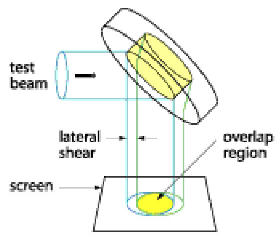
Laser Beam Measurement

Shear-Plate Collimation Tester Theory

A shear plate is a very simple interferometer (i.e., an optical arrangement that combines two wavefronts). Constructive and destructive interference between the two wavefronts leads to a series of light and dark fringes, corresponding to in-phase and out-of- phase portions of the wavefronts.

Shear plates are thick, high-quality optical flats. The wavefront or beam to be tested is incident on the shear plate at a 45-degree angle for maximum sensitivity. The uncoated front and rear surfaces generate reflections of almost equal intensity. These reflected wavefronts are "laterally sheared," (i.e., offset with respect to each other) because of the finite thickness of the plate. Interference occurs in the region where the wavefronts overlap as shown in the figure below.



Fringes appear in the region where the light reflected from the front and rear surfaces of the shear plate overlap

Parallel-sided shear plates are sometimes used, but wedged plates produce fringes that are usually straightforward and relatively easy to interpret. Wedged shear plates produce a graded path difference between the front and back surface reflections. Consequently, a parallel beam of light produces a linear fringe pattern where the reflections overlap. The fringes are equally spaced, and the fringe direction for perfect collimation can be easily marked by a reference line either on the plate itself, or on a viewing screen placed in the reflected beam path. The use of a viewing screen greatly simplifies matters when measurements have to be made using the shear plate. For this reason Melles Griot shear plates are mounted in aluminum housings that contain viewing screens.

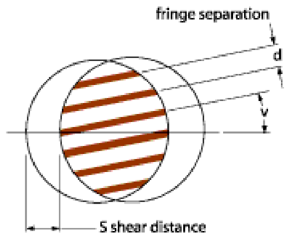
Shear plates are ideally suited to determine the proper adjustment for a laser collimation system. They can also be used to measure wavefront radius of curvature, determine wavefront symmetry, measure the power of long-focal-length optics and in some cases analyze wavefront aberrations.

Quantitative Interpretation of the Fringes

When a noncollimated beam (curved wavefront) is incident on a wedged shear plate, the path difference between the two reflected wavefronts is increased or decreased from the collimated light case. When the beam is reasonably close to collimation, the interference pattern on the screen is still a series of equally spaced straight fringes. However, the pattern is rotated from the collimated light situation (i.e., the fringes are no longer parallel to the reference line on the screen). In such cases, the wavefront radius of curvature (*R*) is given by the shear equation,

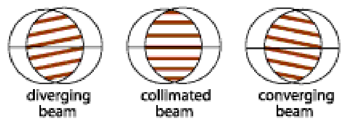
$$R = s\delta / (\lambda \sin \theta)$$

where s is the shear distance, δ is the fringe spacing, and θ is the angular deviation from the collimated light case. All three parameters are measurable from the viewing screen as shown in the illustration below.



Measurable quantities need to determine wavefront radius from the shear equation

The direction of fringe rotation depends on the orientation of the wedge direction relative to the input and viewing directions. All Melles Griot shear plate modules follow the same sign convention: a convergent beam of light produces a clockwise rotation, and a divergent beam produces a counter-clockwise rotation, when viewed on the display screen.



Orientation of fringes with respect to the collimation reference line