7. Prisms

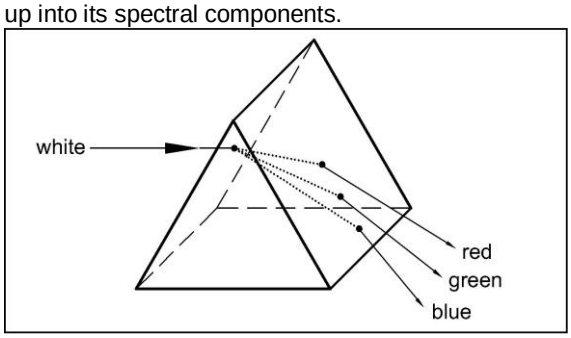
Prisms are the most varied group of optical components. In general, a prism is a transmitting optical component limited by two surfaces intersecting along a line called the edge of the prism and making the refracting angle γ of the prism.

Considering their use, prisms are divided into two groups:

- ❑ dispersion prisms
- ❑ reflection prisms

7.1 Dispersion prisms

The way in which dispersion prisms work is connected with dispersing properties of the material they are made of.
A beam of polychromatic light, after double deflection on the media border leaves the prism deflected by an angle which is called the angle of deflection, depending on the material and refracting angle of the prism, and which is different for different wavelengths.
For this reason, beam of light is dispersed and split up into its spectral components.



The most typical dispersion prism is equilateral prism (with the refraction angle of 60°) made of material of high difference of refraction indexes for different wavelengths (for ex. N-SF10). The dispersion prisms of special use are: Litrow prisms; Pellin-Broca prisms, Amici (direct vision prism).

The glass dispersion is the relationship between its refraction index and the wavelength ($dn'/d\lambda$). The unit of dispersion measure is Abbe number ν_e (high Abbe number means small dispersion).

$$\nu_e = \frac{n_e - 1}{n_{F'} - n_{C'}}$$

n_e — refraction index for λ = 546,1 nm

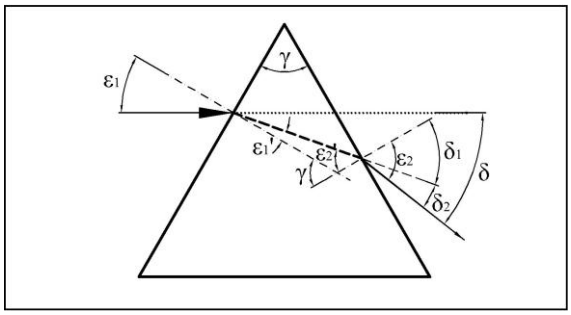
$n_{F'}$ — refraction index λ = 479,99 nm

$n_{C'}$ — refraction index λ = 643,85 nm

Typical materials for dispersion prisms:

Material	ν_e	n_e
N-BK7	63.96	1.51872
F2	36.11	1.62408
N-SF10	28.19	1.73430
Quarz glass	69.00	1.46018

One can use optical glasses for visible light and for near infrared radiation (up to 2 μm). For transmission of UV light, down to 200 nm, CaF_2, LiF, or some kind of quartz glasses are used. For NIR special IR glasses, or special kinds of quartz glasses or crystals are used.
Typical material for IR: fluorite (CaF_2), Si, Ge, KBr, NaCl.



γ — angle of refraction
ε_1 — angle of incidence
ε_2' — output angle
δ — angle of deviation

Optical path calculation formulas.

Beam deflection δ

$$\delta_1 = \varepsilon_1 - \varepsilon_1'$$
$$\delta_2 = \varepsilon_2' - \varepsilon_2$$
$$\gamma = \varepsilon_1' + \varepsilon_2$$
$$\delta = \delta_1 + \delta_2$$

therefore

$$\delta = \varepsilon_1 + \varepsilon_2' - \gamma$$

Spectral resolution

$$\frac{\lambda}{d\lambda} = a \cdot \frac{d\delta}{d\lambda} \quad \frac{\lambda}{d\lambda} = b \cdot \frac{dn}{d\lambda}$$

a — beam width
b — fully lighted prism base

Minimal deviation $\delta_{min.}$

$$\delta_{min.} = 2 \cdot \arcsin\left(n' \sin\frac{\gamma}{2}\right) - \gamma$$

(corresponds to symmetric crossing)

$$|\varepsilon_1'| = |\varepsilon_2| = \left|\frac{\gamma}{2}\right|$$

Angle dispersion

$$\frac{d\delta}{d\lambda} = \frac{d\delta}{dn'} \cdot \frac{dn'}{d\lambda} = \frac{-2\sin\frac{\gamma}{2}}{\sqrt{1 - n'^2 \sin^2\frac{\gamma}{2}}} \cdot \frac{dn'}{d\lambda}$$

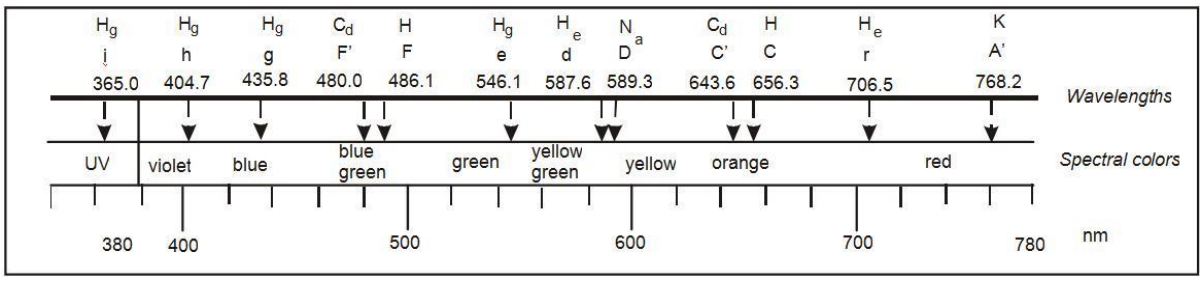
Approximate $\frac{dn'}{d\lambda}$ can be changed by: $\frac{\Delta n}{\Delta\lambda}$

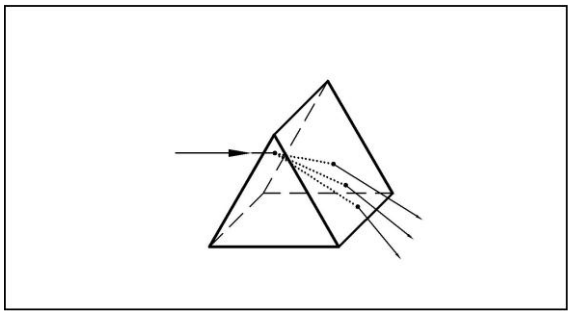
Spectral distribution

N-BK7	125
F2	273
N-SF11	510

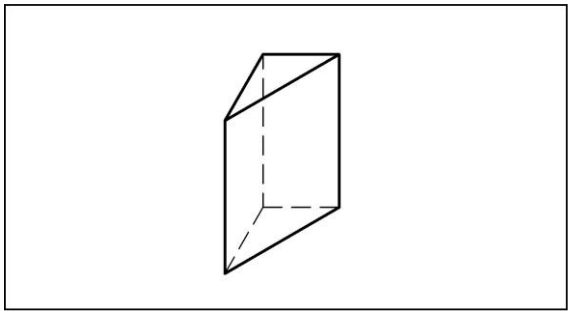
$\gamma = 60°$; a = 2 mm; average refraction index:

$$n' = \frac{n_{F'} + n_{C'}}{2}$$

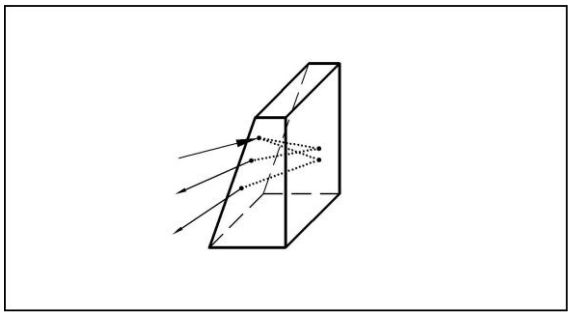




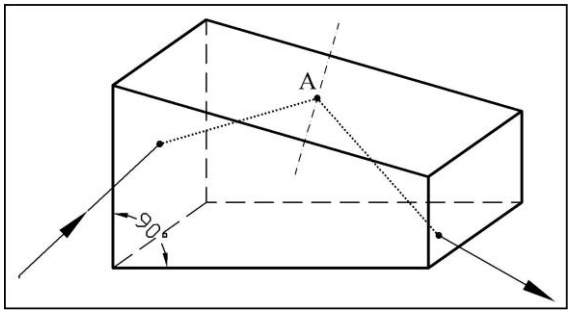
EQUILATERAL dispersion prism
EQUILATERAL dispersion prisms have three equal 60^{o} angles.



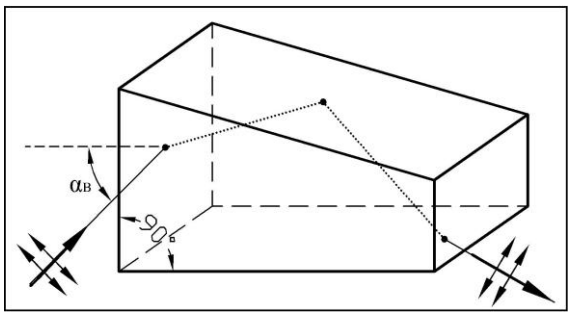
ISOSCELE prism
ISOSCELE dispersion prisms (30^{o} – prism).



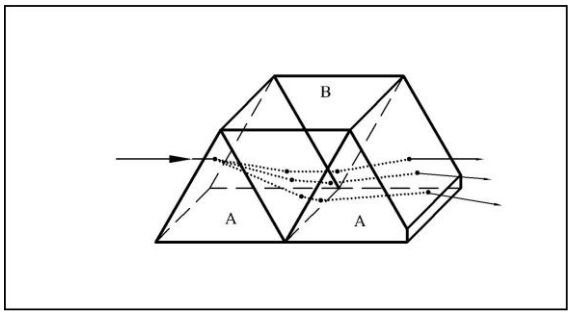
LITTROW prism
Light crossing the LITTROW prism is spectrally dispersed with simultaneous inversion of the path of rays caused by the reflection taking place on the back surface of the prism, which have to be mirrored.



PELLIN-BROCA prism
PELLIN-BROCA prism is a special kind of dispersion prism which besides dispersing properties has the property of diverging rays by 90°. The prism rotation around it's A axis enables wavelength selection of required length.



BREWSTER prism
BREWSTER prism is recommended for polarized light: p-polarized beam is transmitted with no losses when input beam is at the Brewster angle.



AMICI prisms (Direct Vision Prisms)
The AMICI prism causes dispersion of polychromatic light with simultaneous correction of divergence so that the exit beam is parallel to the input one. These prisms consist of three parts and two different materials A and B. Typical combination of materials:
A crown
B flint

Technical specification – dispersion prisms	
	Standard
Material	on request
Range of sizes	4 mm ÷ 100 mm
Size tolerance	± 0,1 mm
Clear aperture	90%
Thickness tolerance	± 0,1 mm
Angle accuracy	± 10 arcmin
Pyramid error	± 10 arcmin
Surface accuracy (633 nm)	1λ (λ/4)
Surface finish (scratches - digs)	60 – 40
Coatings	On request
Mounting	On request

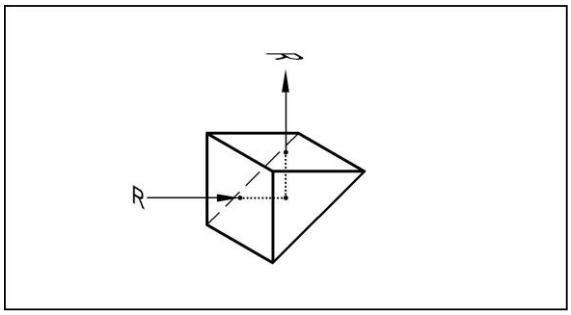
According to customer specification, we can deliver non-standard dispersion prisms with significantly higher optical parameters: 20-10; λ/10 (633 nm), 2 arcmin, for example.

7.2. Reflection prisms

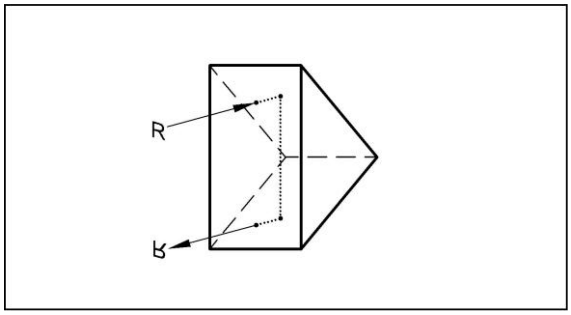
The operation principle of this kind of prisms is identical as that of plane mirrors. These prisms are usually used for diverging the ray or for changing image location in relation to the subject (rotation, inversion).
All surfaces of reflection prisms are flat. Reflecting surfaces are mirrored, but it is possible, however, to make use of full internal reflection. In the other case surface does not have to be coated but must be very finely polished.
There are different groups of prisms according to their function in optical sets.

The main tasks of the prisms in optical sets are:
❑ deviation of beam of light without changing the image position.
❑ deviation of beam of light with horizontal displacement
❑ deviation of beam of light with total inversion of image position (horizontal and vertical displacement),
❑ deviation with rotation (typical rotation by 90°).

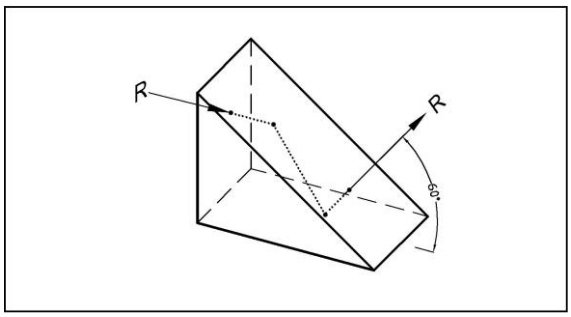
Below there are the samples of the prisms offered by us. The selection presented here is not complete and it does not exhaust our production possibilities. In case you need, some special prisms do not hesitate to send us your specification or description of its task in optical set.



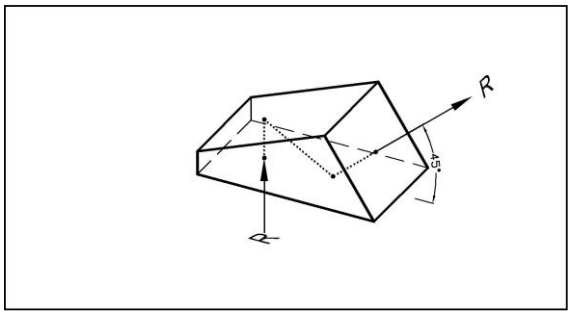
RIGHT ANGLE PRISMS (half cube prism, isosceles)
Right angle prisms are generally used for deflecting the beam through an angle of 90^o, when the input surface is one of the short faces and the hypotenuse one can be mirror coated.



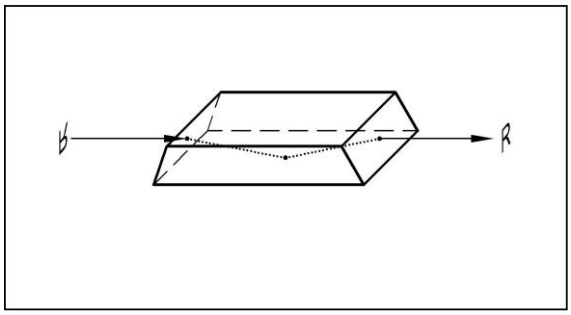
RIGHT ANGLE PRISMS
If the input surface is hypotenuse (Porro type) – the ray is reversed of 180°.



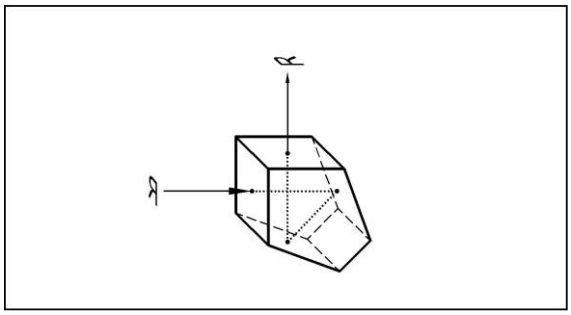
BAUERNFEIND prism 60^o
The input beam is deflected by the δ angle which depends on the γ angle between the input surface and the first reflection surface. There is neither horizontal nor vertical displacement of the image. Typical divergence angles are 45° and 60° (prism 45° or 60°).



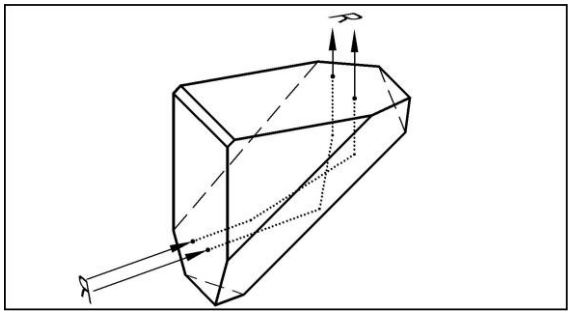
BAUERNFEIND prism 45^o
In both these cases it is necessary to put the mirror coating on the longer short face of the prism (larger face opposite hypotenuse), as there is no total internal reflection on it.



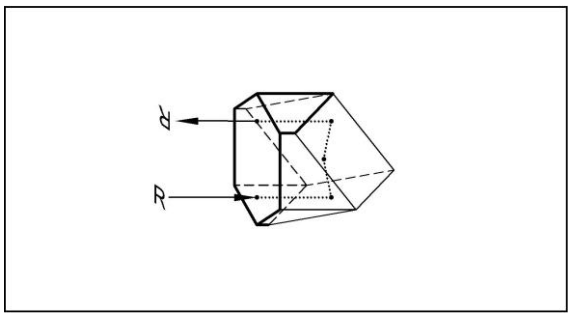
DOVE prism (Image Rotator)
This prism rotates the image without changing the direction of input beam, which is parallel to the hypotenuse. Rotation of the prisms in relation to the subject causes double rotation of the image. DOVE prism should be used in parallel beam.



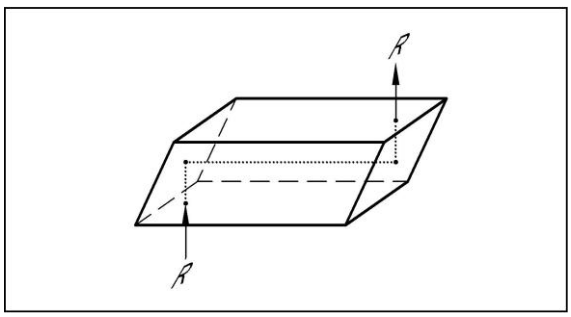
PENTA PRISM
PENTA PRISM is five – sided prism in which the beam is deflected through an angle of 90° by two reflections. As compared to the right angle prism a little change of the angle of incidence in penta prism has no influence on the angle of deflected beam of light. The image of the subject is neither reverted nor inverted. For this reason penta prisms are also used for shortening of the optical path length. In these prisms total internal reflection does not occur, so reflecting faces have to be mirrored.



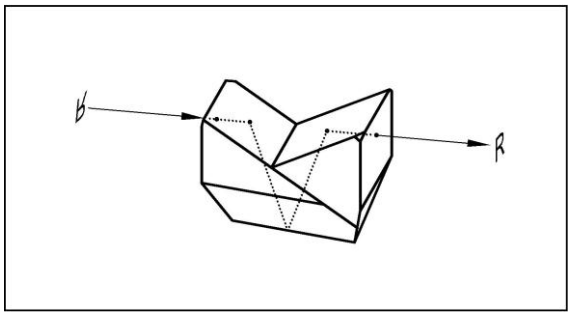
AMICI roof prism
AMICI reflection prism called also roof prism or right angle roof prism deflects the beam through an angle of 90^{o} and inverts the image; for this reason optical sets are perfect for erect images inverted by the objectives.



CORNER CUBE prism
(**Retroreflector; TRIHEDRAL prism)**
In the corner cube prism three reflecting surfaces are perpendicular each to the other (like side walls of the cube). The input surface is perpendicular to the cube diagonal. Disregarding the angle of incidence the output beam is parallel to the input one, but it is of opposite direction. In set of several corner prisms, for better matching, their entrance – exit surface is often hexagonal. In case of this prisms the phenomenon of full internal reflection occurs so it is not necessary, (however it is possible) to put mirror coating on the reflecting faces.



RHOMBOID prism (off-set prism)
The RHOMBOID prism is a simple means of displacing beam without its deviation and without influence on orientation of the image.



ABBE-KOENIG prism
ABBE-KOENIG prism is an image erector. It is set of prisms with roof faces for complete image reversal.

Technical specification – reflection prisms	
	Standard
Material	on request
Range of sizes	4 mm ÷ 100 mm
Size tolerance	± 0,1 mm
Clear aperture	90%
Thickness tolerance	± 0,1 mm
Angle accuracy	± 10 arcmin
Pyramid error	± 10 arcmin
Surface accuracy (633 nm)	1λ (λ/4)
Surface finish (scratches - digs)	60 – 40
Coatings	on request
Mounting	on request

According to customer specification, we can deliver non-standard reflection prisms with significantly higher optical parameters: 20-10; λ/10 (633 nm), for example