Assignment 2

OPTI 502 Optical Design and Instrumentation I

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1 Exercise 1

a) *Tunnel diagrams* are schemes that unfold the optical path at each reflection, so that the total propagation of the ray remains straight. For the prisms below, at each reflecting surface they must be flipped to achieve the above. The diagram then consists of a geometric figure composed of multiples flipped of the original prism.

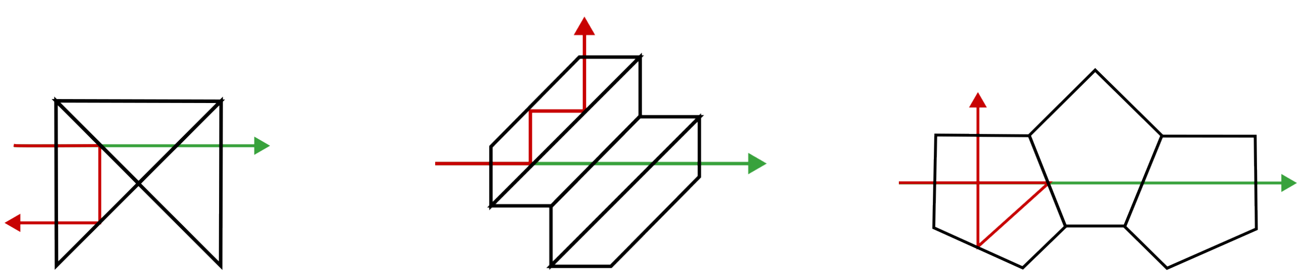
On the other hand, *parity change* is the change in orientation of the object when looking backward through the z optical axis to the object. Therefore, the parity change will be due to the y axis (reversion) and x axis (inversion). However, no parity change is due rotations with respect to the z axis. In addition, only an odd number of reflection will change the parity.

In the following three prisms, we will assume the ray propagates with total internal reflection or the surface is coated so that only reflection is studied. The last surface is not coated and the ray exits perpendicular to its normal.

i. **Right-angle prism** The ray is reflected twice (figure 1a), therefore there is no parity change.

ii. **Dove prism** The ray is reflected three times (figure 1b), so there will be a parity change.

iii. **Pentaprism** The ray is reflected twice (figure 1c) so that there will be no parity change.



(a) Right-Angle prism. (b) Dove prism (c) Penta prism

Figure 1: Tunnel diagram for the given prisms.

b) To obtain an equivalent effect of the Dove and Right-Angle prisms, we must see the propagation inside the geometry. In figure 2 we have shown how can be disposed to achieve this, with dashed lines reinforcing this position as it can be seen as similar to a truncated right-angle prism.

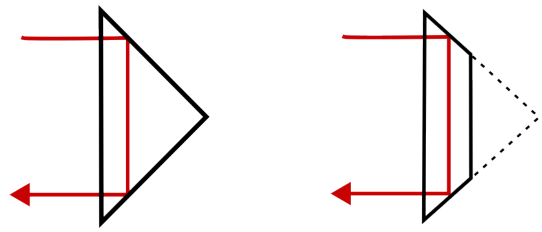


Figure 2: Equivalent orientation of the Dove prism to achieve an equivalent propagation as the Right-Angle prism.

2 Exercise 2

The configuration is a lens of focal legnth $f = 100\ mm$ with a pentaprism of n just behind the lens with some sides of length a. The image plane is required to be at f and outside the prism. If we denote d_{in} as the distance traveled by the ray inside the prism and d_{out} outside, then the total length must be

$$d_{in} + d_{out} = f = 100\ mm.$$

a) In this case, the maximum value of a will imply that there is no space left for the air propagation and therefore $d_{out} = 0$. If we create the tunnel diagram of the pentaprism (figure 3a), we will see that the distance traveled by the ray is twice the length a plus $\sqrt{2}a$ due to the diagonal propagation along the geometry. Therefore, the reduced thickness is

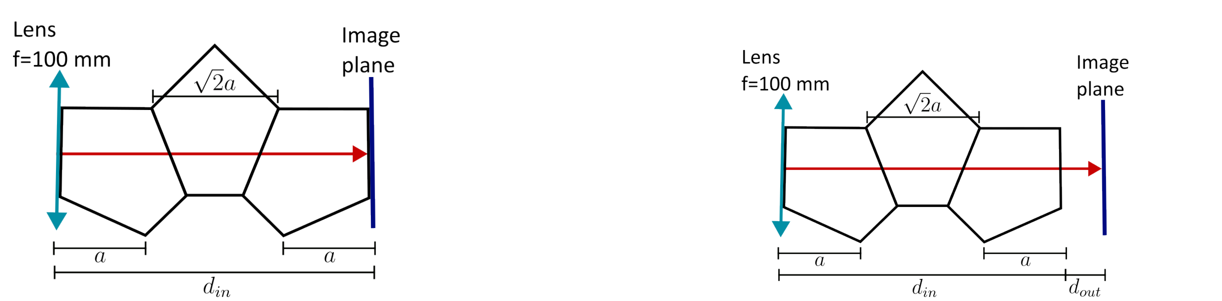
$$d_{in} = \frac{(2+\sqrt{2})a}{n}.$$

Thus, replacing $n = 1.5$ and solving for a yields

$$\frac{(2+\sqrt{2})a_{max}}{1.5} + 0 = 100 \longrightarrow a_{max} = \frac{100(1.5)}{2+\sqrt{2}} = 43.934\ mm.$$

b) If the length is given to be $a = 40\ mm$ and the refractive index changes to $n = 1.66$, then the image will be located d_{out} away from the exit surface of the pentaprism (figure 3b), that is,

$$\frac{(2+\sqrt{2})(40)}{1.66} + d_{out} = 100 \longrightarrow d_{out} = 100 - \frac{(2+\sqrt{2})(40)}{1.66} = 17.729\ mm.$$



(a) Distance only atributed to d_{in}

(b) d_{in} and d_{out} contributes to tha total propagation

Figure 3: Tunnel diagrams allows us to reduces the complexity of the optical configuration.