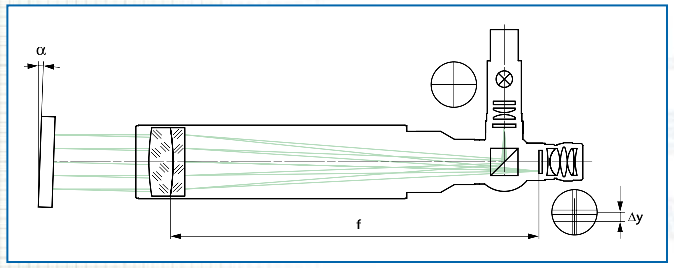
AUTOCOLLIMATORS

INTRODUCTION

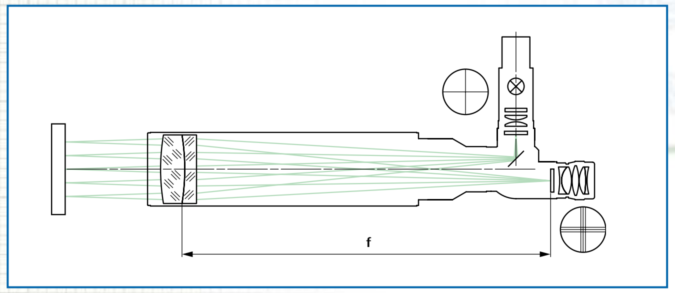
Layout and principle of operation

An autocollimation telescope (autocollimator) combines the function of a collimator and a telescope in one unit. The collimator and telescope share the same optical path, which is accomplished using either a physical or geometrical beam splitter.

The illustration below shows the schematic set-up of an autocollimator with straight viewing, a physical beam splitter and infinity adjustment. The autocollimation telescope projects the image of the collimator reticle to infinity. A target mirror, located in the beam path of the autocollimator objective, returns the projected image into the autocollimator and creates an image of the collimator reticle via the beam splitter in the eyepiece reticle plane (autocollimation image).
The mechanical (objective tube) axis is adjusted to the optical axis with angle accuracy of ±30 µm/f for autocollimators with $f \leq 300$ mm. The reticle adjustment amount ±10 µm.



An autocollimator with geometrical beam splitter is arranged similarly (see illustration below). The collimator reticle is reflected into the beam path by the path-folding mirror which has a small angle in relation to the optical axis. The beam reflected off the target mirror passes below the path-folding mirror and produces an image of the collimator reticle in the eyepiece reticle plane.



Calculation of the angles

An autocollimator can be used to measure the angle of a mirror in two axes with respect to the optical axis of the autocollimator. If the mirror is exactly perpendicular to the optical axis, the beam is reflected upon itself. If the mirror is tilted by the angles α_x and α_y, the reflected beam enters the objective obliquely. Depending on the amount of tilt, the autocollimation image in the eyepiece reticle plane is displaced to a greater or lesser amount. The displacement Δx and Δy of the autocollimation image in X and Y direction provides a measure of the angular displacement of the mirror:

$$\alpha_x = \arctan\left(\frac{\Delta x}{2f}\right) \approx \frac{\Delta x}{2f}$$

$$\alpha_y = \arctan\left(\frac{\Delta y}{2f}\right) \approx \frac{\Delta y}{2f}$$

f: focal length of the autocollimation objective.

Numerical example:
A displacement of the reticle image of 3 mm measured with an autocollimator with 300 mm focal length corresponds to a tilting angle of:

$\alpha \approx 3/2/300$ rad $= 5 \cdot 10^{-3}$ rad $= 0{,}2865° = 17'11''$.

The image displacement of 10 µm in the reticle plane corresponds to an angular tilt of:

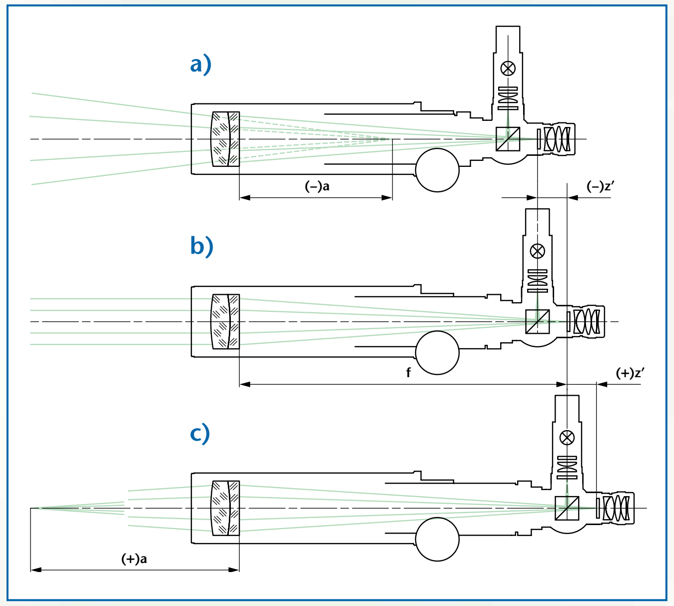
Focal length	Angular tilt
50 mm	21″
90 mm	11″
140 mm	7,4″
200 mm	5,2″
300 mm	3,4″
500 mm	2,1″
600 mm	1,7″
1100 mm	0,9″

Adjustable Focus

Autocollimators with adjustable distance between reticle and objective are also available. This adjustment by the user allows objective focus at distances other than infinity. If the reticle is displaced out of the focal plane by a distance z', then the autocollimator is focused at a distance a according to:

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

$z'<0$ 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?
Depending on the magnification of the instrument a longer focal length leads to a greater measuring sensitivity and measurement accuracy. As the focal length increases, the measuring range decreases proportionally. 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 mirror and autocollimator or a partially reflective surface demands a relatively large free aperture (or aperture ratio). For these measurements a relatively large aperture diameter should be used.

Geometrical or physical beam splitter?
The geometrical beam splitter results in smaller image angles, but greater image brightness and less stray light. These autocollimators are used mainly with small targets. Due to their internal layout, these autocollimators cannot be used for measurement of triple mirrors or corner cubes. In most cases an autocollimator with physical beam splitter is recommended, due to the larger measuring range of this configuration.

Fixed or variable distance setting?
The measurement of the angles of plane mirrors in autocollimation is made with a parallel, or infinity focus, beam. Fixed, infinite focus is generally the best choice. For measurement tasks requiring an adjustable focal distance, use an objective tube with focus adjustment. Fixed focus tubes set at other than infinity can be ordered.

Eyepiece focal length?
In contrast to eyepiece with f=14,7 mm eyepiece with f=10 mm gives a larger magnification but lesser FOV and eyepiece with f=25 mm gives a smaller magnification but larger FOV. In case a C-Mount–Camera adapter should be used, the eyepieces f=14,7 or f=25 mm must be selected.

INTRODUCTION
COLLIMATORS
TESTING TELESCOPES
AUTOCOLLIMATORS
MODULES
RETICLES
ALIGNMENT SYSTEMS
OTHER INSTRUMENTS
ACCESSORIES