Quality Assurance of Precision Optics

Figures and Images for Instructors

Module 2
Characterization of Optical Materials and Precision Optics

Precision Optics Series

National Center for Optics and Photonics Education

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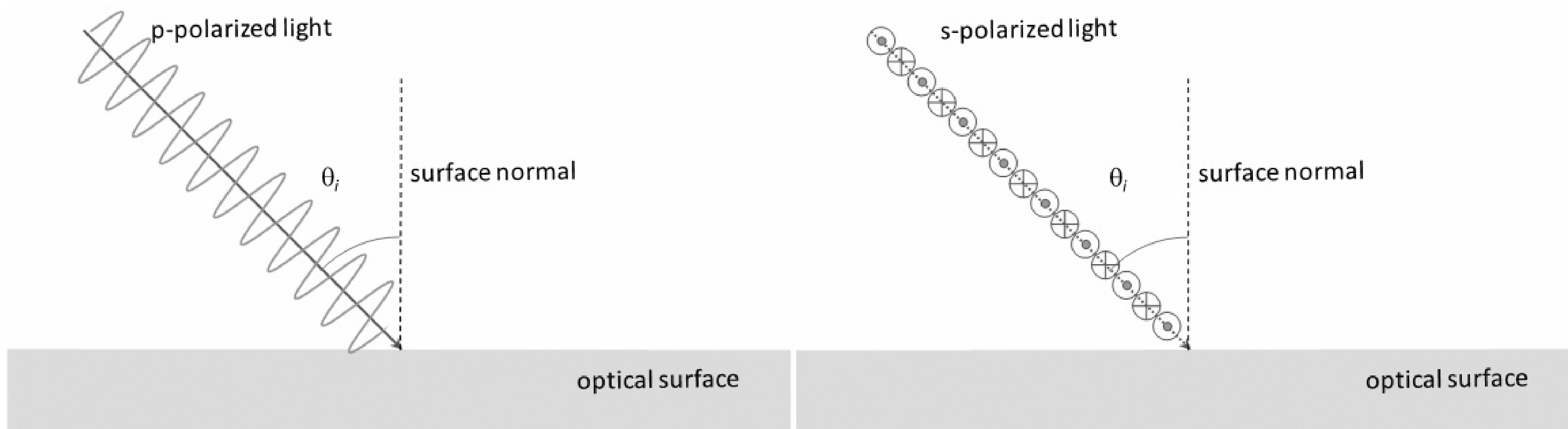

Figure 2-1 *This illustration differentiates p-polarized light (left figure) from s-polarized light (right figure). In each case, the angle of incidence is given by the parameter θ_i. It is simple to represent p-polarized light vibrating in the plane of the page as a wave, but s-polarized light vibrates in and out of the page, so it is represented by arrowheads ⊙ and arrowtails ⊗.*

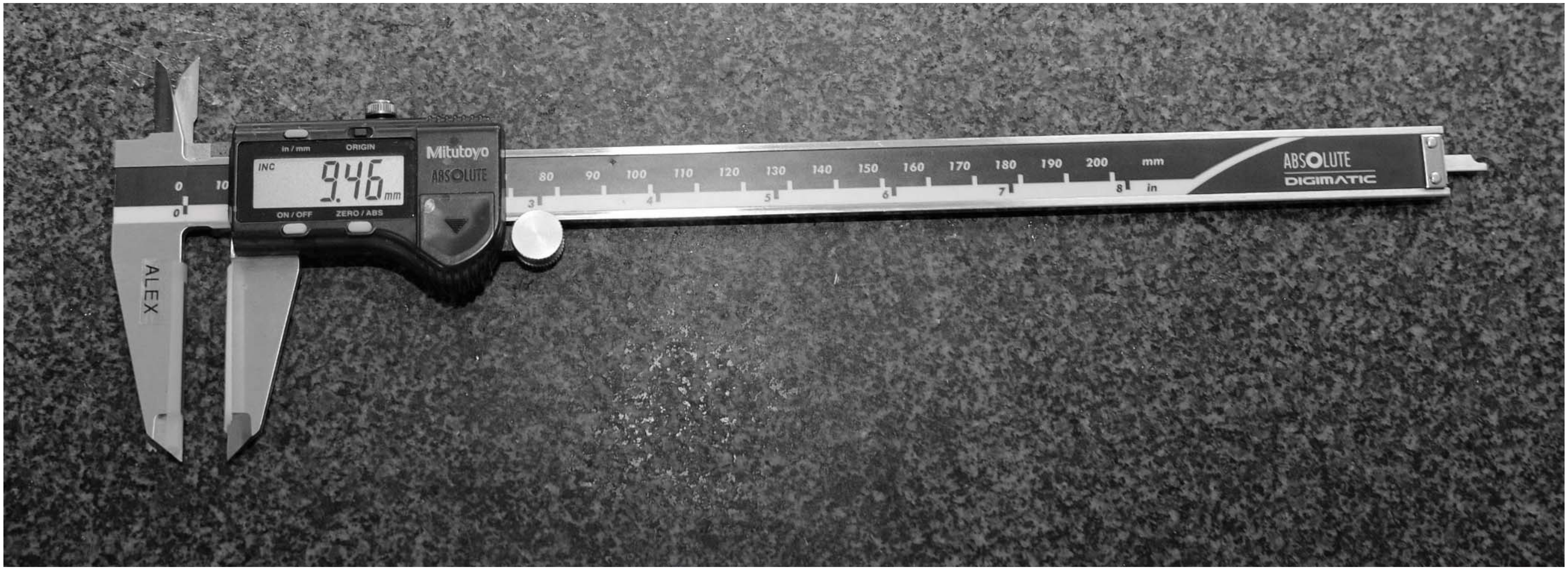

Figure 2-2 *Digital calipers on a granite-slab workbench*

Figure 2-3 *This precision optics technician is using a micrometer to measure the diameter of a precision retroreflector*

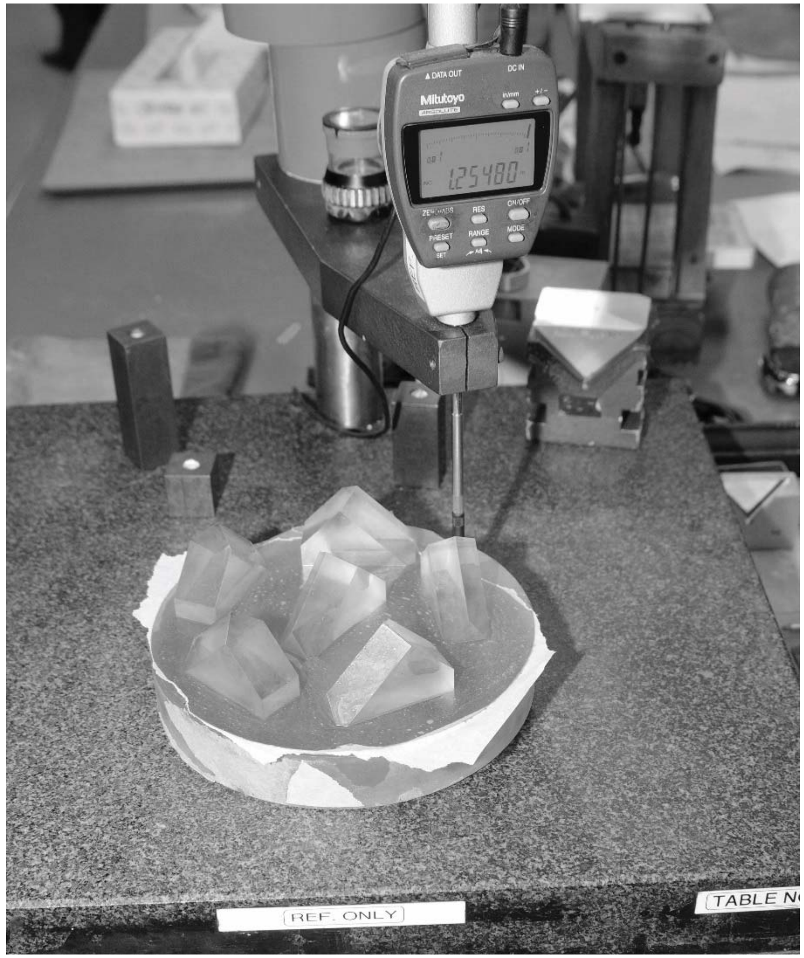

Figure 2-4 *A digital height gauge measures precision prisms relative to a flat granite-slab workbench*

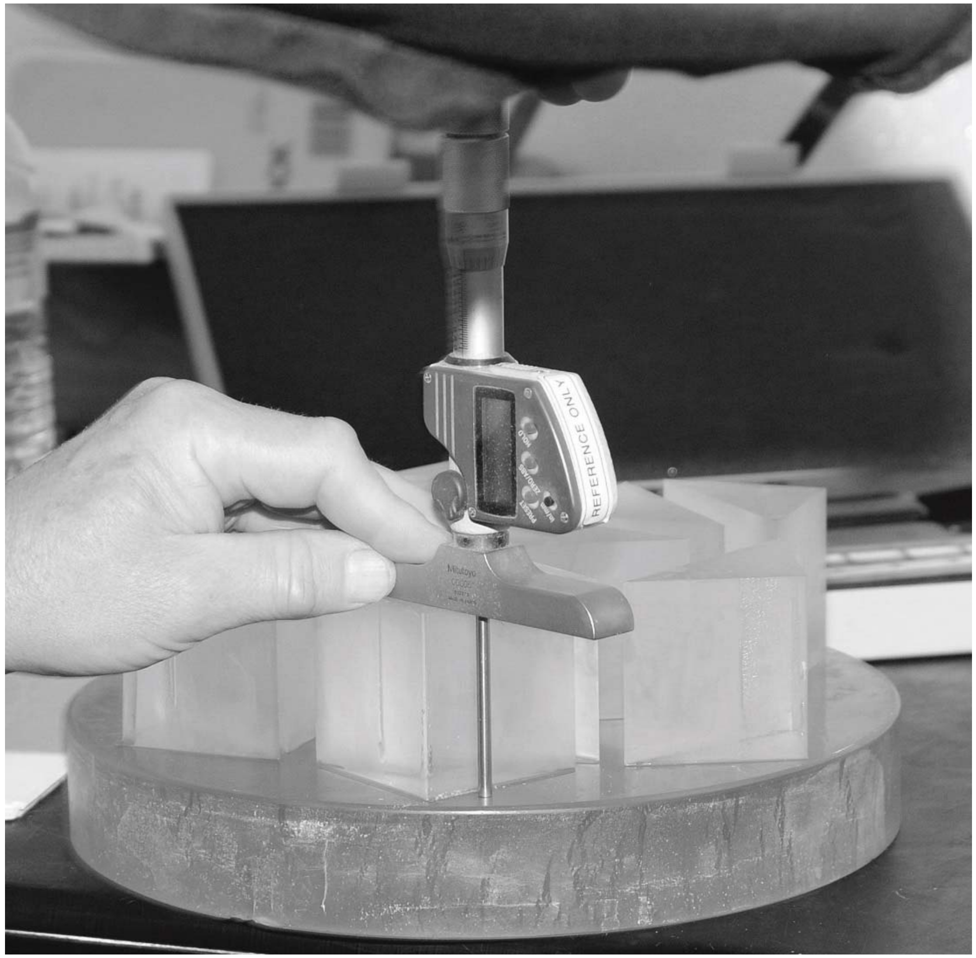

Figure 2-5 *A precision optics technician uses a manual height gauge to measure prisms' lengths*

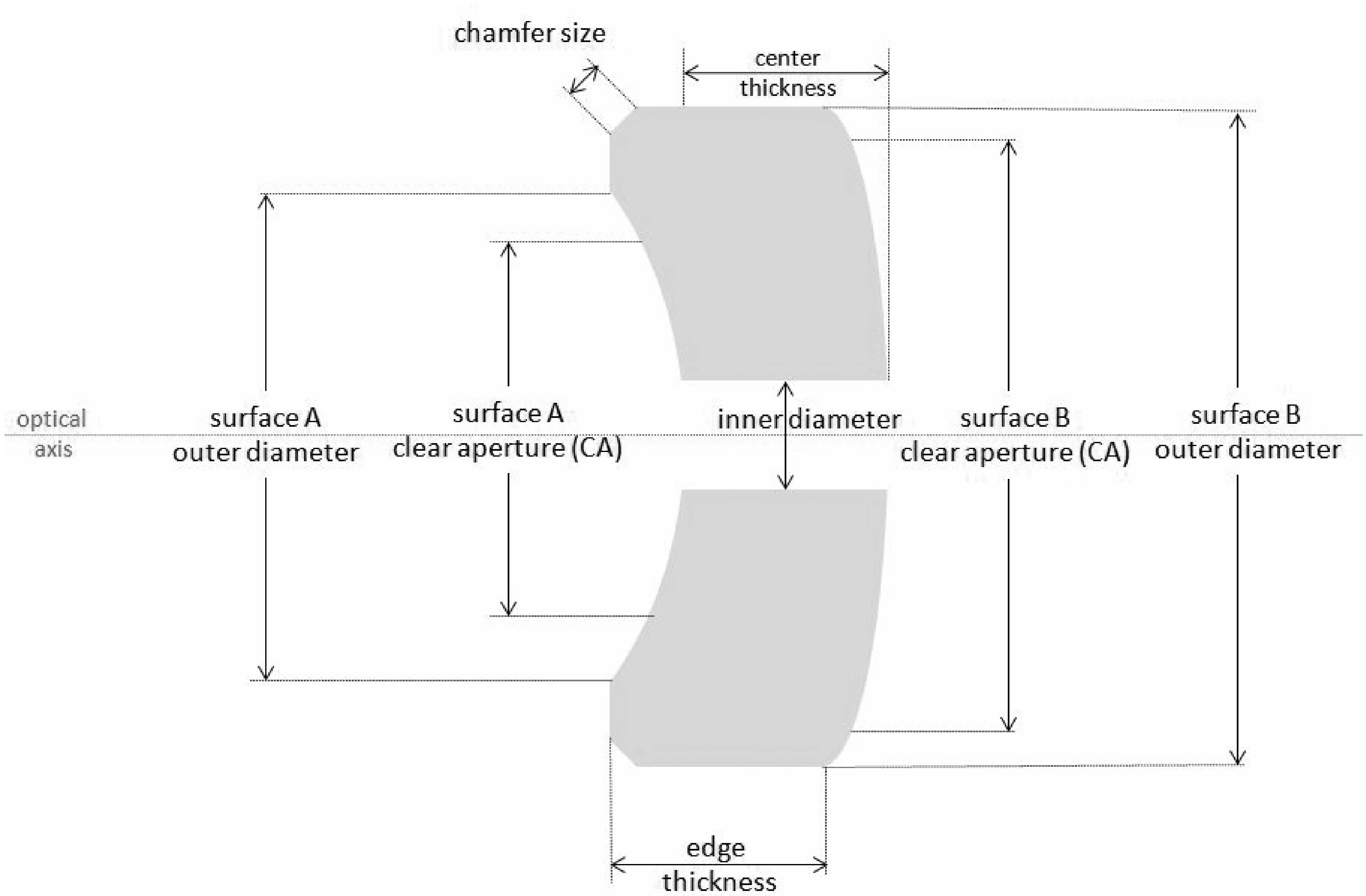

Figure 2-6 *Length features of a cross section of a precision optic*

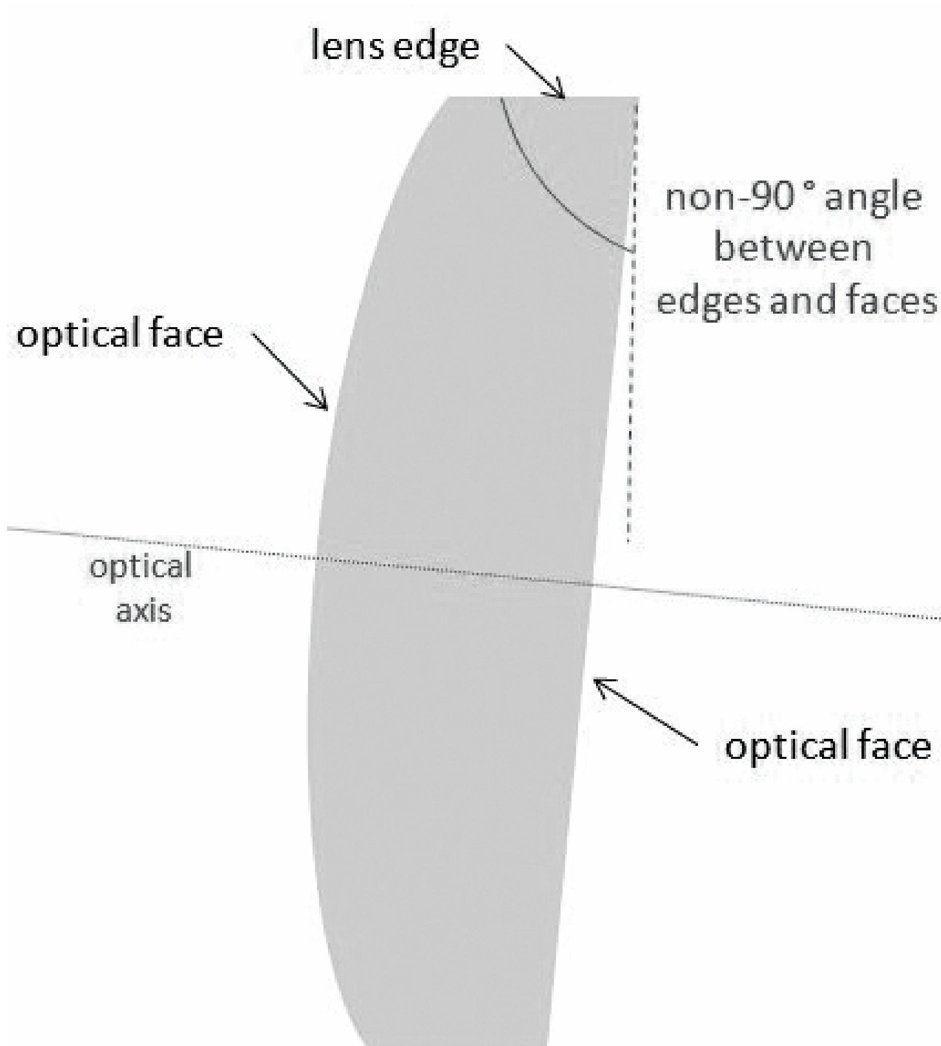

Figure 2-7 *Lens tilt, exaggerated, due to improper edging relative to the optical faces*

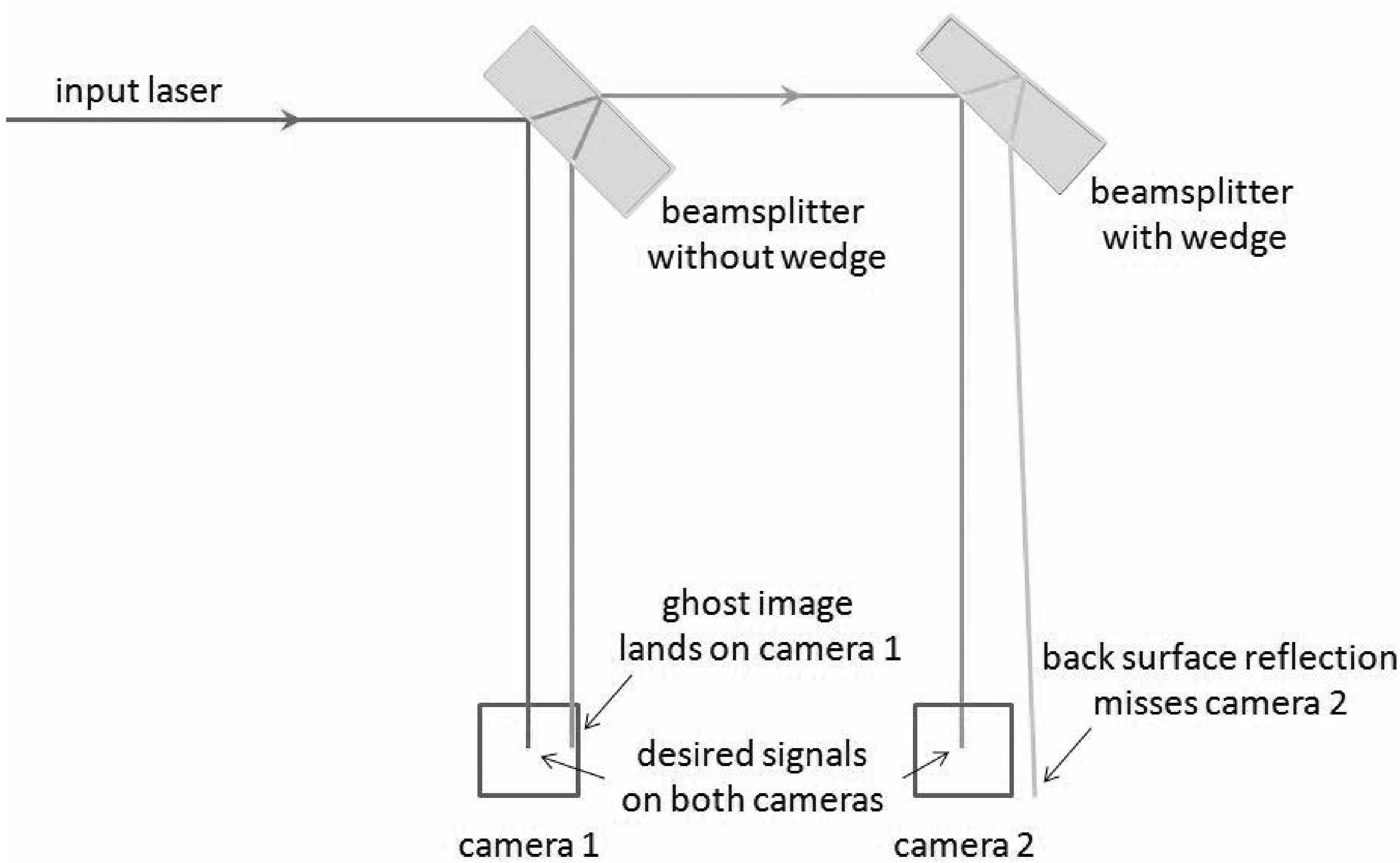

Figure 2-8 *Two beamsplitters, one with and one without wedge. The laser that reflects from the back surface of the beamsplitter without wedge creates a ghost image on camera 1, while the reflection from the back surface of the beamsplitter with wedge misses camera 2 completely*

Figure 2-9 *A precision optics technician uses an autocollimator to measure the angular deviation of a prism during final polishing*

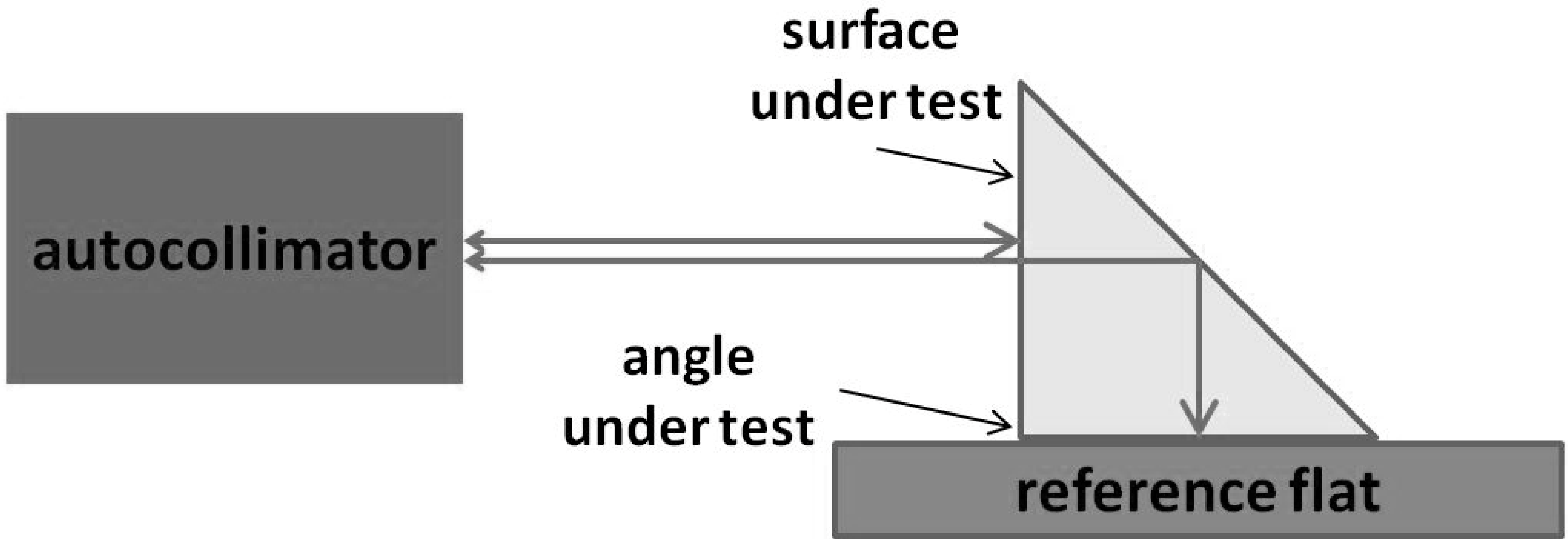

Figure 2-10 *Schematic of a prism angle measurement*

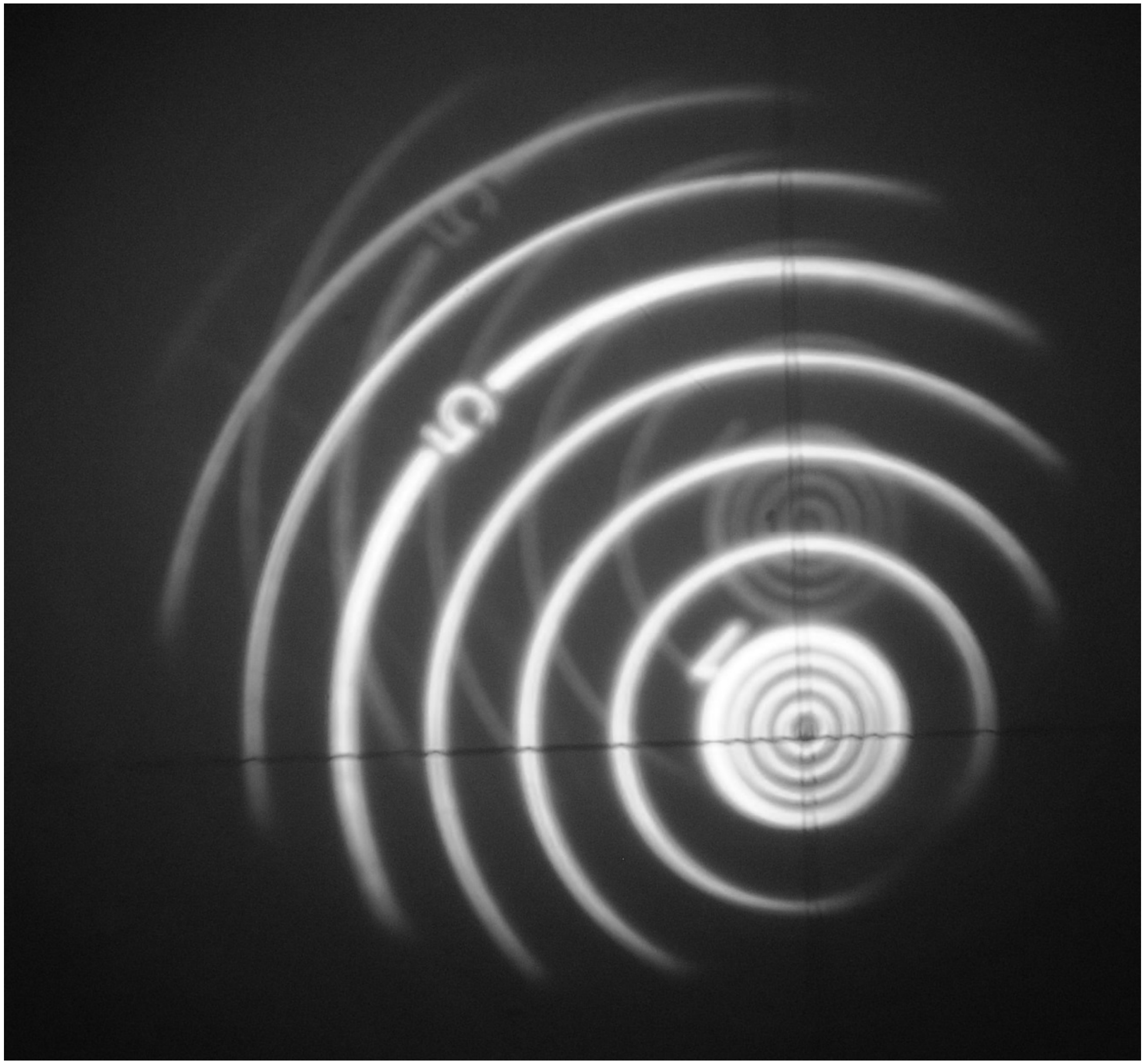

Figure 2-11 *Technicians use the reticle and crosshairs of an autocollimator to determine a prism’s angular features*

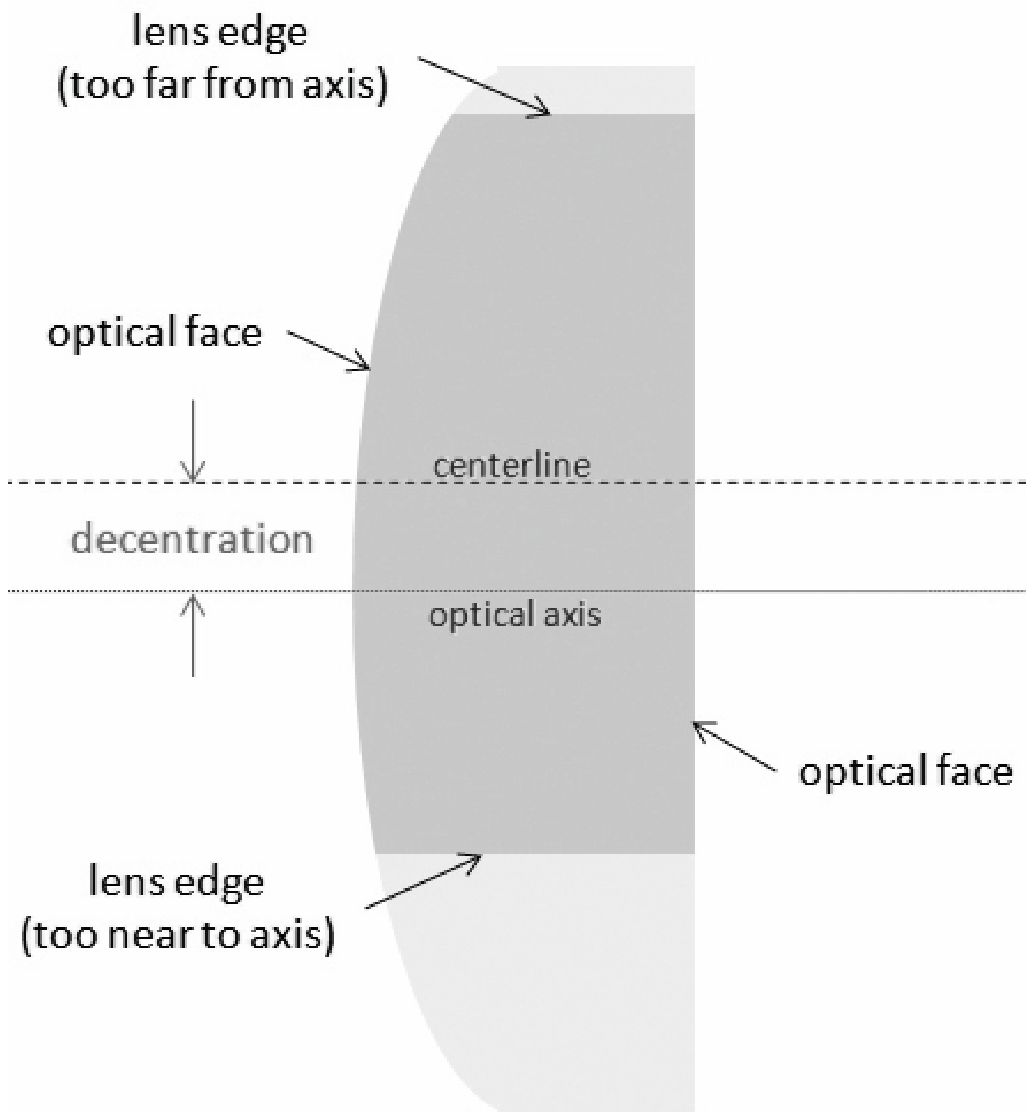

Figure 2-12 *Vertical centration of an optic*

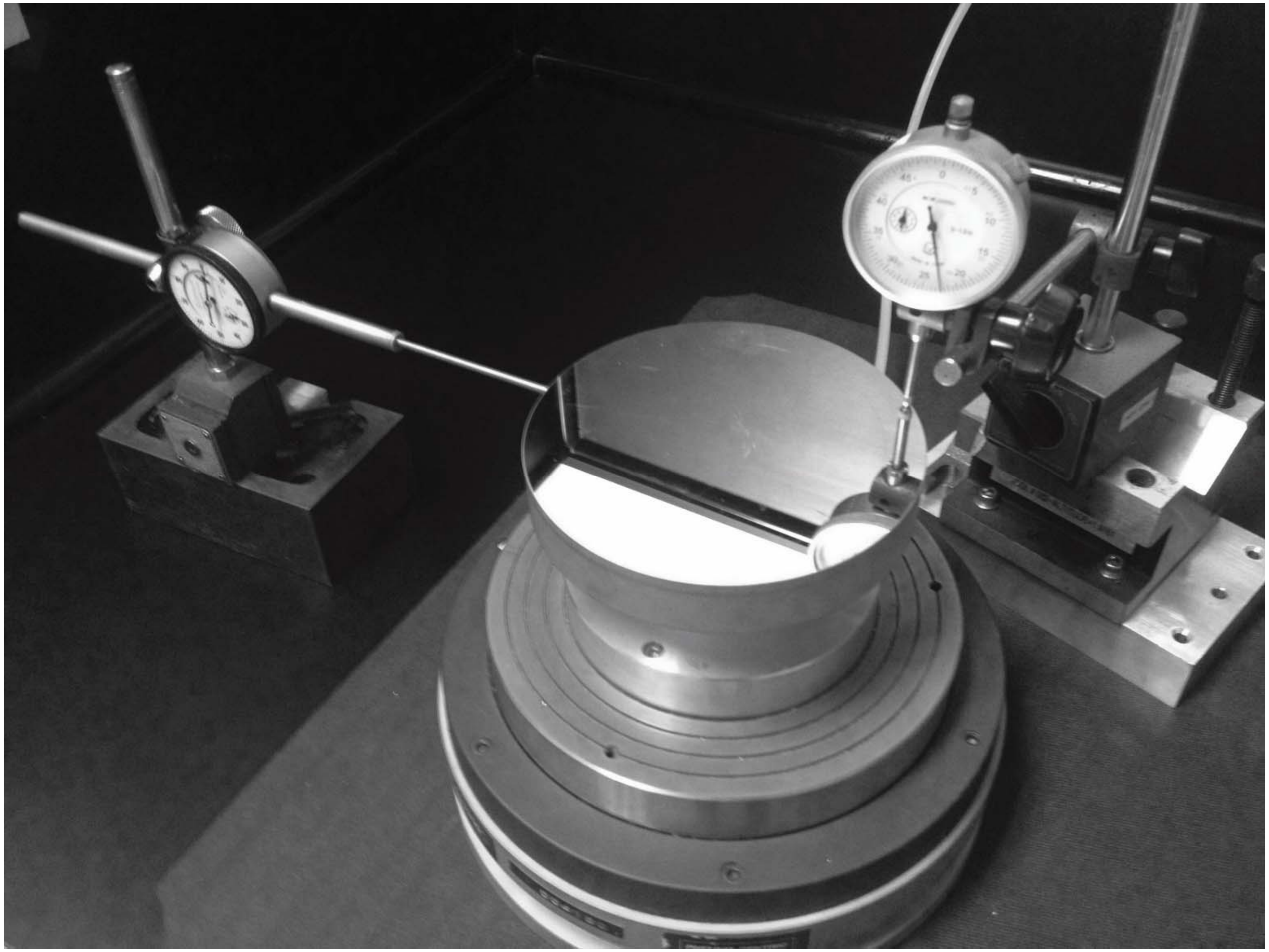

Figure 2-13 *In this total indicated runout (TIR) measurement setup, the gauge on the left measures TIR along the edge of the part, and the height gauge on the right ensures that the optical surface of the precision optical element remains in the same plane as it is rotated*

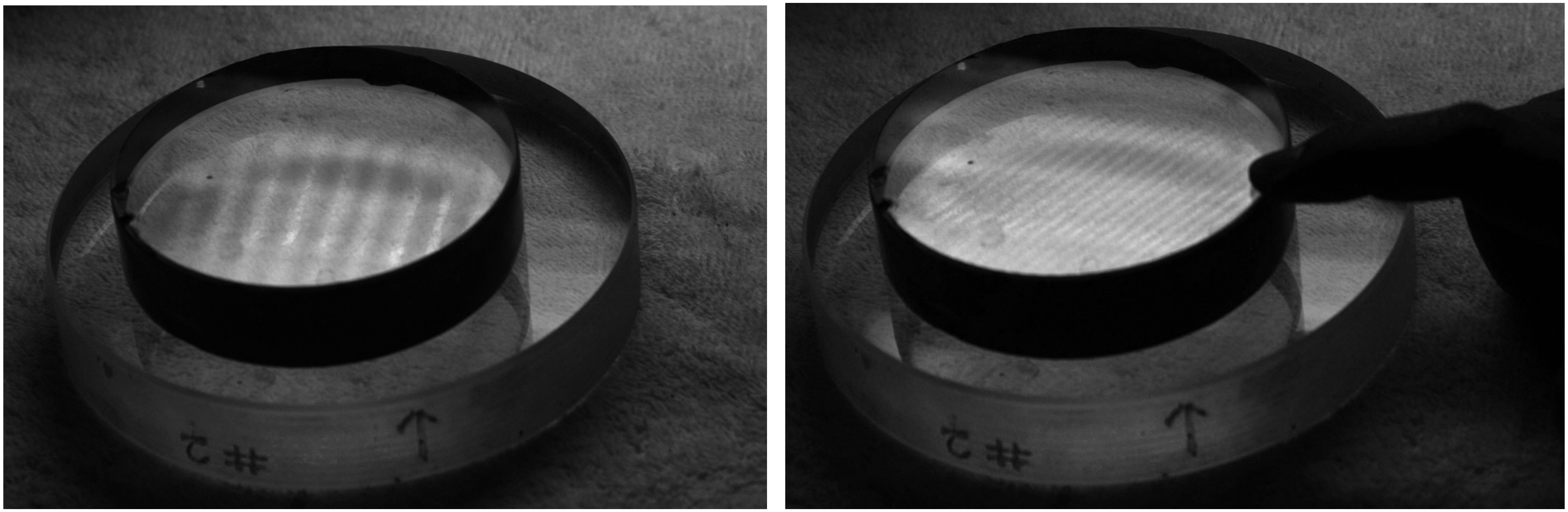

Figure 2-14 *The bottom surface of a flat window (top optic) is tested against a flat test plate (bottom optic, top surface) under narrowband light. Linear Newton's fringes indicate that there is little curve to the flat surface. In the left figure, there are about ten tilt fringes across the window. When the precision optics technician pushes gently on the window, many more tilt fringes result. The presence of only straight fringes indicates that this part is quite flat with respect to the test plate. (Precision Optical)*

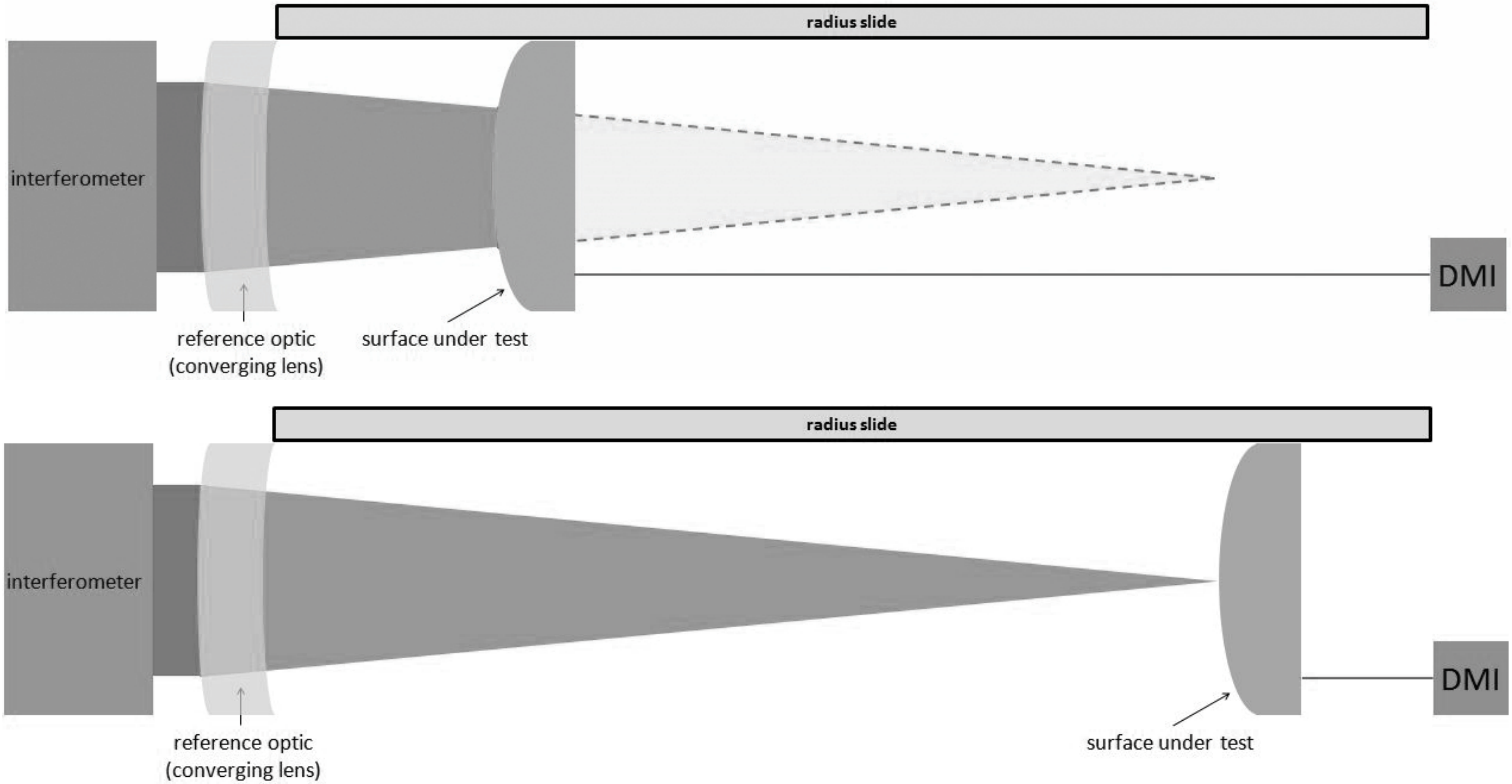

Figure 2-15 *The surface being tested is moved along an extremely straight radius slide from the position at which its surface figure is measured (top) to the position of "cat's eye" focus, at which point its (virtual) focal point is located directly on the surface under test. The radius is equal to the distance between these two positions. To accurately measure this distance, the technician reflects a thin laser beam from a DMI off the optic's mount.*

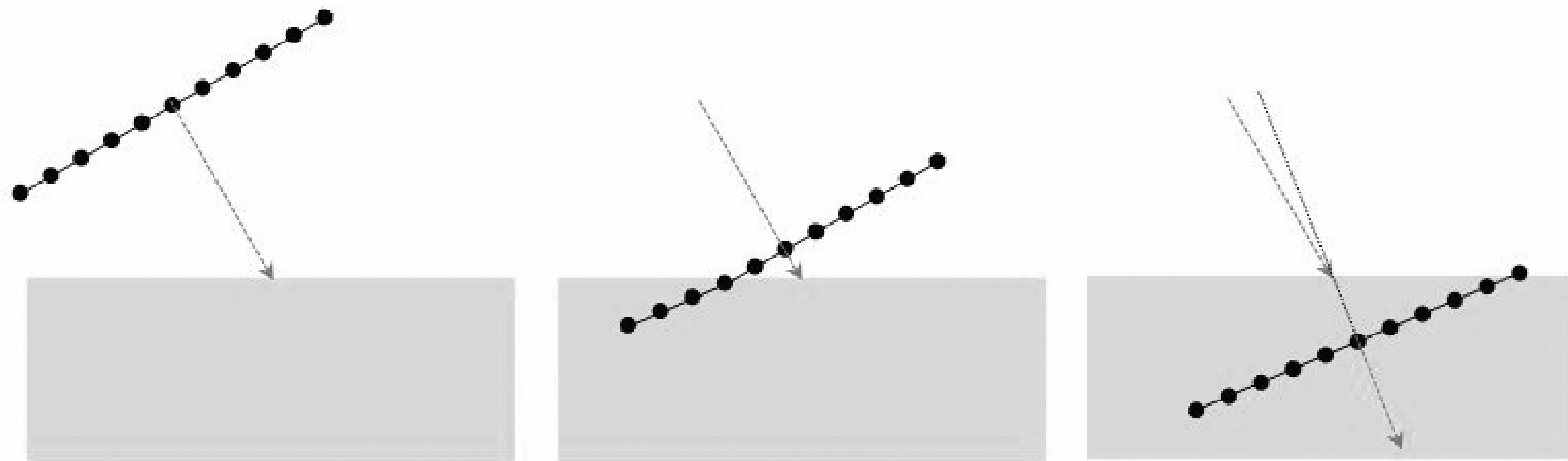

Figure 2-16 *As a wavefront of light (represented by the row of dots) approaches a material along a path (the dashed line), the light refracts. That is, its direction bends because the side of the wavefront that enters the material first is slowed down. The image on the right shows the difference in direction before (incident) and after (refracted) the wavefront enters the material.*

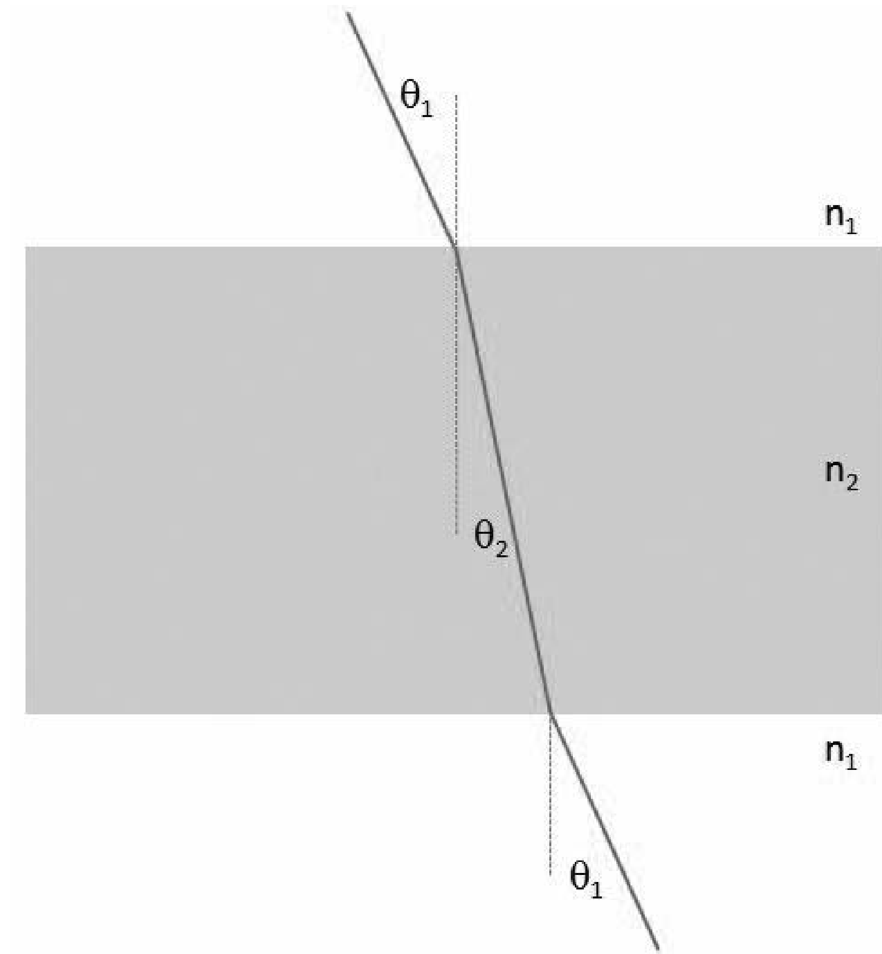

Figure 2-17 *A graphical representation of Snell's Law of refraction, showing the angle of incidence, θ_1, the angle of refraction, θ_2, the refractive index of the incident material, n_1, and the refractive index of the refracting material, n_2*

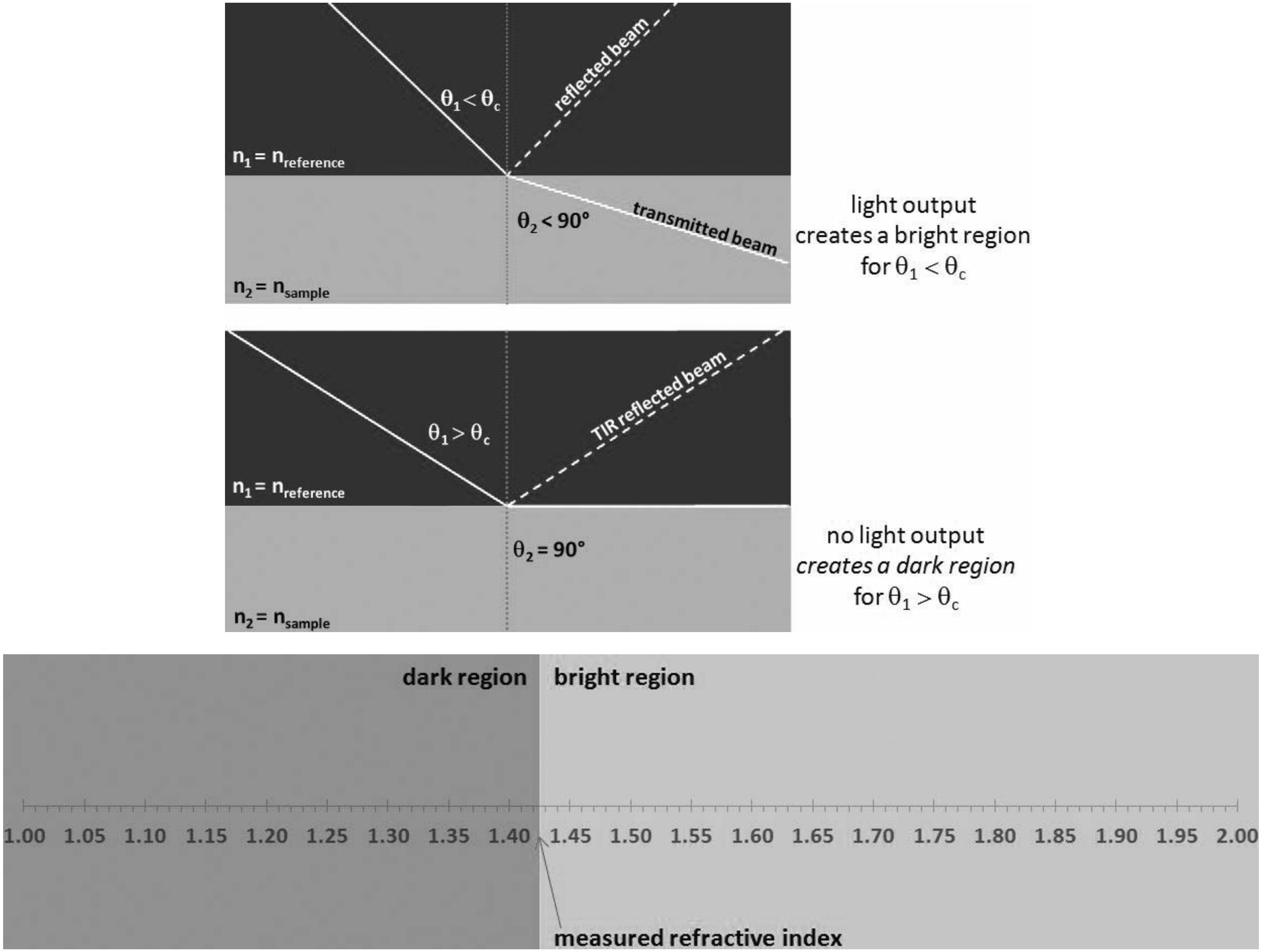

Figure 2-18 *The operation of a refractometer*

Figure 2-19 *A precision optics technician operates a refractometer to precisely measure the refractive index of a glass sample*

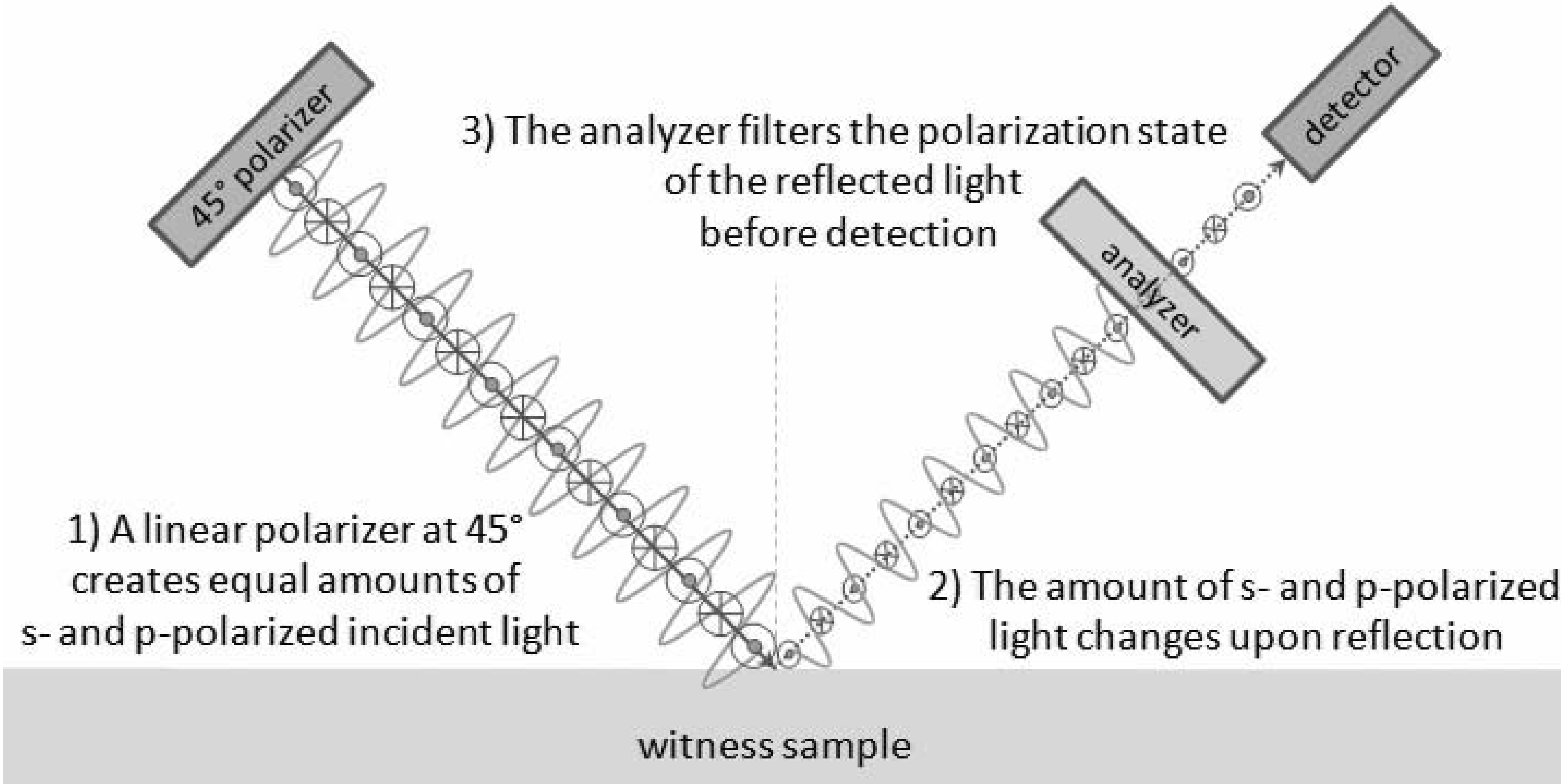

Figure 2-20 *Birefringence measurements using polarimetry and ellipsometry*

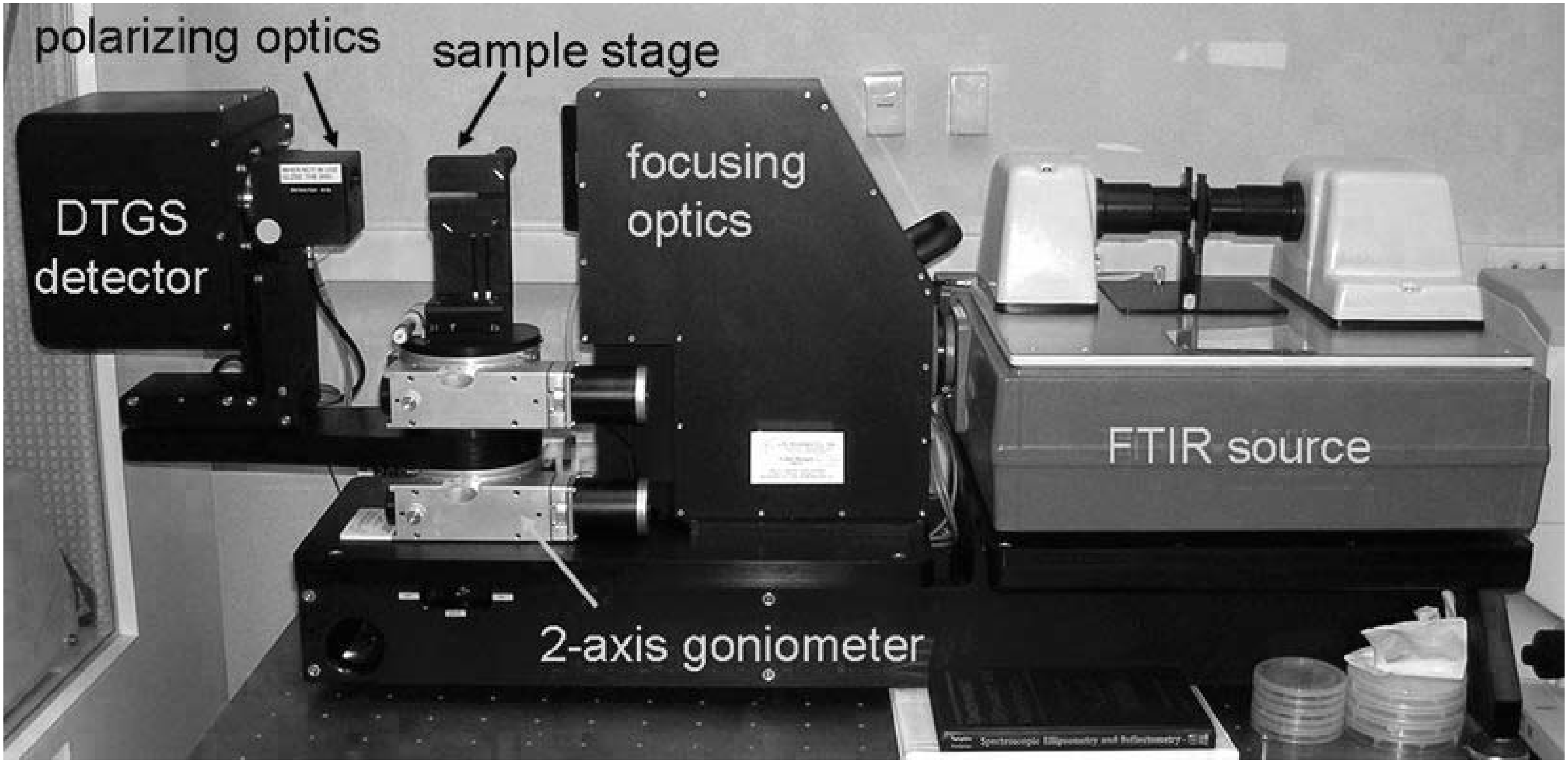

Figure 2-21 *A variable-angle spectroscopic ellipsometer by J.A. Woollam Company*

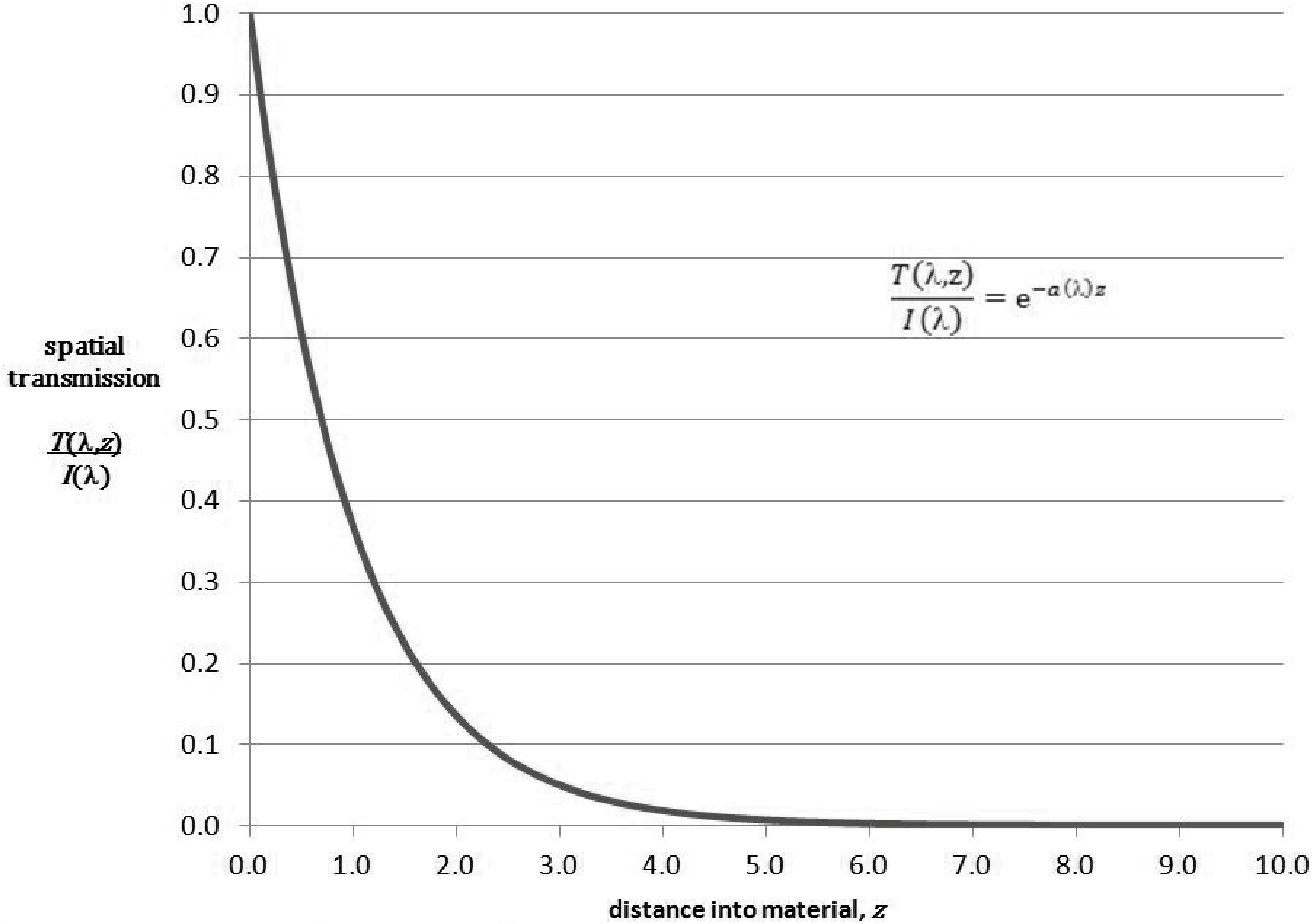

Figure 2-22 *Spatial transmission into a material due to Beer-Lambert attenuation*

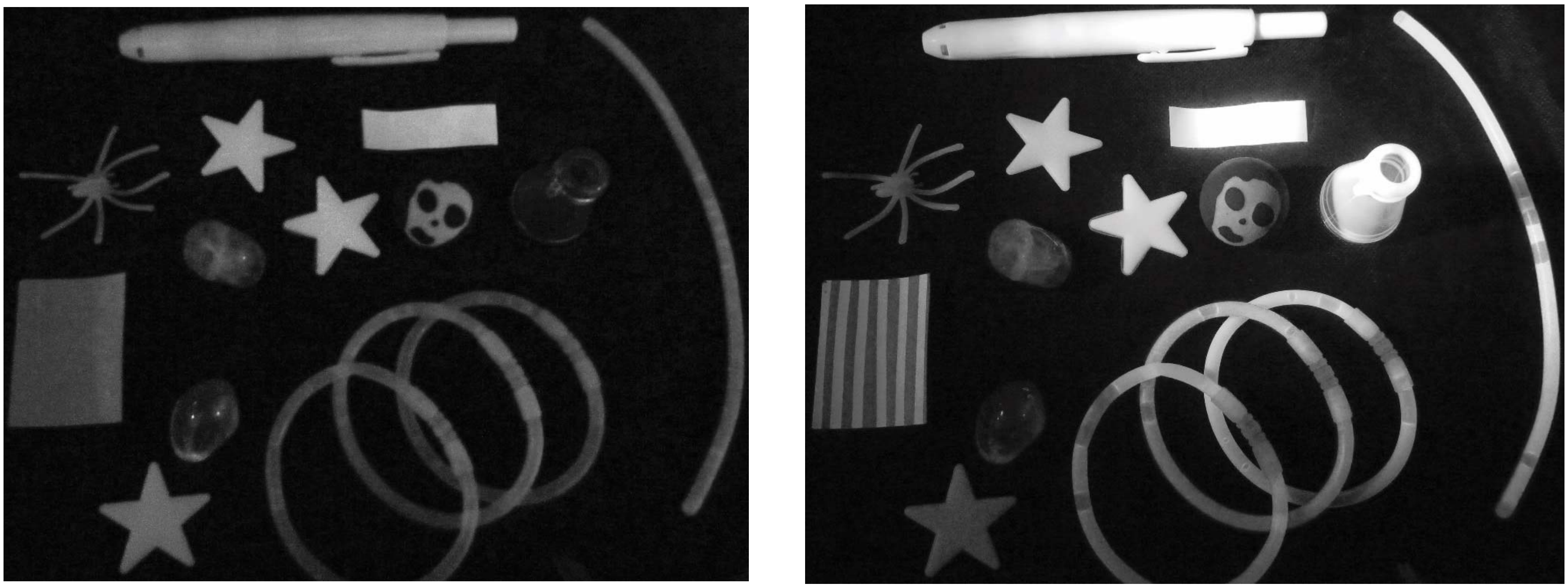

Figure 2-23 *The objects shown fluoresce reds, oranges, yellows, and greens when illuminated in violet light. (The two objects between the stars are fluorescent crystals.)*

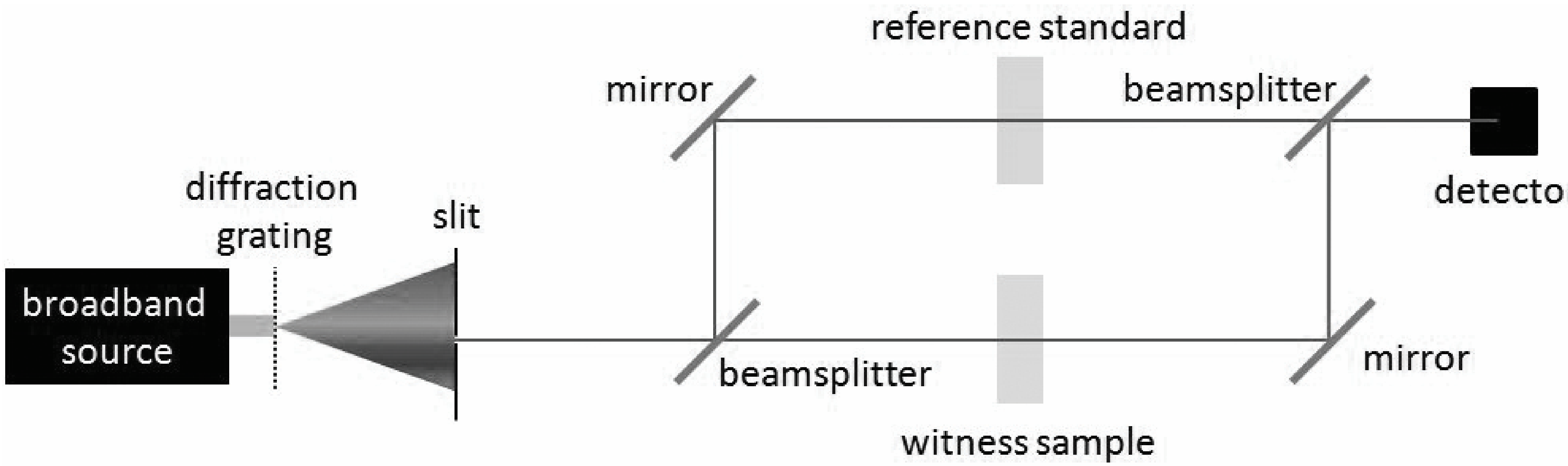

Figure 2-24 *A dual-beam transmissivity-measurement configuration for a spectrophotometer or spectroradiometer, used to measure the transmissivity of a witness sample relative to a calibrated reference standard. In the case shown, the grating is allowing green light to be tested. Other wavelengths may pass through the slit by moving the grating.*

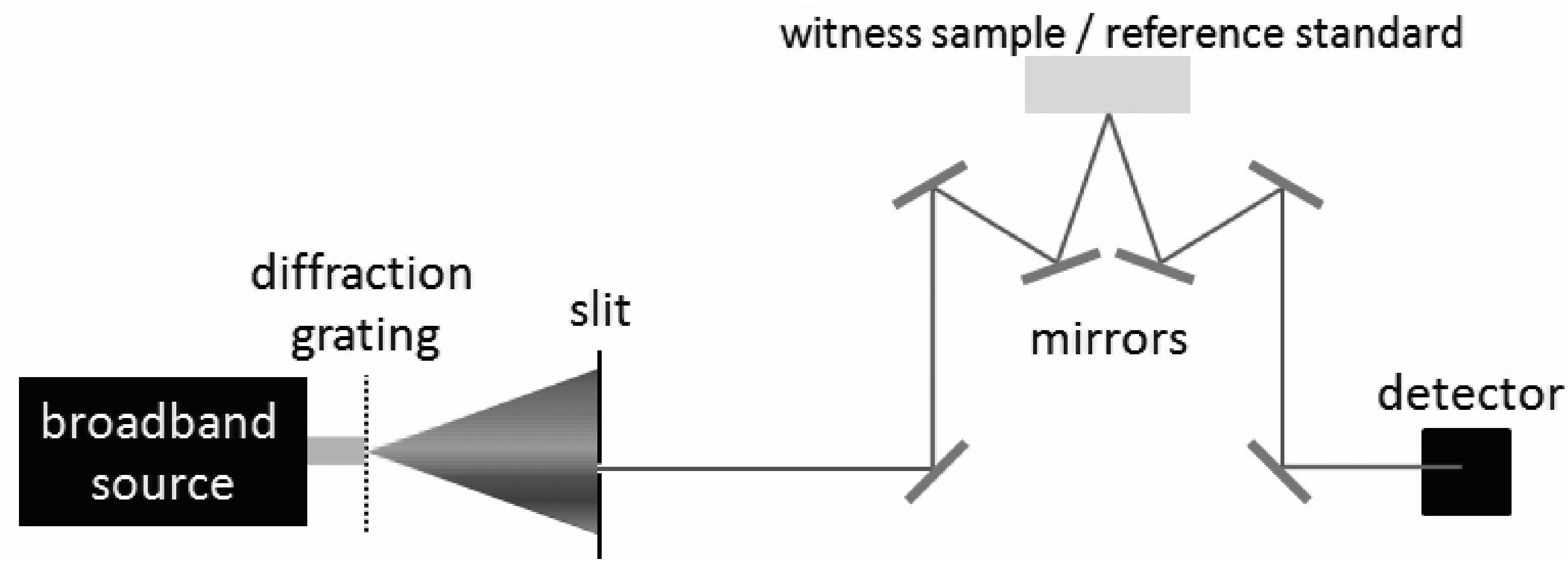

Figure 2-25 *A single-beam reflectivity-measurement configuration for a spectrophotometer or spectroradiometer, used to measure the reflectivity of a witness sample or reference standard at various angles of incidence (achieved by adjusting the mirrors). This single-beam setup requires that the reference standard and the witness sample are interchanged, and their data can be later compared using the instrument's software.*

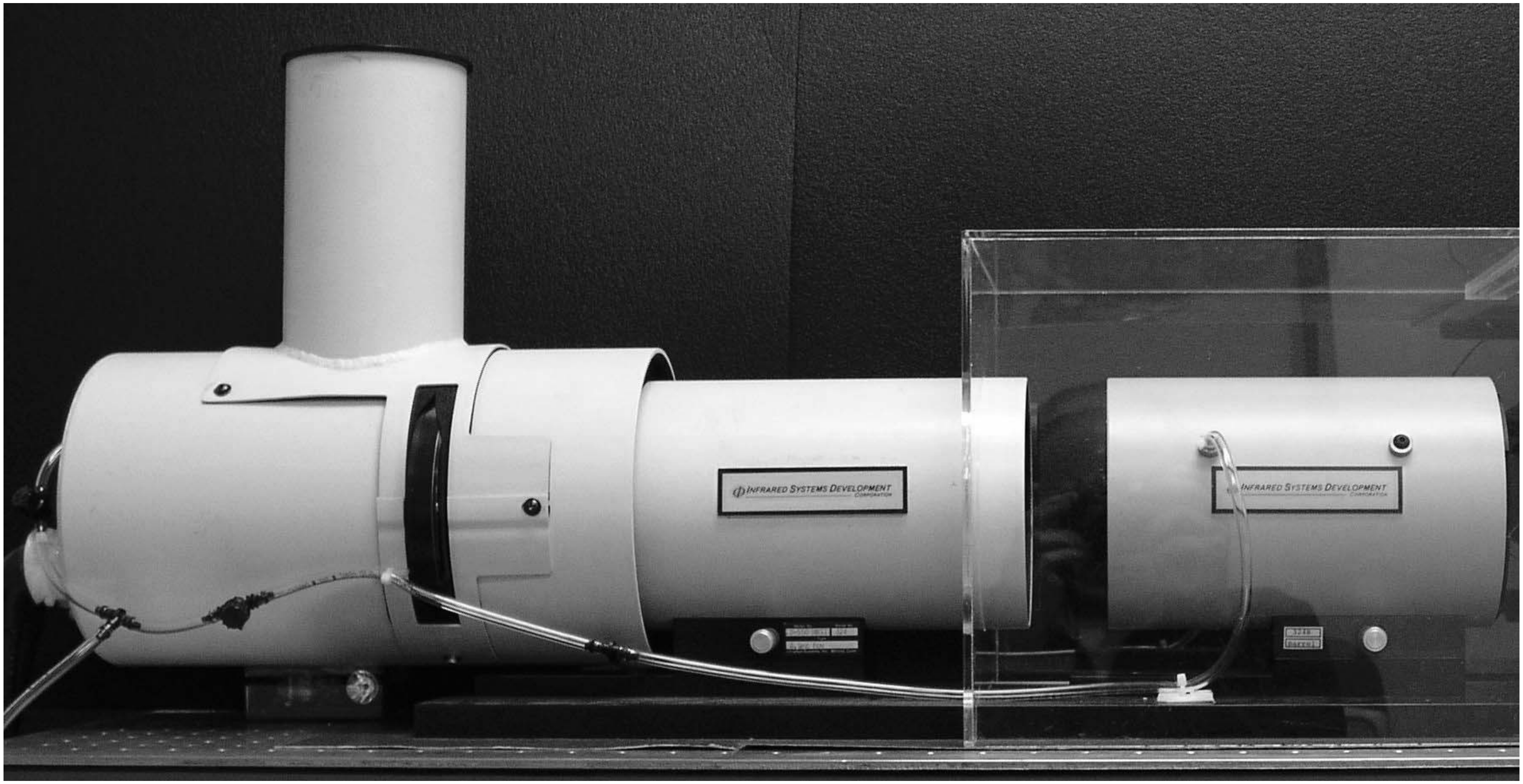

Figure 2-26 *This spectroradiometer measures optical properties in the infrared from 1 to 15 micrometers*

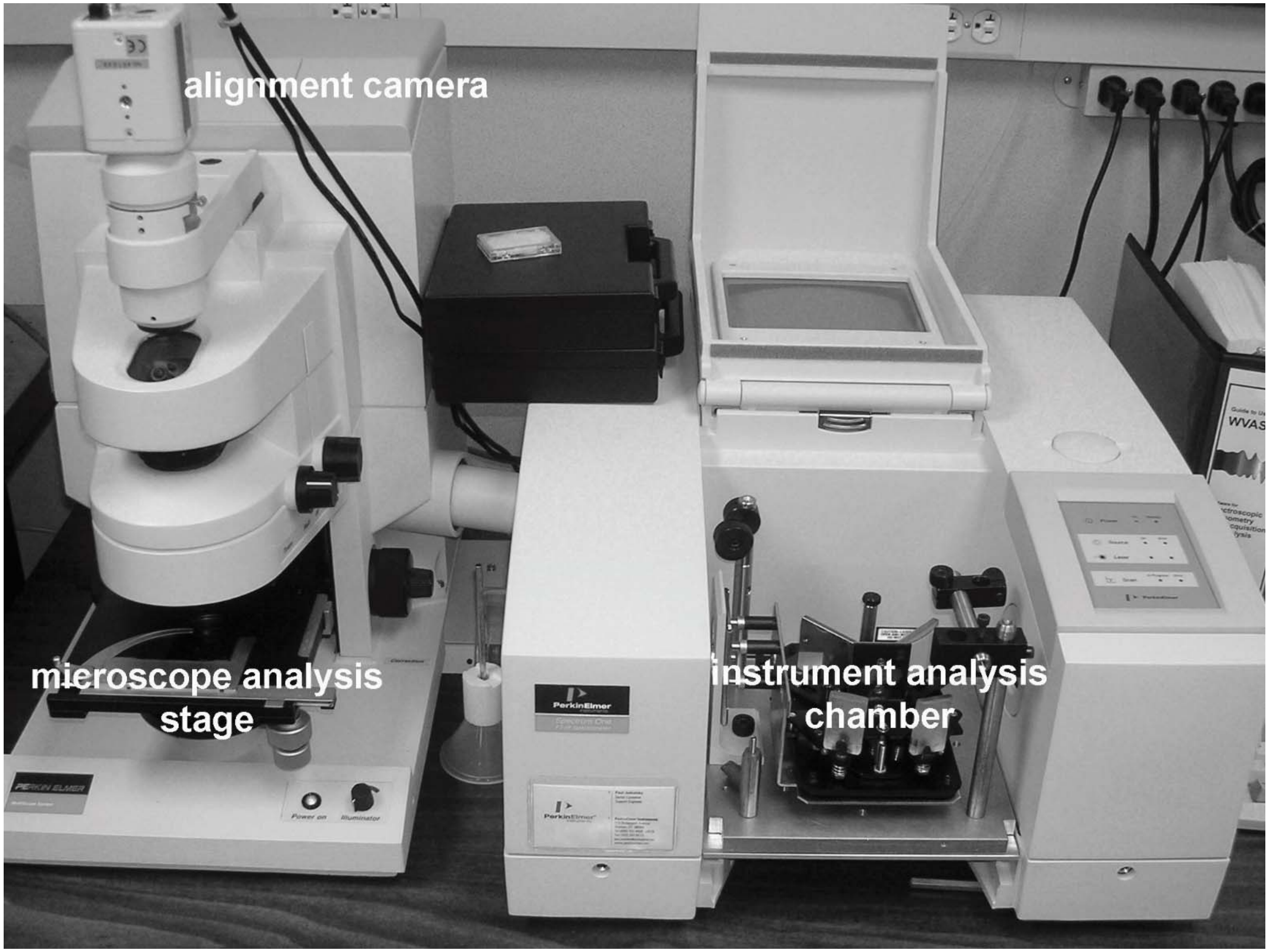

Figure 2-27 *This FTIR spectrometer is capable of measuring the spectral properties of materials from wavelengths ranging from 2 to 25 micrometers. A microscope accessory (on the left) is able to measure extremely small samples.*