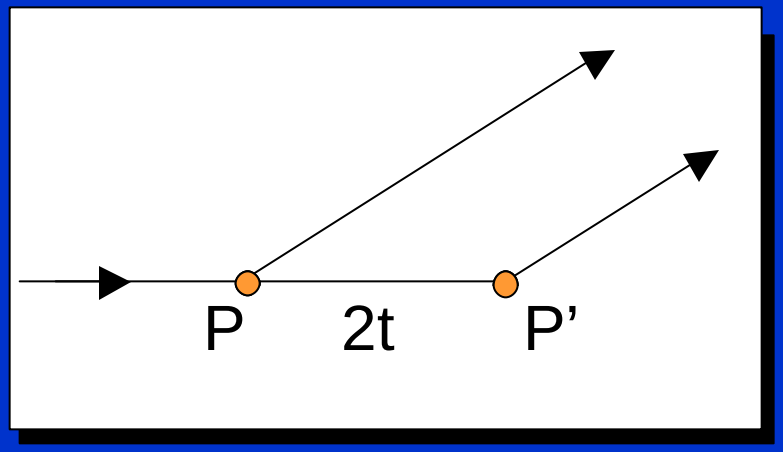
forward scatter

Scatter Fringes with White Light



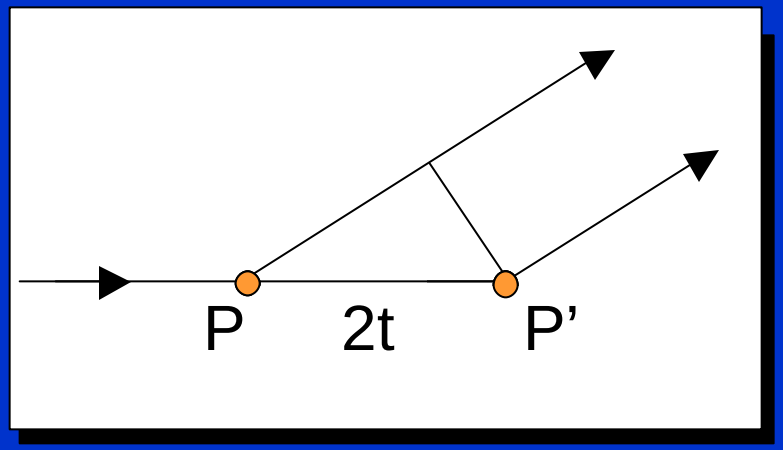
forward scatter

Scatter Fringes with White Light



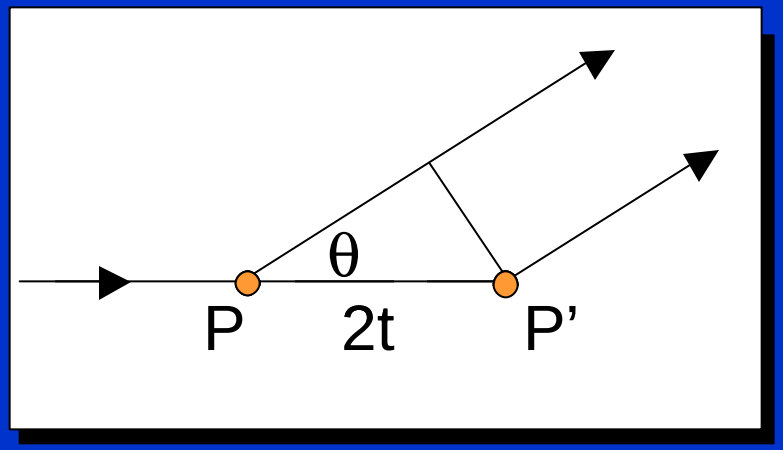
forward scatter

Scatter Fringes with White Light



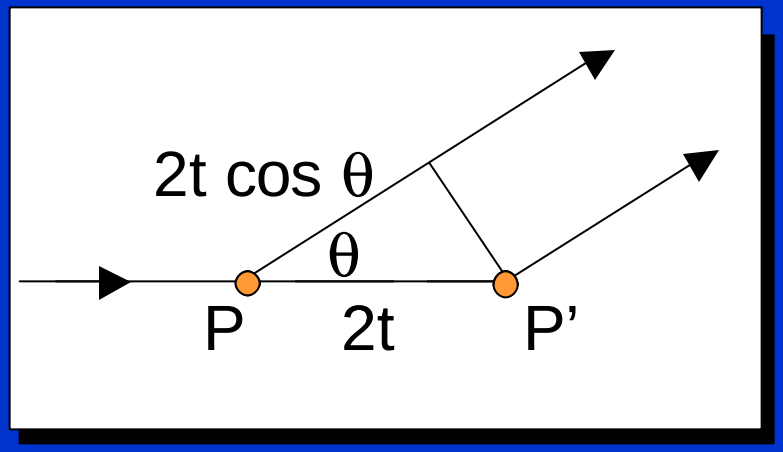
forward scatter

Scatter Fringes with White Light



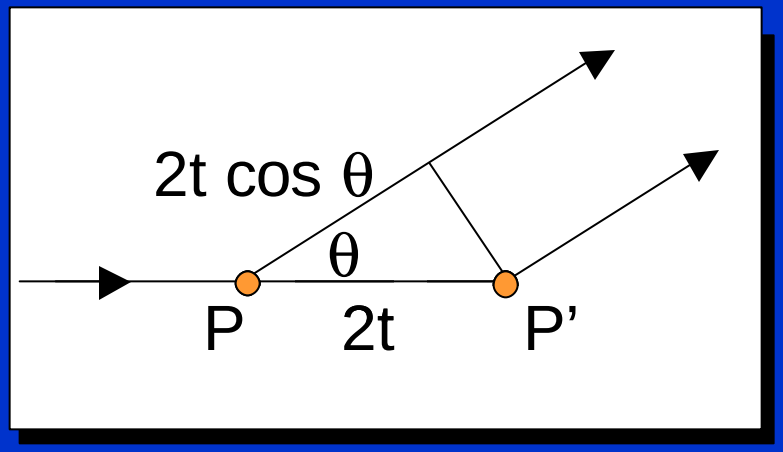
forward scatter

Scatter Fringes with White Light



forward scatter

Scatter Fringes with White Light

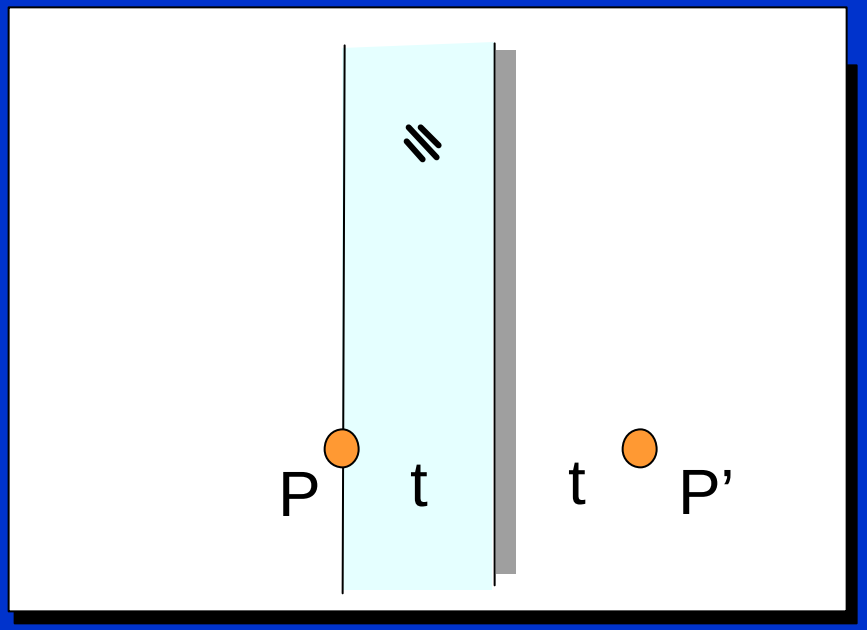


forward scatter

OPD $= 2t - 2t \cos\theta$
$\approx t\,\theta^2$
$= m\lambda$
$(m=1,2,3,\ldots)$

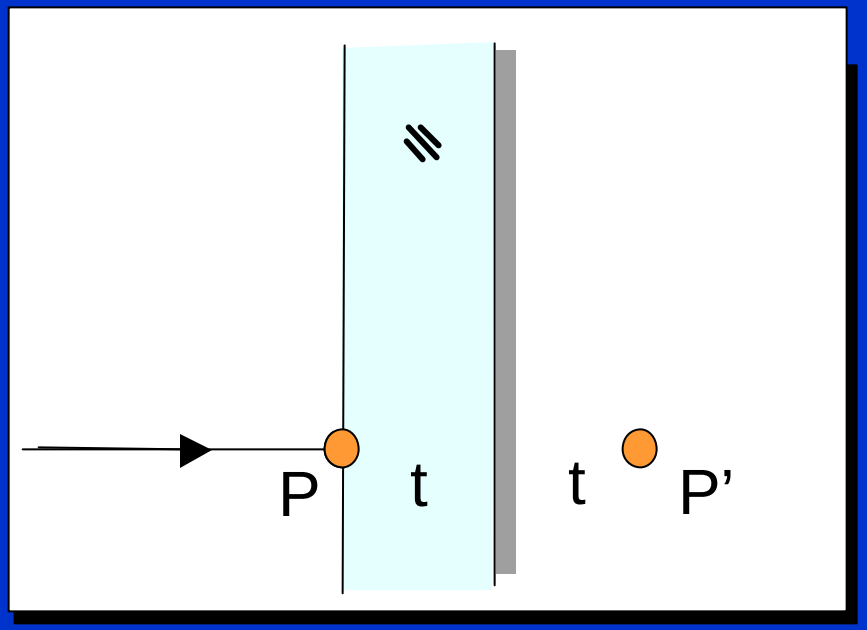
First Fringe $= t\,\theta_1^2 = \lambda$
2nd Fringe $= t\,\theta_2^2 = 2\lambda$

Scatter Fringes with White Light



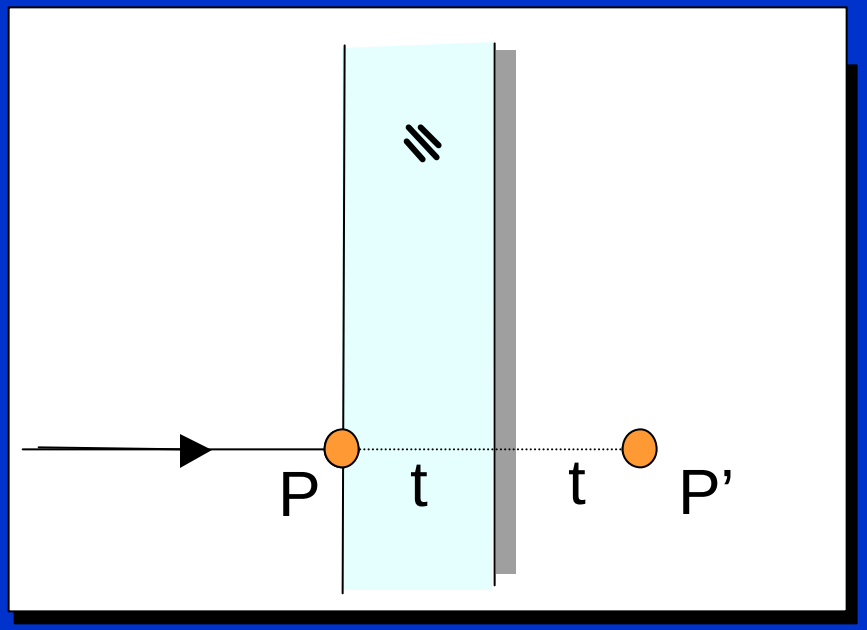
reflected forward scatter

Scatter Fringes with White Light



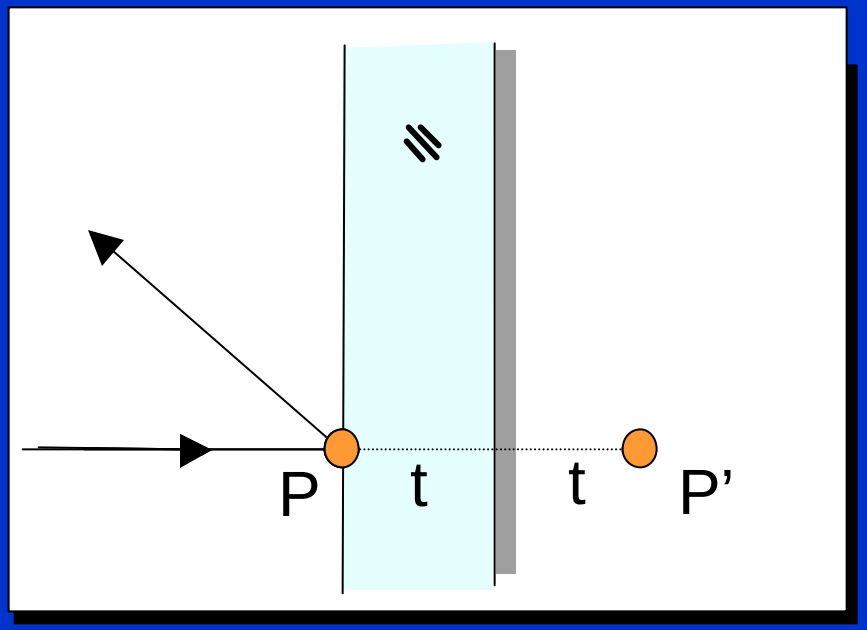
reflected forward scatter

Scatter Fringes with White Light



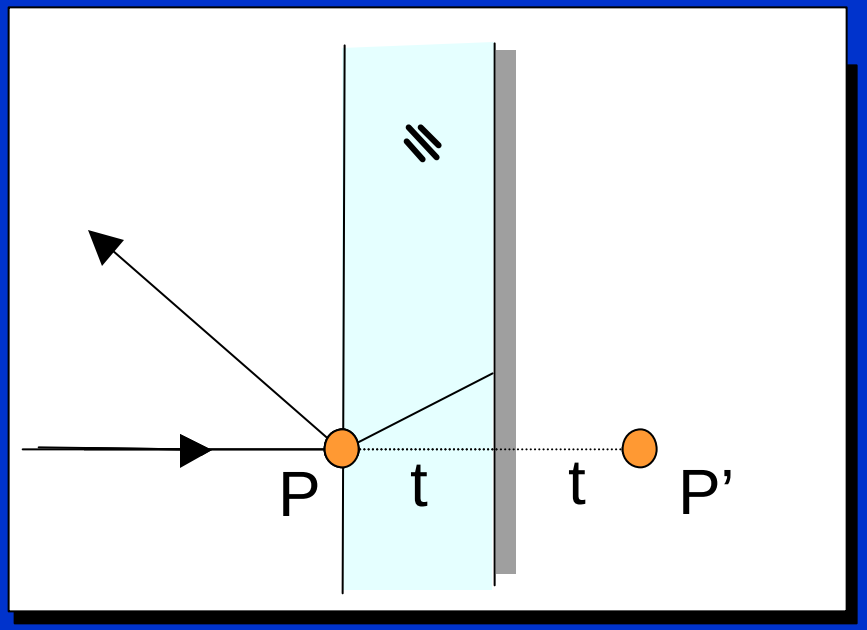
reflected forward scatter

Scatter Fringes with White Light



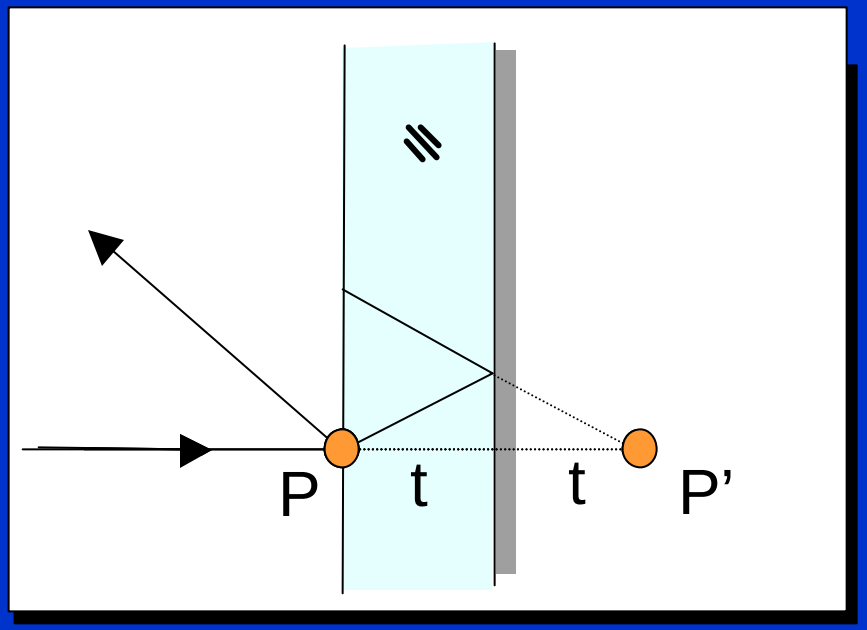
reflected forward scatter

Scatter Fringes with White Light



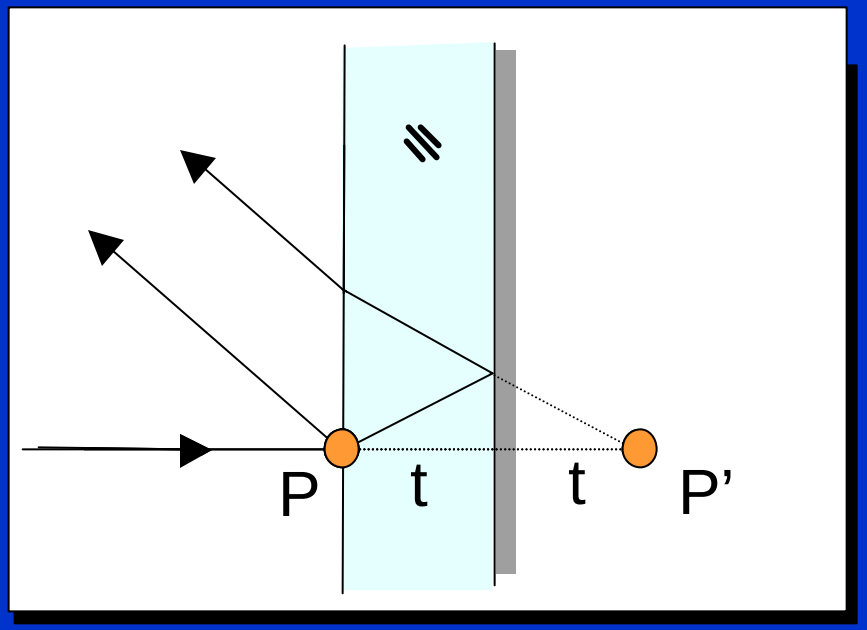
reflected forward scatter

Scatter Fringes with White Light



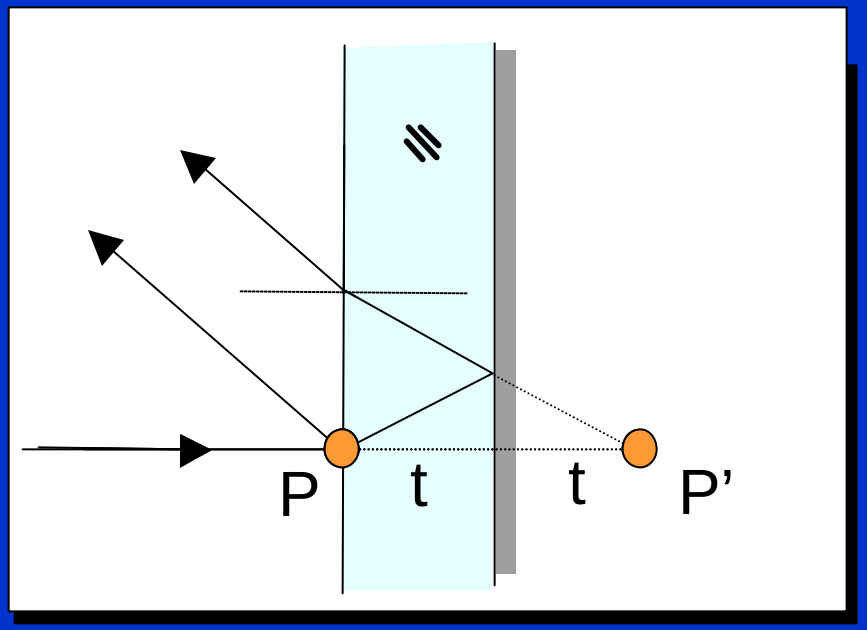
reflected forward scatter

Scatter Fringes with White Light



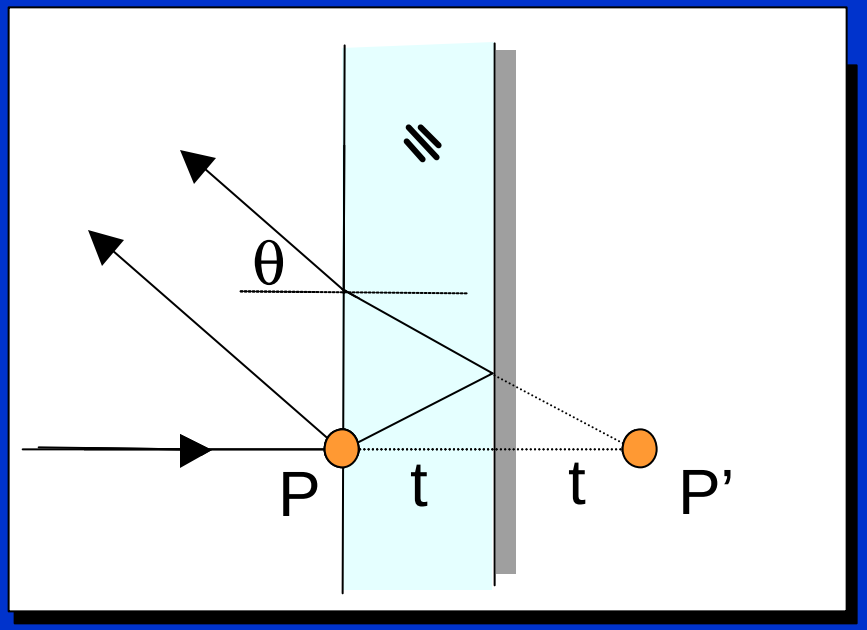
reflected forward scatter

Scatter Fringes with White Light



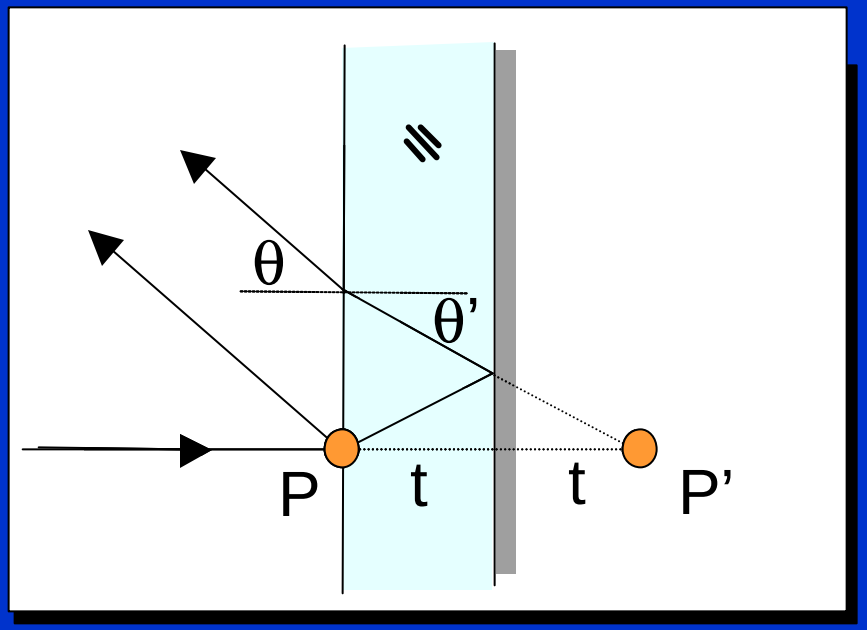
reflected forward scatter

Scatter Fringes with White Light



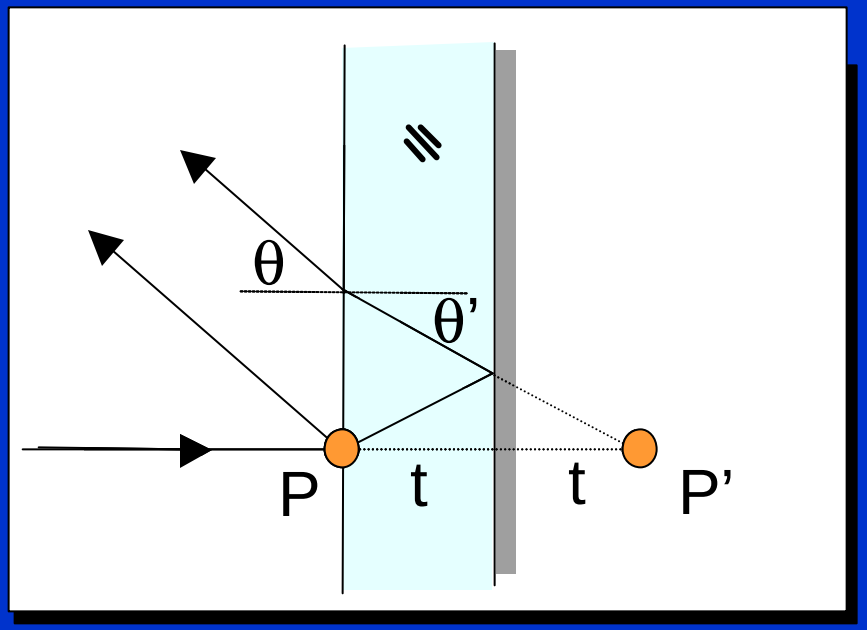
reflected forward scatter

Scatter Fringes with White Light



reflected forward scatter

Scatter Fringes with White Light

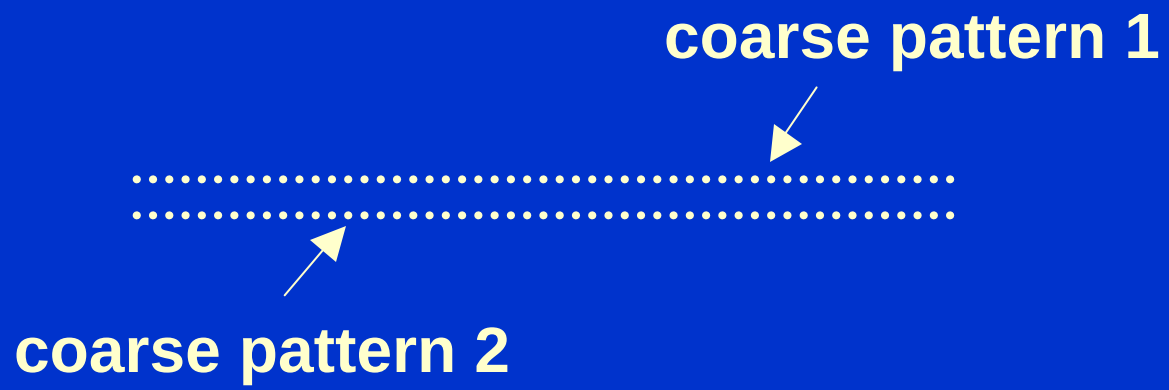


reflected forward scatter

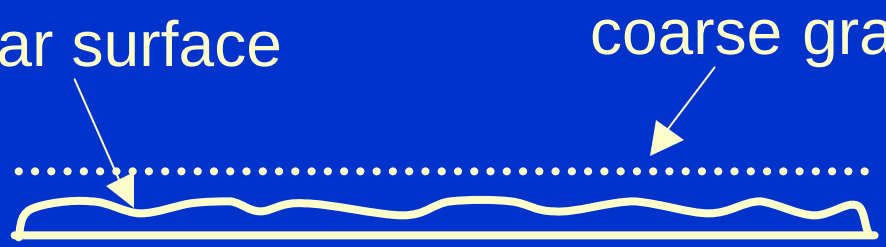
OPD = $2nt - 2nt \cos \theta'$
$\approx t\,\theta^2/n$
$= m\lambda$

First Fringe = $t\,\theta_1^2/n = \lambda$
2nd Fringe = $t\,\theta_2^2/n = 2\lambda$

Fun with Moire Patterns



Moire Patterns Reveal Contours



without grating

with grating

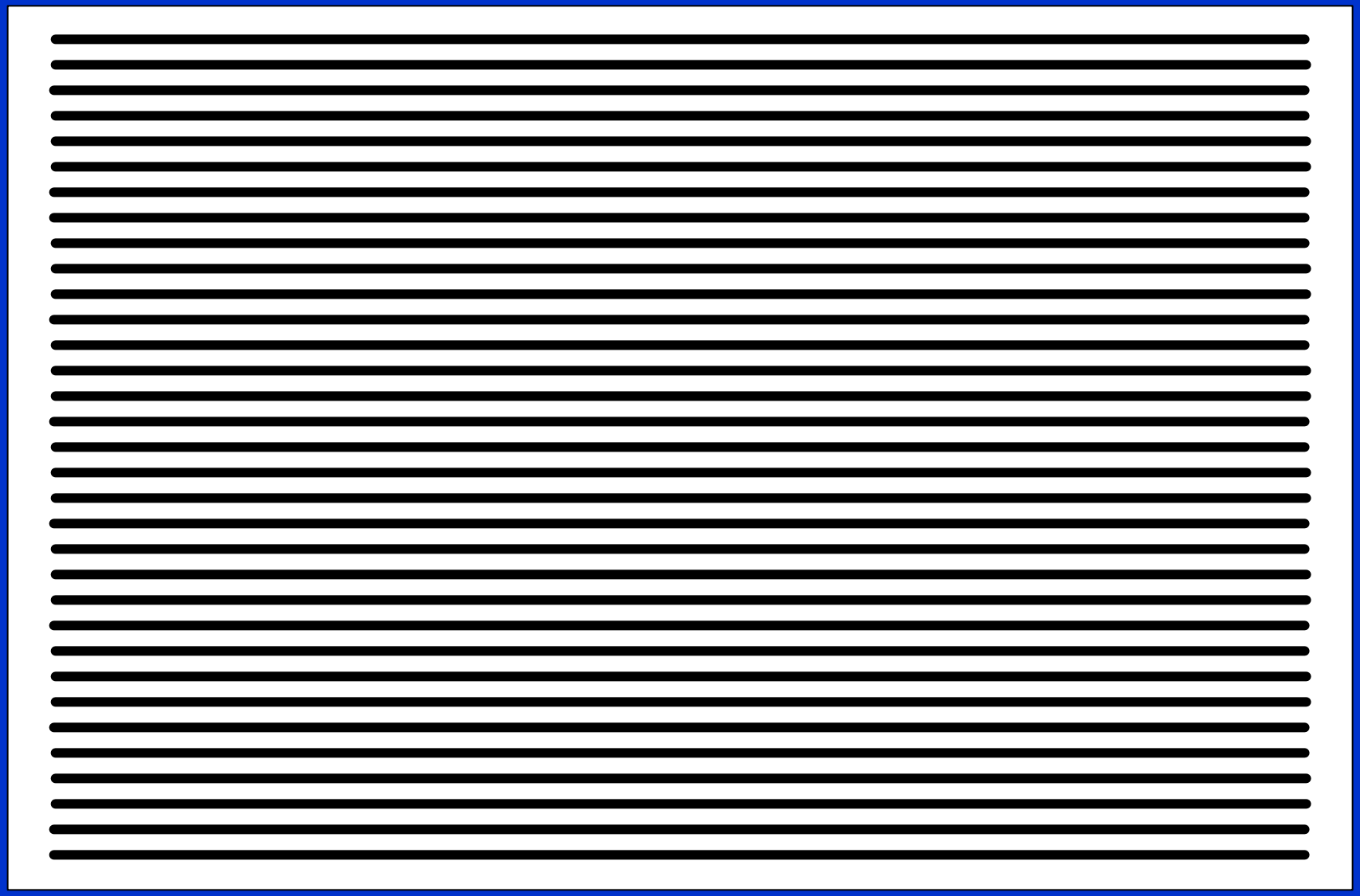
Fun with Moire Patterns

Equal Straight Lines
+
Equal Straight Lines

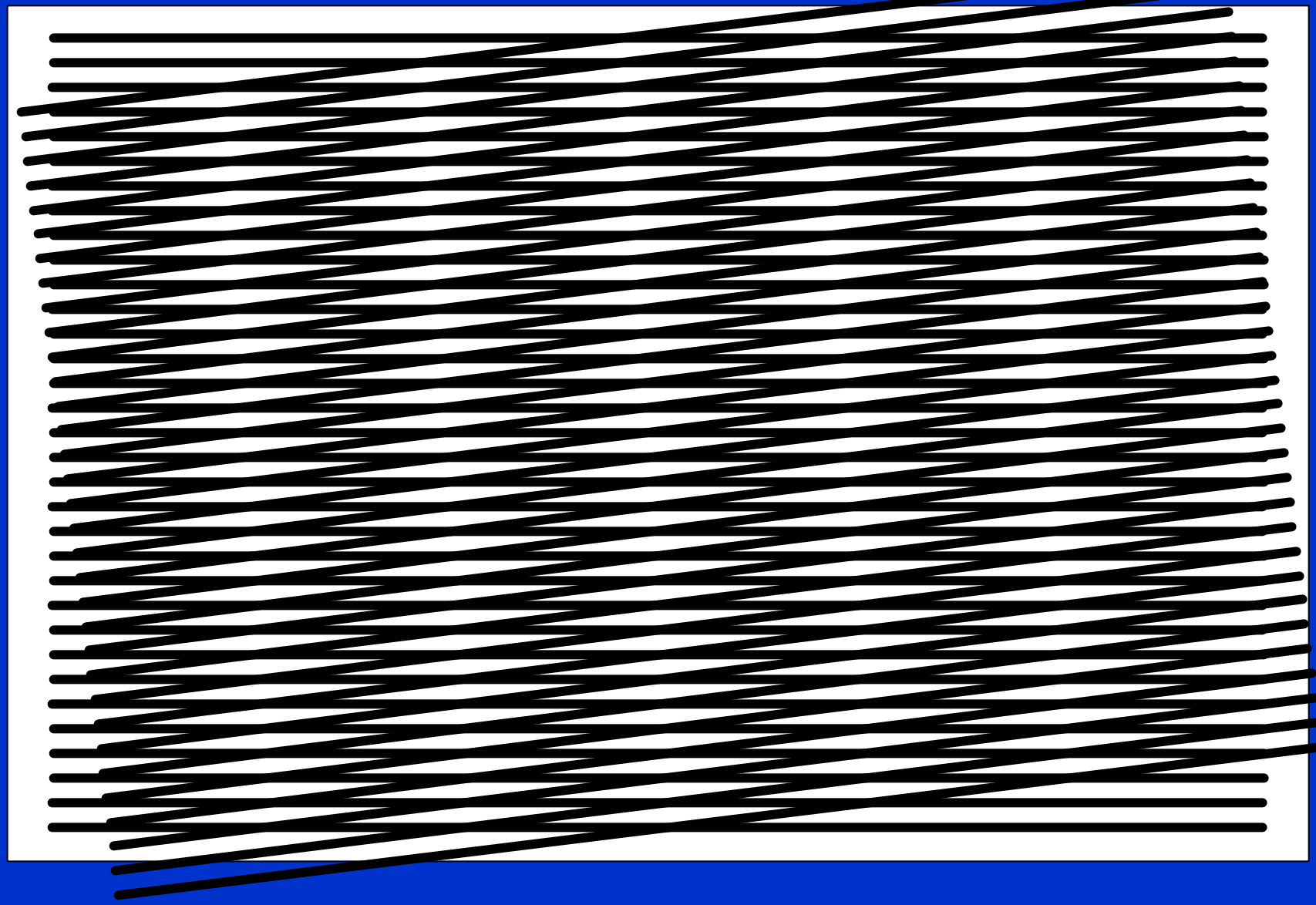
= Equal Straight Fringes

(spacing dependent on the angle)

Fun with Moire Patterns



Fun with Moire Patterns



Fun with Moire Patterns

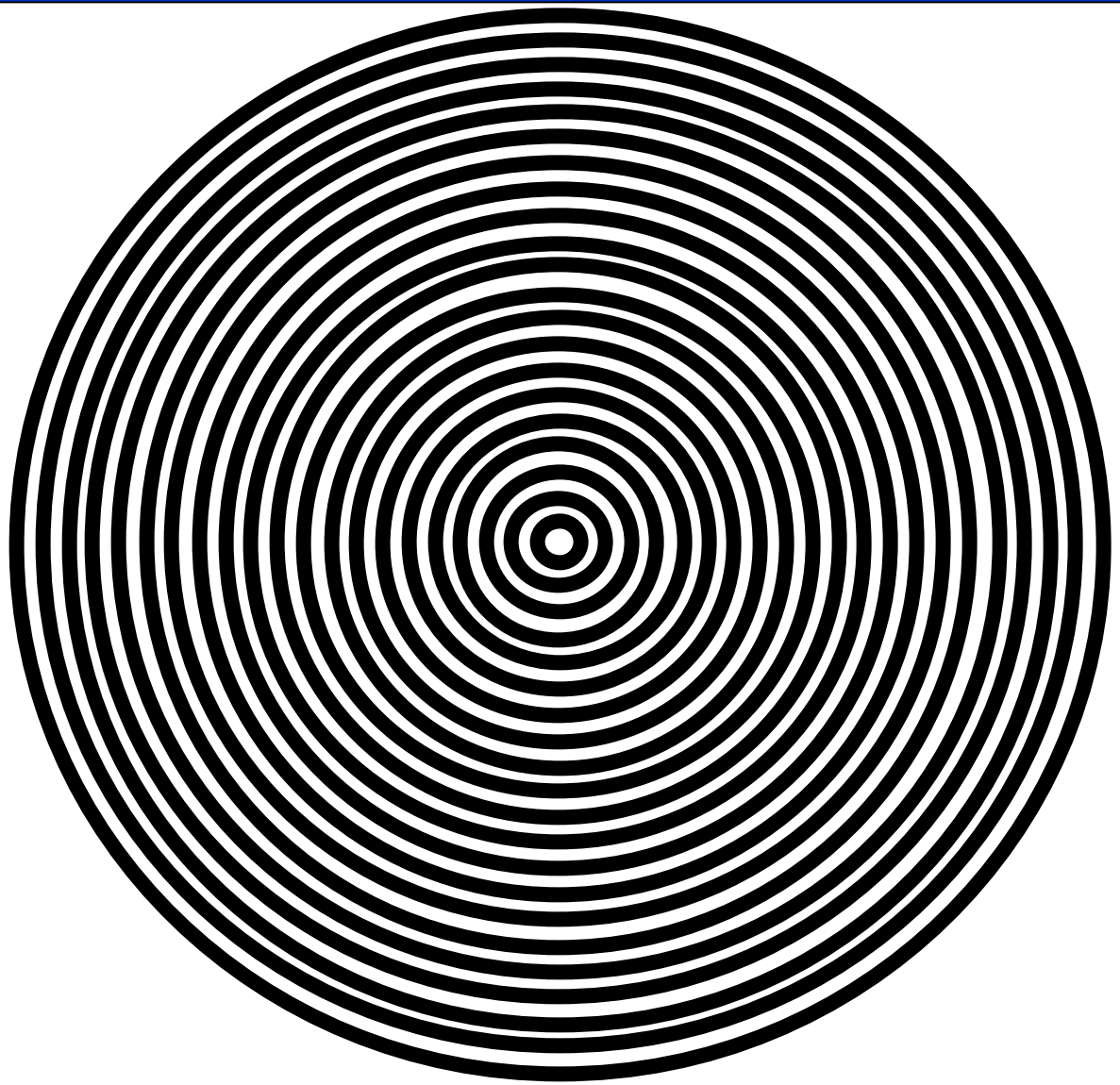
Equal Concentric Circles

+

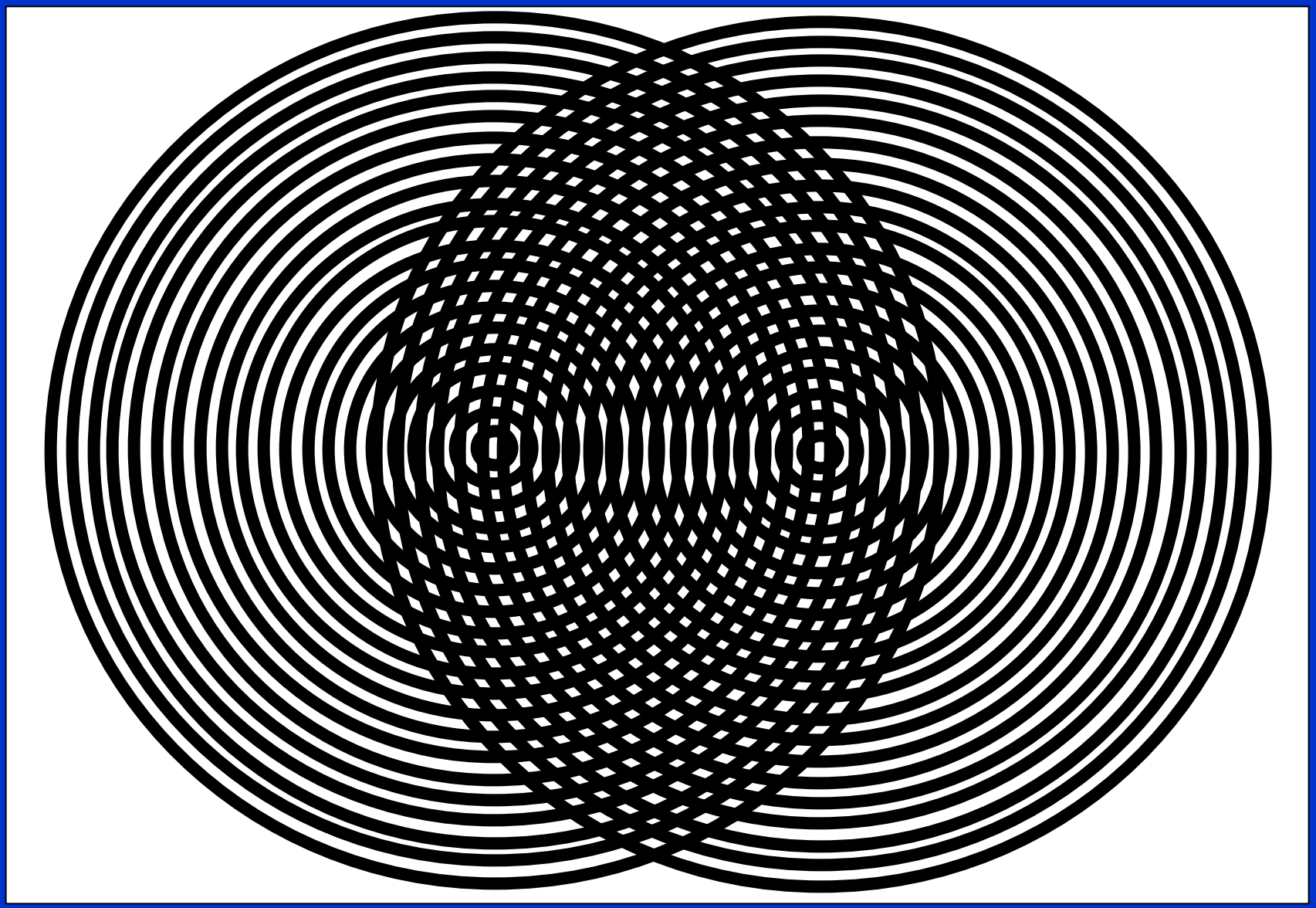
Equal Concentric Circles

= Ellipses and Hyperbolas

Fun with Moire Patterns



Fun with Moire Patterns



Fun with Moire Patterns

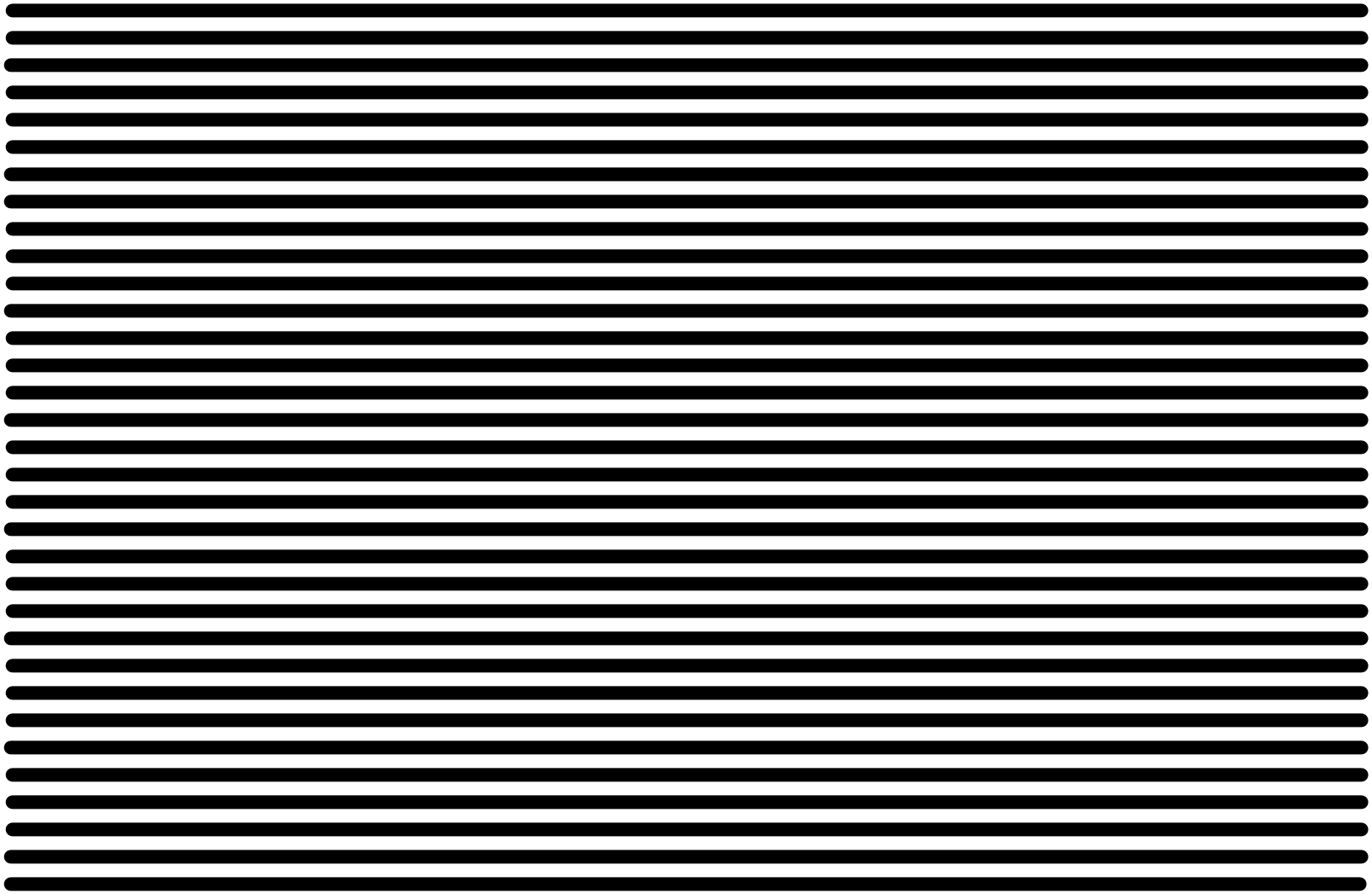
Equal Concentric Circles

+

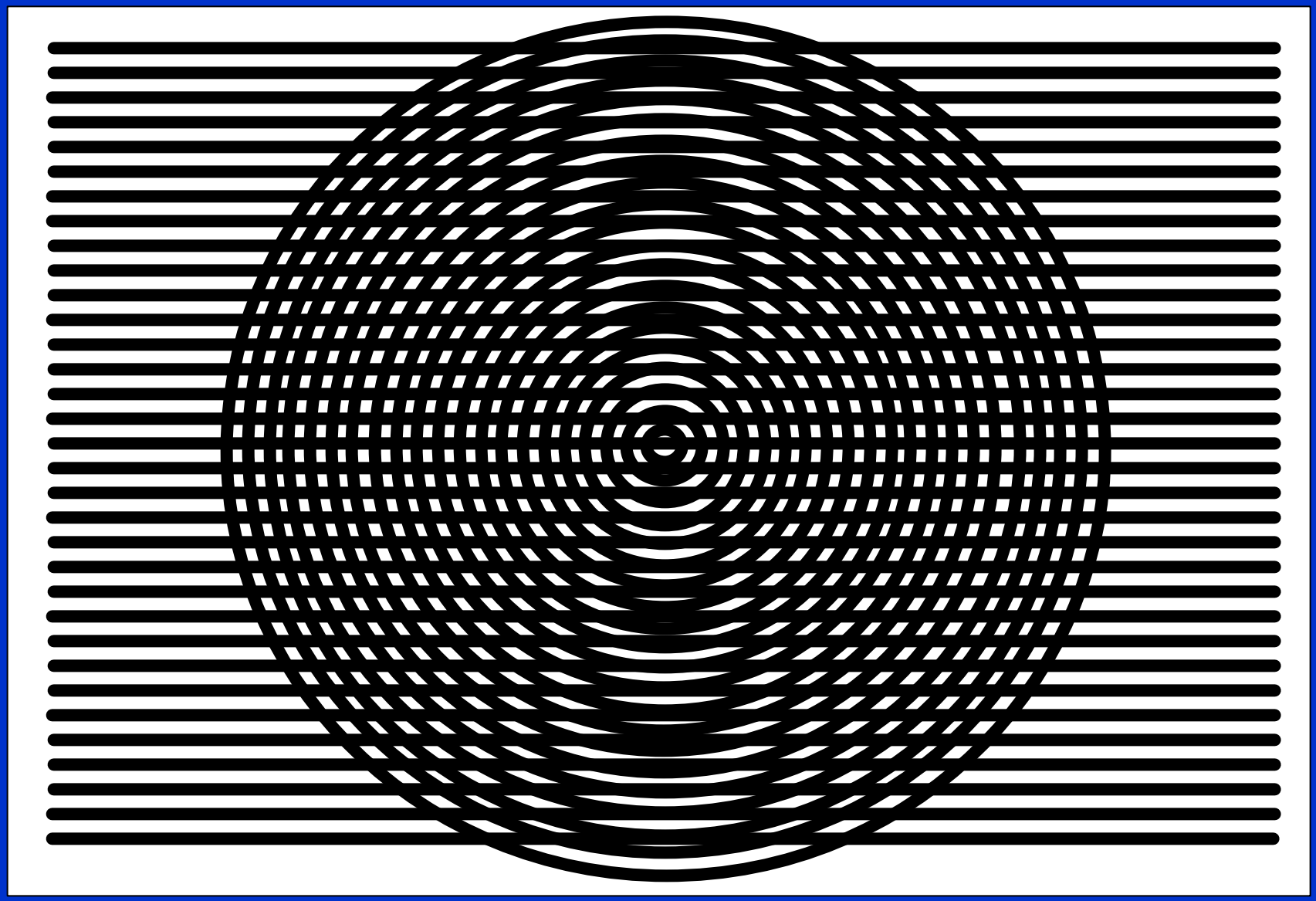
Equal Straight Lines

= Ellipses, Parabolas, & Hyperbolas
(depending on relative spacing)

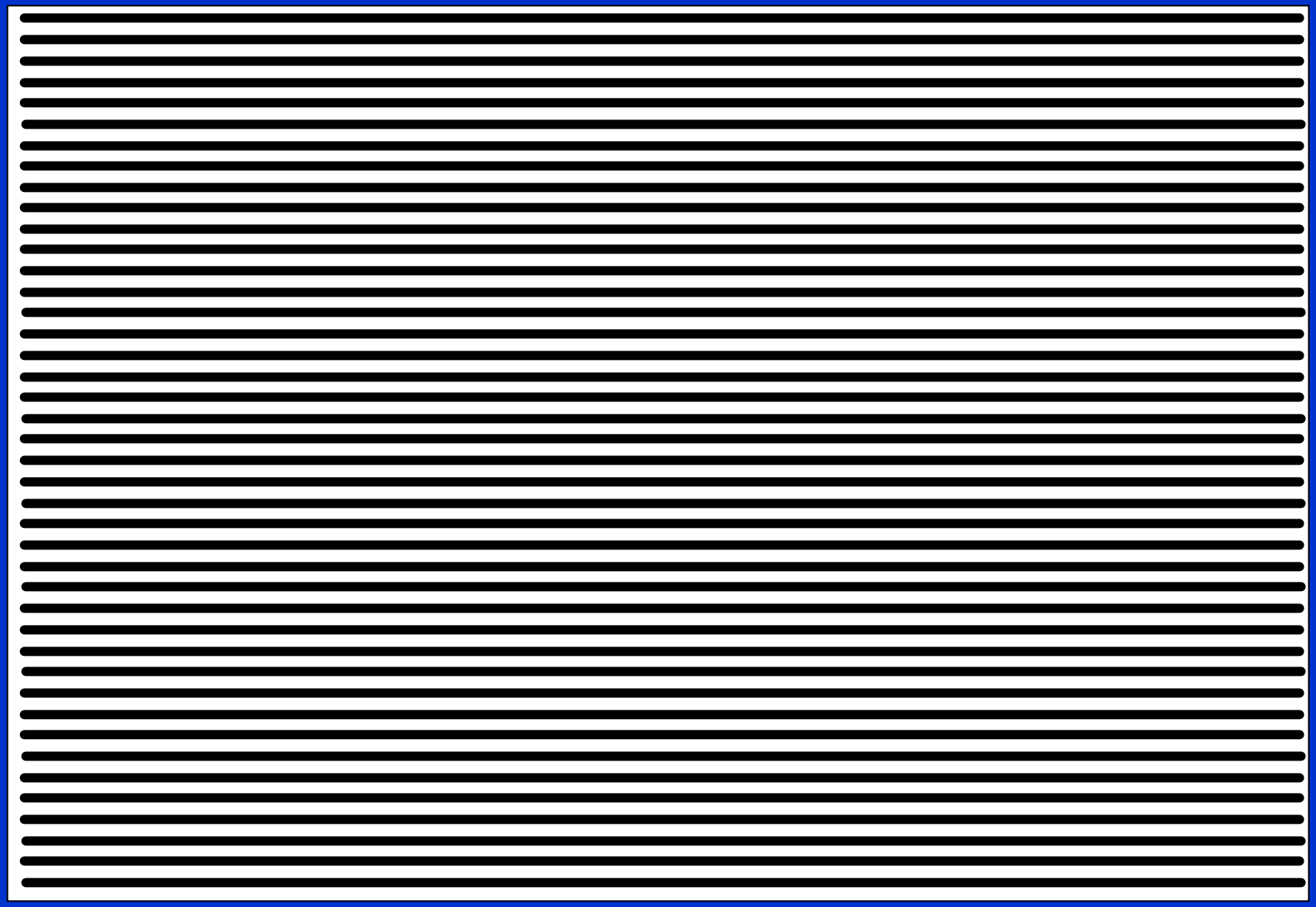
Fun with Moire Patterns



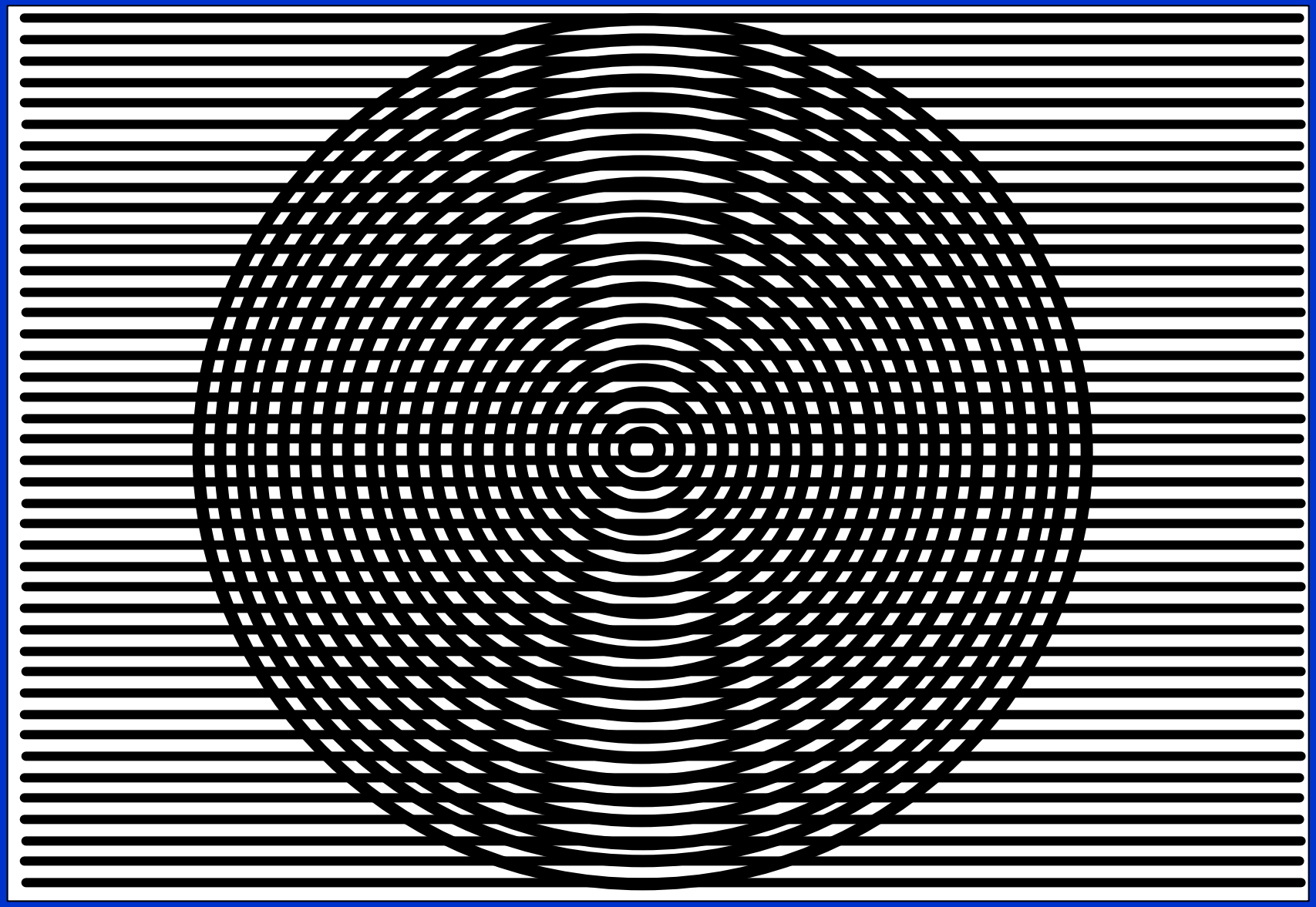
Fun with Moire Patterns



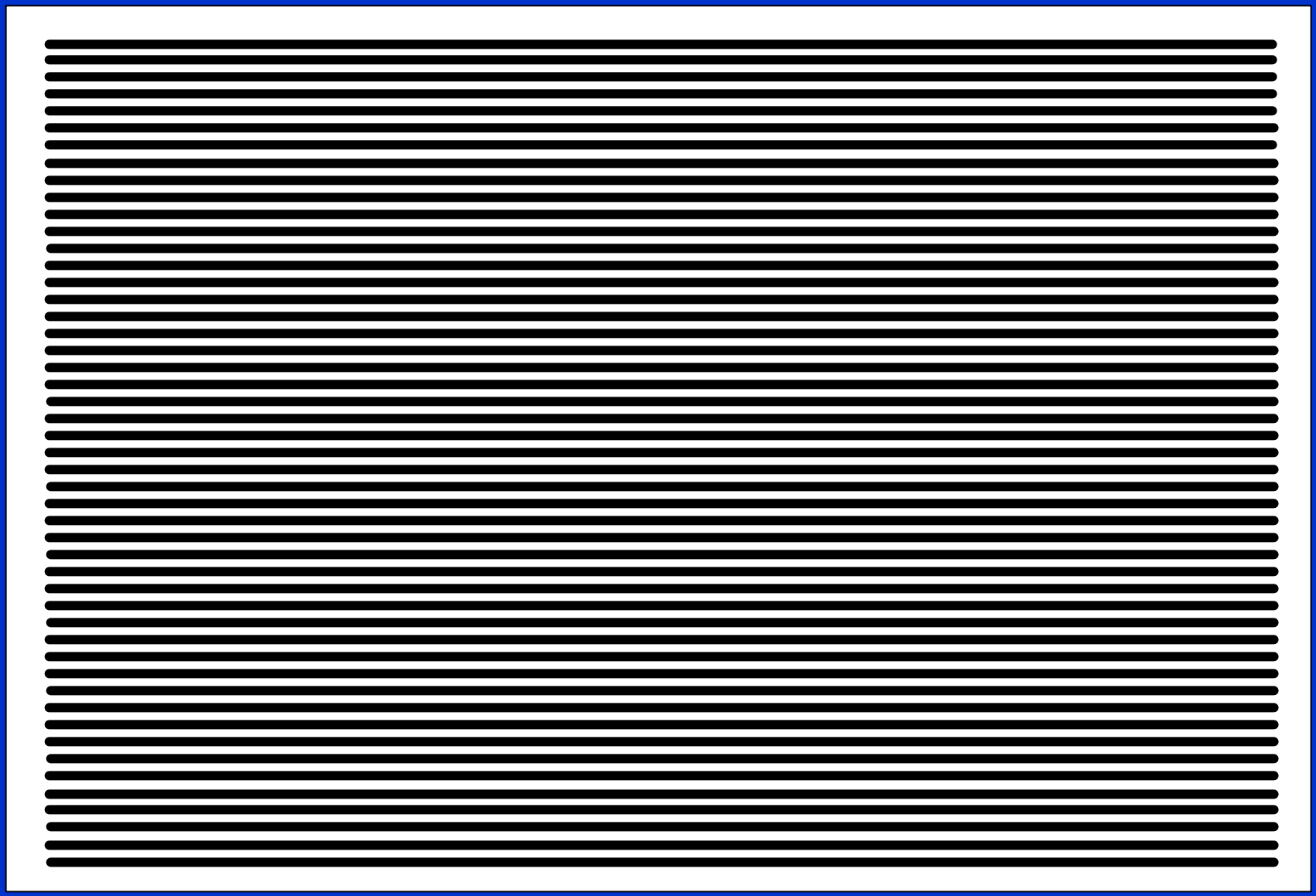
Fun with Moire Patterns



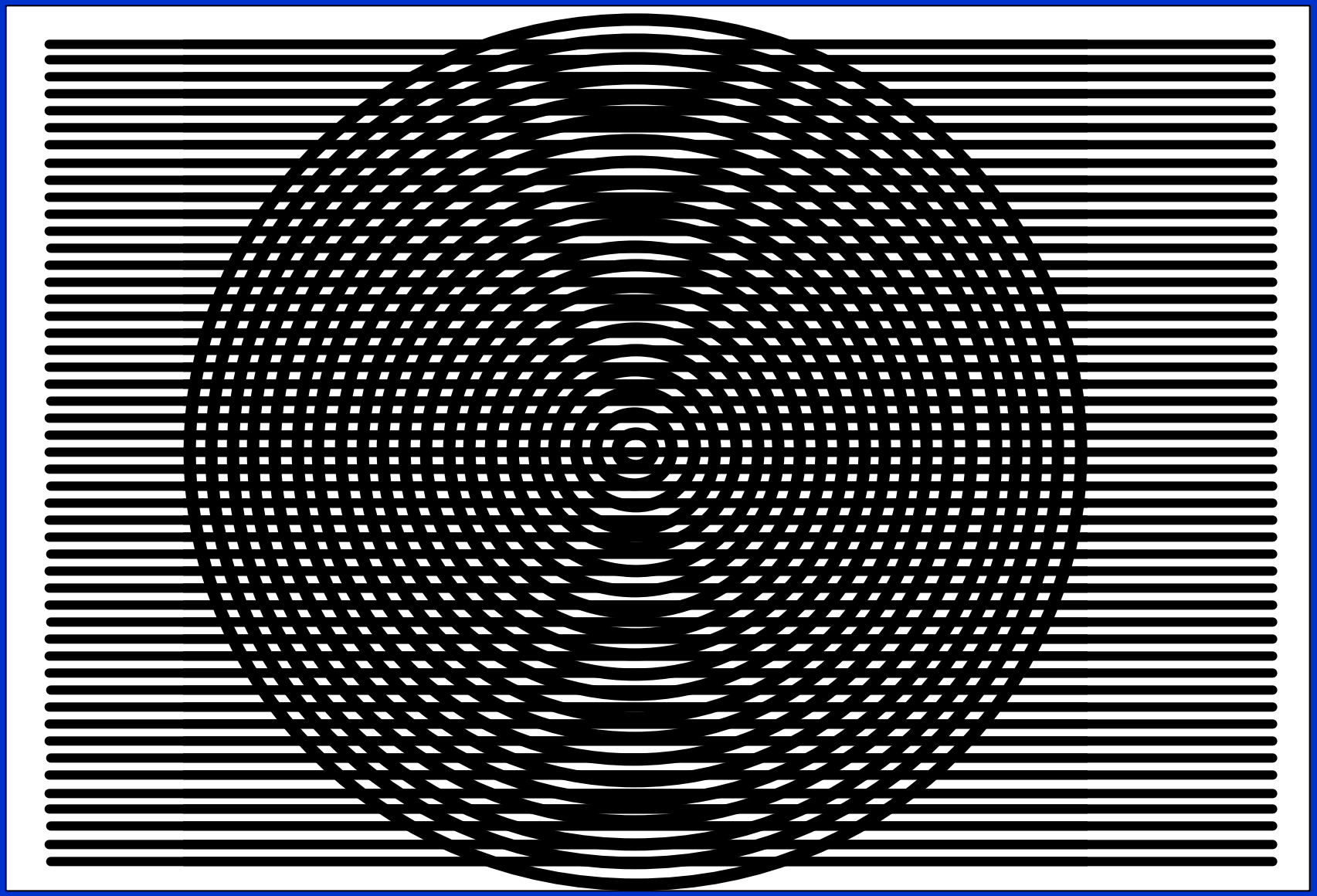
Fun with Moire Patterns



Fun with Moire Patterns



Fun with Moire Patterns



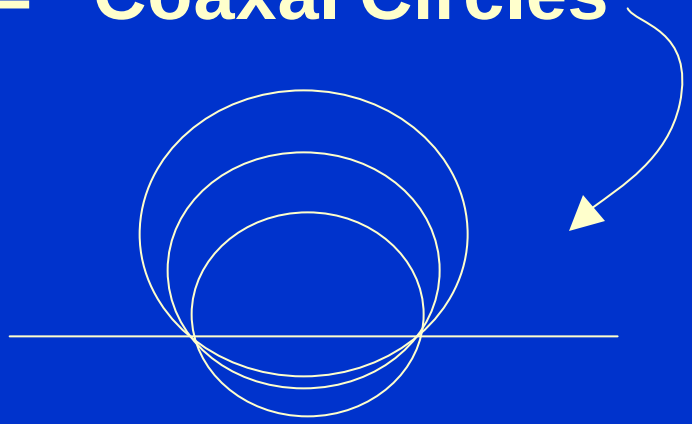
Fun with Moire Patterns

Equal Radial Lines

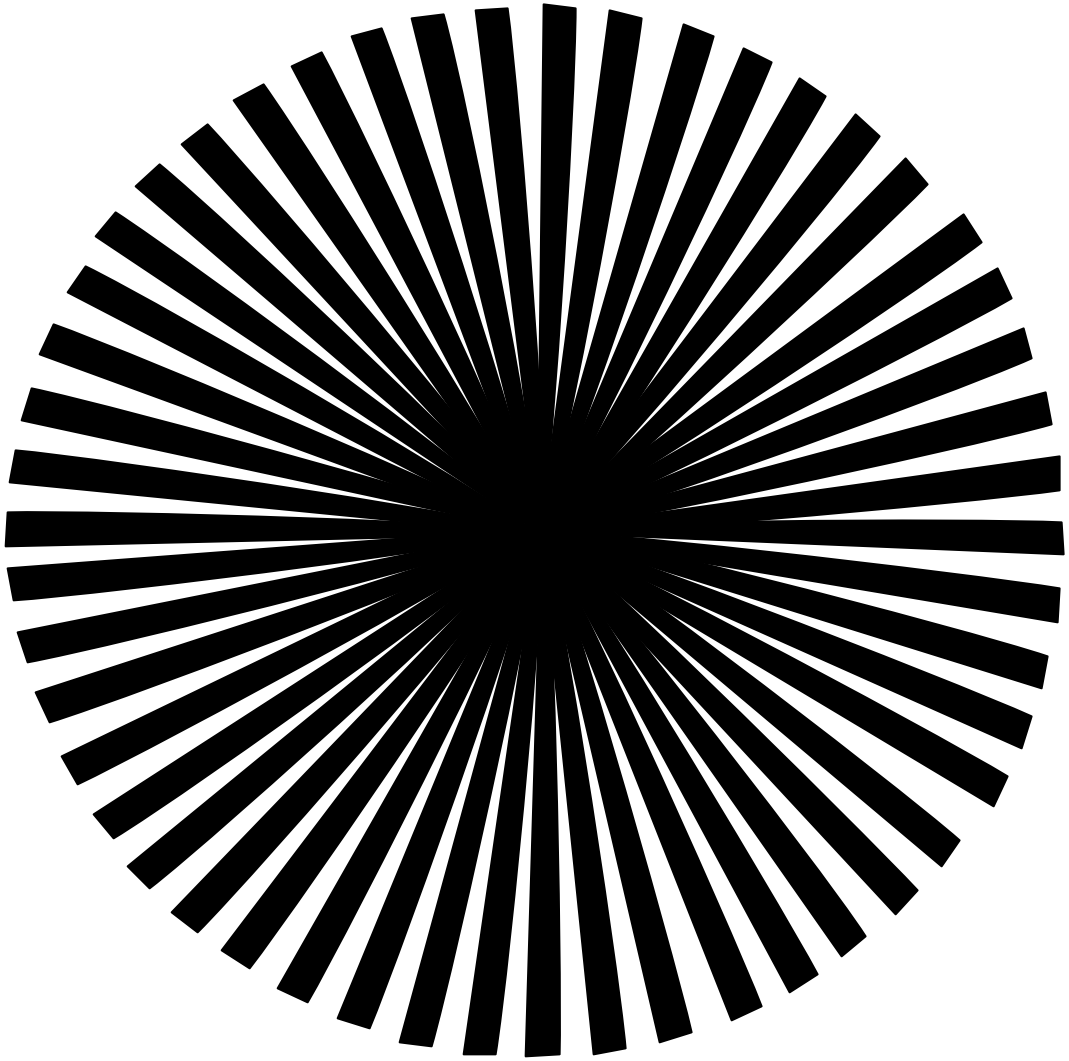
+

Equal Radial Lines

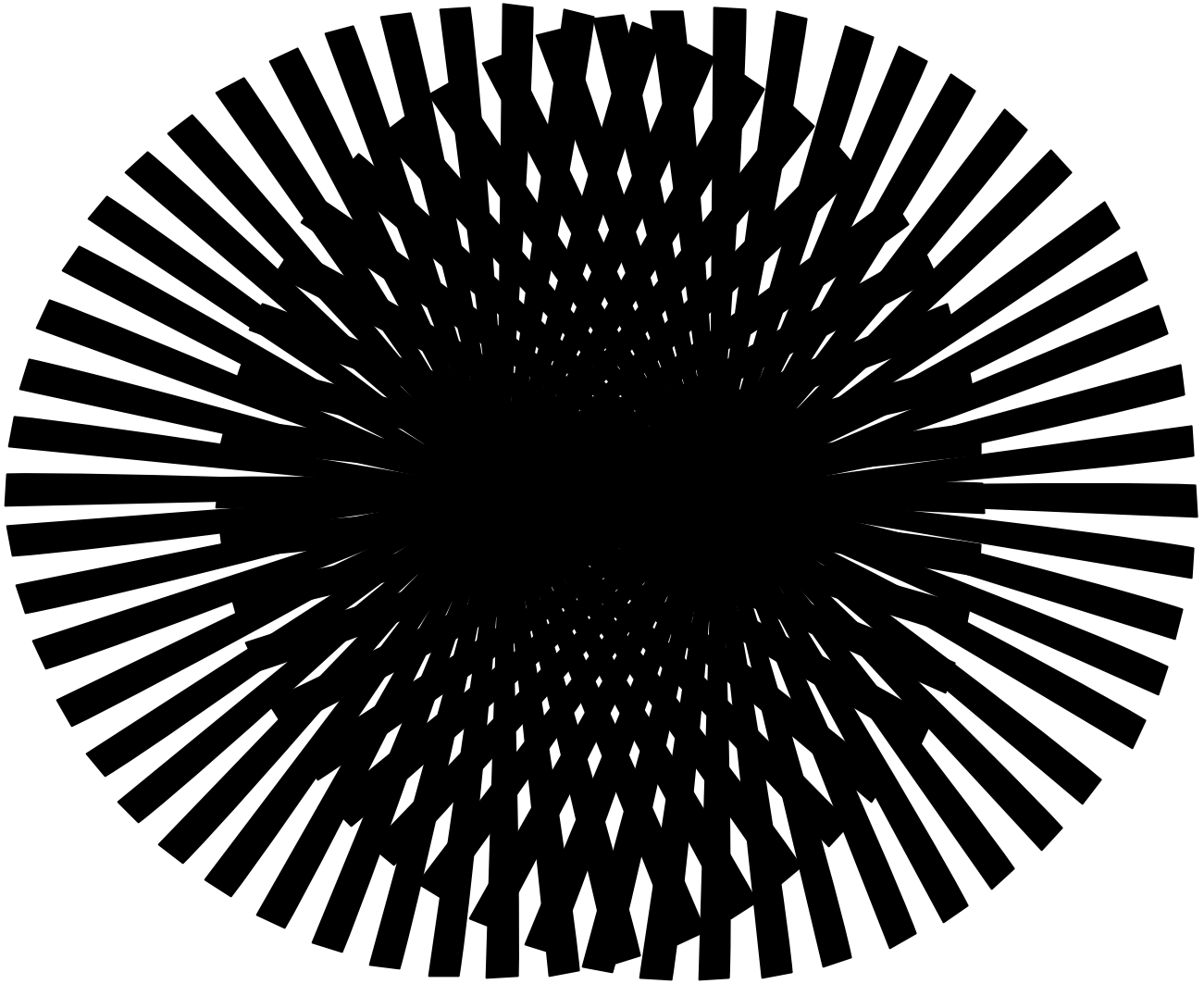
= Coaxal Circles



Fun with Moire Patterns



Fun with Moire Patterns



Fun with Moire Patterns

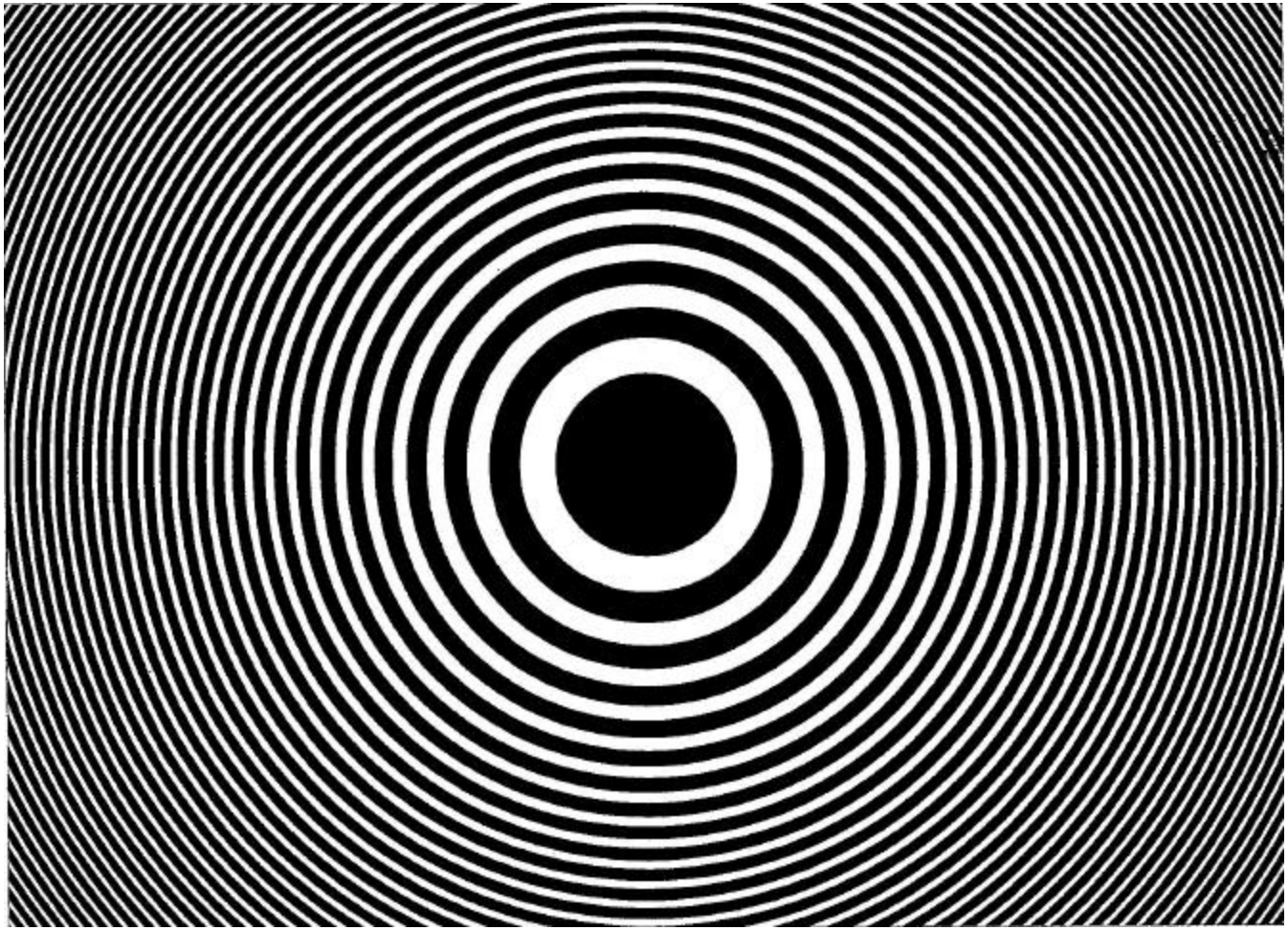
Newton Circles

+

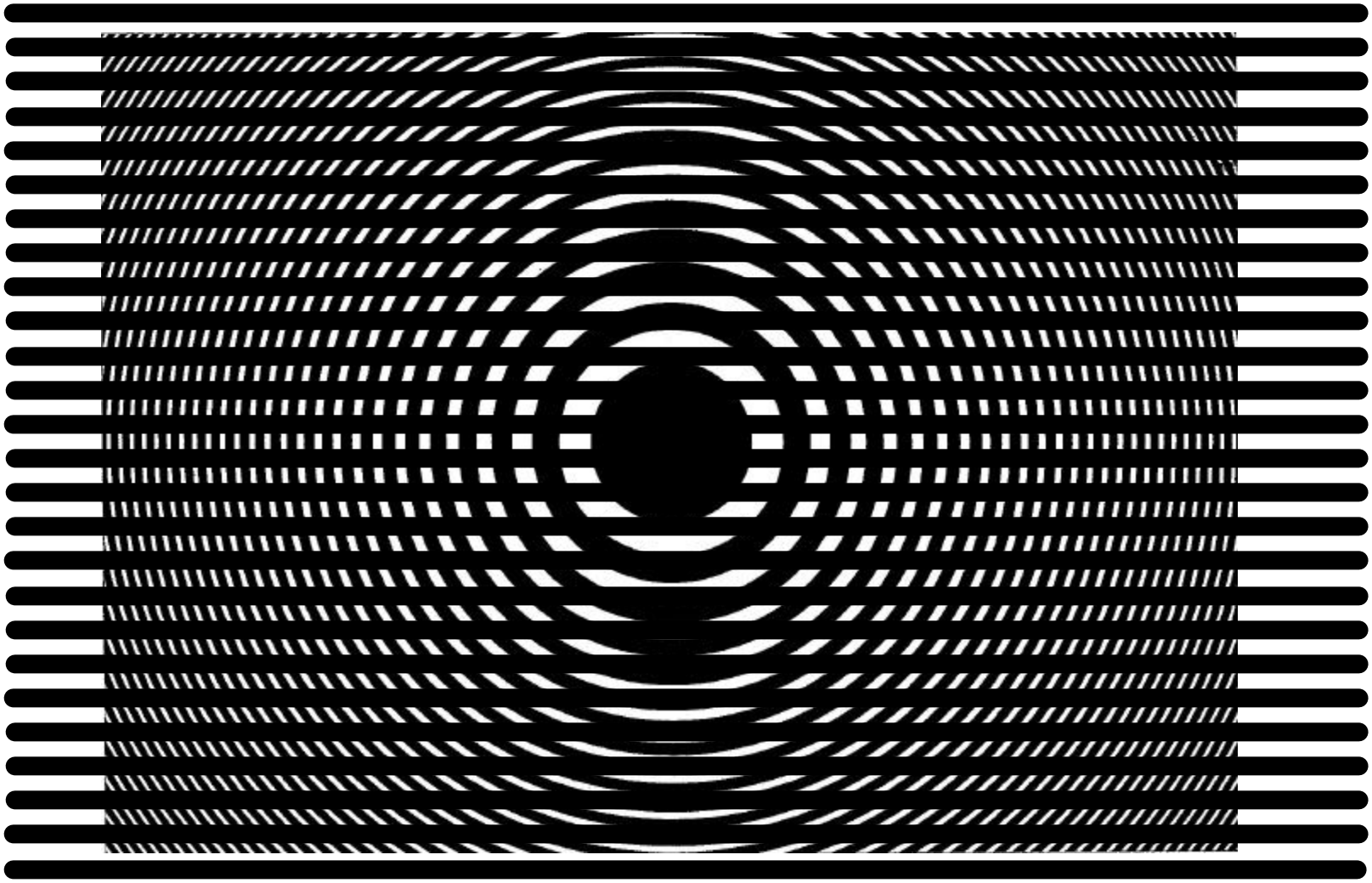
Equal Straight Lines

= Newton Circles

Fun with Moire Patterns



Fun with Moire Patterns



Fun with Moire Patterns

Newton Circles

+

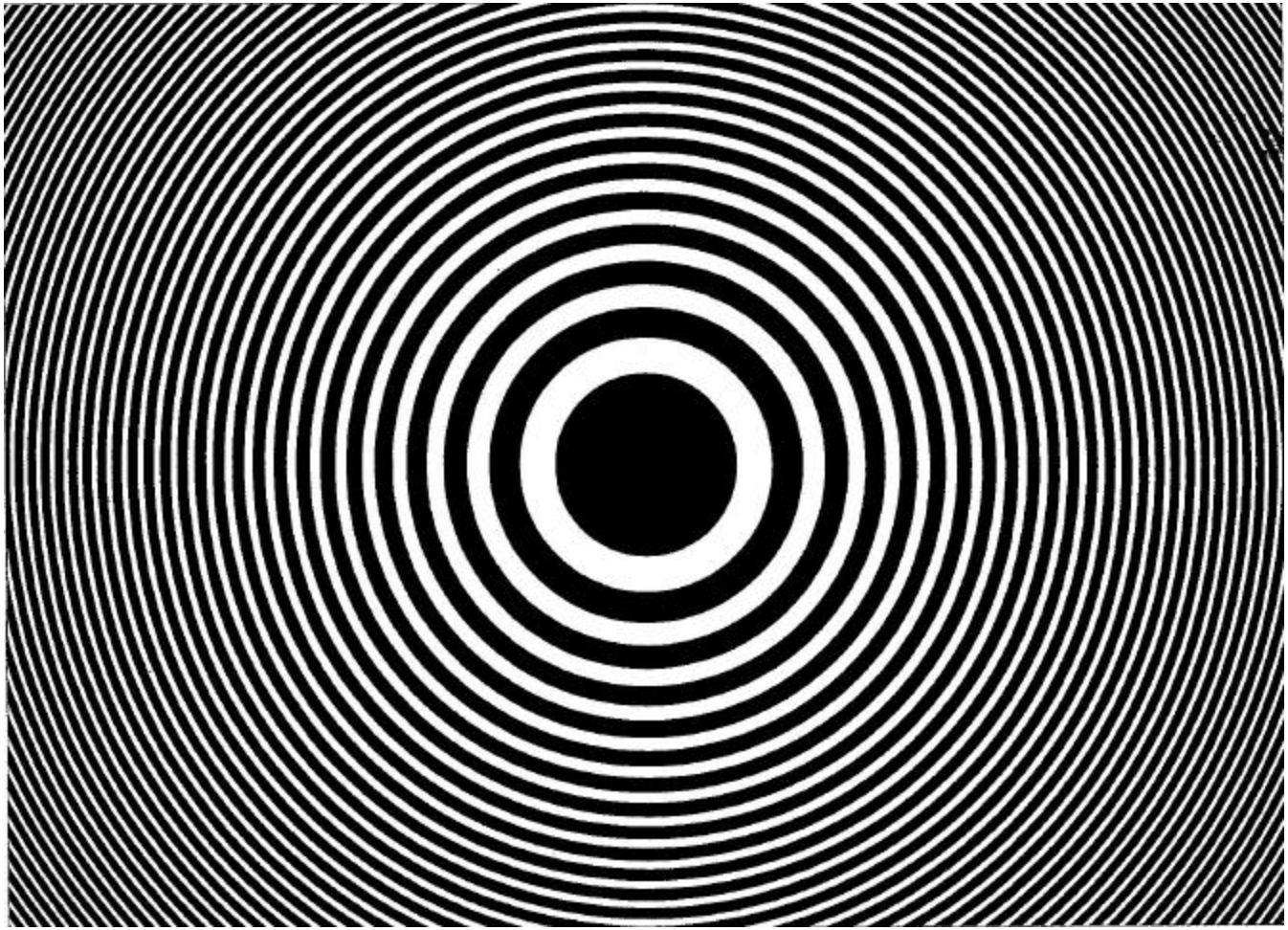
Newton Circles

= Straight Lines with Small Displacement

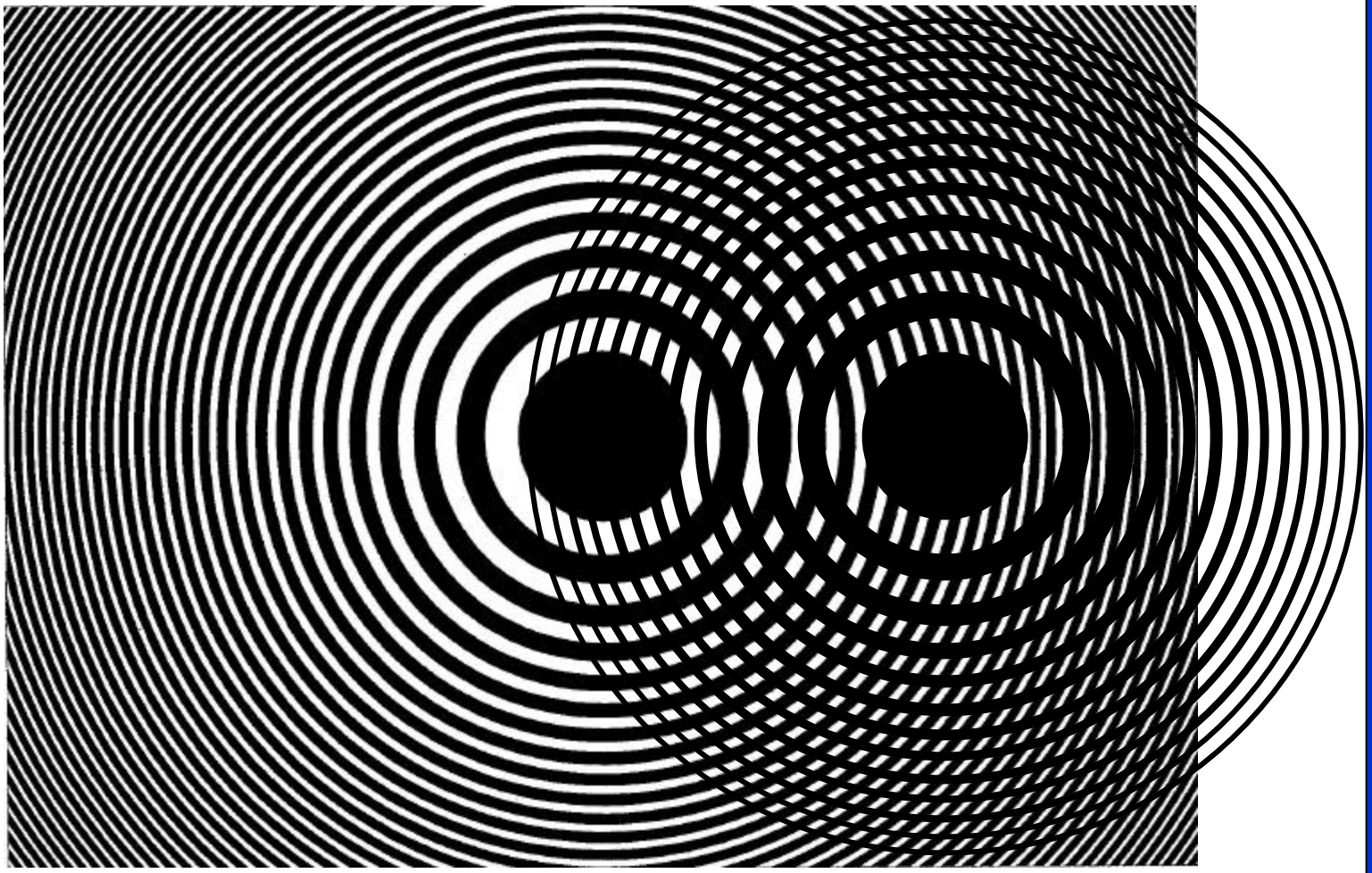
or

Newton Circles with Large Displacement

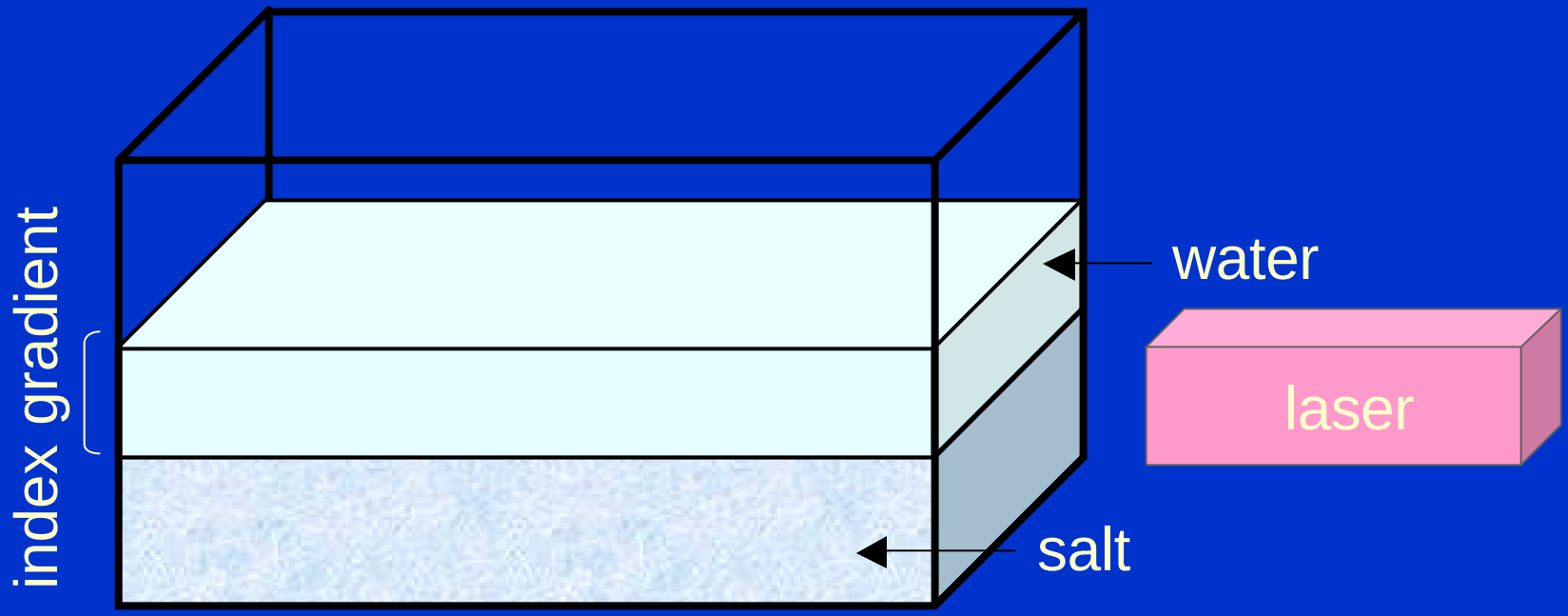
Fun with Moire Patterns



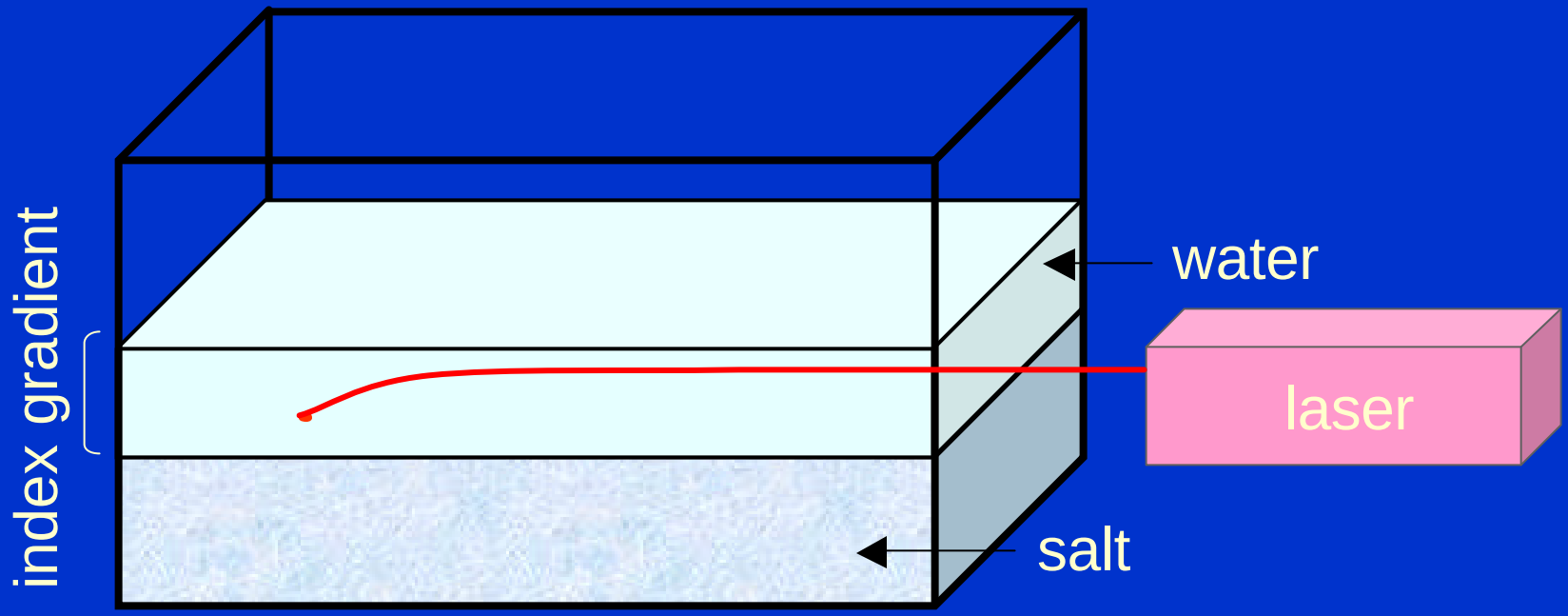
Fun with Moire Patterns



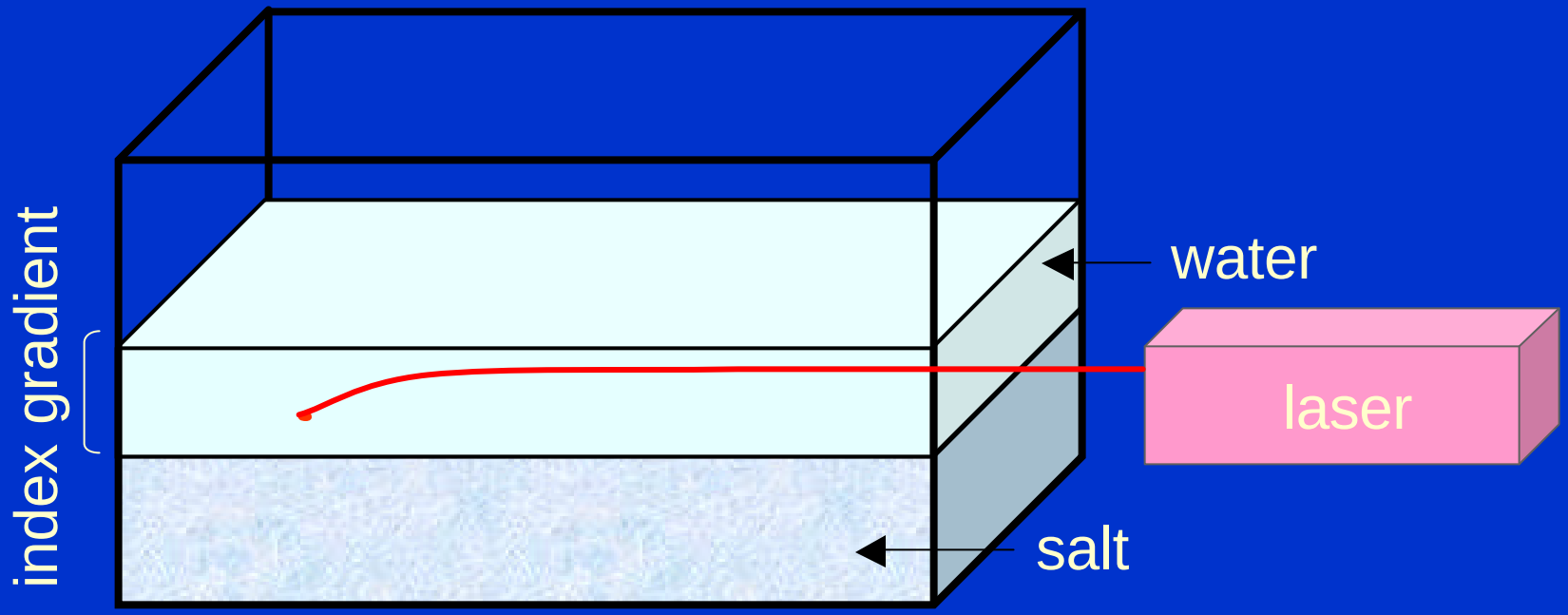
Gradient Index → Curved Light Path



Gradient Index → Curved Light Path

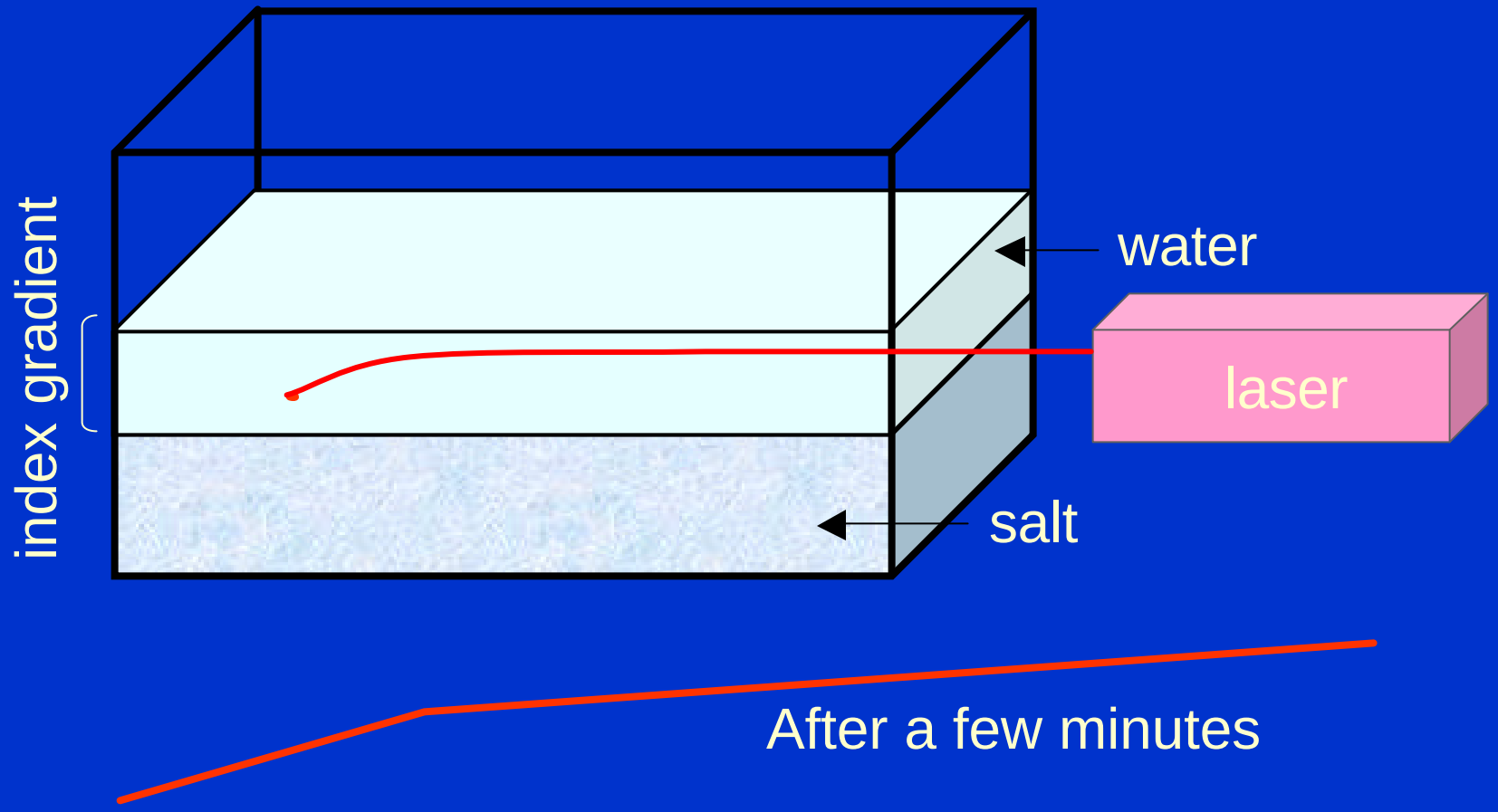


Gradient Index → Curved Light Path

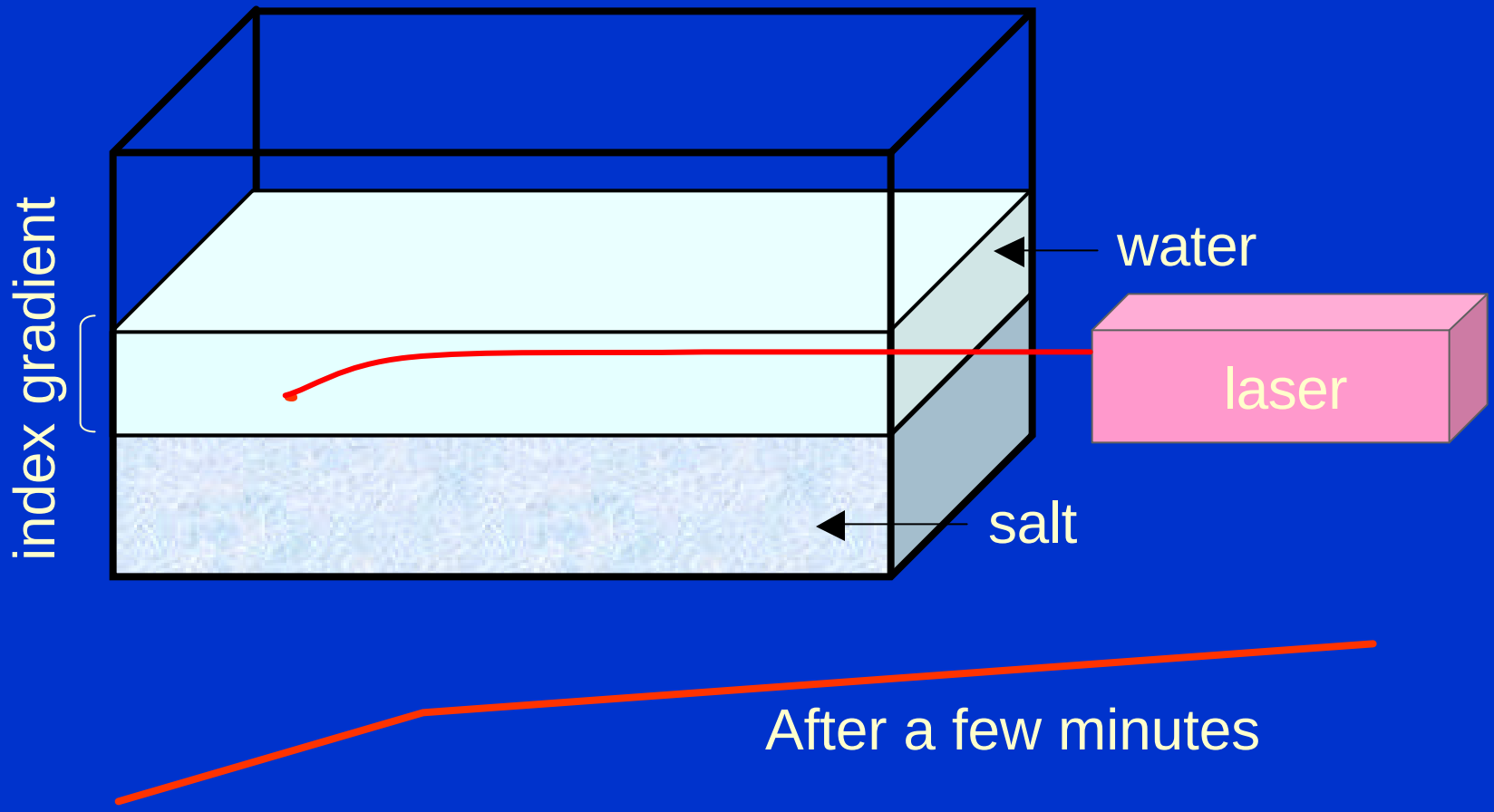


After a few minutes

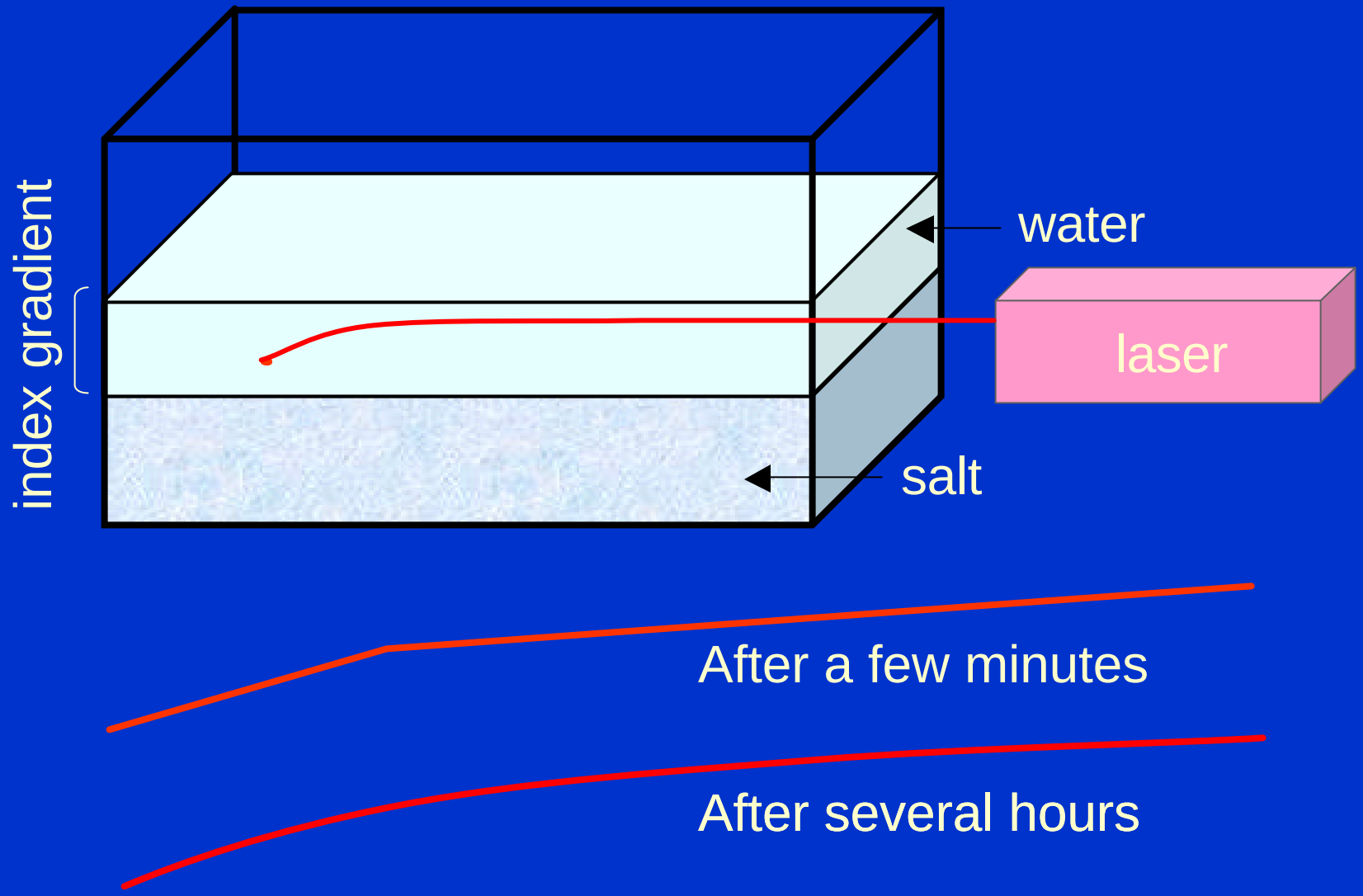
Gradient Index → Curved Light Path



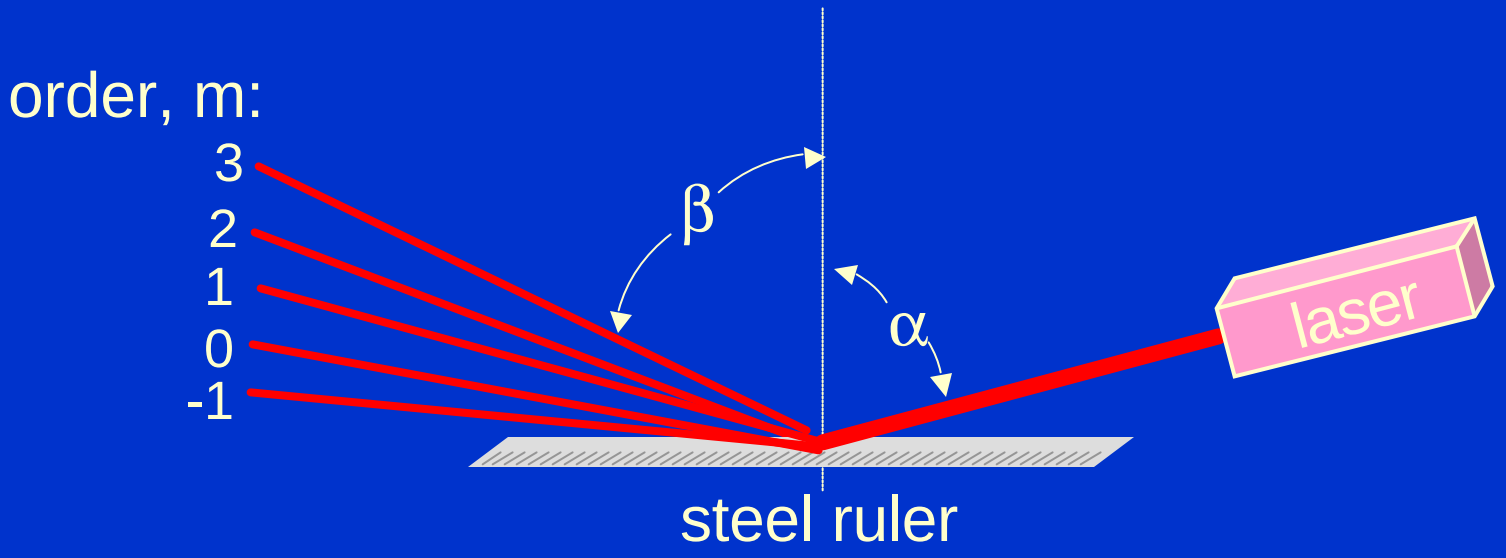
Gradient Index → Curved Light Path



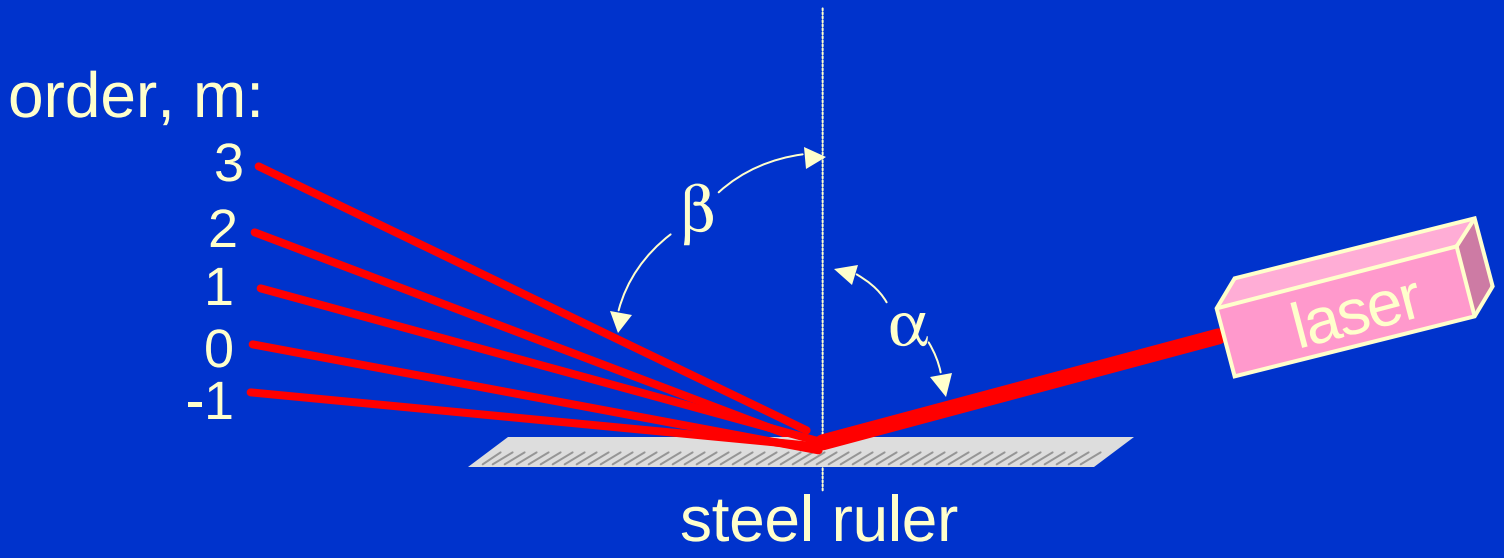
Gradient Index → Curved Light Path



Ruler Diffraction Grating



Ruler Diffraction Grating



$\sin \alpha - \sin \beta = m\lambda/d$

where m = 0,1, 2, 3…

λ = laser wavelength

and d = ruler spacing