Checking and Adjusting Binocular Alignment

Mike Whybray and Ray Larsen

Outline of Workshop

Introduction to Binoculars

What is collimation?

Simple checks

Methods of adjustment

Methods of checking alignment

Practical session

Introduction to Binoculars

Construction & types of binoculars

Operation of binoculars

How to use binoculars

Different types of binocular

Inside a typical binocular

What is Collimation?

Aka Alignment

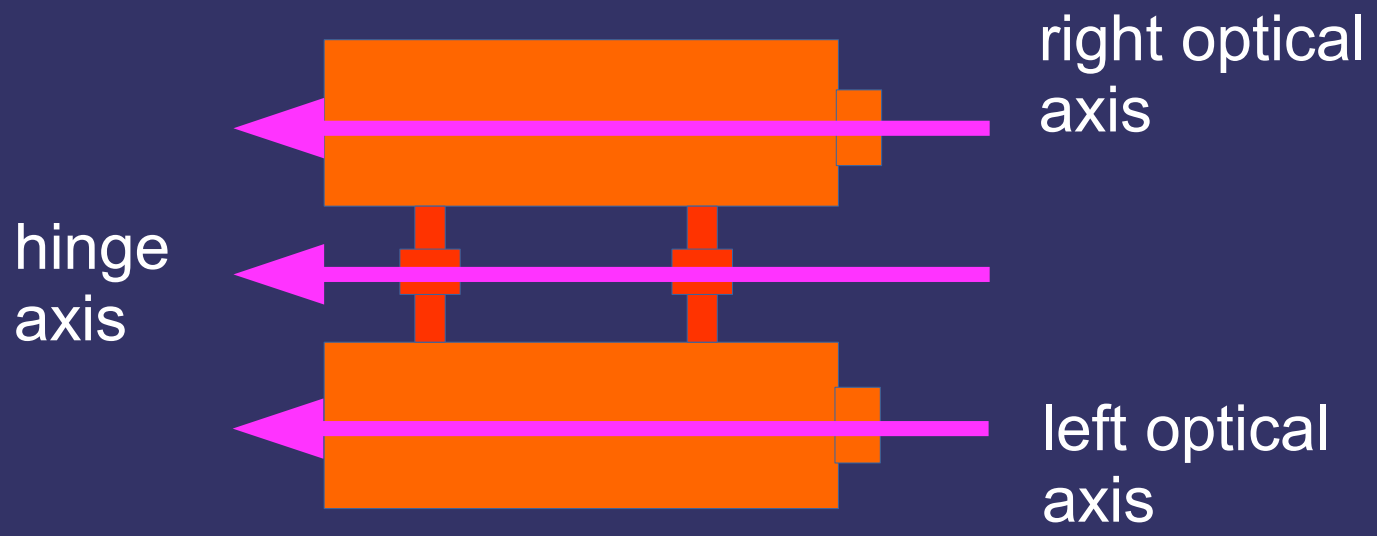
Characteristics of human eye/brain

Collimation standards

Object space & image space

Conditional & full collimation

3 axes to align



Alignment tolerances (arc-minutes)

Ref	Vertical	Diverging	Converging
At input to eye (**image space**)			
Other	35	50	100
Soviet	15	20	60
Tonkin	15	20	45
Seyfried (X10)	4	6	10
AAMRL	3.4	3.4	8.6

Conditional vs Full Alignment

Conditional Alignment is alignment of the two optical axes, but not necessarily aligning with the hinge axis

Full Alignment is alignment of all 3 axes

Conditional Alignment is rather easier, but means it is only correct at one chosen binocular spacing (inter-pupillary distance)

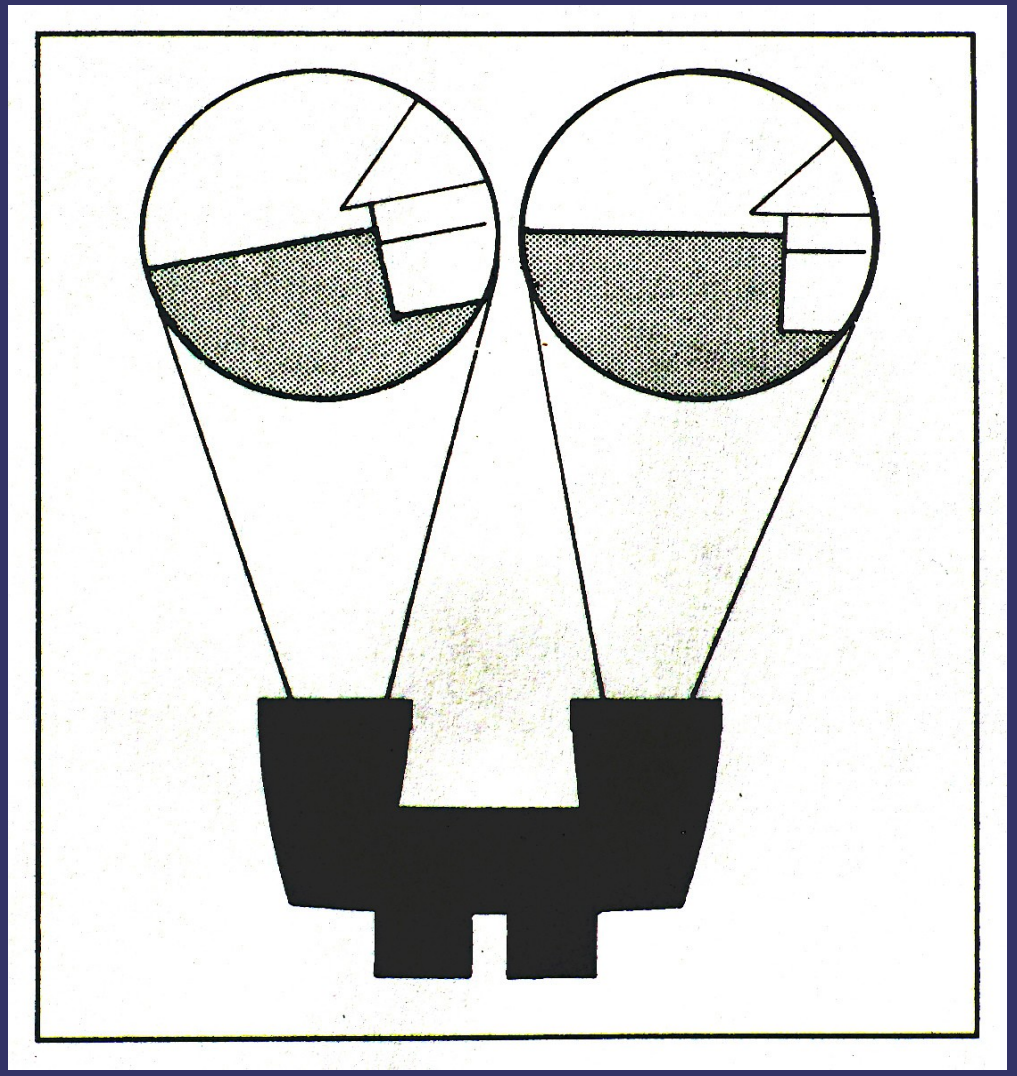
Simple checks (& what can go wrong)

External damage

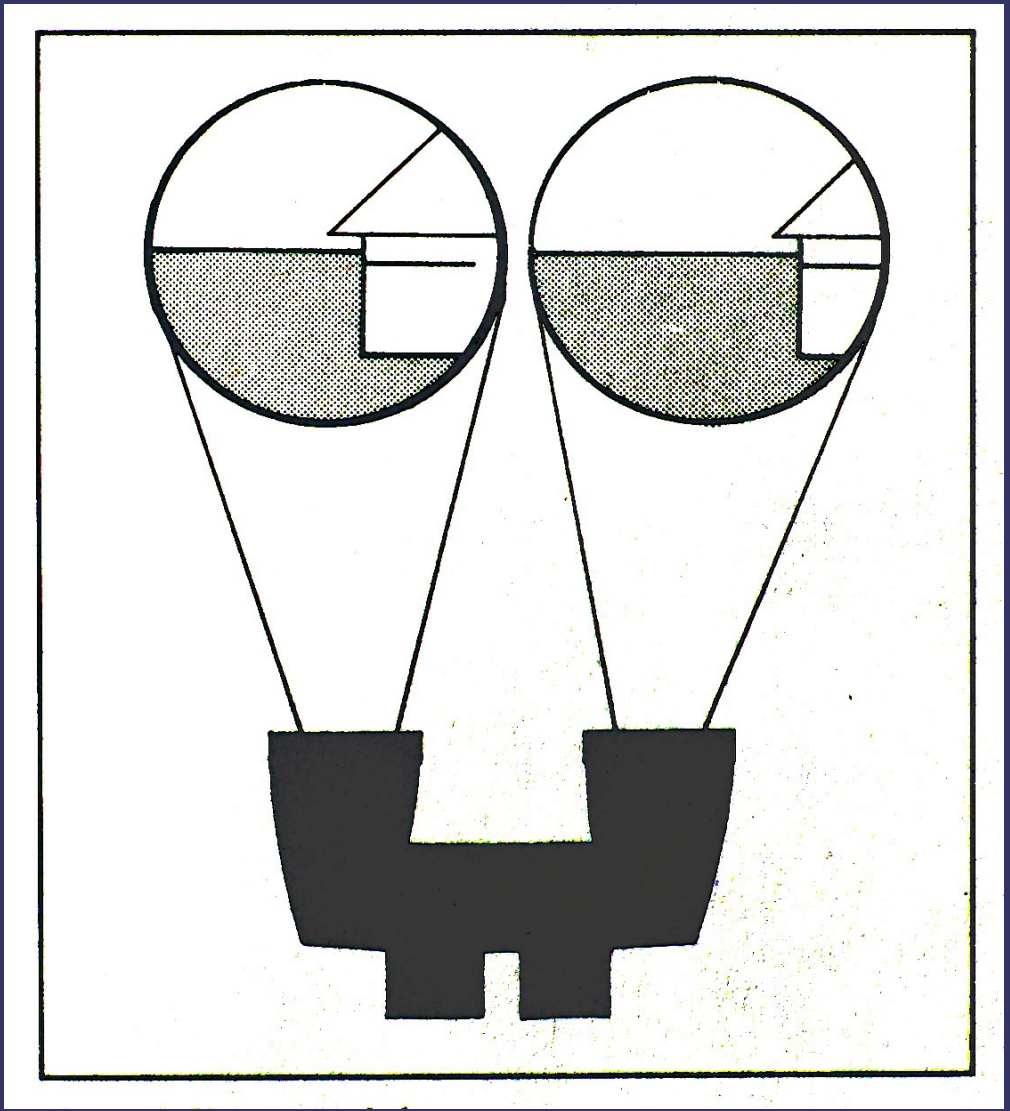
Look into objectives

Look into eyepieces
- rotation errors
- lateral displacements

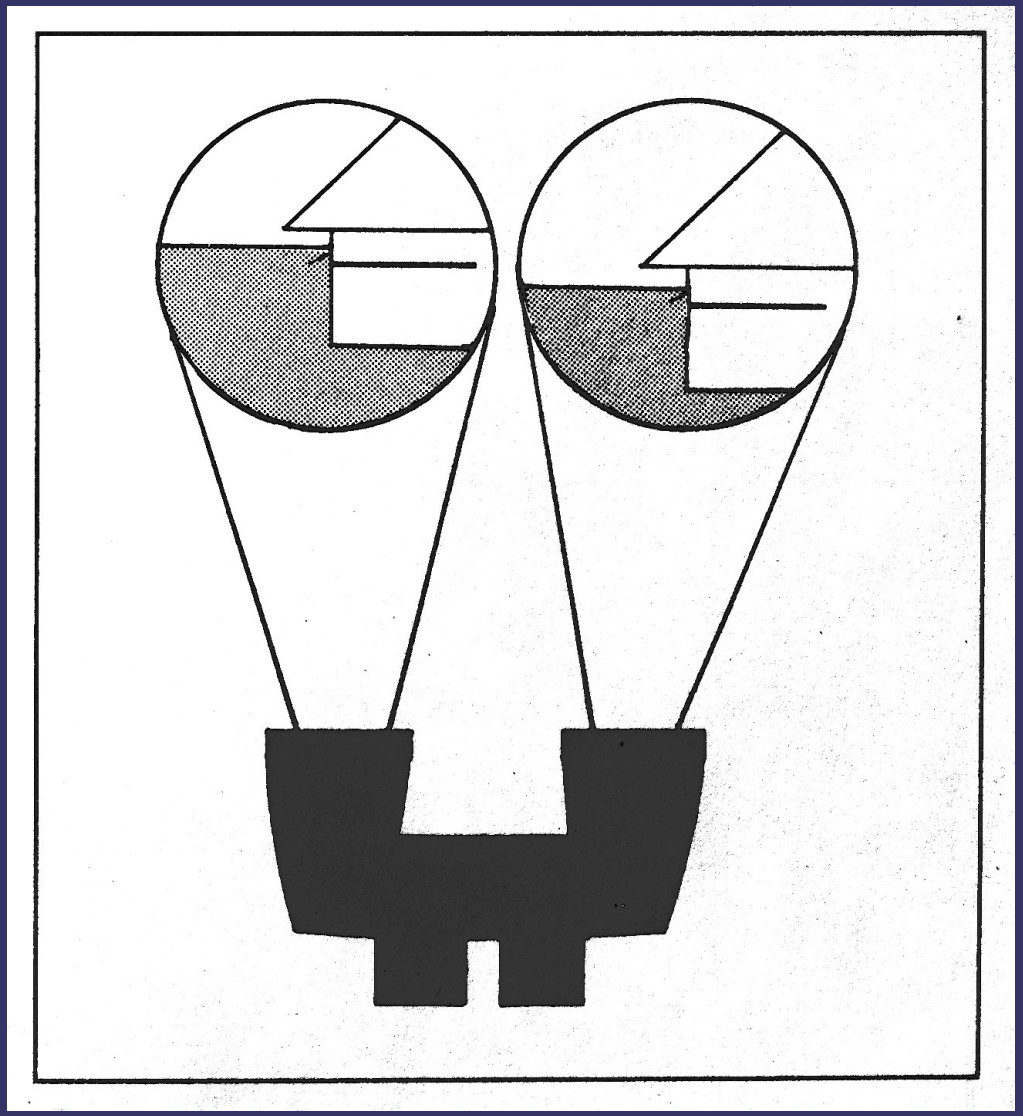
Rotation error



Lateral error



Vertical error



The heroine's dilemma

The heroine's dilemma

Methods of adjustment

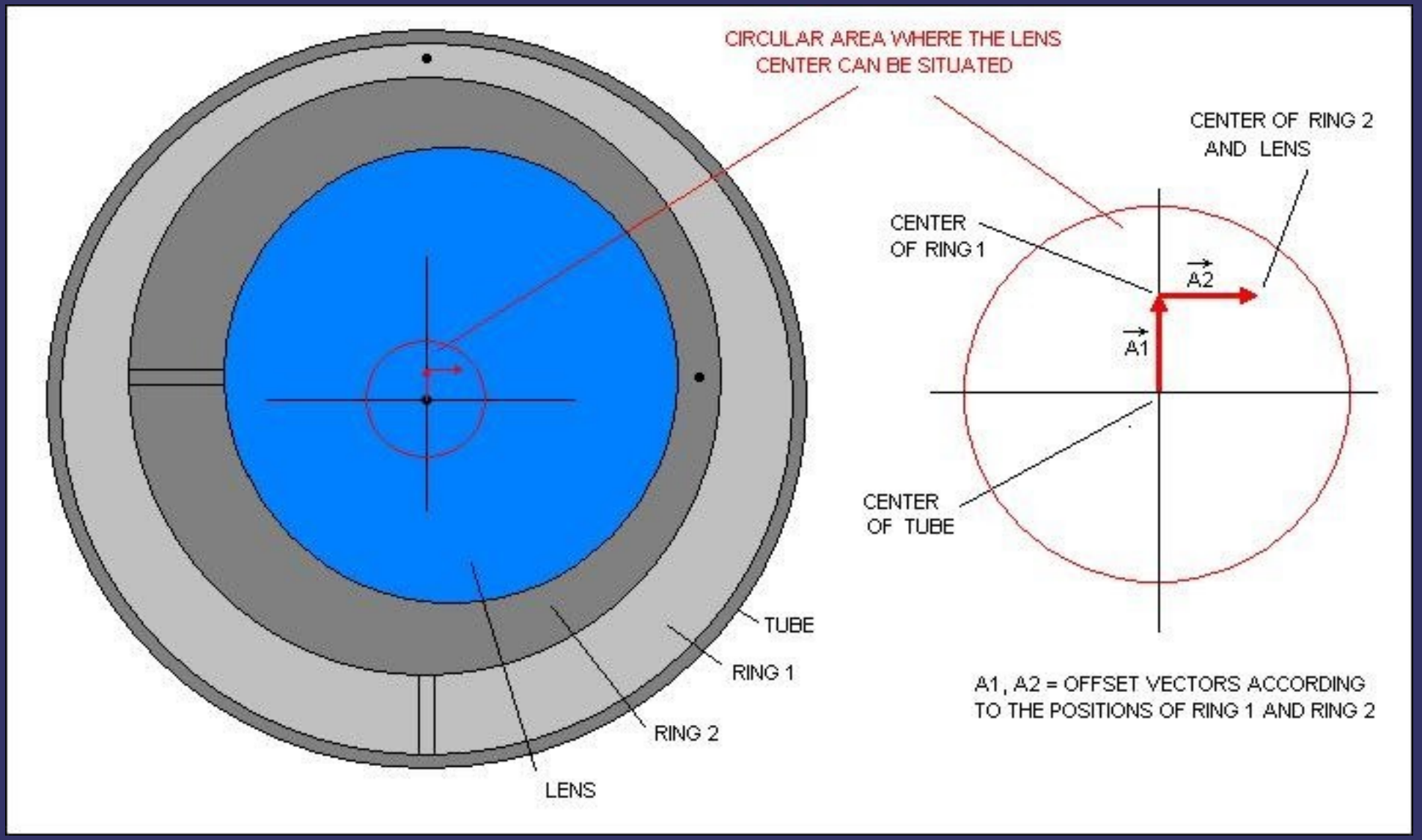
Eccentric rings

Prism adjusting screws

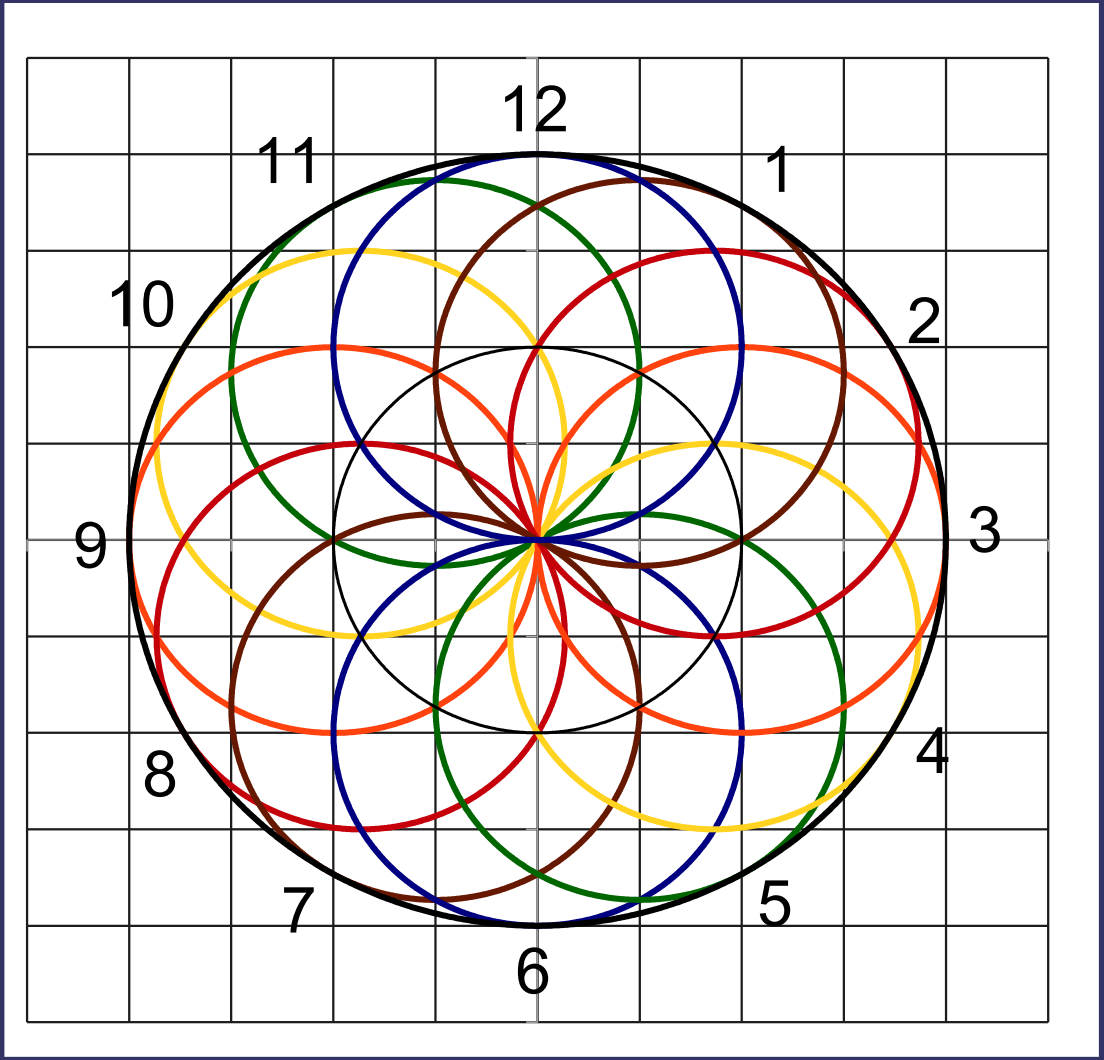
Eyepiece prism screws (pocket folding bins)

Eccentric objective rings

Eccentric ring adjustment



Eccentric rings clock diagram



Prism mounting

Prism adjustment screw locations

Prism adjustment screw locations

Folding binocular adjustment

Eyepiece focussing

Methods of checking alignment

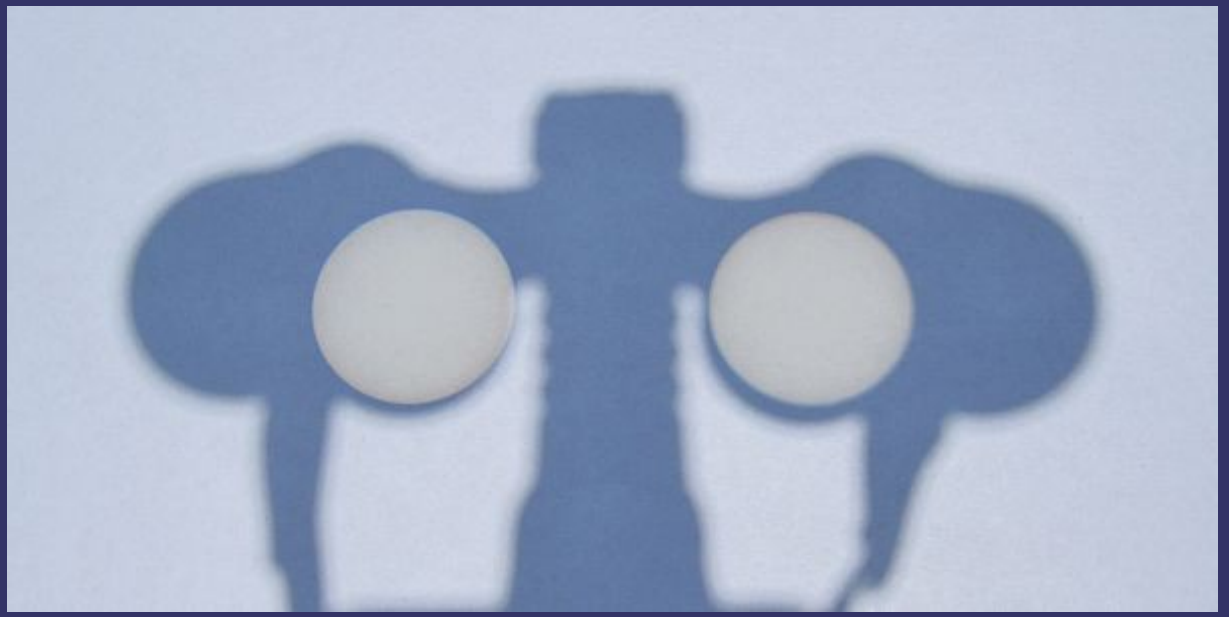
Solar projection

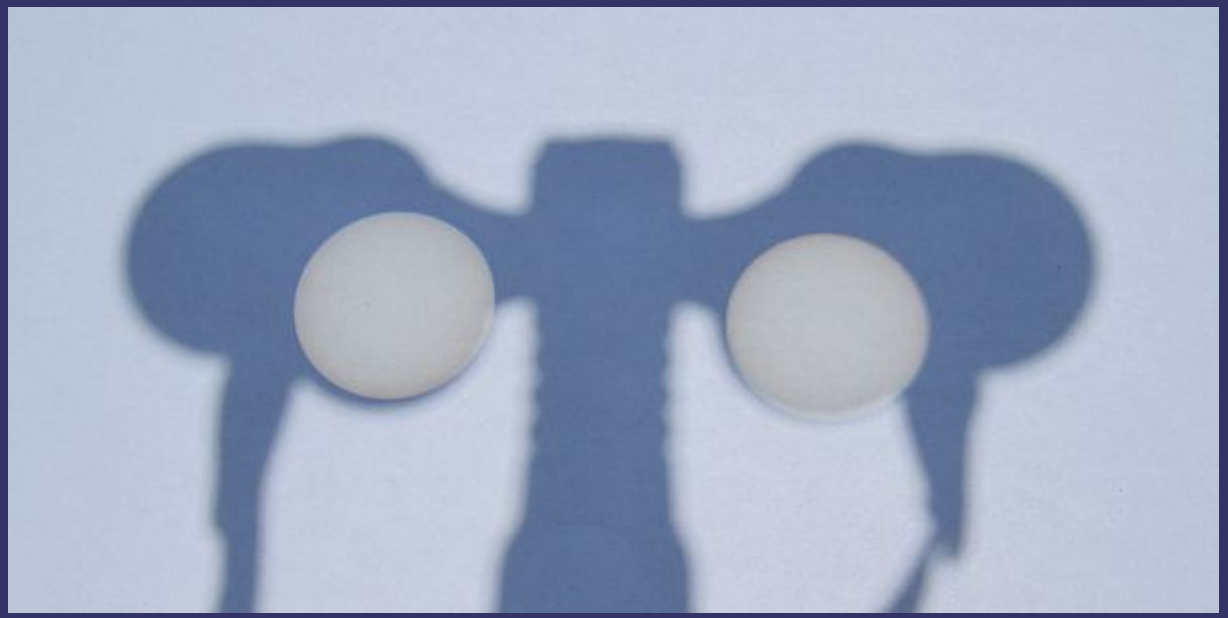
Indoor twin-light

Optical bench
- General layout
- Ray diagram

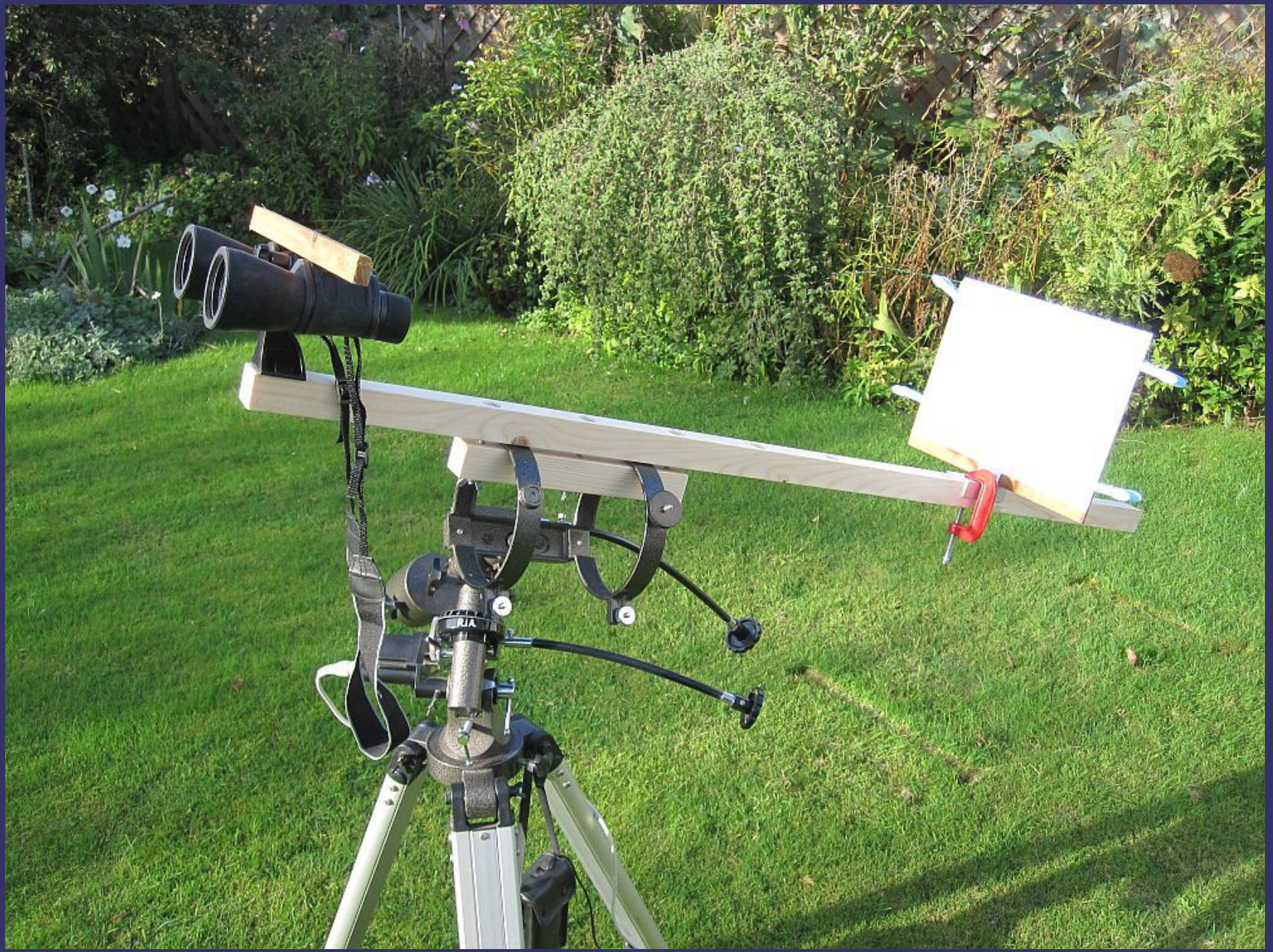
Simple solar projection

Simple solar projection





Tracking solar projection



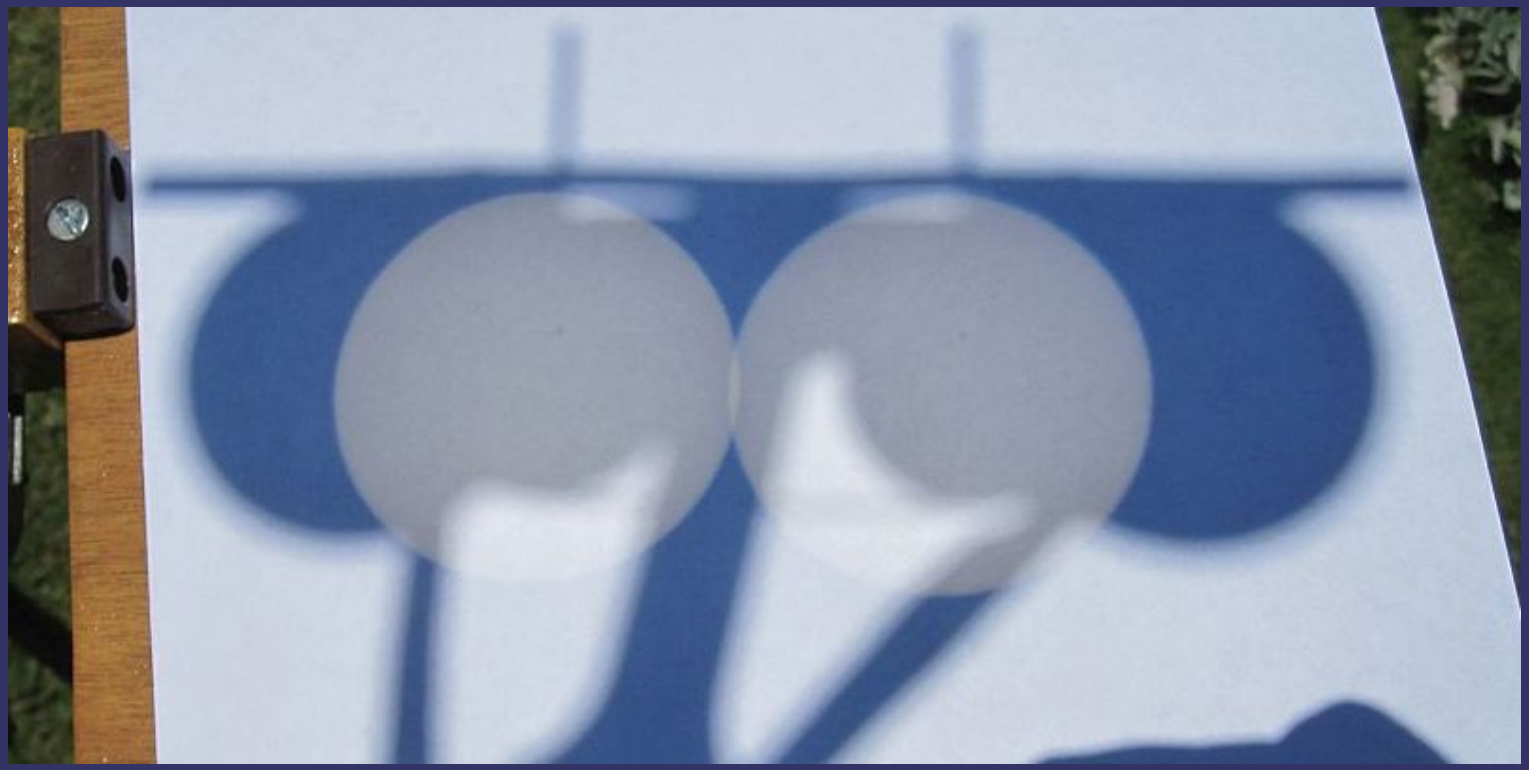
Tracking solar projection

Horizontal bar with pins at eyepiece spacing

Projected image

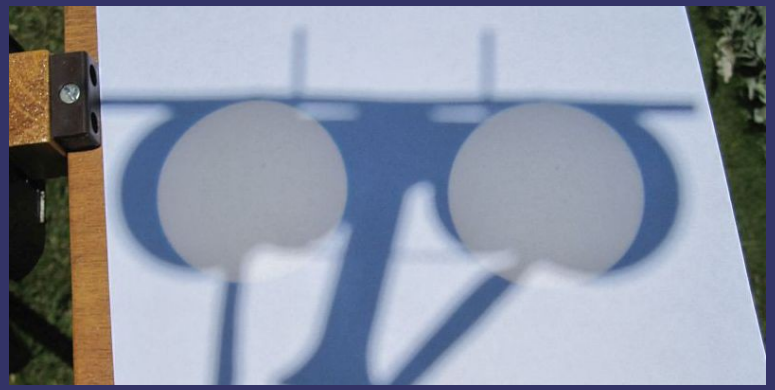
Screen distance from eyepieces adjusted so that
Sun image diameter = Eyepiece spacing (also = pin spacing)

If binoculars correctly aligned, sun images will be:
- Level with the projected bar
- Just touching

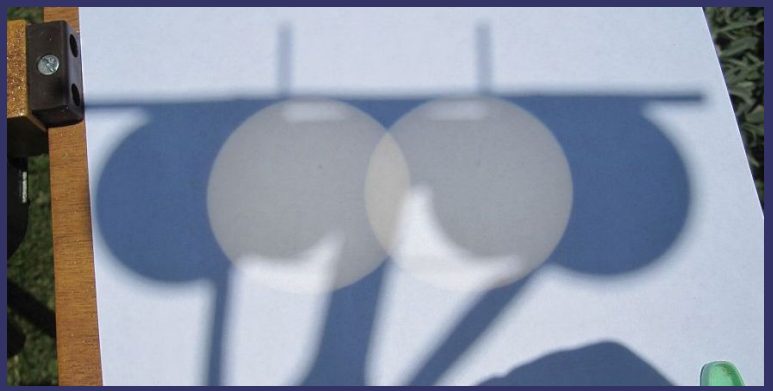


Images denoting mis-alignment

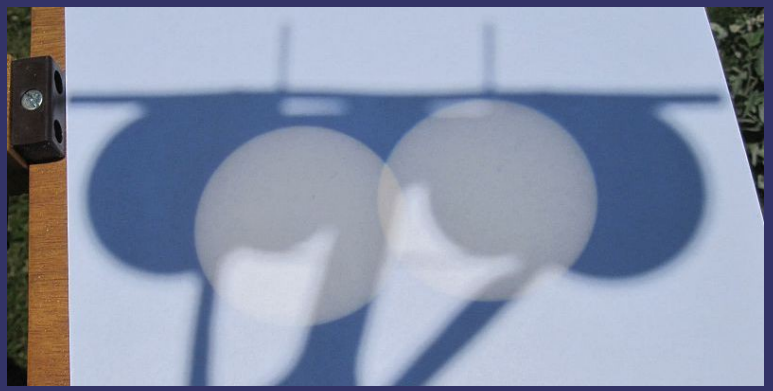
Diverging optical axes
→ diverging exit rays
→ converging eyes



Converging objectives
→ converging exit rays
→ diverging eyes



Vertical and horizontal misalignment



Measurement accuracy of solar projection method

Typical eyepiece spacing (=interpupillary distance) = 65mm

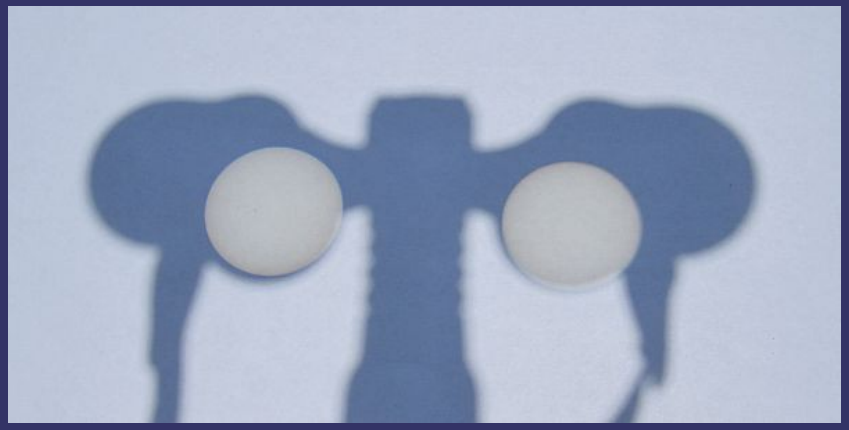
Screen to eyepiece distance for 10x50 binoculars ~ 750mm
(To achieve sun image diameter = 65mm)

1mm positional error on screen = 360/(2*Pi*750) degrees
= 4.6 arcmin

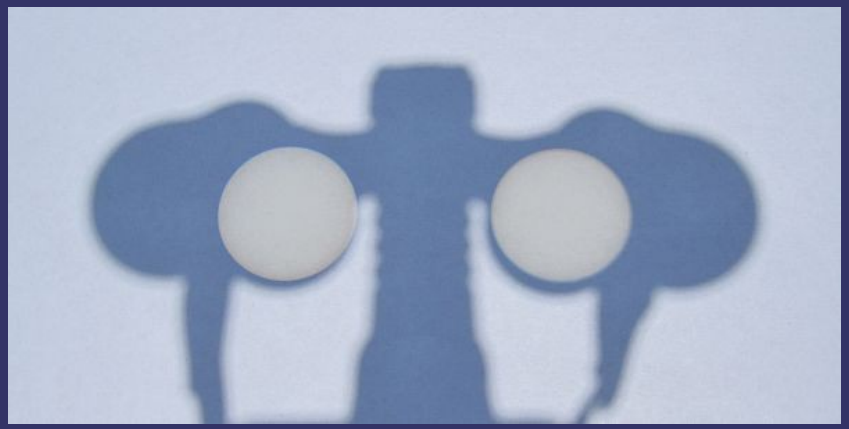
Arcmin (mm)	Vertical	Diverging	Converging
Other	35 (7)	50 (11)	100 (22)
Soviet	15 (3)	20 (4)	60 (13)
Tonkin	15 (3)	20 (4)	45 (10)
Seyfried (X10)	4 (1)	6 (1)	10 (2)
AAMRL	3.4 (1)	3.4 (1)	8.6 (2)

But what about the hinge axis??

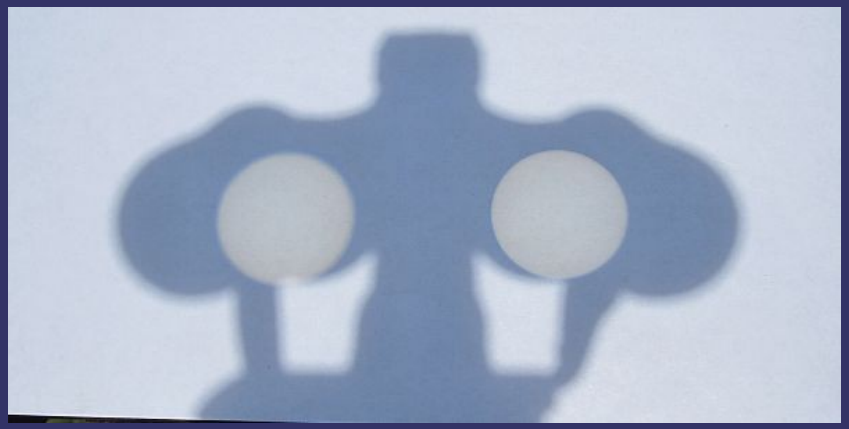
Hinge wide open
(73mm IPD)



Hinge midway
(69mm IPD)

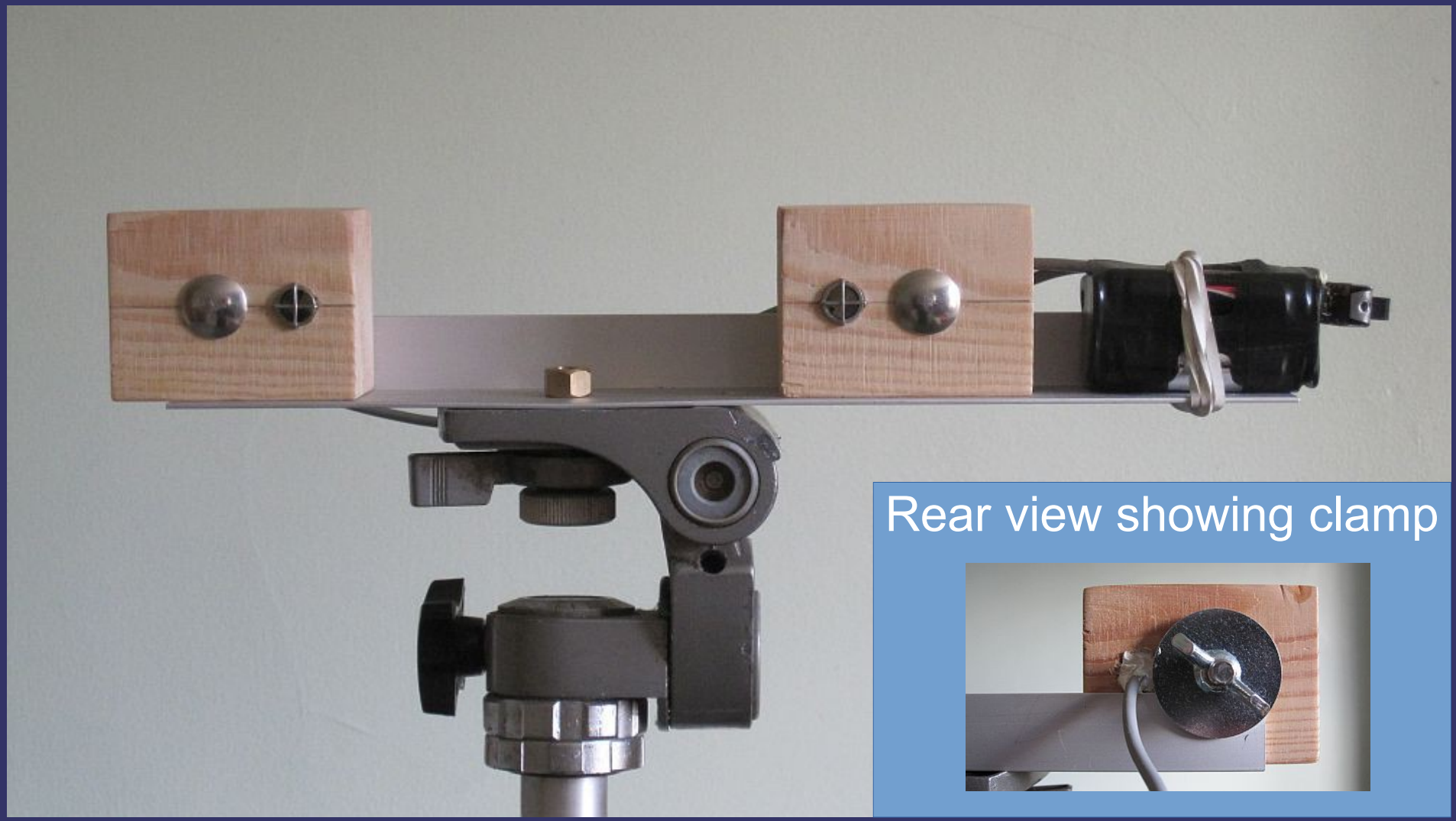


Hinge closed
(55mm IPD)



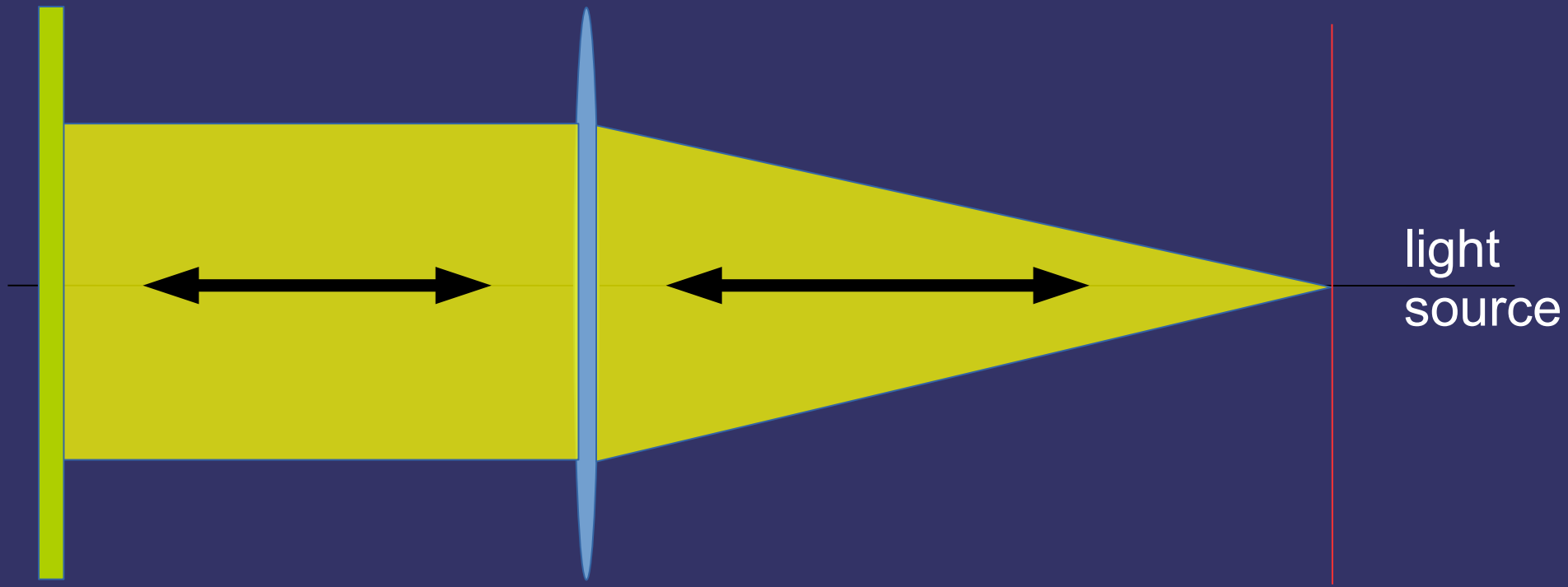
When the sun don't shine

Twin lights (LEDs with cross-wires)
Spaced same distance apart as objectives → Parallel rays

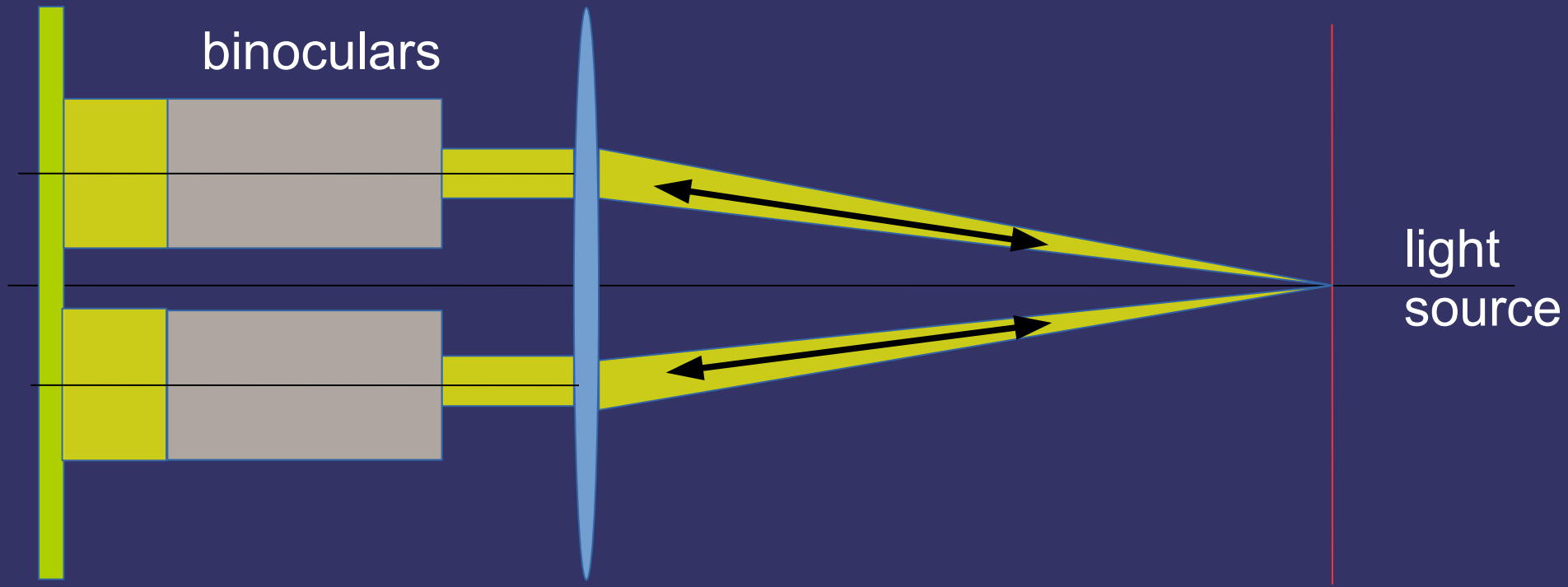


Rear view showing clamp

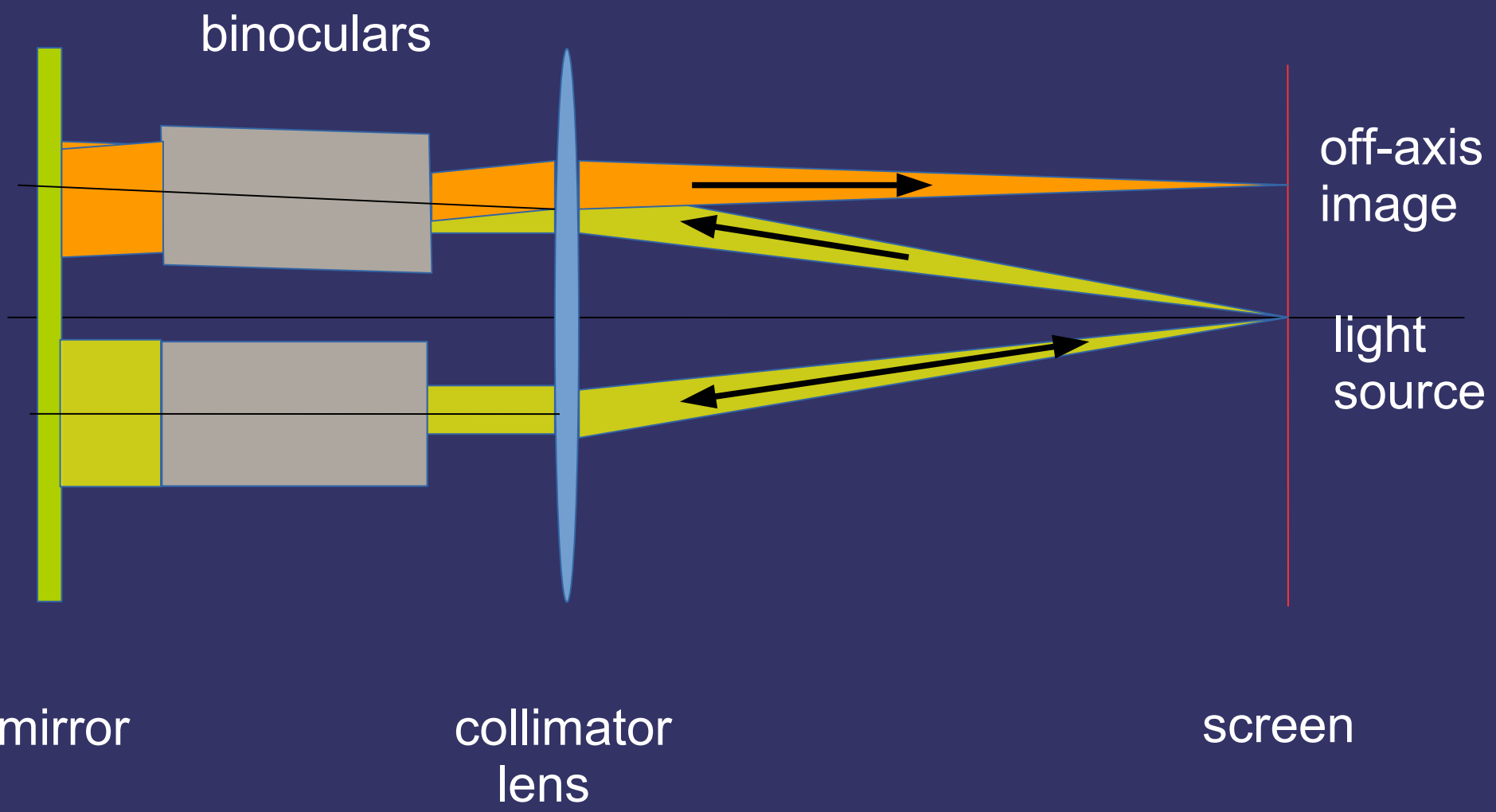
Autocollimator principle



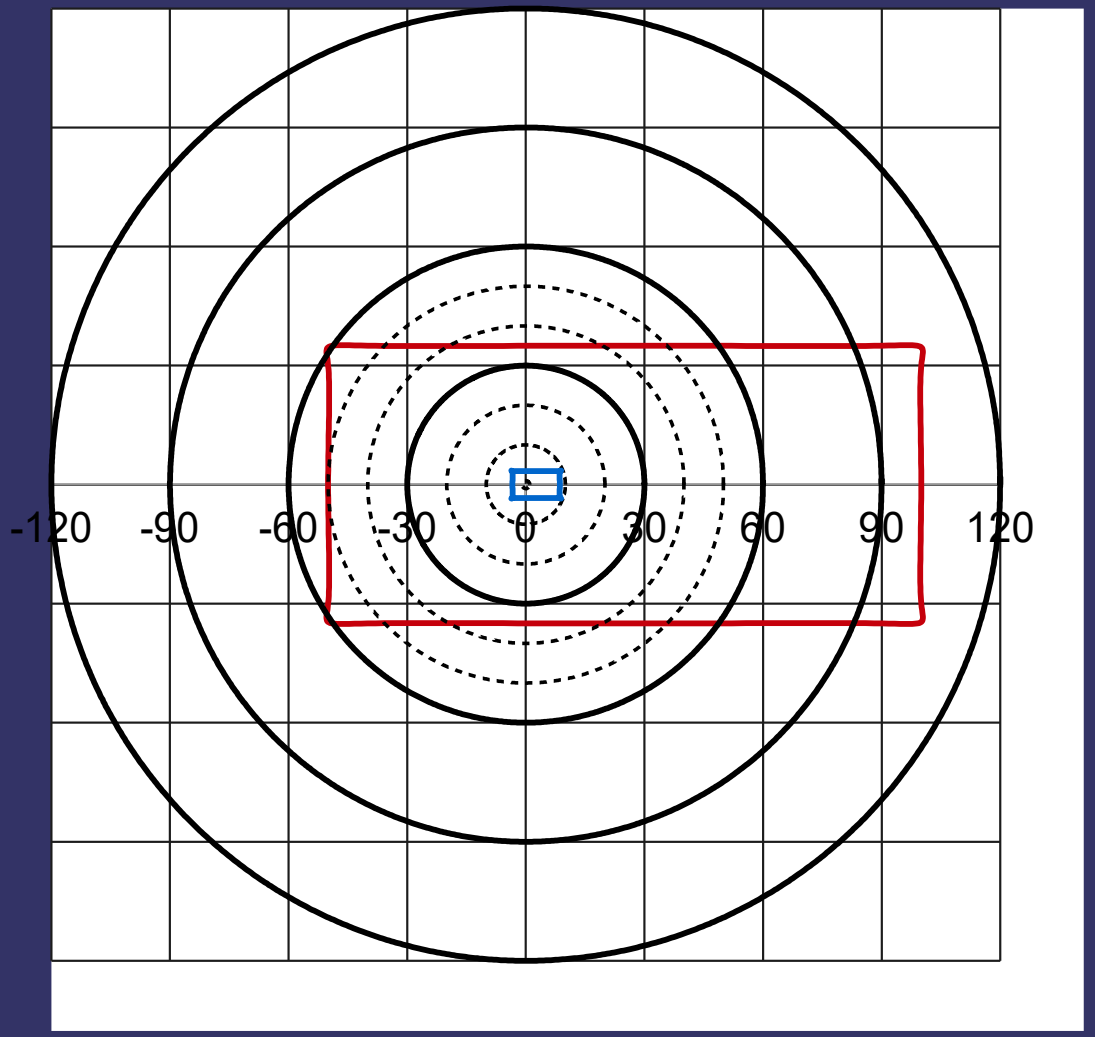
Binoculars under test



Effect of axis error

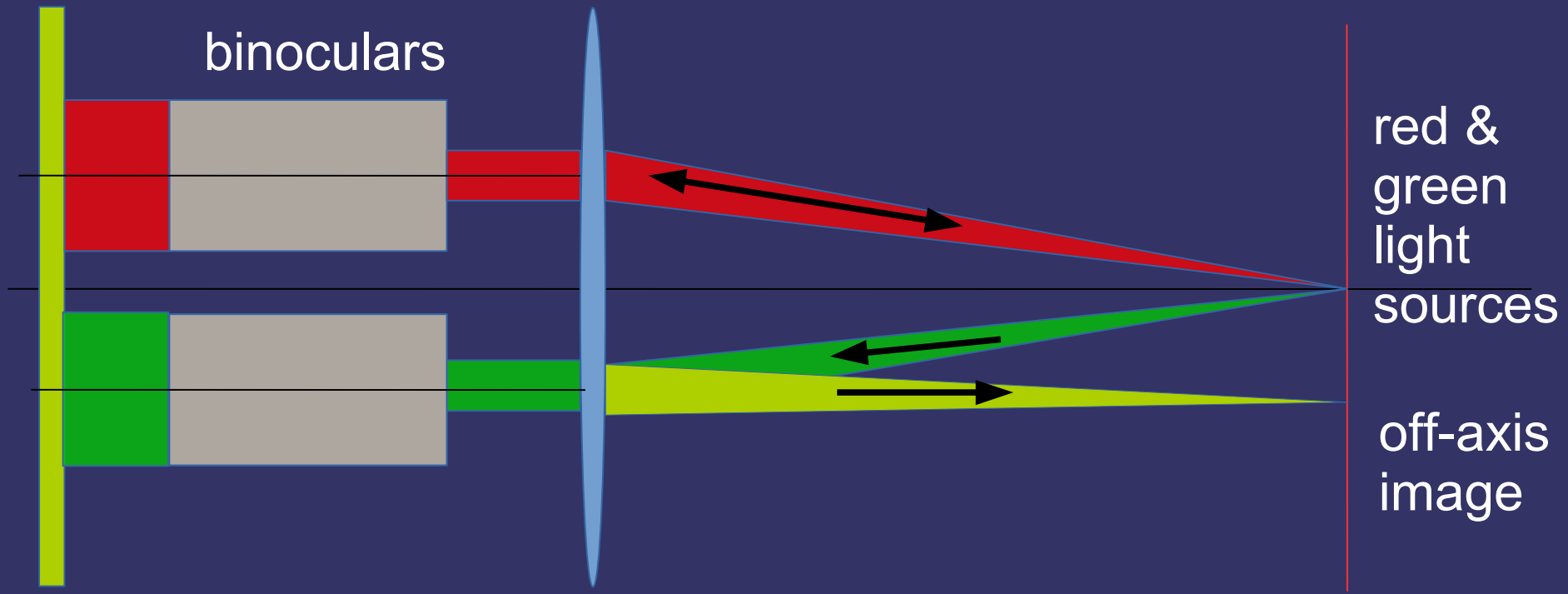


Autocollimator screen



arc-minutes in eyepiece field

Practical implementation



Steps to full collimation

Open hinge

Adjust objectives/prisms to align L & R axes

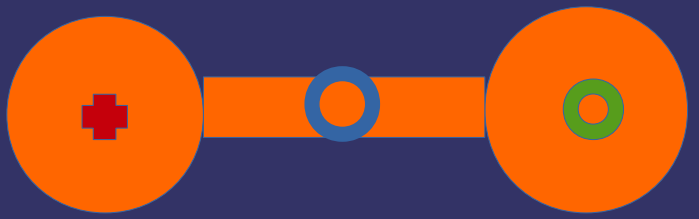
Close hinge

Use hinge axis finder to identify hinge location

Adjust both L & R axes to coincide with hinge

Principle of full collimation

1 – Hinge open

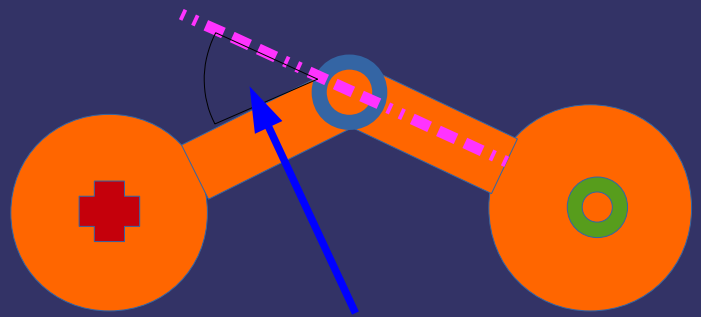


L&R axes adjusted to coincide

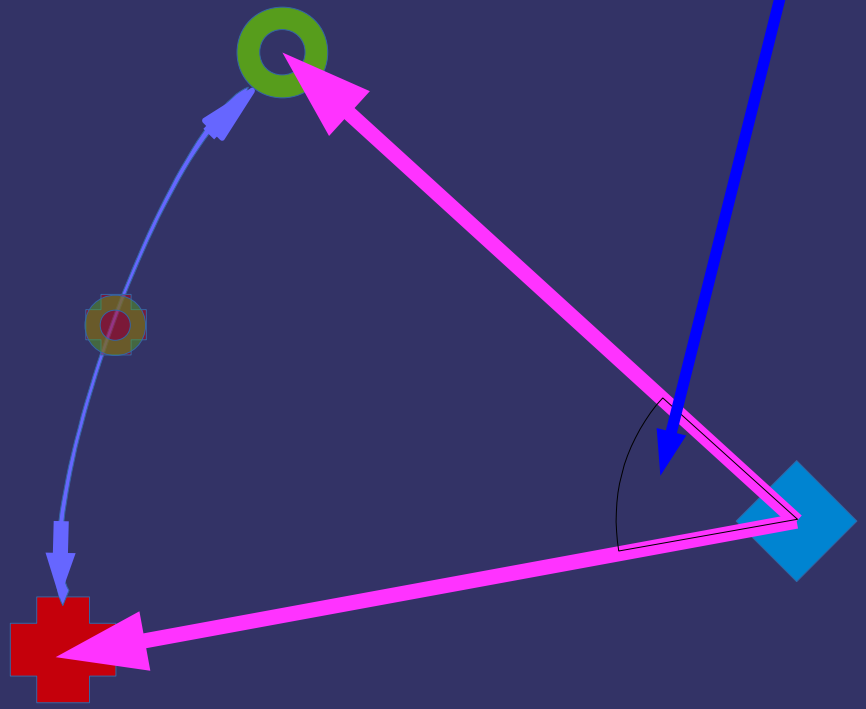
hinge axis
(unknown position)

Principle of full collimation

2 – Hinge closed

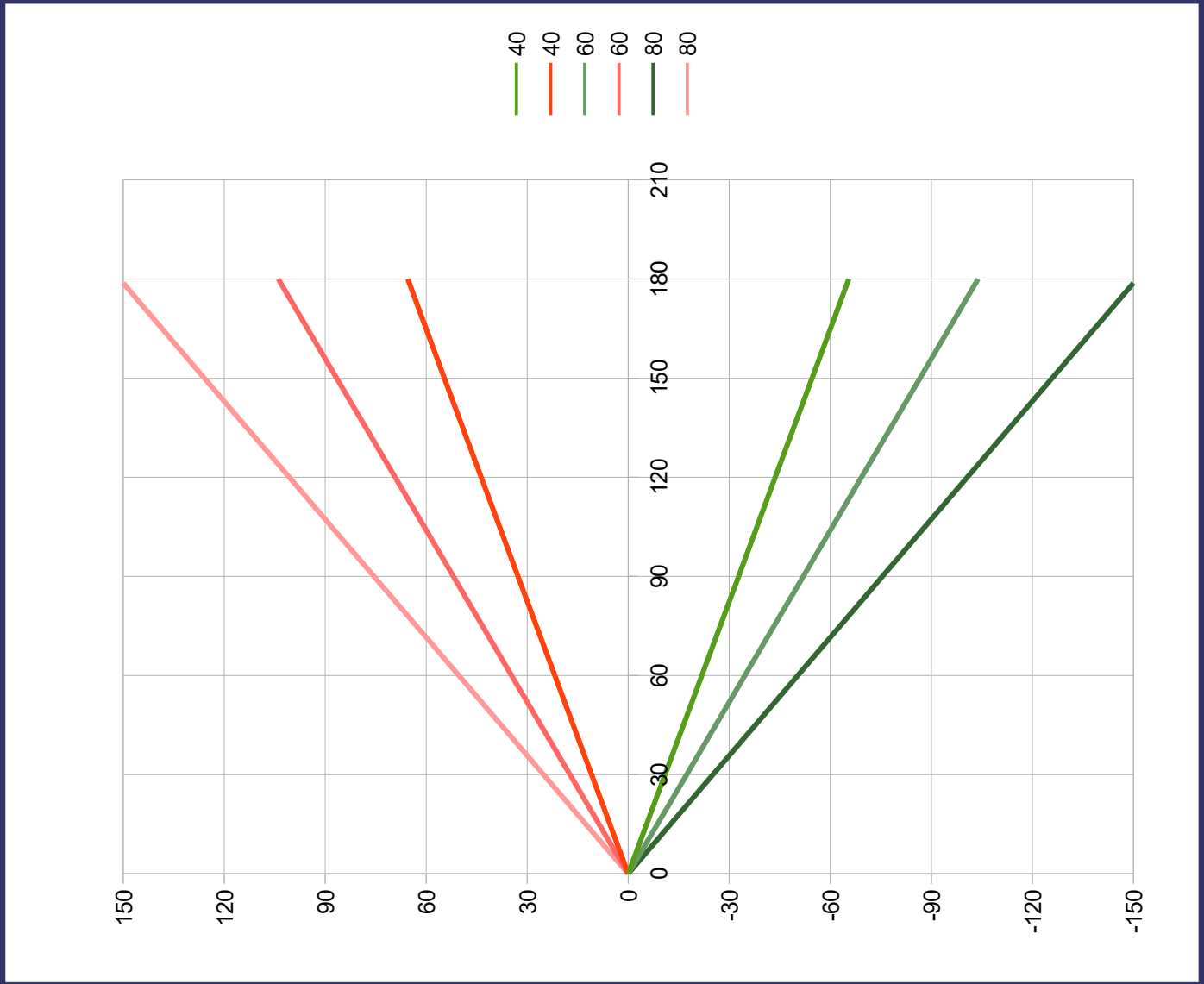


hinge angle

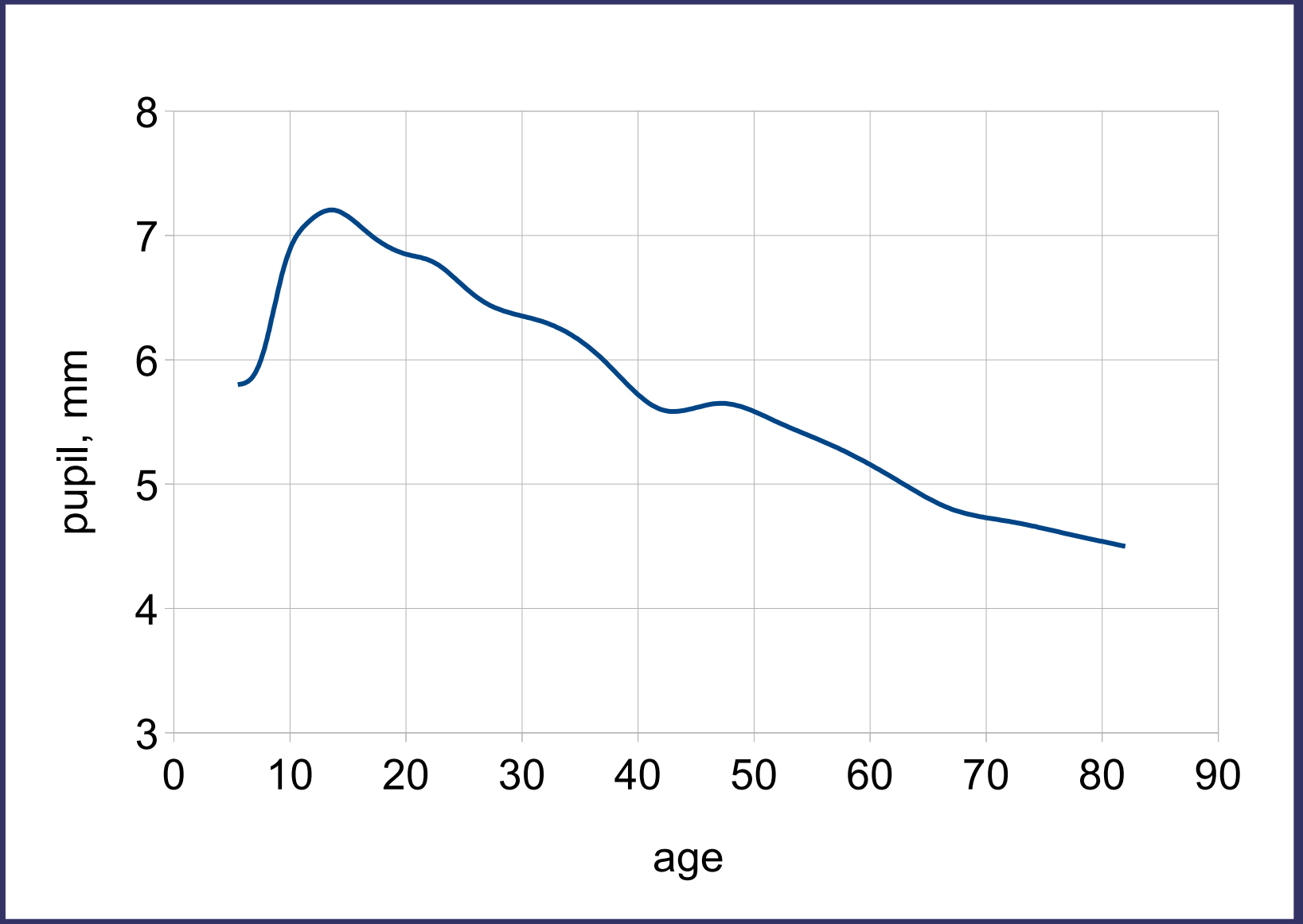


hinge axis

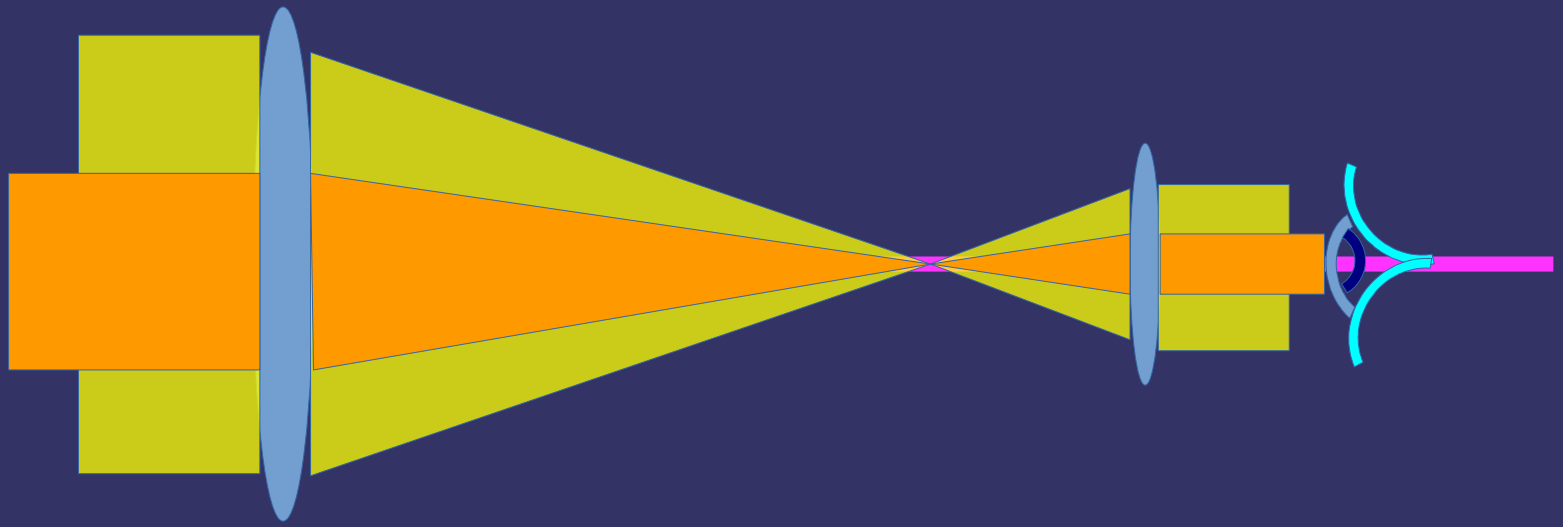
Hinge axis finder



Dark-adapted pupil size vs. age



Large exit pupil – not fully utilised



References

Initial inspiration for solar projection method:

Sun images method for checking alignmement of binoculars
by Rafael Chamón Cobos
https://sites.google.com/site/rchamon/home/sun-images-method-for-collimation-of-binoculars

Good practical book on binoculars
(copy now in the OASI library):

Choosing, Using & Repairing Binoculars by J.W. Seyfried

References for Alignment Tolerances table

Other:

Archives of an email list on the history of binoculars.
http://home.europa.com/~telscope/listp200.txt
Binocular List #246: 25 February 2003.
(Possibibly a US Military spec)

Soviet: Ostrovskaya, M.A. et. al. Allowable Deviations From Parallelism for the Optical Axes of Binoculars. Soviet Journal of Optical Technology, 45 (10), Oct. 1978, pp613-616.

Tonkin: Binocular Astronomy, Ch. 2, ISBN 1846283086, Springer-Verlag, 2006

Seyfried: Choosing, Using & Repairing Binoculars, J.W. Seyfried, University Optics Inc, Ann Arbor, Michigan, 1995.

AAMRL: Optical Tolerances for Alignment & Image Space Differences for Binocular Helmet-Mounted Displays, Armstrong Aerospace Medical Research Laboratory, Report No AD-A174 536, May 1986.

Practical session