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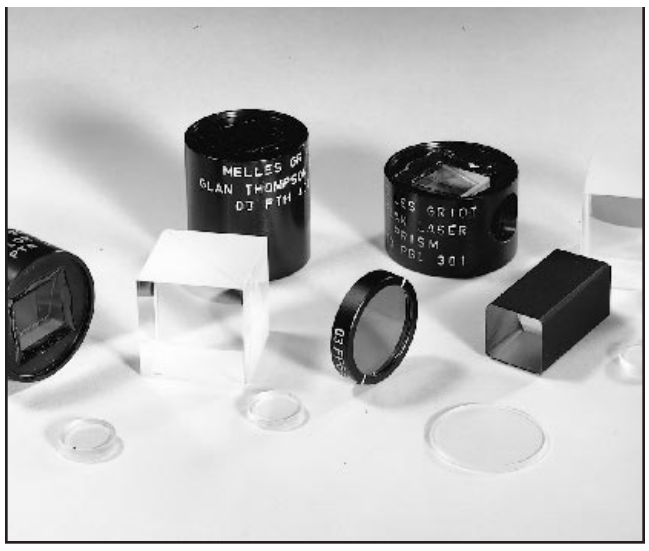
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Polarization Components

Polarized light carries valuable information about the various physical parameters that have been acting on it. Magnetic fields, chemical interactions, molecular structures, and mechanical stress all affect optical polarization. Applications relying on these polarization changes include astrophysics, agricultural production, electric power generation, and molecular biology.

Polarization states are linear, circular, or elliptical according to the paths traced by electric field vectors in a propagating wave train. Unpolarized light (such as from an incandescent bulb) is a combination of all linear, circular, and elliptical states. Randomly polarized light, in reference to laser output, is composed of two orthogonally linearly polarized collinear beams whose power randomly varies over time. Although random, this radiation is always linearly polarized.

Depolarized light is usually linearly polarized light that has been randomized by either temporal or spatial retardation variations across or along the beam. If the various retardations are integrated enough, the beam will appear to be depolarized. The randomization process usually varies the linear polarization in a fairly smooth and predictable manner.

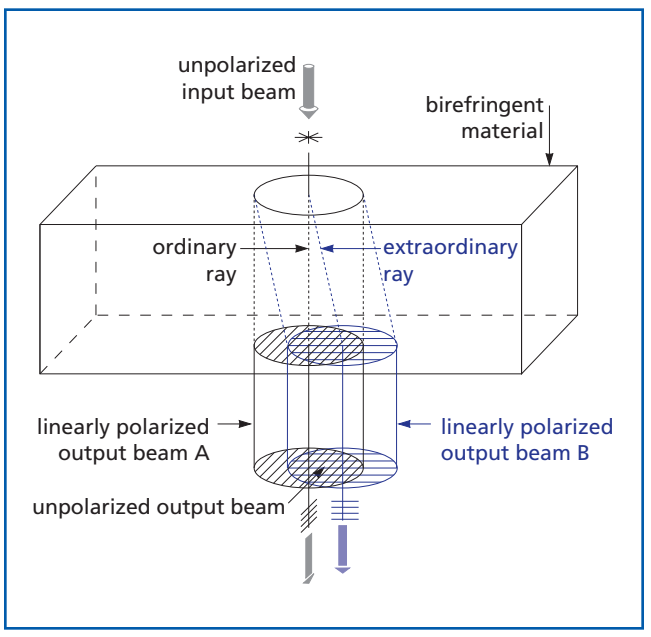
BIREFRINGENCE

A birefringent crystal, such as calcite, will divide an entering beam of monochromatic light into two beams having opposite polarization. The beams usually propagate in different directions and will have different speeds. There will be only one or two optic axis directions within the crystal in which the beam will remain collinear and continue at the same speed, depending on whether the birefringent crystal is uniaxial or biaxial.

If the crystal is a plane-parallel plate, and the optic axis directions are not collinear with the beam, radiation will emerge as two separate, orthogonally polarized beams. The beam will be unpolarized where the beams overlap upon emergence. The two new beams within the material are distinguished from each other by more than just polarization and velocity. The rays are referred to as extraordinary (E) and ordinary (O). These rays need not be confined to the plane of incidence. Furthermore, the velocity of these rays changes with direction. Thus, the index of refraction for extraordinary rays is also a continuous function of direction. The index of refraction for the ordinary ray is constant and is independent of direction.

The two indices of refraction are equal only in the direction of an optic axis within the crystal. The dispersion curve for ordinary rays is a single, unique curve when the index of refraction is plotted against wavelength. The dispersion curve for the extraordinary ray is a family of curves with different curves for different directions. Unless it is in a particular polarization state, or the crystalline surface is perpendicular to an optic axis, a ray normally incident on a birefringent surface will be divided in two at the boundary. The extraordinary ray will be deviated; the ordinary ray will not. The ordinary ray index n, and the most extreme (whether greater or smaller) extraordinary ray index n_E, are together known as the principal indices of refraction of the material.

If a beam of linearly polarized monochromatic light enters a birefringent crystal along a direction not parallel to the optical axis of the crystal, the beam will be divided into two separate beams. Each will be polarized at right angles to the other and will travel in different directions. The original beam energy, which will be divided between the new beams, depends on the original orientation of the vector to the crystal.



Double refraction in a birefringent crystal

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The energy ratio between the two orthogonally polarized beams can be any value. It is also possible that all energy will go into one of the new beams. If the crystal is cut as a plane-parallel plate, these beams will recombine upon emergence to form an elliptically polarized beam.

The difference between the ordinary and extraordinary ray may be used to create birefringent crystal polarization devices. In some cases, the difference in refractive index is used primarily to separate rays and eliminate one of the polarization planes, for example, in Glan-type polarizers. In other cases, such as Wollaston and Thompson beamsplitting prisms, changes in propagation direction are optimized to separate an incoming beam into two orthogonally polarized beams.

QUARTZ WAVEPLATES: OPTICAL ACTIVITY VS BIREFRINGENCE

Birefringence is applicable to nonactive crystals, such as calcite, that have a specific direction and index of refraction exactly equal for the ordinary and extraordinary rays. Active crystals, such as quartz, have no such axis, so there is no direction within the crystal in which the indices of refraction are equal. These types of materials exhibit a phenomenon known as optical activity, whereby the axis of incident, linearly polarized light appears to rotate as it propagates along the optic axis. The optic axis for active crystals is the direction in which the index difference between the O and E indices is minimum.

Melles Griot quartz retardation plates do not use the principle of optical activity to create a phase retardation. Instead, the crystals are cut with the optic axis parallel to the surfaces of the plate. When quartz is used in this manner, the retardation is caused by the birefringence of the quartz, not the optical activity of the material.

DICHROISM

Dichroism is selective absorption of one polarization plane over the other during transmission through a material. Sheet-type polarizers are manufactured from organic materials imbedded into a plastic sheet. The sheet is stretched, aligning molecules and causing them to be birefringent, and then dyed. The dye molecules selectively attach themselves to aligned polymer molecules, so that absorption is high in one plane and weak in the other. The transmitted beam is linearly polarized. Polarizers made of such material are very useful for low-power and visual applications. The usable field of view is large (up to grazing incidence), and diameters in excess of 100 mm are available.

POLARIZATION BY REFLECTION

When a beam of ordinary light is incident at the polarizing angle on a transmissive dielectric such as glass, the emerging refracted ray is partially linearly polarized. For a single surface (with n = 1.50) at Brewster's angle, 100% of the light whose electric vector oscillates parallel to the plane of incidence is transmitted. Only 85% of the perpendicular light is transmitted (the other 15% is reflected). The degree of polarization from a single-surface reflection is small.

If a number of plates are stacked parallel and oriented at the polarizing angle, some vibrations perpendicular to the plane of incidence will be reflected at each surface, and all those parallel to it will be refracted. By making the number of plates within the stack large (more than 25), high degrees of linear polarization may be achieved. This polarization method is utilized in Melles Griot polarizing beamsplitter cubes which are coated with many layers of quarter-wave dielectric thin films on the interior prism angle. This beamsplitter separates an incident laser beam into two perpendicular and orthogonally polarized beams.

THIN METAL FILM POLARIZERS

Optical radiation incident on small, elongated metal particles will be preferentially absorbed when the polarization vector is aligned with the long axis of the particle. Melles Griot infrared polarizers utilize this effect to make polarizers for the near-infrared. These polarizers are considerably more effective than dichroic polarizers.

Polarizing thin films are formed by using the patented Slocum process to deposit multiple layers of microscopic silver prolate spheroids onto a polished glass substrate. The exact dimensions of these spheroids determine the optical properties of the film. Peak absorption can be selected for any wavelength from 400 to 3000 nm by controlling the deposition process. Contrast ratios up to 10,000:1 can be achieved with this method.

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CALCITE

Calcite, a rhombohedral crystalline form of calcium carbonate, is found in various forms such as limestone and marble. Since calcite is a naturally occurring material, imperfections are not unusual. The highest quality materials, those that exhibit no optical defects, are difficult to find and are more expensive than those with some defects. Applications for calcite components typically fall into three broad categories: laser applications, optical research, and general use. Melles Griot offers most calcite components in several quality grades, to meet those various needs.

There is no generally agreed upon set of quality specifications for commercial calcite. Most manufacturers base their quality ratings on U.S. military specification MIL-G-174B. Since these specifications are actually written for optical glass, they are inadequate to describe completely the quality and performance of calcite. There are three main areas of importance in defining calcite quality.

Spectral Properties

Trace amounts of chemical impurities, as well as lattice defects, can cause calcite to be colored, which change absorption. For visible light applications, it is essential to use colorless calcite. For near-infrared applications, material with a trace of yellow is acceptable. This yellow coloration results in a 15% to 20% decrease in transmission below 420 nm.

Wavefront Distortion (Striae)

Striae, or streaked fluctuations in the refractive index of calcite, are caused by dislocations in the crystal lattice. They can cause distortion of a light wavefront passing through the crystal. This is particularly troublesome for interferometric applications. Melles Griot uses a simple letter system for classifying the effect of striae in calcite:

A–Less than λ/10 peak-to-peak wavefront distortion over the clear aperture. This substantially exceeds MIL Spec Grade A specified by paragraph 3.3.8.1 in MIL-G-174B.

B–No more than λ/4 peak to peak of wavefront distortion over the clear aperture. This is essentially equivalent to MIL Spec Grade A.

C–No more than one wave peak to peak over the clear aperture. This is essentially equivalent to MIL Spec Grade B.

Scatter

Small inclusions within the calcite crystal account for the main source of scatter. They may appear as small cracks or bubbles. In general, scatter presents a significant problem only when the polarizer is being used with a laser. The amount of scatter centers that can be tolerated is partially determined by beam diameter and power. Scatter in Melles Griot calcite is indicated by a simple number designation. Scatter evaluation designators are based on performance when illuminated with 5-mW red HeNe laser:

0–The material is free from any visible scatter centers.

1–Some visible grayness due to scatter.

2–Numerous individually visible scatter centers.

MELLES GRIOT CALCITE GRADES

Melles Griot has selected the most applicable combinations of calcite qualities, grouped into four grades:

Laser Grade

Components that meet both striae category **A** and scatter category **0**.

Low-Scatter Grade

Components that meet scatter category **0** and striae category **B** or **C**.

Optical Grade

Components that meet either combined categories **A1** or **B1**.

Standard Grade

Components that meet either combined categories **A2** or **B2** or **C1**.

Notice that, in all except the laser grade, several categories are encompassed for each grade. Where two or more categories are included in a grade, a component meeting this grade will meet one, but not all, individual categories. For example, a component carrying a quality specification of optical grade (categories **A1** or **B1**) will exhibit low scatter and have between one-tenth and one-quarter wave of peak-to-peak wavefront distortion.

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CALCITE OPTICAL POLARIZERS

Although many forms of calcite polarizers have been designed, the Glan-Taylor, Glan-Thompson, and Wollaston are the most useful. All Glan-type prisms are designed so that both entrance and exit faces are normal to the intended direction of use. The prism angle has been cut so that the O ray is totally internally reflected at the first face. In the Glan-Thompson prism, two halves are cemented together. In the Glan-Taylor and Glan-Laser prisms, the two polarizer halves are separated by an air space. Although the air space allows the prisms to handle substantially higher power and greater ultraviolet transmission than cemented prisms, the useful angular field is reduced and loss caused by internal Fresnel reflections is slightly increased. In general terms, the acceptance angle for a Glan-Taylor polarizer is typically 8.5 degrees, and for a Glan-Thompson polarizer, it is 18.5 degrees. Wollaston prisms transmit both linearly polarized beams. The beams, polarized in mutually perpendicular planes, emerge from the prism in different directions. Both beams may be manipulated independently farther down the optical path.

OPEN TRANSMISSION AND EXTINCTION RATIO

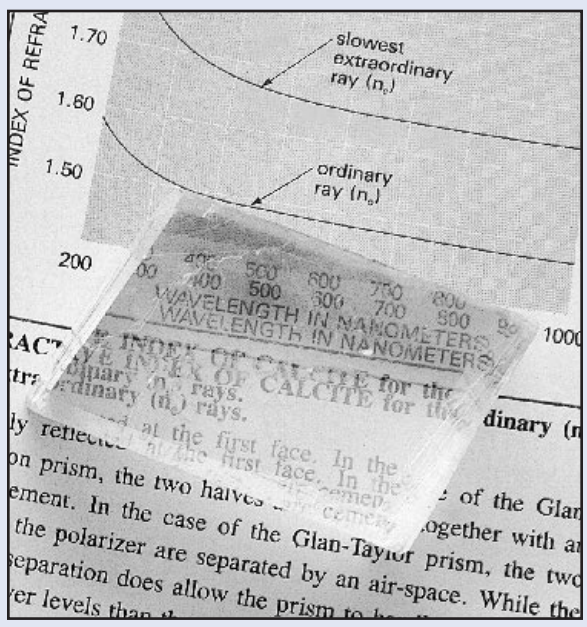
The open transmission of a pair of polarizers with their polarization directions parallel to each other is denoted by the quantity H_0. The extinction ratio, or transmission of a pair of polarizers with perpendicular polarization direction, is denoted by the quantity H_{90}.

APPLICATION NOTE

Calcite for Polarizers

Calcite is a natural, birefringent material. The calcite miner must understand and search for the calcite outcroppings that are of optical quality. Then, the raw calcite must be internally examined through a small, polished window to determine how the crystal will be cut and used. Finally, the calcite must be cut, ground, and polished at exact angles to its optical axis.

These skills are very different from those found in a more normal optical fabrication shop. Melles Griot calcite is mined and manufactured by skilled, carefully trained technicians who understand these special requirements.



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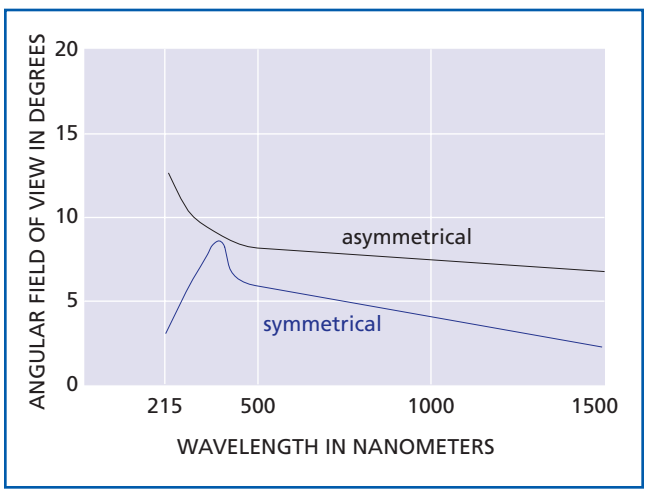
Glan-Taylor Polarizing Prisms

Melles Griot recommends Glan-Taylor polarizing prisms for applications requiring a high degree of polarization purity, high total transmission, and low-to-medium power requirements:

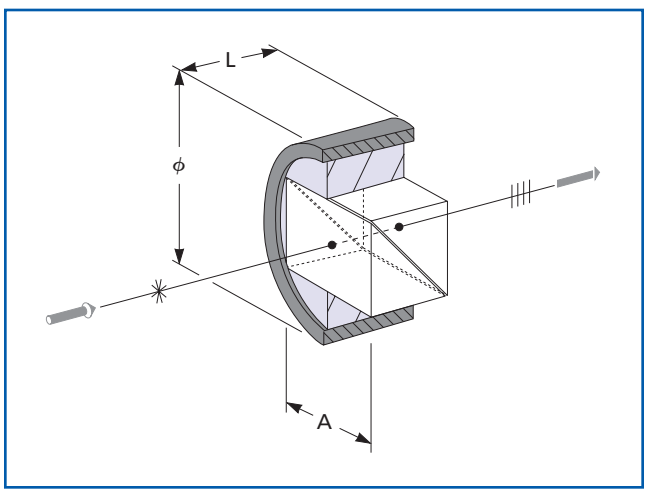
- Glan-Taylor prisms transmit well from 350 nm to 2300 nm.
- Calcite prisms are separated by an air space with the transmitted beam incident at Brewster's angle on the air-space interface to minimize reflection losses.
- The linearly polarized extraordinary beam is not deviated from its initial path.

When selecting Glan-Taylor polarizing prisms, remember:

- The length-to-aperture ratio is 0.85. The usable, full angular field of view is asymmetrical about the mechanical axis, and it varies as a function of wavelength as shown in the graph.
- The rejected (ordinary) beam is absorbed by the prism housing. Recommended maximum cw power-handling capability of this device is 2 watts.
- The prisms are available coated with a broadband antireflection coating centered at either 550 nm or 830 nm. Append the appropriate coating suffix to the product number.



Glan-Taylor angular field of view



03 PTA Glan-Taylor polarizing prisms

SPECIFICATIONS: GLAN-TAYLOR POLARIZING PRISMS

Wavelength Range: 350–2300 nm

Material: Calcite

Transmission (Ratio of Total Output to Total Unpolarized Input): $\frac{1}{2}(k_1+k_2) = 38\%$

Open Transmission for Pair of Prism Polarizers (H_0): >28%

Extinction Ratio (H_{90}): $<1\times10^{-5}$

Useful Field Angle: See graph

Length/Aperture: 0.85

Dimensional Tolerance: ±0.25 mm

Centration: 10 arc minutes

Surface Quality: 80–50 scratch and dig

Maximum Operating Temperature: 60ºC

Mounting:
Cylindrical black anodized aluminum housing; direction of polarization and product number permanently engraved on side of housing

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Single-Layer MgF_2 Antireflection Coatings

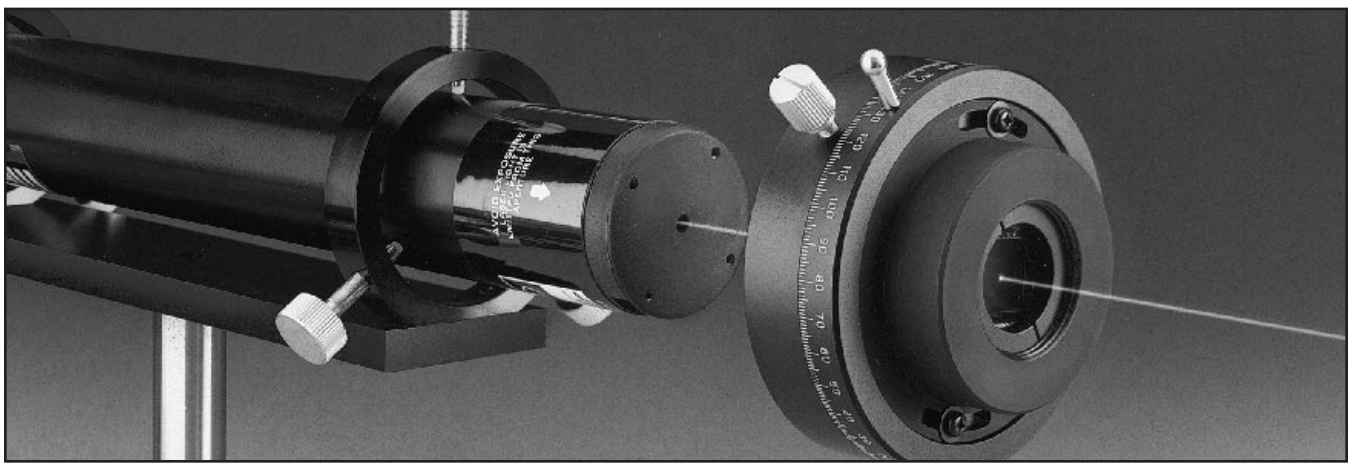
Center Wavelength (nm)	Wavelength Range (nm)	Maximum Reflectance (%)	COATING SUFFIX
550	400–700	2.0	/A
830	650–1100	2.0	/C*

**Parts with the coating /C may have slightly reduced transmission below 420 nm. Call for availability.*

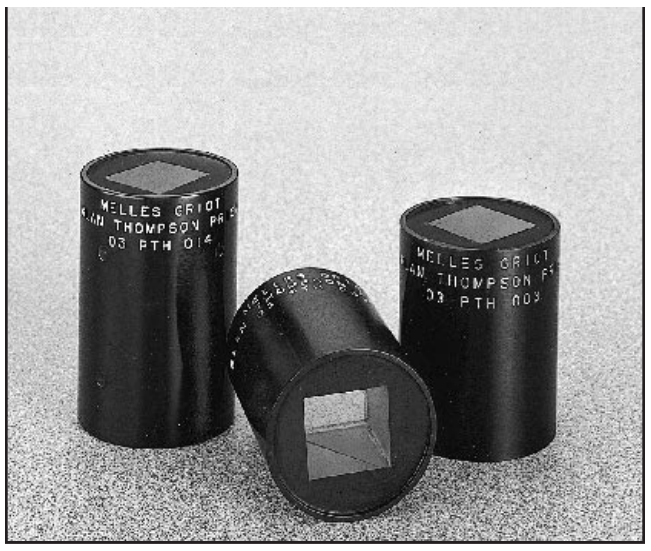
Glan-Taylor Polarizing Prisms

Grade	Outside Diameter ϕ (mm)	Housing Length L (mm)	Clear Aperture A (mm)	PRODUCT NUMBER
Laser	25.0	14.6	10 × 10	03 PTA 101
	30.0	19.6	15 × 15	03 PTA 103
	40.0	23.9	20 × 20	03 PTA 105
Optical	25.0	14.6	10 × 10	03 PTA 001
	30.0	19.6	15 × 15	03 PTA 003
	40.0	23.9	20 × 20	03 PTA 005
Standard	25.0	14.6	10 × 10	03 PTA 401
	30.0	19.6	15 × 15	03 PTA 403
	40.0	23.9	20 × 20	03 PTA 405

Note: For antireflection coated prisms please append coating suffix from coatings table above. Polarizer holders can be found in Chapter 24, Lens, Filter, and Polarizer Mounts.



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Available in:
✔**Production Quantities**

Glan-Thompson Polarizing Prisms

Melles Griot Glan-Thompson polarizing prisms offer increased field of view and high polarization purity for low-to-medium power requirements:

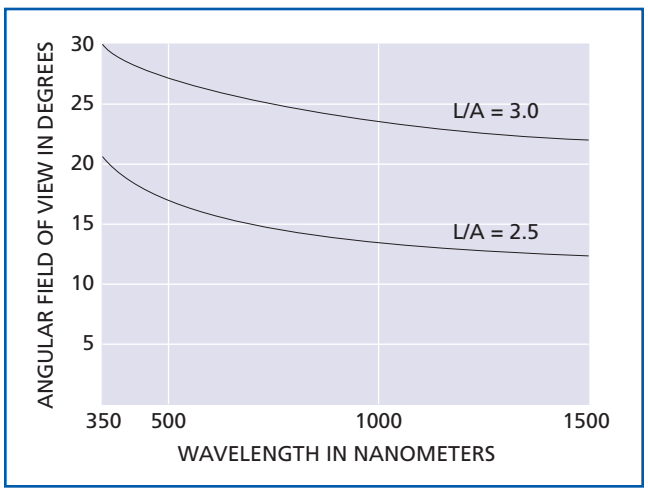
- Glan-Thompson prisms transmit from 350 nm to 2300 nm.
- A usable field of >12 degrees and >24 degrees may be expected from the 2.5 and 3 length-to-aperture-ratio prisms.
- The increased field of view allows system throughput to be increased by maximizing cone angles through the system.
- The linearly polarized extraordinary beam is not deviated from its initial path.

It should be noted that:

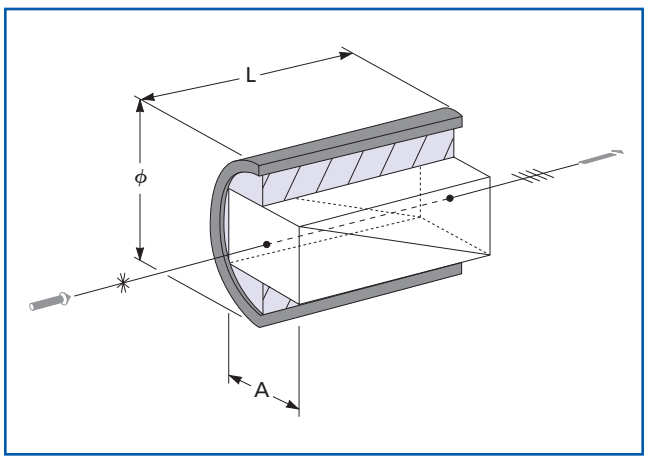
- The usable full angular field of view is asymmetrical about the mechanical axis, and it varies as a function of wavelength as shown in the graph.
- The calcite prisms are cemented together.
- The rejected (ordinary) beam is absorbed by the prism housing. Recommended cw maximum power handling capability of this device is 2 watts.
- The prisms are available coated with a broadband antireflection coating centered at either 550 nm or 830 nm. Append the appropriate coating suffix to the product number.

SPECIFICATIONS: GLAN-THOMPSON POLARIZING PRISMS

Wavelength Range: 350–2300 nm
Material: Calcite
Transmission (Ratio of Total Output to Total Unpolarized Input): $\frac{1}{2}(k_1+k_2) = 36\%$
Open Transmission for Pair of Prism Polarizers (H_0): >25%
Extinction Ratio (H_{90}): $<1\times10^{-5}$
Useful Field Angle: See graph
Dimensional Tolerance: ±0.25 mm
Centration: 10 arc minutes
Surface Quality: 80–50 scratch and dig
Maximum Operating Temperature: 60ºC
Mounting:
Cylindrical black anodized aluminum housing; direction of polarization and product number permanently engraved on side of housing



Glan-Thompson angular field of view



03 PTH Glan-Thompson polarizing prisms

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Single-Layer MgF_2 Antireflection Coatings

Center Wavelength (nm)	Wavelength Range (nm)	Maximum Reflectance (%)	COATING SUFFIX
550	400–700	2.0	/A
830	650–1100	2.0	/C*

**Parts with the coating C may have slightly reduced transmission below 420 nm. Call for availability.*

Glan-Thompson Polarizing Prisms

Grade	Length/Aperture	Outside Diameter ϕ (mm)	Housing Length L (mm)	Clear Aperture A (mm)	PRODUCT NUMBER
Laser	2.5	17.0	14.5	5×5	03 PTH 109
	2.5	25.0	27.0	10×10	03 PTH 101
	2.5	30.0	39.5	15×15	03 PTH 103
	2.5	40.0	52.0	20×20	03 PTH 105
	3.0	17.0	17.0	5×5	03 PTH 118
	3.0	25.0	32.0	10×10	03 PTH 112
	3.0	30.0	47.0	15×15	03 PTH 114
	3.0	40.0	62.0	20×20	03 PTH 116
Optical	2.5	17.0	14.5	5×5	03 PTH 009
	2.5	25.0	27.0	10×10	03 PTH 001
	2.5	30.0	39.5	15×15	03 PTH 003
	2.5	40.0	52.0	20×20	03 PTH 005
	3.0	17.0	17.0	5×5	03 PTH 018
	3.0	25.0	32.0	10×10	03 PTH 012
	3.0	30.0	47.0	15×15	03 PTH 014
	3.0	40.0	62.0	20×20	03 PTH 016
Standard	2.5	17.0	14.5	5×5	03 PTH 409
	2.5	25.0	27.0	10×10	03 PTH 401
	2.5	30.0	39.5	15×15	03 PTH 403
	2.5	40.0	52.0	20×20	03 PTH 405
	3.0	17.0	17.0	5×5	03 PTH 418
	3.0	25.0	32.0	10×10	03 PTH 412
	3.0	30.0	47.0	15×15	03 PTH 414
	3.0	40.0	62.0	20×20	03 PTH 416

Note: For antireflection coated prisms please append coating suffix from coatings table above. Polarizer holders can be found in ***Chapter 24, Lens, Filter, and Polarizer Mounts.***

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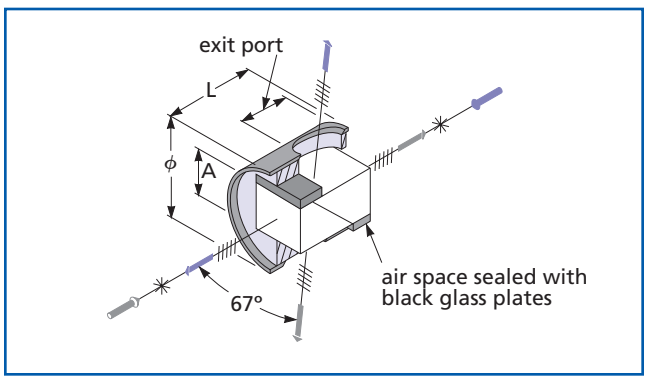


Available in:
✔**Production Quantities**

Glan-Laser Polarizing Prisms

Melles Griot Glan-Laser polarizing prisms provide high polarization purity and have exit ports for the rejected (ordinary) beam. They are ideal for use with lasers that have high output energies.

- The Glan-Laser prisms transmit from 350 nm to 2300 nm.
- Each polarizer consists of two air-spaced calcite prisms.
- Two exit ports, 180 degrees apart, are provided for use in either or both directions.
- The rejected beam exits at approximately 67 degrees from the linearly polarized extraordinary beam, which is not deviated from its initial path.
- Single-layer antireflection coatings are available centered at either 550 nm or 830 nm. Append the appropriate coating suffix to the product number.



03 PGL Glan-Laser polarizing prisms

SPECIFICATIONS: GLAN-LASER POLARIZING PRISMS

Wavelength Range: 350–2300 nm

Material: Optical grade calcite

Transmission (Ratio of Total Output to Total Unpolarized Input): $\frac{1}{2}(k_1+k_2) = 38\%$

Extinction Ratio (H_{90}): $<5\times10^{-5}$

Dimensional Tolerance: ±0.25 mm

Centration: 10 arc minutes

Surface Quality: 80-50 scratch and dig

Mounting:
Cylindrical black anodized aluminum housing with two exit ports; product number permanently engraved on side of housing

LASER-INDUCED DAMAGE:

Surface damage at an air-crystal interface, or bulk damage within the crystal structure, may occur if the optical surface is contaminated, or the laser power exceeds the material damage threshold. A single value cannot be placed on damage resistance for calcite, because it is a naturally occurring material. Our Glan-Laser polarizers, tested at Big Sky Laser Technologies, Inc., were found to withstand between 430 and 630 MW/cm^2, 20 nsec pulse at 1064 nm. Values are guidelines and no warranty is implied.

Single-Layer MgF_2 Antireflection Coatings

Center Wavelength (nm)	Wavelength Range (nm)	Maximum Reflectance (%)	COATING SUFFIX
550	400–700	2.0	/A
830	650–1100	2.0	/C*

**Parts with the coating C may have slightly reduced transmission below 420 nm. Call for availability.*

Glan-Laser Polarizing Prisms

Outside Diameter ϕ (mm)	Housing Length L (mm)	Clear Aperture A (mm)	Exit Port Diameter (mm)	PRODUCT NUMBER
27	17.5	10×10	10	03 PGL 301
34	24.5	15×15	15	03 PGL 303
40	28.5	20×20	20	03 PGL 305

Note: For antireflection coated prisms please append coating suffix from coatings table above. Polarizer holders can be found in Chapter 24, Lens, Filter, and Polarizer Mounts.

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Wollaston Prisms

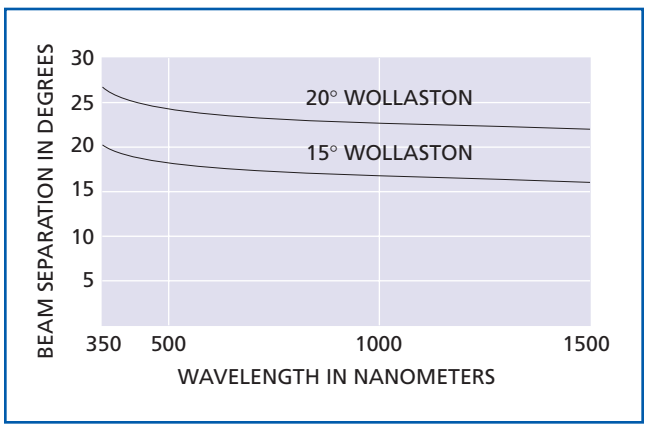
Available in:
✔**Production Quantities**

Wollaston prisms provide a simple way to split a beam of light into two mutually orthogonal, linearly polarized beams, convenient for double imaging of a single source.

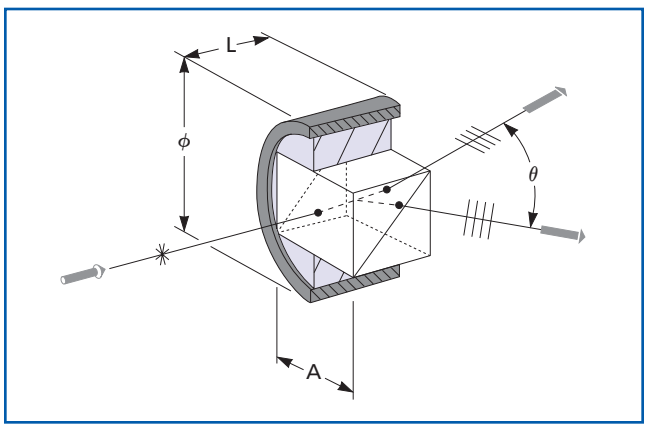
- They offer beam divergence of either 15 or 20 degrees.
- They provide useful transmission from 350 nm to 2300 nm.

When specifying a Wollaston prism, the following points should be considered:

- Two calcite prisms are cemented together.
- The beam separation angle between the orthogonally plane-polarized output is wavelength dependent, as shown in the graph.
- Single-layer antireflection coatings are available centered at either 550 nm or 830 nm. Append the appropriate coating suffix to the product number.



03 PPW beam separation



03 PPW Wollaston prisms

SPECIFICATIONS: WOLLASTON PRISMS

Wavelength Range: 350–2300 nm

Material: Optical grade calcite

Transmission (Ratio of Total Output to Total Unpolarized Input): $(k_1+k_2) = 84\%$

Extinction Ratio (H_{90}): $<1\times10^{-5}$

Length/Aperture: 1.0

Dimensional Tolerance: ±0.25 mm

Centration: 10 arc minutes

Surface Quality: 80–50 scratch and dig

Maximum Operating Temperature: 60ºC

Mounting:
Cylindrical black anodized aluminum housing; product number permanently engraved on side of housing

Wollaston Prisms

Outside Diameter ϕ (mm)	Housing Length L (mm)	Beam Deviation θ (degrees)	Clear Aperture A (mm)	PRODUCT NUMBER
25.0	13.0	15	10×10	03 PPW 001
30.0	18.0	15	15×15	03 PPW 003
25.0	13.0	20	10×10	03 PPW 012
30.0	18.0	20	15×15	03 PPW 014

Note: For antireflection coated prisms please append coating suffix from coatings table at left.
Polarizer holders can be found in Chapter 24, Lens, Filter, and Polarizer Mounts.

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Available in:
✔**Production Quantities**

Beamsplitting Thompson Prism

Beamsplitting Thompson prisms provide two orthogonally polarized output beams, separated by 45 degrees.

- The beam separation angle and direction are independent of wavelength throughout the transmission range.
- These prisms provide a high extinction ratio.
- The ordinary beam is transmitted through an escape window; the extraordinary beam is transmitted undeviated.
- Calcite prisms are cemented together.
- Single-layer antireflection coatings are available centered around 550 nm or 830 nm. Append the appropriate coating suffix to the product number.

SPECIFICATIONS: BEAMSPLITTING THOMPSON PRISMS

Wavelength Range: 350–2300 nm

Material: Optical grade calcite

Transmission (Ratio of Total Output to Total Unpolarized Input): $(k_1+k_2) = 84\%$

Extinction Ratio (Extraordinary Beam): $<1\times10^{-5}$

Extinction Ratio (Ordinary Beam): $<5\times10^{-5}$

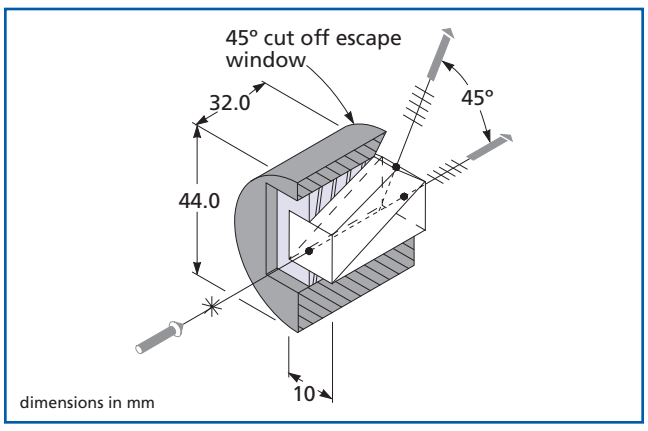
Separation Angle: $45^\circ \pm 1^\circ$

Dimensional Tolerances: ±0.25 mm

Centration: 10 arc minutes

Surface Quality: 80–50 scratch and dig

Mounting:
Cylindrical black anodized aluminum housing; product number is permanently engraved on side. The 45 degrees diagonal exit face is on the front of the mount.



03 PTB 001 beamsplitting Thompson prism

Single-Layer MgF_2 Antireflection Coatings

Center Wavelength (nm)	Wavelength Range (nm)	Maximum Reflectance (%)	COATING SUFFIX
550	400–700	2.0	/A
830	650–1100	2.0	/C*

**Parts with the coating /C may have slightly reduced transmission below 420 nm. Call for availability.*

Beamsplitting Thompson Prism

Angular Field (degrees)	Clear Aperture (mm)	PRODUCT NUMBER
16 ± 1	10 × 10	03 PTB 001

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Available in:
✔Production Quantities

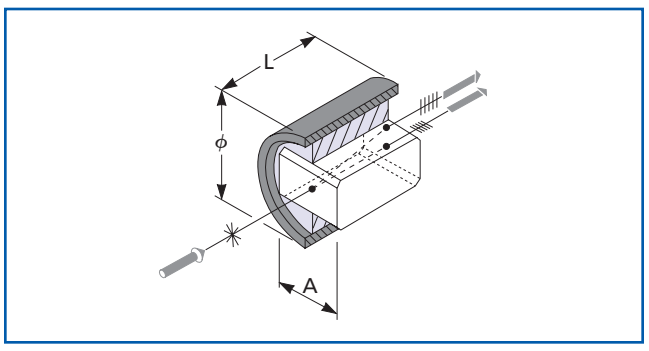
Beam-Displacing Prisms

Two parallel, but laterally displaced, orthogonally polarized output beams are transmitted from one unpolarized input beam when passing through a Melles Griot beam-displacing prism. If the input beam is linearly polarized, the output can be made to vary continuously and sinusoidally from one parallel beam to the other by rotating the input polarization angle.

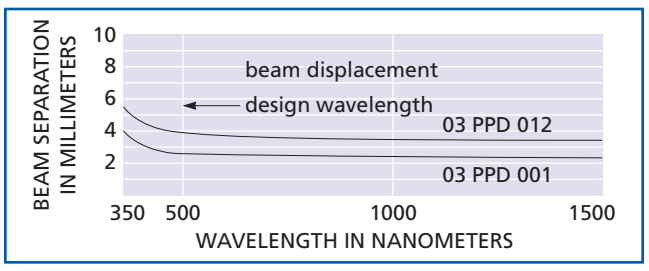
- The ordinary beam is undeviated.
- The extraordinary beam is deviated by 6 degrees within the prism.
- Upon exit, the extraordinary beam is again parallel with the input beam and the exiting ordinary beam.
- Single-layer antireflection coatings are available centered at either 550 nm or 830 nm. Append the appropriate coating suffix to the product number.

SPECIFICATIONS: BEAM-DISPLACING PRISMS

Wavelength Range: 350 nm to 2300 nm
Nominal Design Wavelength: 500 nm
Material: Optical and low-scatter-grade calcite
Transmission (Ratio of Total Output to Total Unpolarized Input): $(k_1+k_2) = 84\%$
Extinction Ratio (H_{90}): $<1\times10^{-5}$
Dimensional Tolerances: ±0.25 mm
Centration: 10 arc minutes
Surface Quality: 80–50 scratch and dig
Mounting:
Cylindrical black anodized aluminum housing; product number and line indicating plane of beam separation engraved on side of housing



03 PPD beam displacing prisms



Beam displacement

Single-Layer MgF_2 Antireflection Coatings

Center Wavelength (nm)	Wavelength Range (nm)	Maximum Reflectance (%)	COATING SUFFIX
550	400–700	2.0	/A
830	650–1100	2.0	/C*

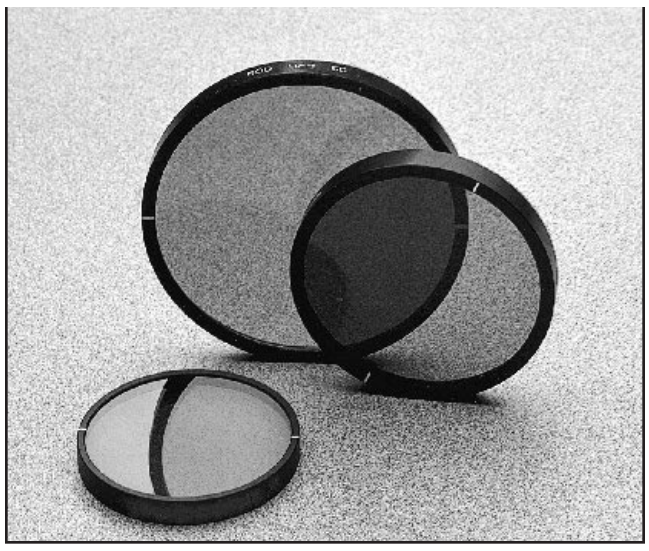
**Parts with the /C coating may have slightly reduced transmission below 420 nm. Call for availability.*

Beam Displacing Prisms

Grade	Outside Diameter ϕ (mm)	Housing Length L (mm)	Beam Displacement at 500 nm (mm)	Clear Aperture A (mm)	PRODUCT NUMBER
Optical Grade	25.0	26.0	2.7	10×10	03 PPD 001
	25.0	38.0	4.0	10×10	03 PPD 012
Low-Scatter Grade	25.0	26.0	2.7	10×10	03 PPD 301
	25.0	38.0	4.0	10×10	03 PPD 312

Note: For antireflection coated prisms please append coating suffix from coatings table above.
Polarizer holders can be found in Chapter 24, Lens, Filter, and Polarizer Mounts.

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Available in:
✔**Production Quantities**

Dichroic Sheet Polarizers

Dichroic sheet polarizers are used to subject one of the two orthogonal polarizations (either ordinary or extraordinary) to strong absorption. Melles Griot polarizers are made of a plastic dichroic polarizing sheet sandwiched between selected strain-free glass plates.

- Dichroic sheet polarizers offer large apertures and acceptance angles.
- They provide excellent extinction ratios and are simple to mount.
- They are suited for low-power applications.
- They are constructed for use in the visible spectrum.

SPECIFICATIONS: DICHROIC SHEET POLARIZERS

Wavelength Range: 350–650 nm

Transmission (Ratio of Total Output to Total Unpolarized Input): $\frac{1}{2}(k_1+k_2) = 32\%$

Open Transmission for Pair of Polarizers (H_0): ≥20%

Extinction Ratio (H_{90}):
10^{-4} for visible white light, closed pair of polarizers

Useful Field Angle: 90° (can be used at grazing incidence)

Diameter: $\phi \pm 0.25$ mm

Thickness: $t \pm 0.5$ mm

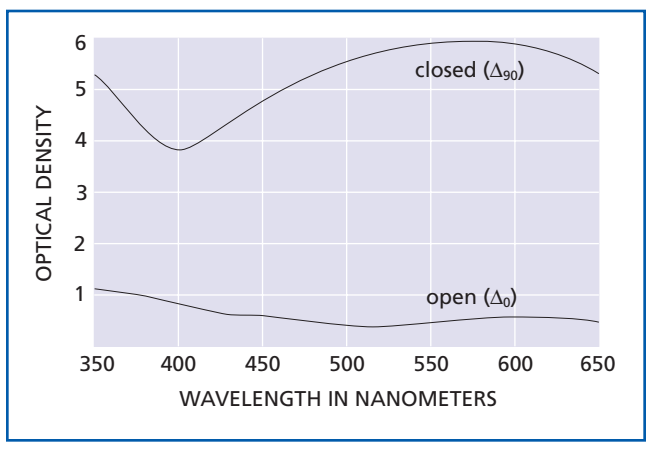
Surface Quality: 80–50 scratch and dig

Mounting:
Between two glass discs, hermetically mounted in a black anodized aluminum ring; polarization plane of maximum transmission indicated by engravings on the outside edge

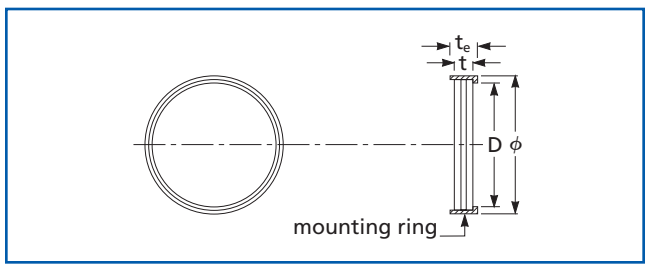
Dichroic Sheet Polarizers

Outside Diameter ϕ (mm)	Clear Aperture D (mm)	Thickness t (mm)	Ring Thickness t_e (mm)	PRODUCT NUMBER
12.5	9.0	2.5	4.0	03 FPG 019
20.6	16.9	2.5	4.0	03 FPG 001
30.2	26.5	2.5	4.5	03 FPG 003
41.3	38.4	2.5	4.8	03 FPG 005
50.8	45.4	2.5	5.3	03 FPG 007
63.5	58.0	3.5	5.6	03 FPG 009
82.6	76.0	3.5	5.6	03 FPG 011
93.0	85.0	3.5	6.0	03 FPG 013
103.0	94.0	3.5	6.0	03 FPG 015
119.0	110.0	3.5	6.0	03 FPG 017

For sheet polarizer holders, see Chapter 24, Lens, Filter, and Polarizer Mounts.



Optical density for pair of 03 FPG dichroic sheet polarizers



03 FPG dichroic sheet polarizers

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APPLICATION NOTE

Variable Transmittance Using Two Sheet Polarizers

The transmittance T of a single-sheet polarizer in a beam of linearly polarized incident light is given by

$$T = k_1 \cos^2(\theta) + k_2 \sin^2(\theta)$$

where θ is the angle between the plane of polarization of the incident beam (more accurately, the plane of the electric field vector of the incident beam) and the plane of preferred transmission of the polarizer. The orientation of the plane of preferred transmission is clearly marked by engravings on the mount. The principal transmittances of the polarizer, k_1 and k_2, are both functions of wavelength. Ideally, $k_1 = 1$, and $k_2 = 0$. In reality, k_1 is always somewhat less than unity, and k_2 always has some small but nonzero value.

If the incident beam is unpolarized, and the angle θ is redefined to be the angle between the planes of preferred transmission (planes of polarization) of two sheet polarizers in near contact, the transmittance of the pair is given by

$$T_{pair} = k_1 k_2 \sin^2\theta + \tfrac{1}{2}(k_1^2 + k_2^2)\cos^2\theta.$$

If we define

$$H_{90} = T_{pair}(90°) = k_1 k_2$$

and

$$H_0 = T_{pair}(0°) = \frac{1}{2}(k_1^2 + k_2^2)$$

the above formula can be simplified to

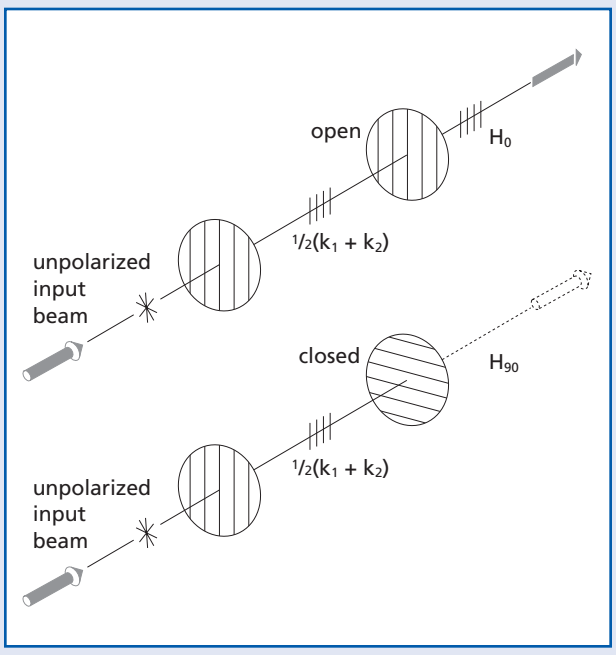
$$T_{pair} = H_{90}\sin^2\theta + H_0\cos^2\theta$$
$$= H_{90} + (H_0 - H_{90})\cos^2\theta$$

The quantity H_{90} is called the closed transmittance or extinction ratio, and the quantity H_0 is called the open transmittance. Both quantities are wavelength dependent. Because of the large ranges of open and closed transmission, it is convenient to plot the optical densities corresponding to these transmissions, rather than the transmissions themselves.The open and closed optical densities are defined as follows:

$$\Delta_0 = \log\left(\frac{1}{H_0}\right)$$

and

$$\Delta_{90} = \log\left(\frac{1}{H_{90}}\right).$$



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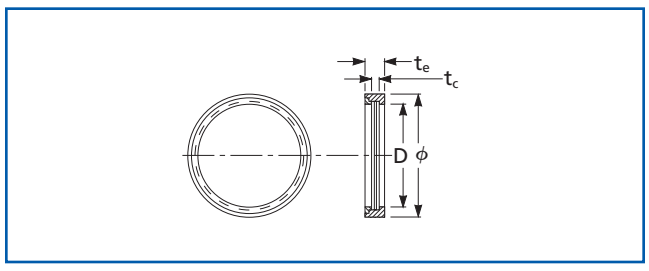


Available in:
✔**Production Quantities**

Near-Infrared Polarizers

These high-contrast polarizers are metallic thin-film devices which provide a high degree of polarization in the near infrared. They consist of a vacuum-deposited thin film made up of microscopic prolate metal spheroids all aligned in the same direction on the glass surface.

- These polarizers are useful with low-power red and near-infrared sources such as laser diodes and LEDs.
- The spheroids strongly absorb the component of polarization aligned with the long axis and transmit the component of polarization aligned with the short axis.
- They are more useful than the wire grid-type polarizers which reflect the unwanted component of polarization.
- The thin-film surface of these devices is protected by a flat piece of glass hermetically sealed in a black anodized aluminum cell.
- These polarizers are thin and most effective for radiation incident perpendicular to their surface.
- Divergent or convergent input cone angles up to 20 degrees can be accepted.
- Advantages include the absence of dead zones within the active area, high contrast ratio over a broad spectral band, large apertures, stability in normal temperature and humidity ranges, and ability to absorb unwanted polarization.



03 FPI near-infrared polarizers

SPECIFICATIONS: NEAR-INFRARED POLARIZERS

Transmission (Ratio of Total Output to Total Unpolarized Input): $\frac{1}{2}(k_1 + k_2) > 20\%$

Open Transmission for Pair of Polarizers (H_0): >16%

Useful Field Angle: ± 20° about normal

Diameter : ϕ+0, −0.15 mm

Thickness (t_c): 2.75 ± 0.2 mm

Edge Thickness (t_e): 4.2 ± 0.15 mm

Surface Quality: 80–50 scratch and dig

Mounting:
Between two glass discs, hermetically mounted in a black anodized aluminum ring; polarization plane of maximum transmission indicated by engravings on the outside edge

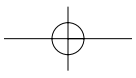
Near-Infrared Polarizers

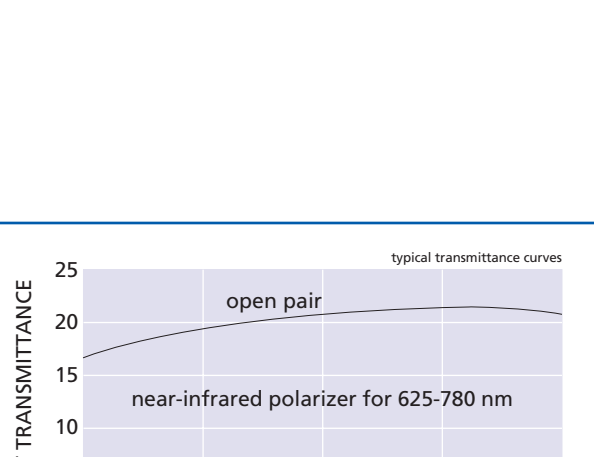
Wavelength Range (nm)	Outside Diameter ϕ (mm)	Clear Aperture D (mm)	Extinction Ratio (H_{90})	PRODUCT NUMBER
625–780	12.5	10.0	2×10^{-3}	03 FPI 029
	20.0	15.0	2×10^{-3}	03 FPI 021
	30.0	25.0	2×10^{-3}	03 FPI 023
	40.0	35.0	2×10^{-3}	03 FPI 025
780–1250	12.5	10.0	1×10^{-3}	03 FPI 009
	20.0	15.0	1×10^{-3}	03 FPI 001
	30.0	25.0	1×10^{-3}	03 FPI 003
	40.0	35.0	1×10^{-3}	03 FPI 005
1250–1550	12.5	10.0	1×10^{-3}	03 FPI 019
	20.0	15.0	1×10^{-3}	03 FPI 012
	30.0	25.0	1×10^{-3}	03 FPI 014
	40.0	35.0	1×10^{-3}	03 FPI 016

Note: For sheet polarizer holders, see Chapter 24, Lens, Filter, and Polarizer Mounts.

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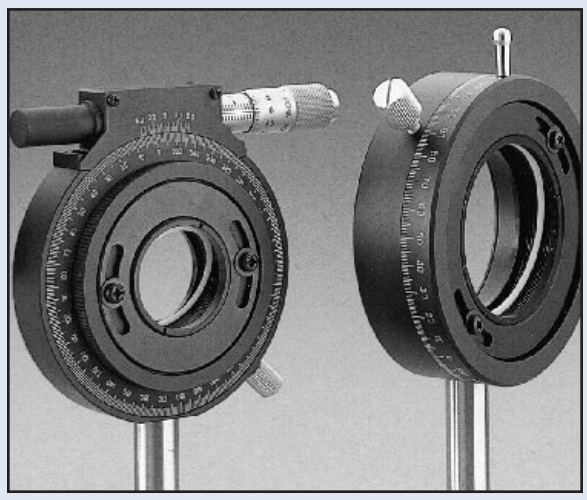




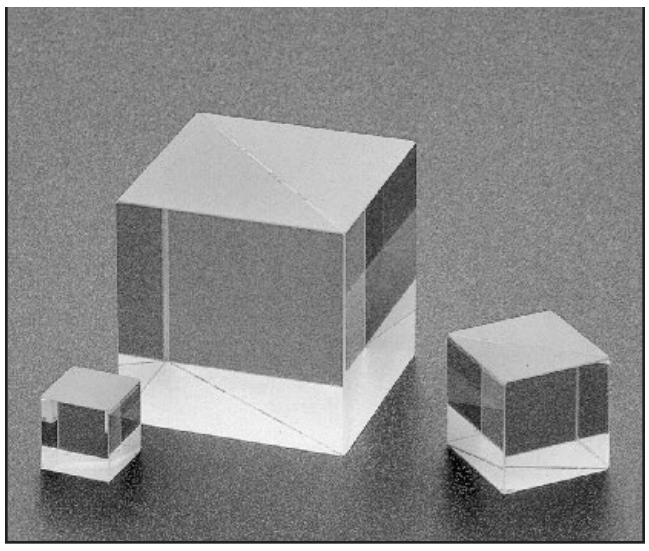
Optical density for pairs of 03 FPI dichroic sheet polarizers

POLARIZER MOUNTS

Melles Griot post-mounted rotators and holders can provide flexibility in holding polarizers.
See Chapter 24, *Lens, Filter, and Polarizer Mounts,* for more information about these products.



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Available in:
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✔**Custom Sizes**

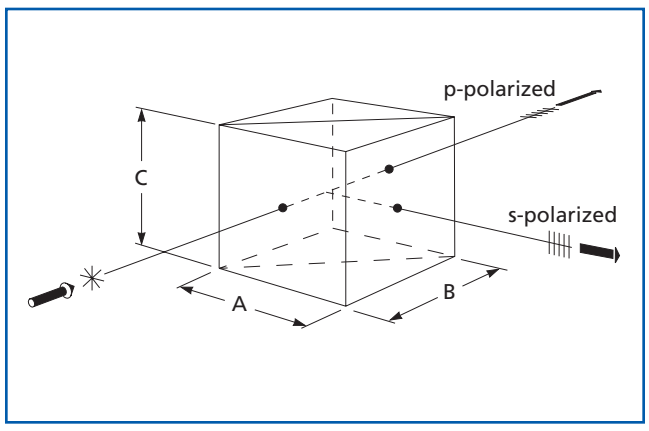
Broadband Polarizing Cube Beamsplitters

Broadband polarizing cube beamsplitters separate the s- and p-polarized components of an incident beam into two highly polarized output beams separated by a 90-degree angle.

- A 50/50 split in laser energy is achieved for unpolarized incident light.
- Broadband coatings are offered for operation for 450 nm to 680 nm and 650 nm to 850 nm.
- These are ideal for use in white light and polychromatic beam-combining applications.

When using a polarizing cube beamsplitter, remember:

- For polychromatic beam-combining applications, the two incoming beams must have properly oriented polarization states. This can be achieved by using a Melles Griot half-wave plate to rotate the polarization state of the beam.
- Light is ideally incident on the beamsplitter coating at an angle of 45° ±2°. The Melles Griot prism table, described in Chapter 25, *Mirror/Beamsplitter Mounts and Prism Tables*, is recommended for accurate positioning of the cube within the beam path.
- Only collimated beams of light can be used. A shear plate may be used to make sure that an expanded laser beam is properly collimated before striking the cube. The Melles Griot shear plate is described in Chapter 51, *Lab Accessories*.



03 PBB broadband polarizing cube beamsplitters

SPECIFICATIONS: BROADBAND POLARIZING CUBE BEAMSPLITTERS

Edge Tolerance: ±0.2 mm

Principal Transmittance:
>95% T for p-polarization
<1% T for s-polarization

Principal Reflectance:
>99% R for s-polarization
<5% R for p-polarization

Transmission (Ratio of Total Straight Through Output to Total Unpolarized Input): $\frac{1}{2}(k_1+k_2) = 48\%$

Extinction Ratio: $H_{90} = k_1 k_2 = 0.01$

Beam Deviation: 5 arc minutes

Entrance/Exit Surface Flatness: <λ/8 at 632.8 nm

Wavefront Distortion: <λ/4 at 632.8 nm

Surface Quality: 20–10 scratch and dig

Material: BK7 grade A fine annealed

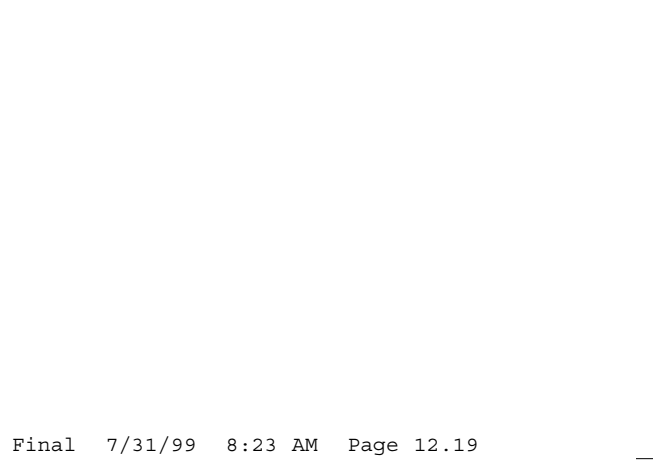
Coating (All Entrance and Exit Faces):
Broadband multilayer antireflector <0.5% R

Broadband Polarizing Cube Beamsplitters

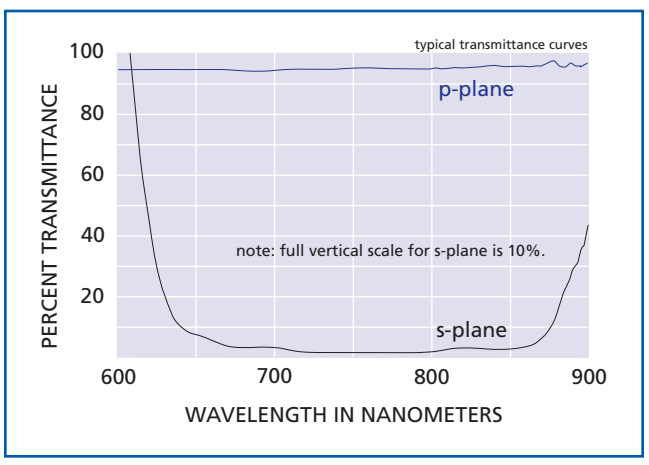
A=B=C (mm)	PRODUCT NUMBER Wavelength Range 450–680 nm	650–850 nm
5.0	03 PBB 009	03 PBB 019
10.0	03 PBB 001	03 PBB 011
12.7	03 PBB 002	03 PBB 012
20.0	03 PBB 003	03 PBB 013
25.4	03 PBB 005	03 PBB 015
38.1	03 PBB 007	03 PBB 017

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Broadband polarizing cube beamsplitter for 450–680 nm wavelength



Broadband polarizing cube beamsplitter for 650–850 nm wavelength

APPLICATION NOTE

Another Broadband Polarizing Beamsplitter

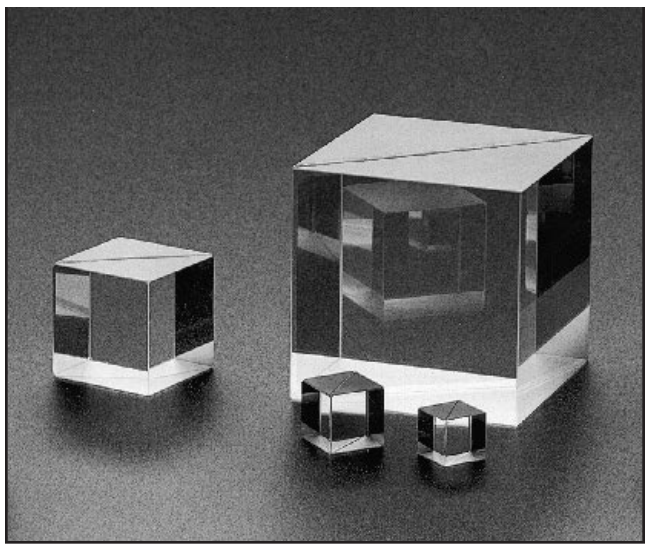
Wollaston prisms (see page 12.11) are another broadband device for splitting a beam into its component polarizations.

The primary advantages of Wollaston prisms are higher polarization efficiency and broader wavelength performance.

The main disadvantage of Wollaston prisms is that the orthogonally polarized beams do not exit from the optic perpendicular to each other, and the angle of their separation is wavelength dependent.



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Available in:
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Laser-Line Polarizing Cube Beamsplitters

Coated polarization beamsplitters are available for twelve common laser wavelengths, from ultraviolet to infrared, providing a polarization purity of 98% or better at their design wavelength.

For normal incident, monochromatic, unpolarized light:

- The incident beam is separated into two polarized beams which emerge through adjacent faces and in directions 90 degrees apart.
- The beam that passes straight through the cube emerges as linearly p-polarized with the electric field vector parallel to the plane of incidence.
- The beam that emerges from the cube at right angles to the incident beam is linearly s-polarized with the electric field vector orthogonal to the plane of incidence.

When used with a linearly polarized monochromatic, incident beam:

- The incident beam is similarly divided.
- The ratio of the emergent beam irradiances depend on the orientation of the incident beam electric field vector.

For greater extinction, each cube can be replaced by a pair of cubes in identical orientation. The resulting extinction ratio will be the square of a single pair.

PRISM TABLES

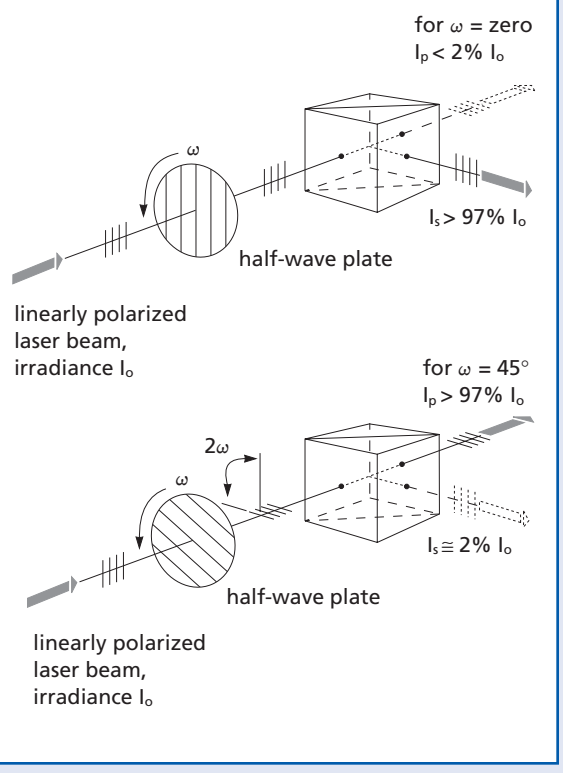
Melles Griot prism tables can provide accurate positioning of cube beamsplitters. See Chapter 25, *Mirror/Beamsplitter Mounts and Prism Tables* for details.



APPLICATION NOTE

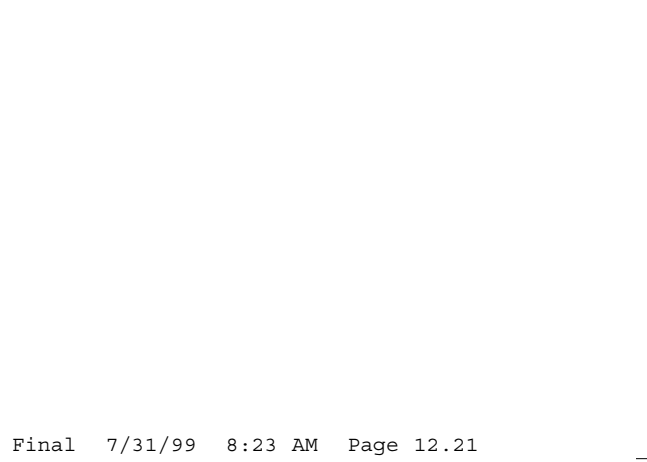
Variable Ratio Beamsplitter

If a polarizing cube is preceded by a half-wave retardation plate, the result is a variable ratio beamsplitter for linearly polarized, monochromatic input. The output beam irradiance ratio can be continuously varied from below 1:49 to above 49:1, or fixed at any value in between, by suitably rotating the half-wave retarder within its plane. A ratio of 1:1 is easily achieved. For unpolarized, monochromatic input at the intended wavelength, and without the retarder, these beamsplitters always achieve a very accurate 1:1 ratio regardless of beamsplitter orientation.



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UV laser-line polarizing cube beamsplitter

Visible and near-IR laser-line polarizing cube beamsplitter

LASER-INDUCED DAMAGE:

Like most cemented cube beamsplitters, the damage threshold of laser-line polarizing cube beamsplitters is limited primarily by the cement interface. At Big Sky Laser Technologies, Inc., the 03 PBS 127 was tested and found to withstand up to 0.8 J/cm^2 ±10%, 10 nsec pulse (68 MW/cm^2) at 355 nm. Values are guidelines and no warranty is implied.

SPECIFICATIONS: UV LASER-LINE POLARIZING CUBE BEAMSPLITTERS

Edge Tolerance: ±0.3 mm

Principal Transmittance:
>90%T for p-polarization
>83%T for p-polarization (for 248 nm only)
<5%T for s-polarization

Principal Reflectance:
>95%R for s-polarization
<10%R for p-polarization

Transmission (Ratio of Straight Through Output to Total Unpolarized Input): ½(k_1+k_2) = 46% (43% for 248 nm)

Open Straight-Through Transmission of Pair Assuming Unpolarized Input: H_0 = ½(k_1^2+k_2^2) = 41% (34% for 248 nm)

Extinction Ratio or Closed Straight-Through Transmission of Pair, Assuming Unpolarized Input: H_{90} = k_1k_2 = 0.05

Beam Deviation: <5 arc minutes

Entrance/Exit Surface Flatness: <λ/4 at 632.8 nm

Wavefront Distortion: <λ/2 at 632.8 nm

Surface Quality: 20–10 scratch and dig

Material: UV grade synthetic fused silica

Coating (All Four Entrance/Exit Faces):
Laser-line multilayer antireflector <0.25% R

Unused faces are fine ground, and all edges are lightly beveled.

UV Laser-Line Polarizing Cube Beamsplitters

Wavelength Range (nm)	A=B=C (mm)	PRODUCT NUMBER
248	12.7	03 PBS 104
	25.4	03 PBS 107
308	12.7	03 PBS 114
	25.4	03 PBS 117
351	12.7	03 PBS 124
	25.4	03 PBS 127

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SPECIFICATIONS: VISIBLE/IR LASER-LINE POLARIZING CUBE BEAMSPLITTERS

Material: BK7, grade A fine annealed

Principal Transmittance:
>98%T for p-polarization
<1%T for s-polarization

Principal Reflectance:
>99%R for s-polarization
<2%R for p-polarization

Transmission (Ratio of Straight-Through Output to Total Unpolarized Input): $\frac{1}{2}(k_1+k_2) = 49\%$

Open Straight-Through Transmission of Pair Assuming Unpolarized Input: $H_0 = \frac{1}{2}(k_1^2+k_2^2) = 49\%$

Extinction Ratio or Closed Straight-Through Transmission of Pair, Assuming Unpolarized Input: $H_{90} = k_1k_2 = 0.01$

Dimensions: ⌀ ± 0.2 mm

Beam Deviation: <5 arc minutes

Entrance/Exit Surface Flatness: <λ/8 at 632.8 nm

Wavefront Distortion: <λ/2 at 632.8 nm

Surface Quality: 40–20 scratch and dig

Coating (All Four Entrance/Exit Faces):
Laser-line multilayer antireflector <0.25% R

Unused faces are fine ground, and all edges are lightly beveled.

CUSTOM BEAMSPLITTERS

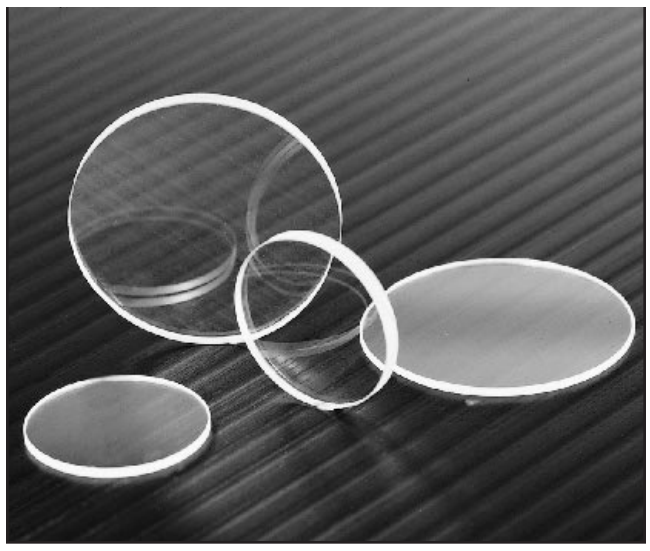
Custom beamsplitters can be made with the standard right angle prisms described on page 10.4–10.5, in Chapter 10, *Prisms and Retroreflectors*. Custom coatings for specific wavelengths from 248 nm through 1.5 μm are available by special request.

Visible/IR Laser-Line Polarizing Cube Beamsplitters

	Wavelength Range (nm)	⌀ (mm)	PRODUCT NUMBER
Visible	488	10.0	03 PBS 013
		20.0	03 PBS 015
		25.4	03 PBS 017
		38.1	03 PBS 019
	514	10.0	03 PBS 023
		20.0	03 PBS 025
		25.4	03 PBS 027
		38.1	03 PBS 029
	543	10.0	03 PBS 033
		25.4	03 PBS 037
	632	10.0	03 PBS 043
		12.7	03 PBS 044
		20.0	03 PBS 045
		25.4	03 PBS 047
		38.1	03 PBS 049
	670	5.0	03 PBS 092
		10.0	03 PBS 093
		12.7	03 PBS 094
		20.0	03 PBS 095
		25.4	03 PBS 097
		38.1	03 PBS 099
Infrared	780	3.2	03 PBS 051
		5.0	03 PBS 052
		10.0	03 PBS 053
		20.0	03 PBS 055
		25.4	03 PBS 057
	830	3.2	03 PBS 061
		5.0	03 PBS 062
		10.0	03 PBS 063
		12.7	03 PBS 064
		20.0	03 PBS 065
		25.4	03 PBS 067
	1300	3.2	03 PBS 071
		5.0	03 PBS 072
		10.0	03 PBS 073
		20.0	03 PBS 075
	1550	3.2	03 PBS 081
		5.0	03 PBS 082
		10.0	03 PBS 083
		20.0	03 PBS 085

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Retardation Plates

Retardation plates, or phase shifters, including quarter- and half-wave plates, are used primarily for synthesis and analysis of light in various polarization states. The quarter-wave plate is appropriate for isolators used in laser interferometry, multistage traveling wave laser amplifiers (to prevent stages from behaving as oscillators), and electro-optic modulators.

The simplest retardation plate is a uniaxial crystal cut to include the crystalline optic axis direction. The velocity difference between ordinary and extraordinary beams, from an unpolarized beam, within the plate is therefore maximized. As O and E beams traverse the plate, a phase difference accumulates between these beams proportional to the distance traveled within the plate. At emergence, the O and E beams recombine to form a second, unpolarized beam.

Within the retarder plane, the crystalline optic axis and another axis normal to it are often called the fast or slow axis, depending on whether the uniaxial crystal is positive or negative. By rotating the retarder slightly about one of these axes, it is possible to adjust the retardation amount.

Rotation around the crystalline optic axis increases effective plate thickness. However, because it does not affect the velocity difference between the O and E rays, accumulated retardation is increased. Rotation around the other axis increases effective plate thickness and reduces the velocity difference between the O and E rays. The latter effect, which dominates for small rotations, reduces accumulated retardation. A narrowband retarder (or combination of retarders) may be tuned over a limited retardation range at fixed wavelength, or over a limited range of wavelengths at fixed retardation.

If plate thickness is such that the phase difference (retardation of the slow ray by comparison with the fast ray at emergence) is a quarter wavelength, the plate is called a first-order quarter-wave plate. If the phase difference at emergence is one half wavelength, the plate is called a first-order half-wave plate*. If the phase difference at emergence is some multiple of one quarter- or one half-wavelength, the plate is called a multi-order or higher-order plate. Notice that that these names refer to phase difference, not physical thickness.

Since O and E ray refractive indices of most materials are wavelength dependent, the retardation that accumulates within a plate of specified thickness is also wavelength dependent. A particular value of retardation can be precisely achieved for normal incidence at only one specified wavelength.

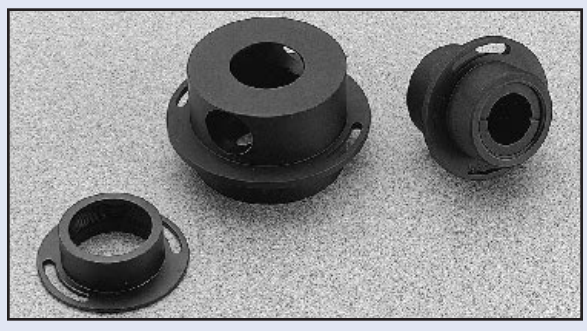
Mica is superior to quartz in broader-band applications in that its principal refraction indices vary more slowly across the visible spectrum. Thus a retarder made for 550 nm and normal incidence will produce closer to the same retardation at other visible wavelengths than quartz, making it more ideal for broadband visible applications.

Crystalline quartz is recommended for higher power applications. It exists in left- and right-handed forms, which cause polarization to rotate in opposite directions. In the case of Melles Griot retardation plates, the form is typically right-handed. Polarization of the O and E rays in quartz rapidly changes from circular to elliptical even for directions that depart only slightly from the optical axis. For the ellipse to be even approximately circular, much smaller angles are required. For this reason, devices that depend on circular polarization are effective only in highly collimated light propagating nearly parallel to the optic-axis direction.

The following retarder applications assume that monochromatic incident light is collimated and is normally incident upon the plate. They describe typical functions and uses for retardation plates.

POLARIZER HOLDERS

Melles Griot polarizer holders, found in Chapter 24, *Lens, Filter, and Polarizer Mounts*, provide an ideal mount for retardation plates. They are intended for use with the post-mountable rotators described in Chapter 28, *Translation and Rotation Stages.*



The term “first-order” is taken from the *Handbook of Optics* (McGraw-Hill, 1995). The term “zero-order” is also often used.

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APPLICATION NOTE

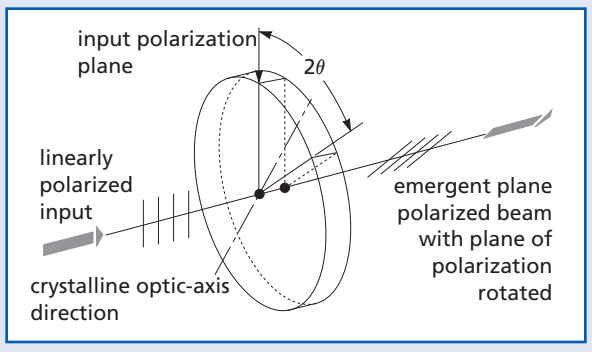
Half-Wave Plate Applications

If the retarder is a half-wave plate (either first- or multiple-order), and the angle between the electric field vector in a plane or linearly polarized incident beam and the retarder principal plane is θ (acute), the emergent beam (also plane or linearly polarized) will make an acute angle θ with the retarder principal plane. Thus the half-wave plate rotates the polarization plane through an angle 2θ.

Half-wave plates are used in laser-line rotators that allow the polarization plane of a laser beam to be continuously adjusted without moving the laser. This can also be accomplished by placing a pair of quarter-wave plates, identically oriented, back to back.

A half-wave plate followed by a polarizing cube will make a variable ratio beamsplitter for monochromatic, linearly polarized inputs. The half-wave plate will convert left circularly polarized light into right circularly polarized light, or vice versa, by reversing the direction of propagation. It will also convert left elliptically polarized light into right elliptically polarized light, or vice versa.

A pair of half-wave plates, identically oriented and back to back, make up a full-wave or tint plate as used in photoelastic stress analysis. Similarly, half-wave plates can be assembled from quarter-wave plates.

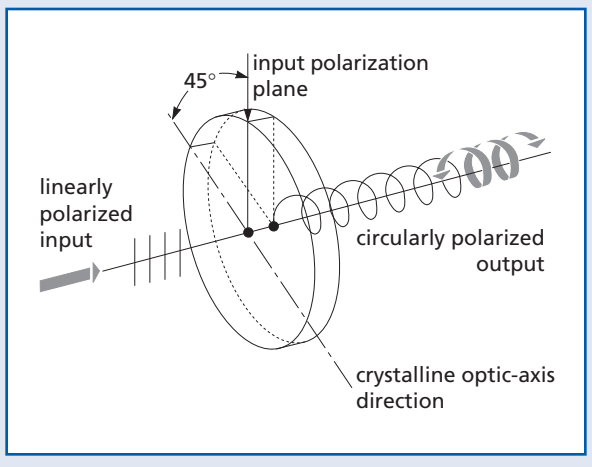


Half-wave retardation plate

APPLICATION NOTE

Quarter-Wave Plate Applications

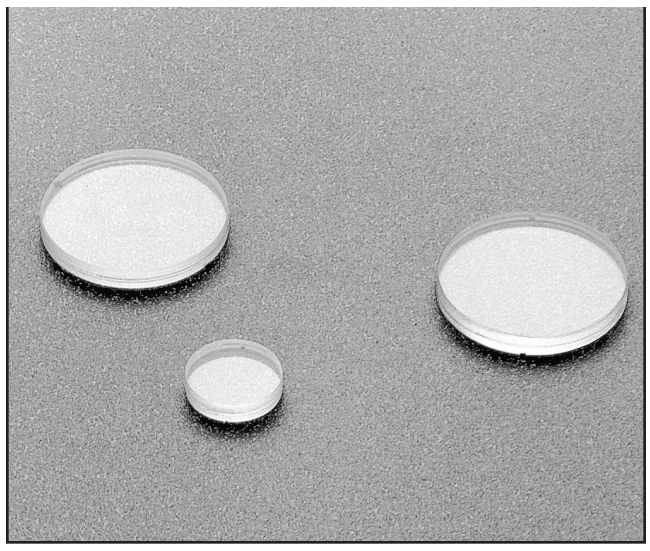
If the retarder is a quarter-wave plate, and the angle θ between the electric field vector of the incident linearly polarized beam and the retarder principal plane is +45 degrees, the emergent beam is circularly polarized as shown in the figure below. Reversing θ to -45 degrees reverses the sense of circular polarization. A quarter-wave plate will also transform circularly polarized into linearly polarized light by reversing the direction of propagation.



Quarter-wavelength retardation plate

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Mica Retardation Plates

Mica retardation plates are recommended for low-power applications such as tint plates in microscopes, visual stress analyzers, and helium neon lasers because of their relatively high absorption coefficient and occasional homogeneities.

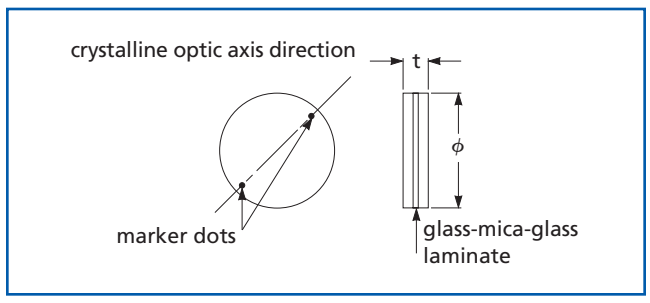
Melles Griot offers two types of mica retardation plates:

- Broadband mica retarders (Type 1) are suitable for use in the visible spectrum (400 nm to 700 nm), are centered at 550 nm.
- Laser-line mica retarders (Type 2) are made for any specific wavelength between 400 nm and 2500 nm. They are exactly quarter-wave or half-wave at the specific wavelength for which the retardation tolerance will be λ/50. The most common laser wavelengths are available directly from stock.

Each mica sheet is cemented between protective glass discs for increased strength.

SPECIFICATIONS: MICA RETARDATION PLATES

Wavelength Range:
Type 1: 400–700 nm
Type 2: Specific wavelength between 400 nm and 2500 nm
Material: Selected mica sheet
Wavefront Distortion: 2λ at 550 nm
Mounting: Cemented between protective glass discs
Retardation Tolerance:
Type 1: λ/20 at 550 nm
Type 2: λ/50
Diameter: $\phi \pm 0.25$ mm
Optic Axis:
Crystalline axis direction indicated by pair of diametrically opposed dots



02 WRM mica retardation plates

Broadband Mica Retarders (Type 1)

Retardation	Diameter ϕ (mm)	Thickness t	PRODUCT NUMBER
λ/2	10	2.5	02 WRM 021
	20	2.5	02 WRM 023
	30	2.5	02 WRM 025
	40	3.5	02 WRM 027
	50	3.5	02 WRM 029
λ/4	10	2.5	02 WRM 001
	20	2.5	02 WRM 003
	30	2.5	02 WRM 005
	40	3.5	02 WRM 007
	50	3.5	02 WRM 009

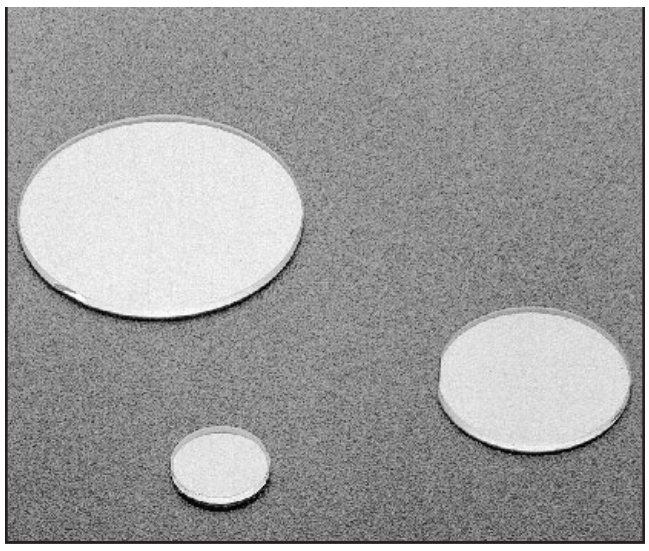
Laser-Line Mica Retarders (Type 2)*

Retardation	Diameter ϕ (mm)	Thickness t	PRODUCT NUMBER
λ/2	10	2.5	02 WRM 031
	20	2.5	02 WRM 033
	30	2.5	02 WRM 035
	40	3.5	02 WRM 037
	50	3.5	02 WRM 039
λ/4	10	2.5	02 WRM 011
	20	2.5	02 WRM 013
	30	2.5	02 WRM 015
	40	3.5	02 WRM 017
	50	3.5	02 WRM 019

**When ordering laser-line retarders, specify product number and wavelength required (for example, specify 02 WRM 011/632.8).*

Note: Antireflection coatings are not available due to the cemented construction of this type of retardation plate.

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Available in:
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Quartz Retardation Plates

Melles Griot offers quarter- or half-wave first-order or multiple-order plates, which are recommended for high- and low-power laser applications.

Multiple-order quartz retarders are made from a single crystalline plate:

- Retardation is slightly temperature dependent.
- The temperature coefficient of retardance (phase difference between O and E rays at emergence) is approximately 1.0 nm/°C, as deviated from 20°C. Retardance decreases as temperature increases.

First-order retarders, also called zero-order retarders, are assembled from pairs of optically contacted crystalline quartz plates:

- The quartz plates have orthogonal optic axis directions; therefore, the roles of the ordinary and extraordinary rays are interchanged in passing from one plate to the other.
- Net retardation is essentially temperature invariant since both plates are nearly equal in thickness (<0.01 nm/°C).

The standard wavelengths carried in stock include many of the most commonly used laser lines, from 193 nm to 1550 nm. Custom quartz retardation plates are available for specific wavelengths from 193 nm to 2300 nm.

APPLICATION NOTE

Wavelength Effects on Quartz Retardation Plates

Due to the high degree of accuracy in the manufacturing of these quartz retardation plates, they should not be used far outside of their design wavelength. However, they can be used at wavelengths that are close to their design wavelength, depending on which type they are. Multiple-order plates are more susceptible to changes in wavelength and they should not be used more than several nanometers outside of their design wavelength, unless some degree of change in the retardation amount is tolerable. First-order waveplates, which are much less susceptible to wavelength changes, can be used up to ~2% above or below the design wavelength with little effect on the retardation.

SPECIFICATIONS: QUARTZ RETARDATION PLATES

Wavelength: Specified by customer
Wavelength Range: 193–2300 nm
Material: Crystal quartz, c-axis cut
Retardation Tolerance: See table below
Wavefront Distortion: λ/10 peak to valley at 632.8 nm
Diameter: ϕ+0, −0.15 mm
Parallelism: 0.5 arc seconds
Optic Axis: Normal to facet on circumference of retarder
Surface Quality: 20–10 scratch and dig
AR Coatings:
For multiple-order plates, see Chapter 5, *Optical Coatings*.
For first-order plates, only antireflection V-coatings are available and are supplied by special order only

Retardation Tolerance for Various Wavelengths

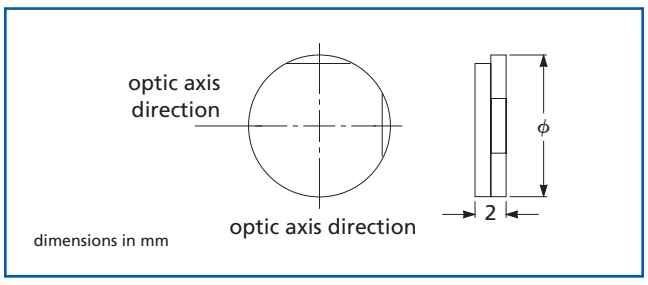
Standard Wavelengths (nm)	Laser Source	Retardation Tolerance (±)
193	ArF (excimer)	λ / 100
248	KrF (excimer)	λ / 200
266	Nd: YAG 4th harmonic	λ / 200
355	Nd: YAG 3rd harmonic	λ / 300
364	Ar-ion	λ / 300
488	Ar-ion	λ / 400
514	Ar-ion	λ / 500
532	Nd: YAG 2nd harmonic	λ / 500
543	HeNe (green)	λ / 500
632	HeNe (red)	λ / 500
670	Diode	λ / 500
780	Diode	λ / 500
830	Diode	λ / 500
1064	Nd: YAG	λ / 500
1300	Diode	λ / 500
1550	Diode	λ / 500

Note: Retardation plates at other wavelengths are available on special order.

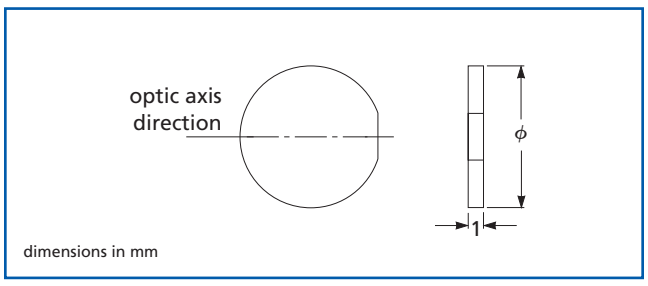
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02 WRQ quartz retardation plates, first order



02 WRQ quartz retardation plates, multiple order

Quartz Retardation Plates, First Order*

Diameter ϕ (mm)	PRODUCT NUMBER Retardation λ/2	λ/4
10	02 WRQ 023	02 WRQ 003
20	02 WRQ 027	02 WRQ 007
30	02 WRQ 031	02 WRQ 011

**Please specify product number and wavelength when ordering (for example, specify 02 WRQ 003/632.8).*

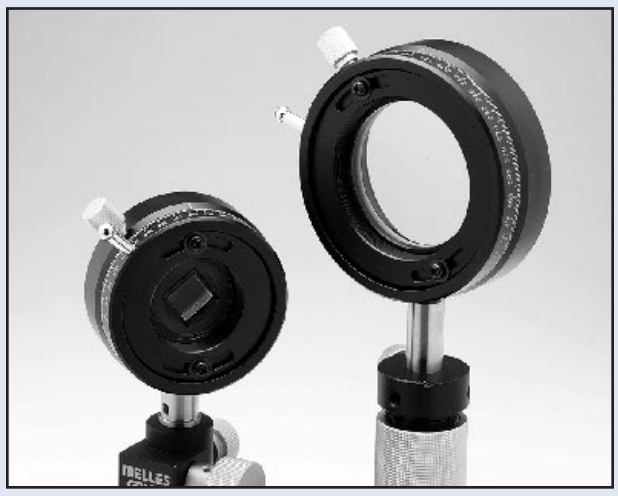
Quartz Retardation Plates, Multiple Order*

Diameter ϕ (mm)	PRODUCT NUMBER Retardation λ/2	λ/4
10	02 WRQ 021	02 WRQ 001
20	02 WRQ 025	02 WRQ 005
30	02 WRQ 029	02 WRQ 009

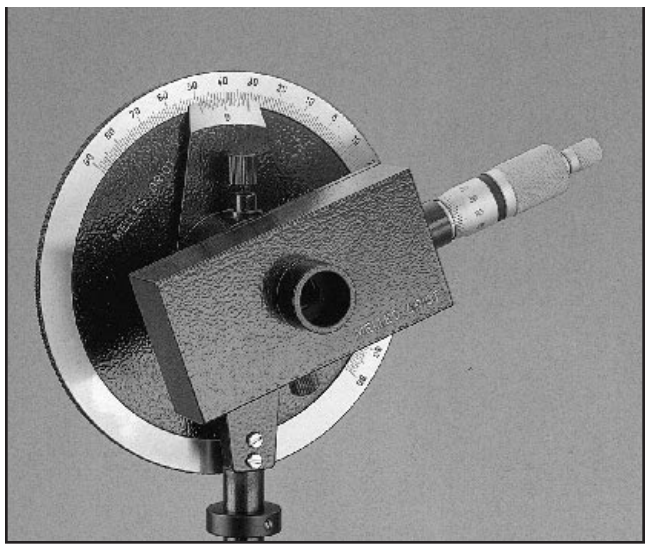
**Please specify product number and wavelength when ordering (for example, specify 02 WRQ 001/632.8).*

HOLDERS FOR WAVEPLATES

Melles Griot offers two types of holders for retardation plates. The precision holder uses a micrometer versus a lever on the standard holder. Both holders offer 360-degree rotation with 1-degree resolution. The holders are post mountable with either a 1/4-20 or M6-threaded post. An assortment of polarizer holder adaptors are available to accommodate various size waveplates. Please see Chapter 24, *Lens, Filter & Polarizer Mounts* for additional information.



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Soleil-Babinet Compensator and Divided-Circle Rotating Mount

The Soleil-Babinet compensator is a continuously adjustable retardation plate.

- Retardation is wavelength dependent, and varies from zero up to two full wavelengths (at 546.1 nm) from 250 nm to 3500 nm.
- Relative retardation is adjusted by turning a micrometer screw.
- The selected retardation value is constant over the entire working aperture of the compensator.
- The compensator comes with a certificate of the retardation vs wavelength.

The Soleil-Babinet compensator is constructed from a pair of crystalline quartz wedges stacked one on top of the other. The lower wedge, separated from the first by a small air space, is moved by a micrometer screw that varies the effective plate thickness. The retardation exhibited by the emergent beam is proportional to the total thickness of the fixed and effective plates.

Melles Griot also offers a nonmagnetic-metal divided-circle rotating mount, 04 SBM 001, which is ideal for orienting the compensator about its optic axis.

SPECIFICATIONS: SOLEIL-BABINET COMPENSATORS

Wavelength Range: 250–3500 nm

Materials:
Schlieren-free crystalline quartz and non-magnetic metals

Retardation Range:
0 to 4λ ± 2% at λ = 300 nm
0 to 2λ ± 1% at λ = 546 nm
0 to 1λ ± 0.5% at λ = 1000 nm
0 to 0.5λ ± 0.5% at λ = 2000 nm

Retardation Resolution: 0.001λ at λ = 632.8 nm

Wavefront Distortion: ≤λ/4 or less at 632.8 nm

Clear Aperture: 10-mm diameter

Temperature Limits: −20°C to +80°C

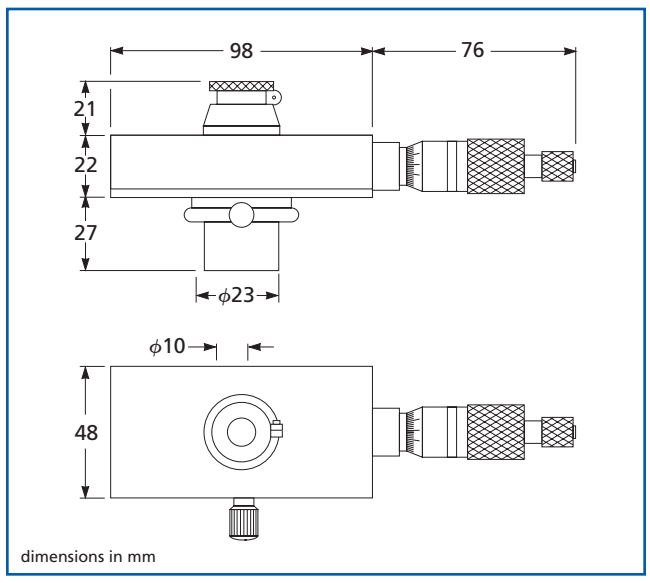
SPECIFICATIONS: DIVIDED-CIRCLE ROTATING MOUNTS

Diameter: 140 mm

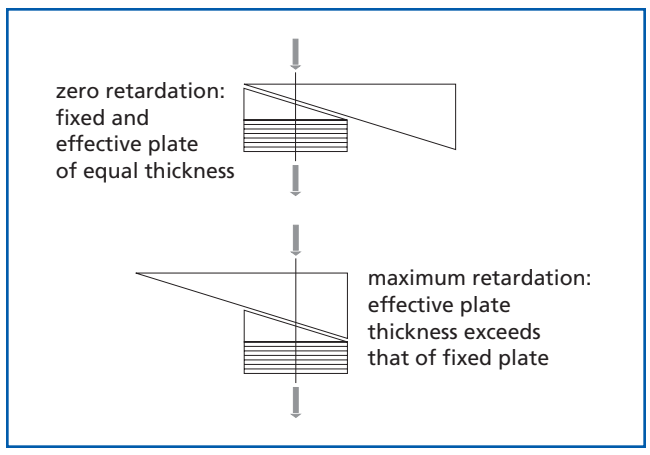
Calibration: ± 90° (from zero at top) in 1° steps

Vernier Precision: ± 3 arc minutes

Post Diameter: 12 mm



04 SBC 001 Soleil-Babinet compensator



Soleil-Babinet compensator

Soleil-Babinet Compensator and Divided Circle Rotating Mount

	PRODUCT NUMBER
Soleil-Babinet Compensator	04 SBC 001
Divided-Circle Rotating Mount	04 SBM 001

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