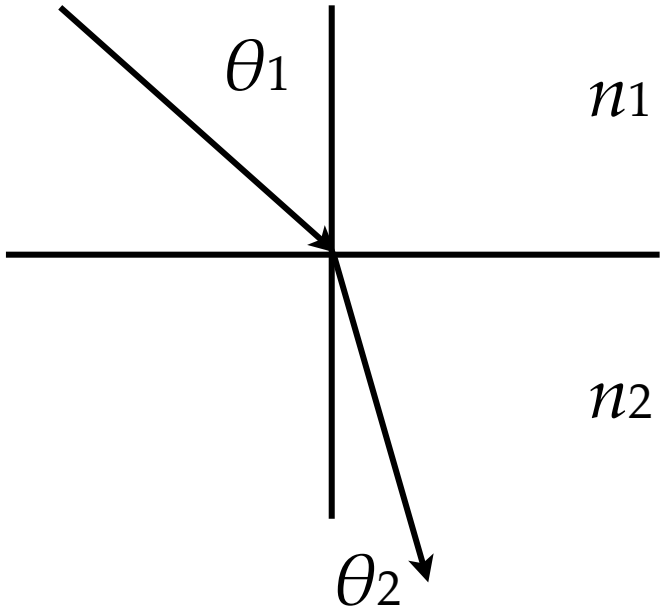
光学 第２章
光の伝搬，反射屈折

第２章　光の伝搬，反射屈折

屈折の法則，Snellの法則

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$



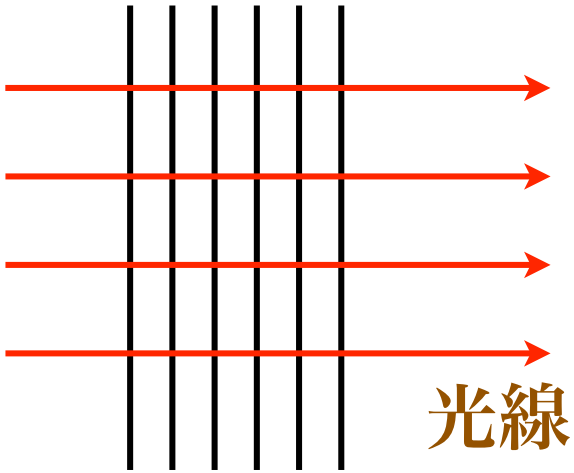
光線と波面の関係について

光線は波面に直交する

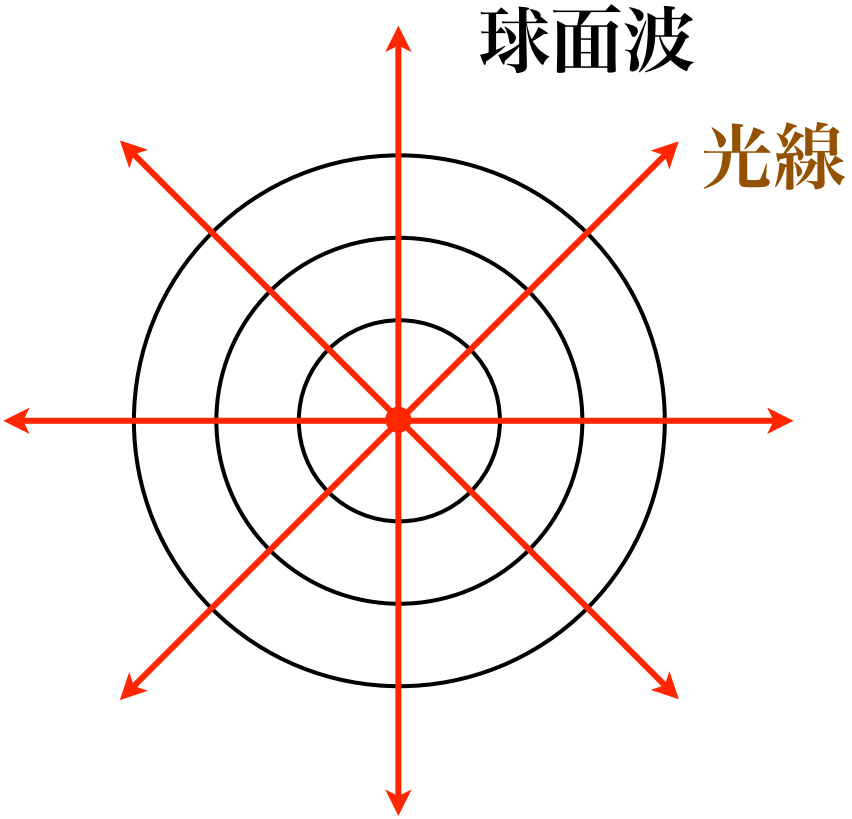
光の伝搬：光線で考えても波面で考えてもよい

光線 ＝ 波面法線

平面波



球面波



Snellの法則

入射光

$$\mathbf{t}_1 = \begin{pmatrix} \sin\theta_1 \\ 0 \\ \cos\theta_1 \end{pmatrix},$$

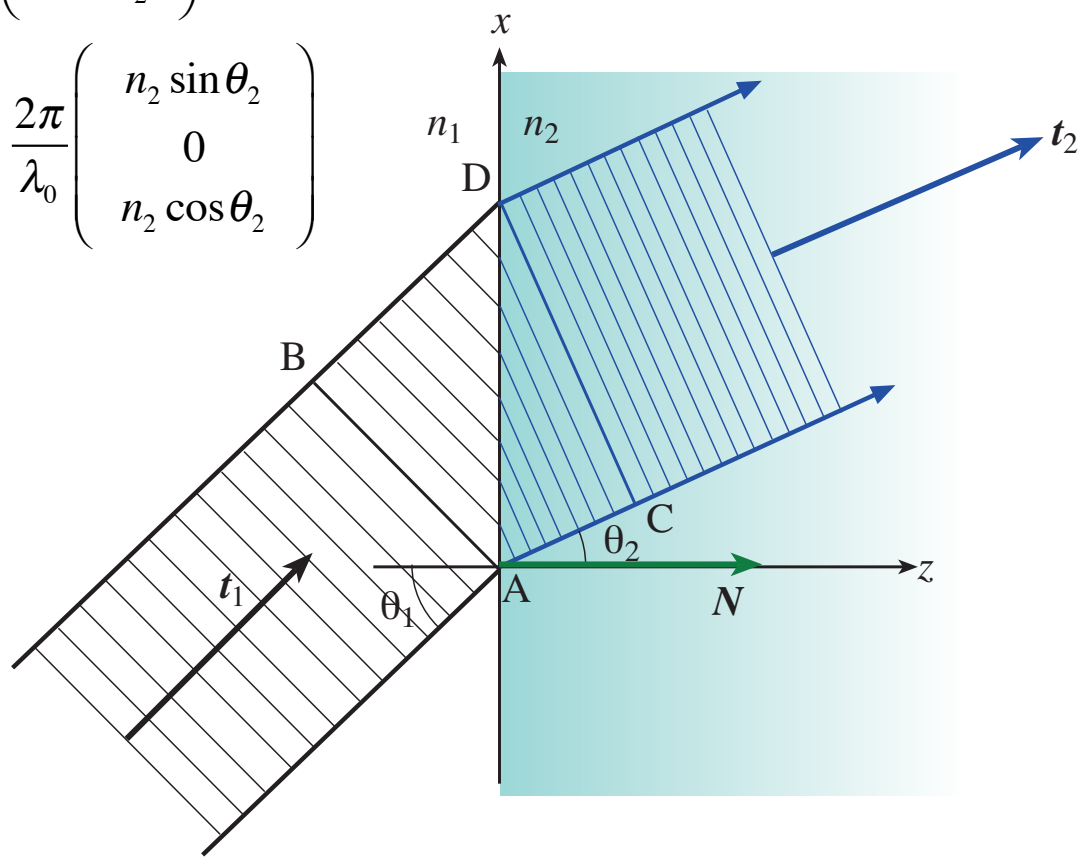
$$\mathbf{k}_1 = \frac{2\pi}{\lambda_0}\begin{pmatrix} n_1 \sin\theta_1 \\ 0 \\ n_1 \cos\theta_1 \end{pmatrix},$$

屈折光

$$\mathbf{t}_2 = \begin{pmatrix} \sin\theta_2 \\ 0 \\ \cos\theta_2 \end{pmatrix}$$

$$\mathbf{k}_2 = \frac{2\pi}{\lambda_0}\begin{pmatrix} n_2 \sin\theta_2 \\ 0 \\ n_2 \cos\theta_2 \end{pmatrix}$$

境界面上で入射波と屈折波の位相が連続



$$\mathbf{k}_1 \cdot \mathbf{r} = \mathbf{k}_2 \cdot \mathbf{r}$$

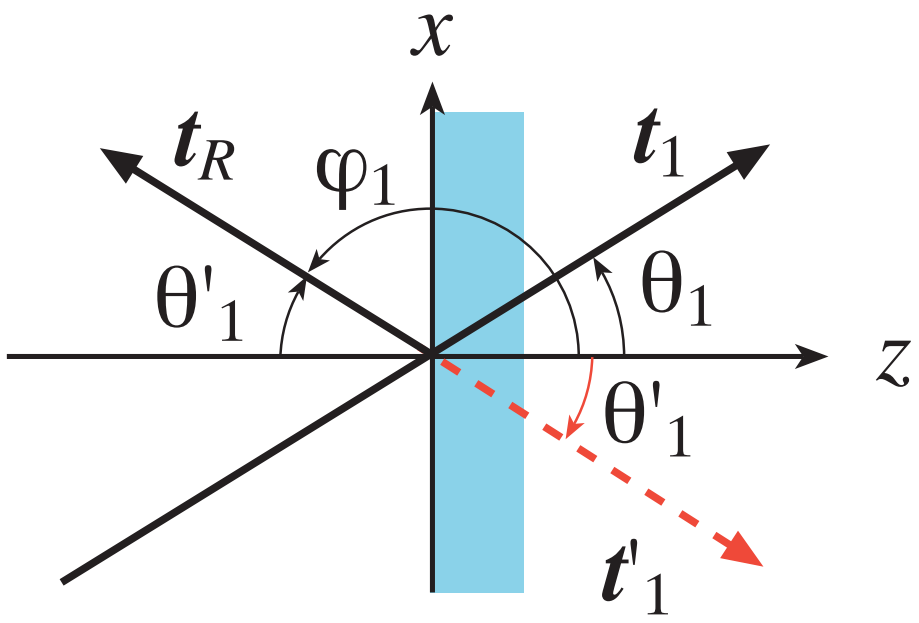
$$\text{at } z = 0$$

$$\lambda = \lambda_0 / n$$

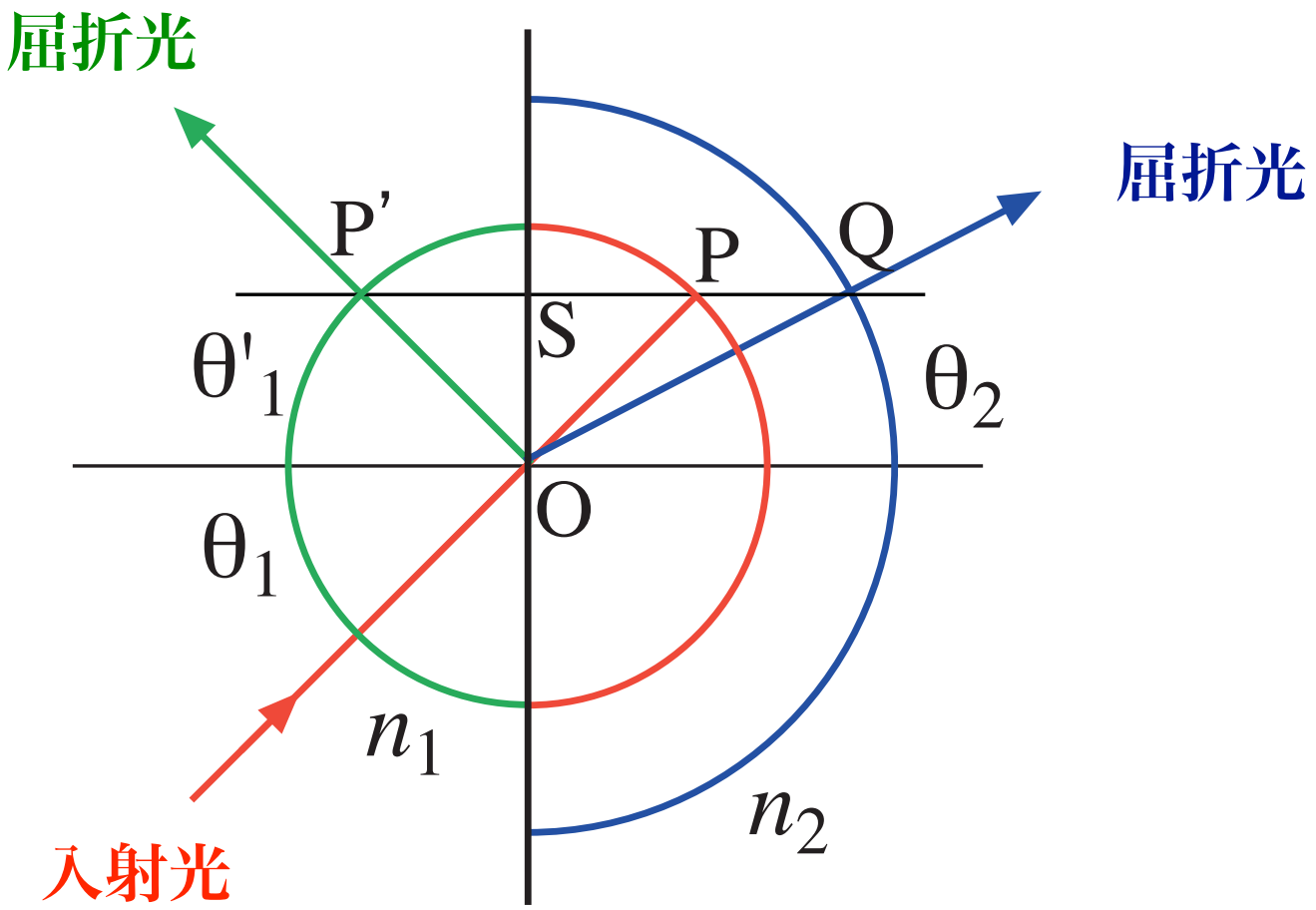
反射の法則

反射角は入射角に等しく
法線に対し対称

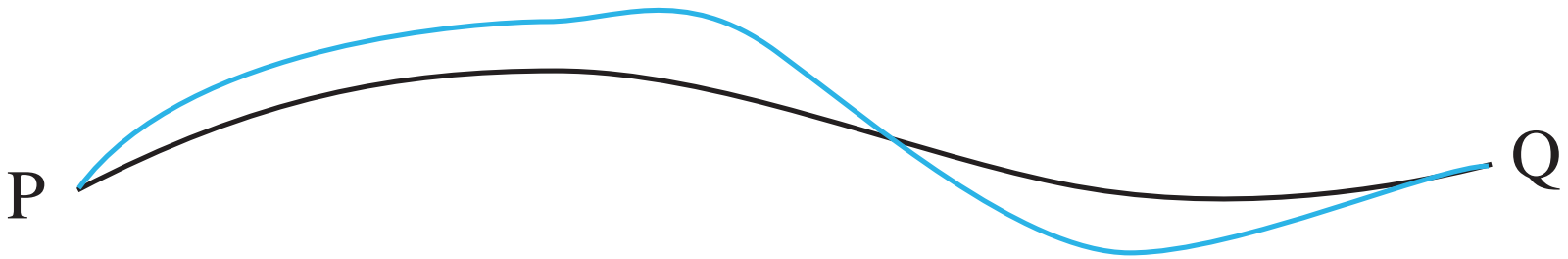
$$\sin\theta_1 = \sin\phi_1$$
$$\phi_1 = \pi - \theta_1$$
$$\theta_1' = \phi_1 - \pi$$
$$\theta_1 = -\theta_1'$$
$$\sin\theta_1 = -\sin\theta_1'$$



反射屈折の図形的解釈



フェルマーの原理



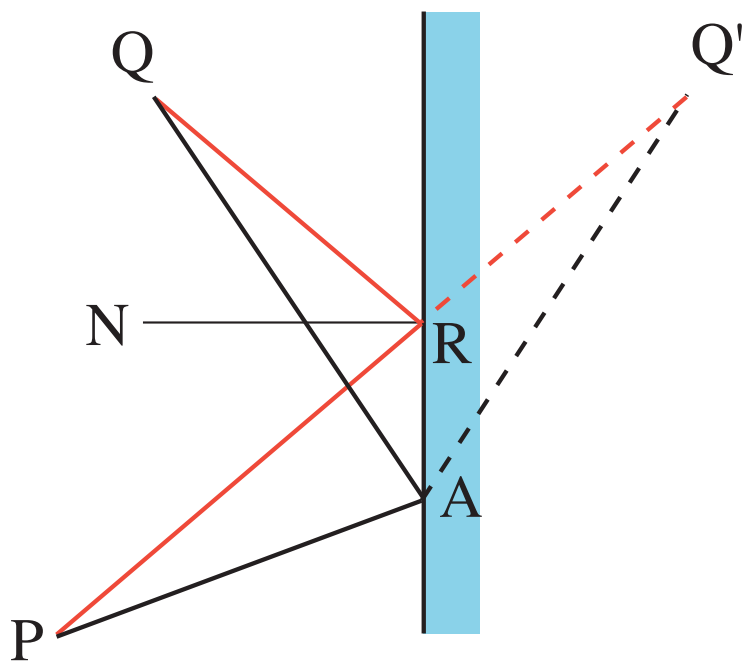
P点を出てQ点に到達する光路：

二点間を**最短時間**で結ぶ道

光路長＝屈折率×距離

所要時間　$T = \frac{d}{v} = \frac{nd}{c} = \frac{L}{c}$

フェルマーの原理による反射の法則

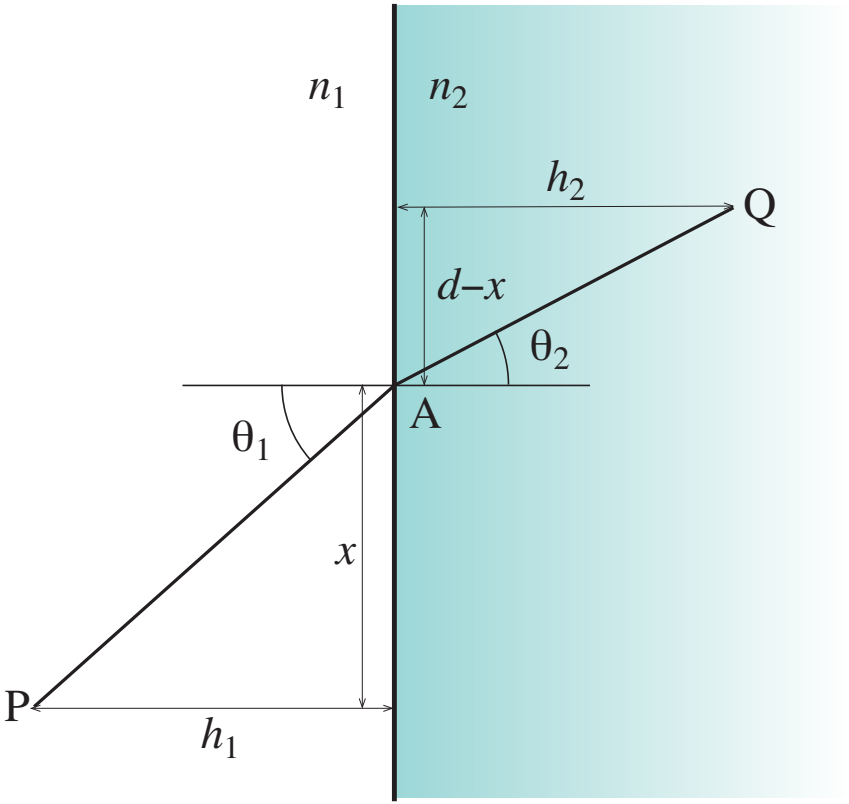


$$L = nPA+nAQ = nPAQ = nPAQ'$$

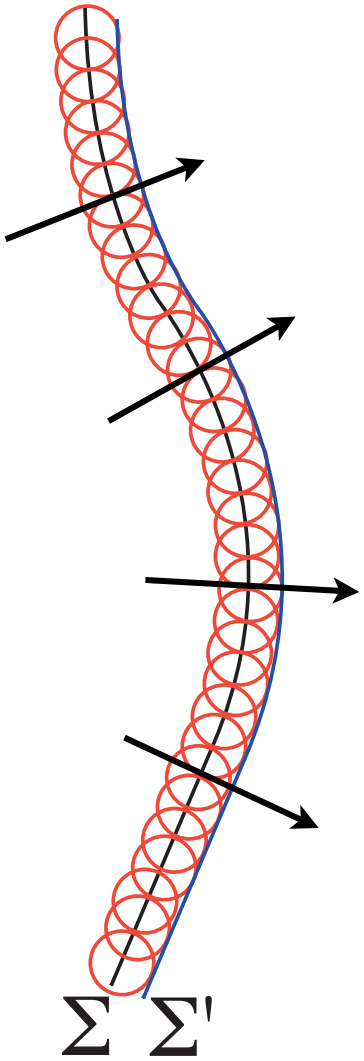
フェルマーの原理による屈折の法則

$$L = n_1\sqrt{h_1^2 + x^2} + n_2\sqrt{h_2^2 + (d-x)^2}$$

$$\frac{\partial L}{\partial x} = \frac{n_1 x}{\sqrt{h_1^2 + x^2}} - \frac{n_2(d-x)}{\sqrt{h_2^2 + (d-x)^2}} = n_1 \sin\theta_1 - n_2 \sin\theta_2 = 0$$



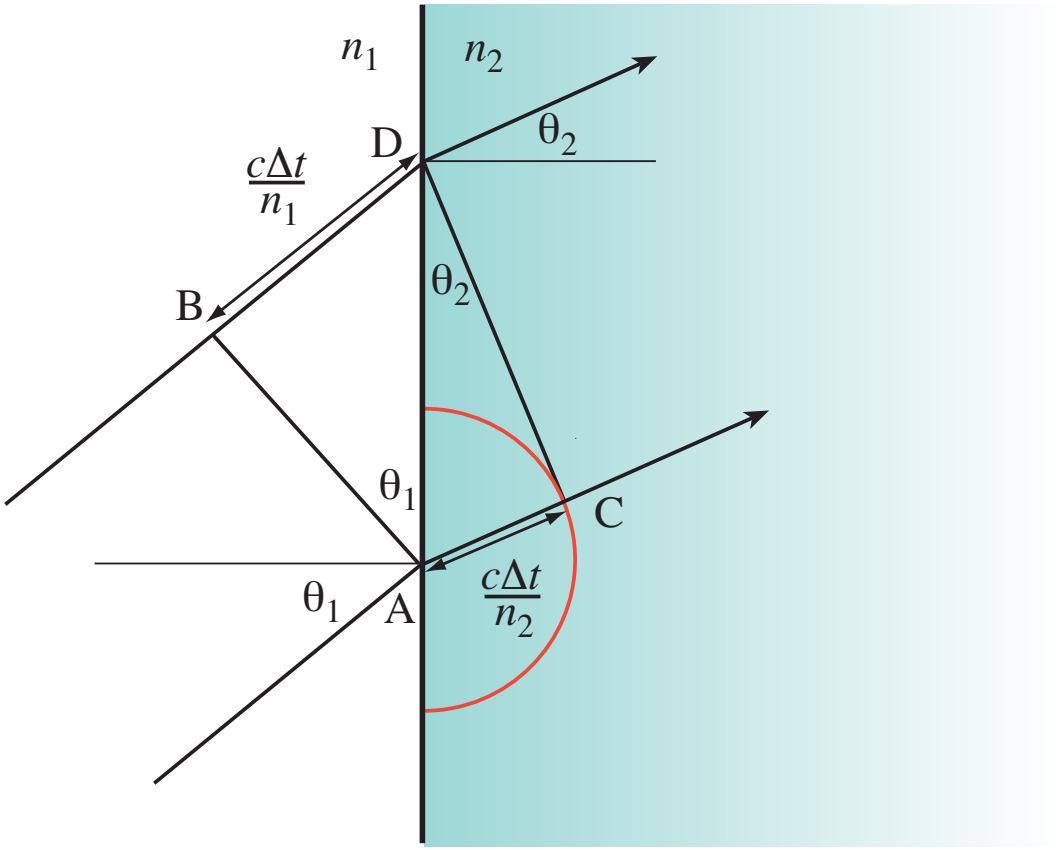
ホイヘンスの原理



光線

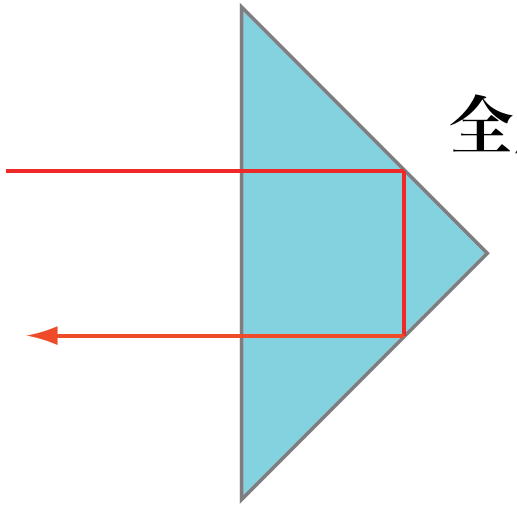
波面に直交

ホイヘンスの原理による屈折の法則

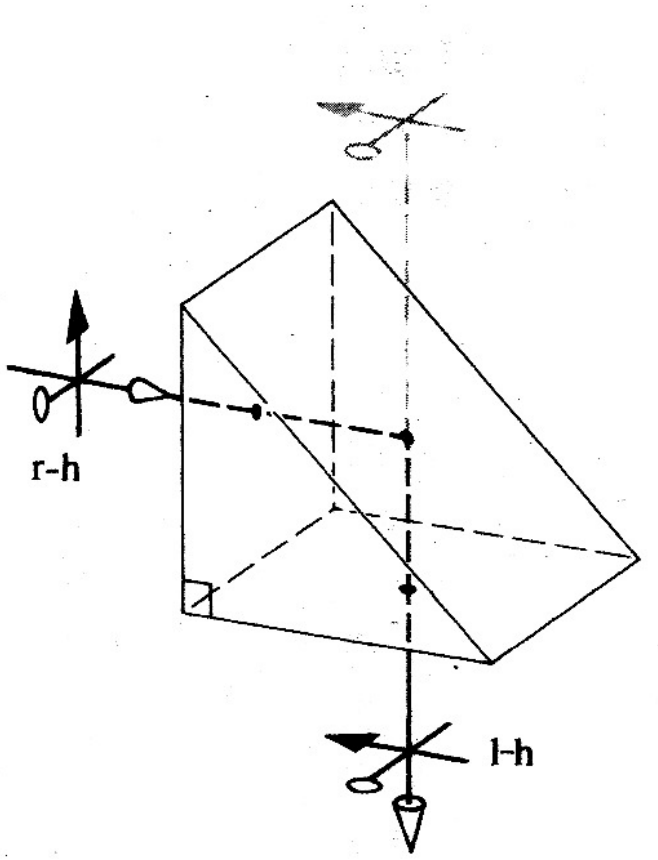


$$v = c/n$$

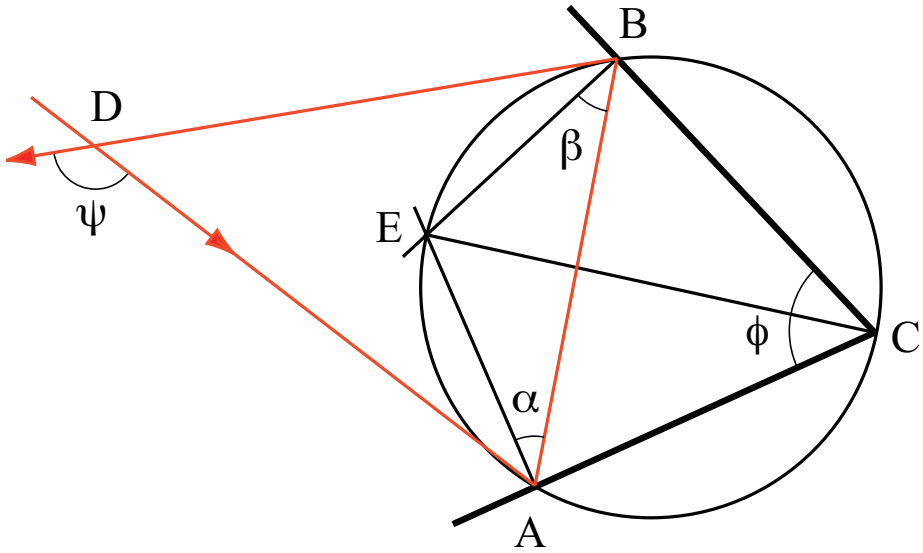
直角プリズム



全反射

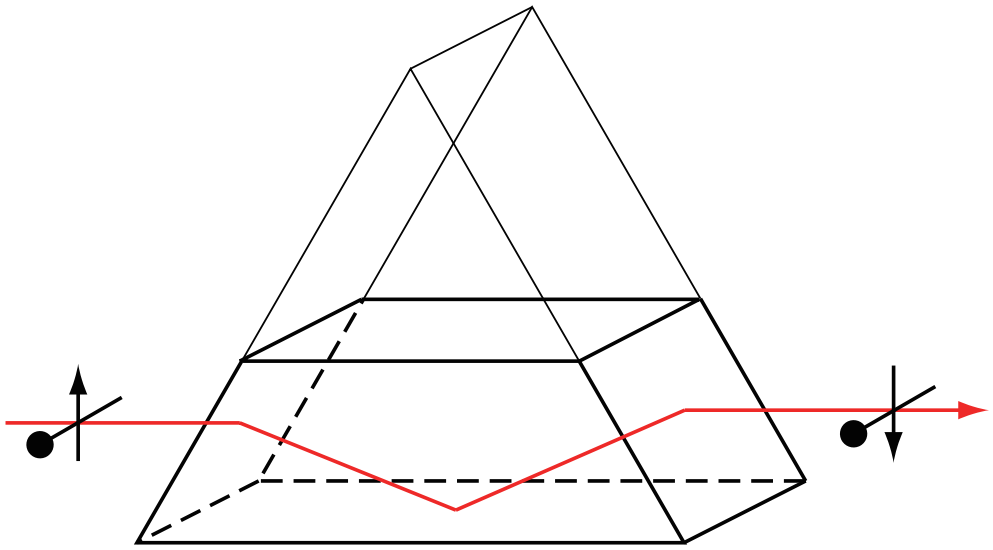


２枚鏡



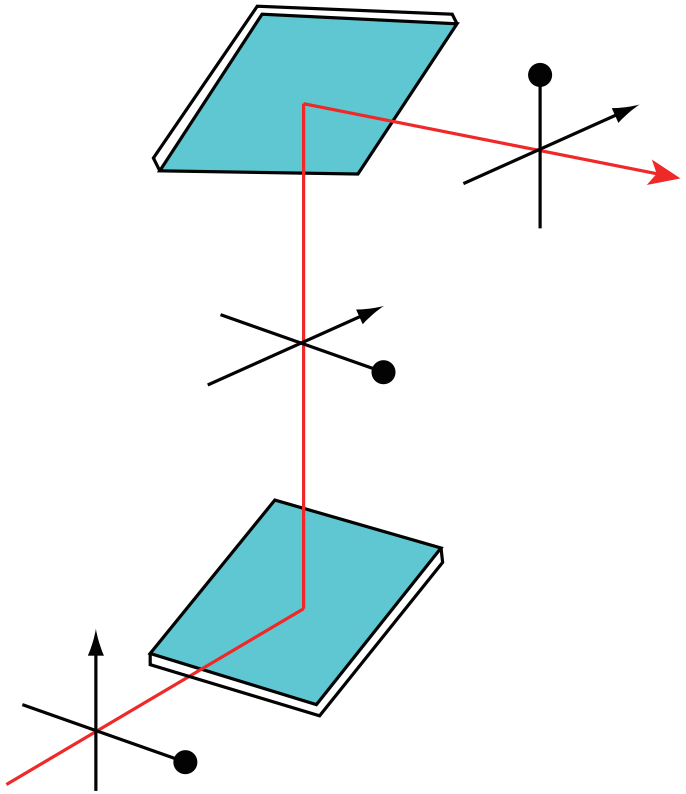
$$\psi = 2\varphi = 2(\alpha + \beta)$$

屋根型プリズム
Dove prism



プリズムを回転すると
透過画像は2倍の速度で回転する

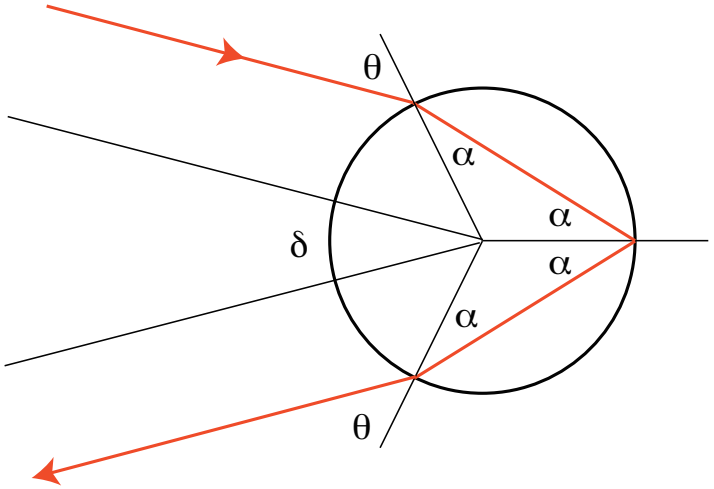
捩れ潜望鏡

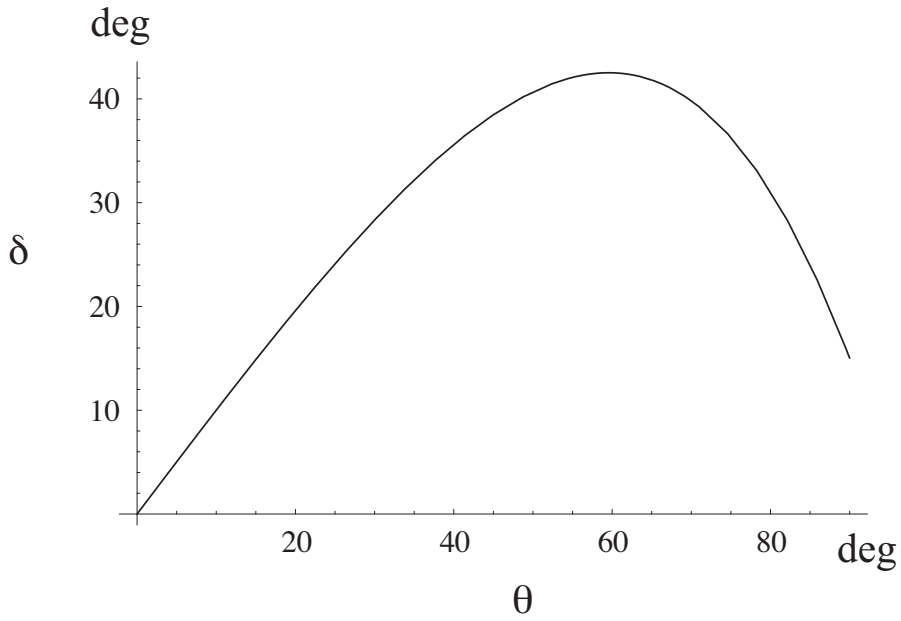


虹

Glasgow

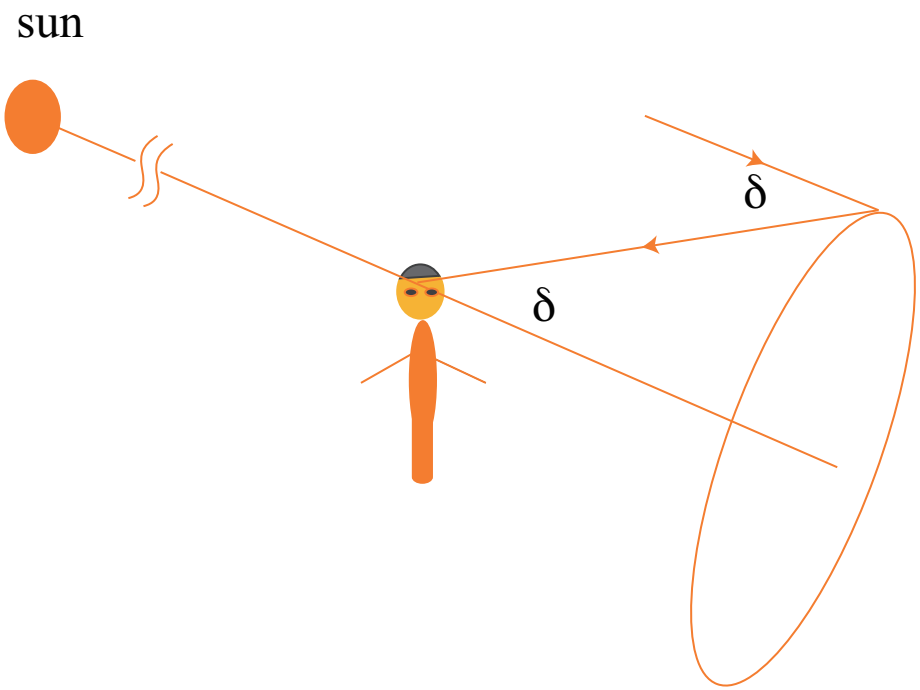
偏角



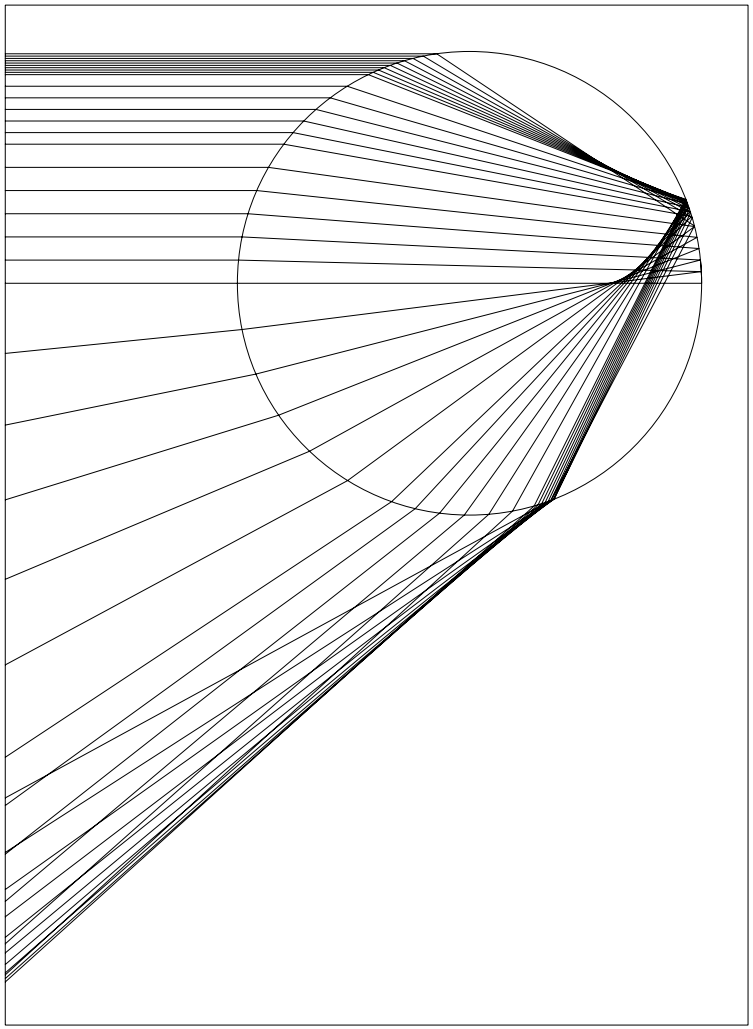


偏角　$\delta = 4\alpha - 2\theta$

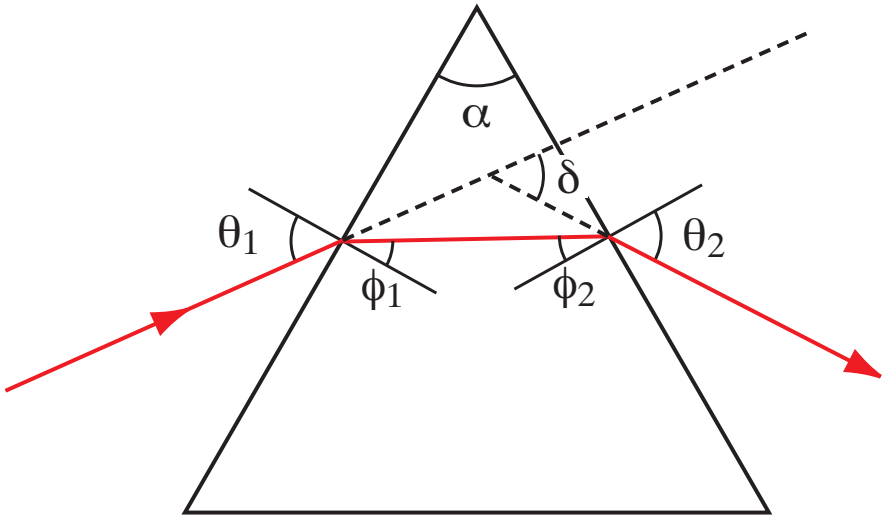
虹の見え方

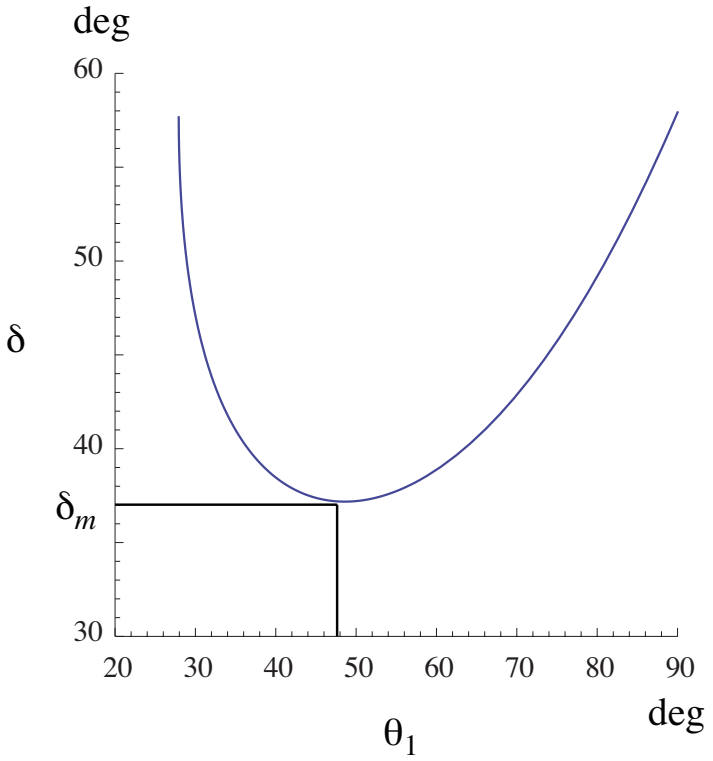


虹の光線追跡



プリズム





最小偏角

$$\theta_1 = \theta_2$$

$$\sin\frac{\delta_m + \alpha}{2} = n\sin\frac{\alpha}{2}$$