APPLICATION NOTE

Collimation Tester

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Researchers have historically tested for laser beam collimation by measuring the diameter of the beam immediately at the output of collimation optics and then down the optical path (typically a few meters down the path where the beam hits the wall of the lab). This technique can be useful, but the Newport Collimation Tester offers the researcher a simpler approach.

The Newport Collimation Tester 20QS20 makes use of a technique called "Shearing Interferometry." This is a null method used to test the collimation of laser light whose coherence length is long compared to the thickness of the collimation tester. The collimating optics can be adjusted until horizontal interference fringes are obtained in the output image, as described below.

The Collimation Tester is simply a high-quality optical window (in this case fused silica) with extremely flat (λ/10 @ 633 nm) optically-polished uncoated surfaces with a slight wedge (4.4 arc-seconds) between the two surfaces. When the plane wave from the laser source is incident on the Collimation Tester at 45°, there are two reflections, one from each surface. The reflections are separated from each other as a result of the thickness (9.4 mm) and the wedge of the Collimation Tester. The separation is what is called "shear" and it is this property that gives the technique its name.

With a plane wavefront incident on the Collimation Tester, the overlapping area shows fringes when projected on a screen. The fringe spacing is $d = \lambda/2n\theta$, where d is the fringe spacing, λ is the wavelength of the light, n is the index of refraction of fused silica, and θ is the wedge angle. The fringes will be horizontal when the wedge angle is vertical.

When the wavefront is not well collimated, it has a radius of curvature, R. As a result, the path difference is increased or decreased (depending upon the direction of the error) and the interference fringes will not be horizontal. The angle of the deviation from horizontal, α, can be found from $\sin \alpha = s\, d / \lambda R$, where s is the shear, or thickness of the Collimation Tester. When good collimation is achieved, R goes to infinity and α goes to zero.

The collimation of the beam can be tested right at the output of the beam at only one location by using the collimation tester. The following details the method of test.

Step 1

Place the collimation tester (model no. 20QS20) in an optics mount or any 2 inch holder with sufficient clear aperture.

The collimation tester is a wedged plate with its thicker side marked on the edge (see figure #2). It is desirable to have the thick edge of the plate pointing upwards when mounted in the optical mount. Set the optic within the mount on a table top. The optic with mount is called the Collimation Tester Assembly.

The plate is shown here in a U200-AC2K on top of a 2" pedestal post (PS-2).
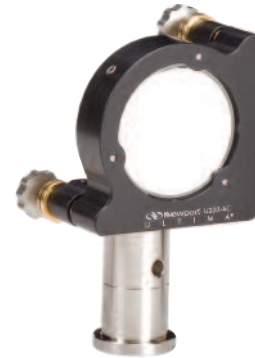

Figure #1

Step 2

Place the Collimation Tester Assembly at a 45° angle in the path of a collimated (or expanded) beam. The beam diameter incident on the Collimation Tester Assembly should be large enough so that fringes can be viewed easily (a beam diameter of 1"-2" will make for easy viewing of the fringes).
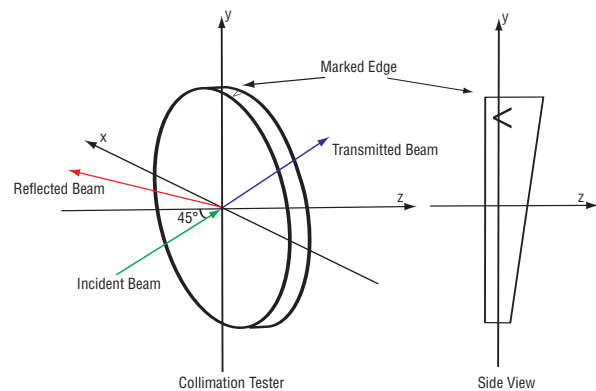

Figure #2

Step 3

Look for fringes in the path of the reflected beam. Inserting a white piece of paper taped on cardboard will help you find the fringe pattern. In the reflection path, you will see a couple of overlapping circles of light. The area of where the two circles overlap is where the fringe pattern will occur.
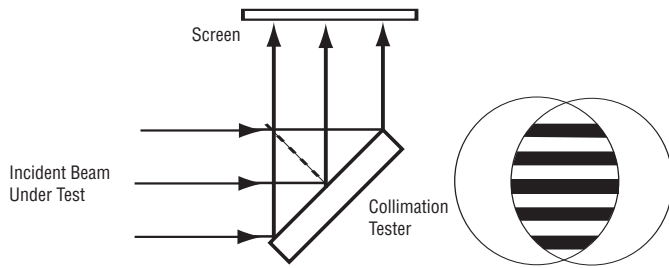
Screen

Incident Beam
Under Test

Collimation
Tester

Figure #3

Step 4

Adjust the position of the lens in the beam expander (or
collimator) until horizontal fringes are observed in the
reflection. For 633 nm, there should be three to five
fringes visible in the reflection (for shorter wavelengths
more fringes will be visible). When fringes are
horizontal, the beam is well collimated. The resolution
of the collimation will depend on user expertise, angle of
incidence and incident wavelength.

For those who are interested in this technology, you can
do an internet search on "shearing interferometry" or
"shear interferometry". The Newport "Projects in
Interferometry" kit guides you through setting up a
Cyclical Shearing interferometer in experiment #1.

Listed here are some resources and examples of
shearing interferometers:

1. Jae Bong Song, Yoon Woo Lee, In Won Lee, Jung
    Hoon Lee, "Lateral shearing interferometer using
    phase-shifting technique without moving element,"
    Optical Manufacturing and Testing V; H. Philip Stahl;
    Ed., p. 445-454, (Dec 2003)

2. T. D. Henning and J. L. Carlsten, "Cyclical shearing
    interferometer for collimating shor coherence-length
    laser beams," Appl. Opt. 31, 1199-1209 (1992)

3. M. E. Riley and M. A. Gusinow, "Laser beam
    divergence utilizing a lateral shearing interferometer,"
    Appl. Opt. 16, 2753- (1977)

4. M. P. Rimmer, "Method for evaluating lateral shearing
    interferograms," Appl. Opt. 13, 623- (1974)

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