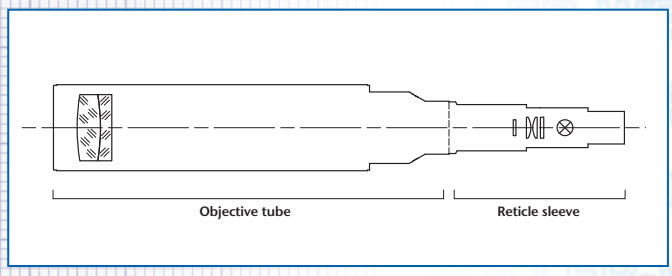
COLLIMATORS
INTRODUCTION

Layout and principle of operation

A collimator projects a reticle to a certain distance. Usually the image is at infinity at a wavelength of 546 nm.
The main components of a collimator are:

- objective tube with objective
- reticle sleeve with reticle, condenser and illumination

The following figure shows the principle set-up of a collimator adjusted to infinity. The reticle is illuminated by an illumination system consisting of a condenser and light source. The reticle is positioned at the front focal point of the objective. Due to this configuration all light beams passing a point in the reticle plane form a parallel light bundle behind the objective.
There is not a real image of the reticle. To get a real image an additional lens, for example a telescope objective, is required.
Mechanical and optical axes of collimators with focal length $f \leq 300$ mm are adjusted with an accuracy of $\pm 30\ \mu m / f$.



A measuring unit for tilt angles can be build by combination of a collimator with a telescope, when there is a need to measure in transmission.

Calculation of the angles

The angles (α_x and α_y) of the parallel beam of a collimator adjusted to infinity in respect to its optical axes can be calculated as follows:

$$\alpha_x = \arctan\left(\frac{\Delta x}{f}\right) \approx \frac{\Delta x}{f}$$

$$\alpha_y = \arctan\left(\frac{\Delta y}{f}\right) \approx \frac{\Delta y}{f}$$

f: focal length of the collimator objective
Δx: displacement of a point in X-direction
Δy: displacement of a point in Y-direction

Numerical example:
A point with 3 mm distance from the reticle center of a collimator with 300 mm focal length is imaged at an angle of:

$$\alpha \approx 3/300 \text{ rad} = 10 \cdot 10^{-3} \text{ rad} = 0{,}5730° = 34'23''$$

A displacement of 10 µm from the centre of collimator reticle is calculated to have the following angle for the different focal length.

Focal length	Angle
50 mm	41″
90 mm	23″
140 mm	15″
200 mm	10″
300 mm	6,9″
500 mm	4,1″
600 mm	3,4″
1100 mm	1,9″

Adjustable Focus

Collimators with adjustable focus are available in addition to those with fixed focus. Adjustable focus collimators vary the distance between reticle and objective.

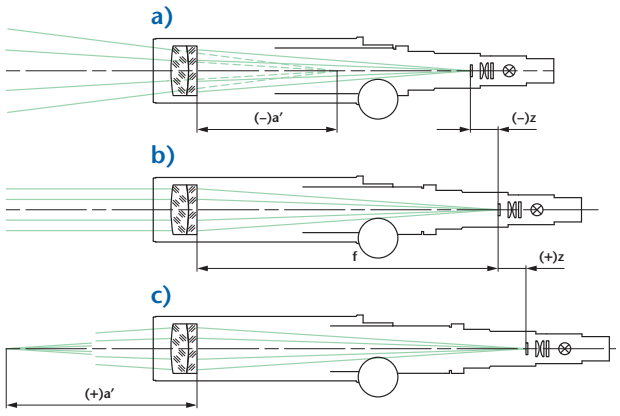
If the reticle is displaced from the focal plane by a distance z, then the collimator is focused at a distance a' according to:

$$a' = \frac{f^2+zf}{z}$$

$z < 0$ corresponds to a decrease of the distance between objective and reticle. The resulting image distance is negative (virtual object position) (a).

$z > 0$ corresponds to a real image with positive object distance (c).

$z = 0$ produces an image at infinite distance (b).



Selection criteria

Long or short focal length?

A longer focal length leads to small field angles. As the focal length increases the field of view decreases proportionally. For resolution testing choose a collimator with equal or slightly larger focal length than the optics under test. When used in conjunction with a testing telescope choose the same focal length. Additionally, the intensity of the light bundle emitted from the collimator decreases with increased focal length. A longer focal length affects the mechanical extension of the tube, as well.

Small or large objective aperture?

Light conditions are more favourable when large apertures are used, and the evaluation of the results is easier and more accurate. A long distance between test specimen and collimator demands a relatively large free aperture (or aperture ratio). For these measurements a relatively large aperture diameter should be used.

Fixed or variable distance setting?

Fixed, infinity focus collimators are generally the best choice when testing systems adjusted to infinity. Fixed focus tubes set at other than infinity can be ordered.

Measuring tasks requiring different wavelengths of light, or measurements requiring focus other than infinity are best accomplished using focusable collimators.