CRYSTAL OPTICS

“Handbook of nonlinear optical crystals” by Dmitriev, Gurzadyan and Nikogosyan

Born and Wolf
Pages 790-795

CRYSTALS

$$P_i = \sum_j \epsilon_0 \chi_{ij} E_j$$

$$D_i = \epsilon_0 E_i + \sum_j \epsilon_0 \chi_{ij} E_j = \sum_j \epsilon_{ij} E_j$$

$$\epsilon_{ij} = \epsilon_0 (\delta_{ij} + \chi_{ij})$$

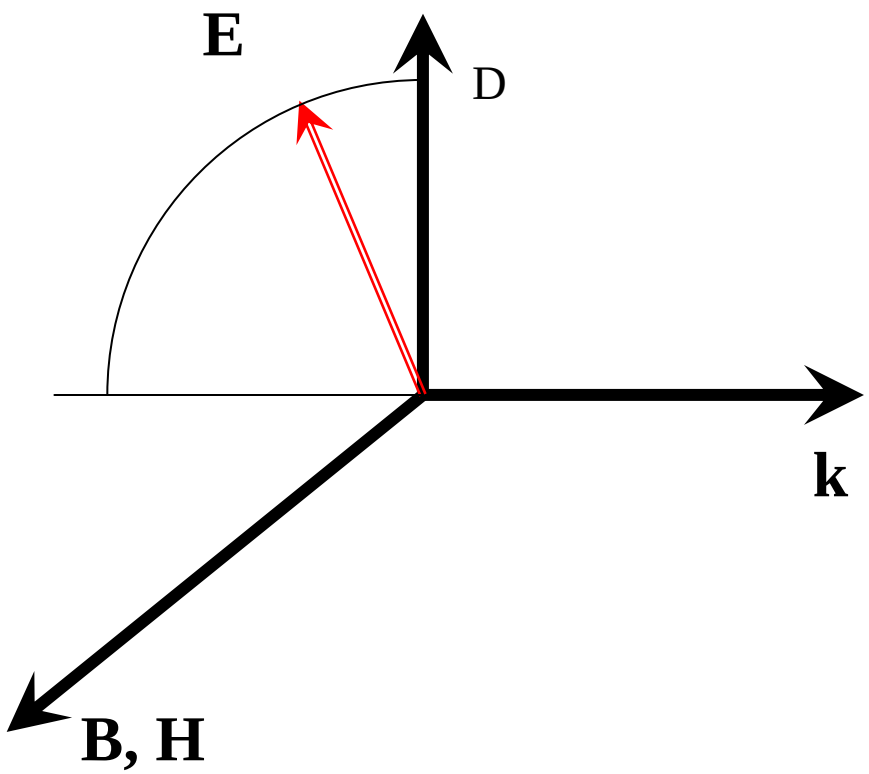
With respect to principal axis:

Uniaxial crystal

$$\begin{vmatrix} \epsilon_1 & 0 & 0 \\ 0 & \epsilon_1 & 0 \\ 0 & 0 & \epsilon_3 \end{vmatrix}$$

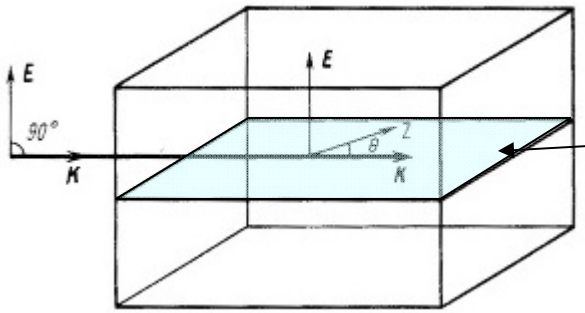
Biaxial crystal

$$\begin{vmatrix} \epsilon_1 & 0 & 0 \\ 0 & \epsilon_2 & 0 \\ 0 & 0 & \epsilon_3 \end{vmatrix}$$


E
D
k
B, H

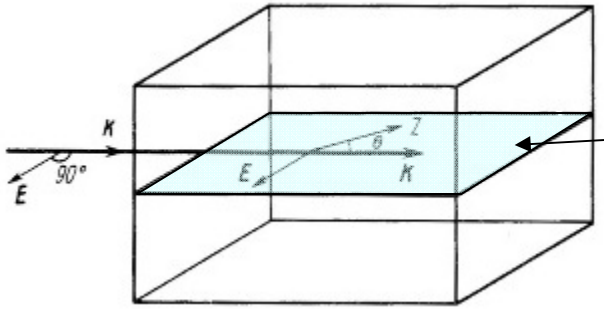
Uniaxial crystals

Ordinary ray



Principal plane

Extraordinary ray



Principal plane

Uniaxial crystals

$$n^e(\theta) = n_0 \sqrt{\frac{1 + \tan^2\theta}{1 + (\frac{n_0}{n_e})^2 \tan^2\theta}}$$

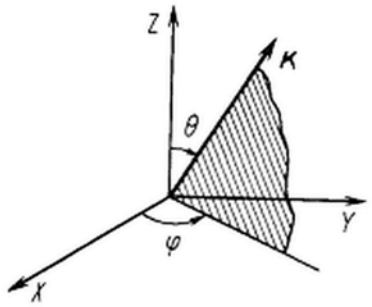


Fig. 2.4. Polar coordinate system for description of refractive properties of uniaxial crystal (*K* is the light propagation direction, *Z* is the optic axis, θ and φ are the coordinate angles)

n^e does not depend on φ

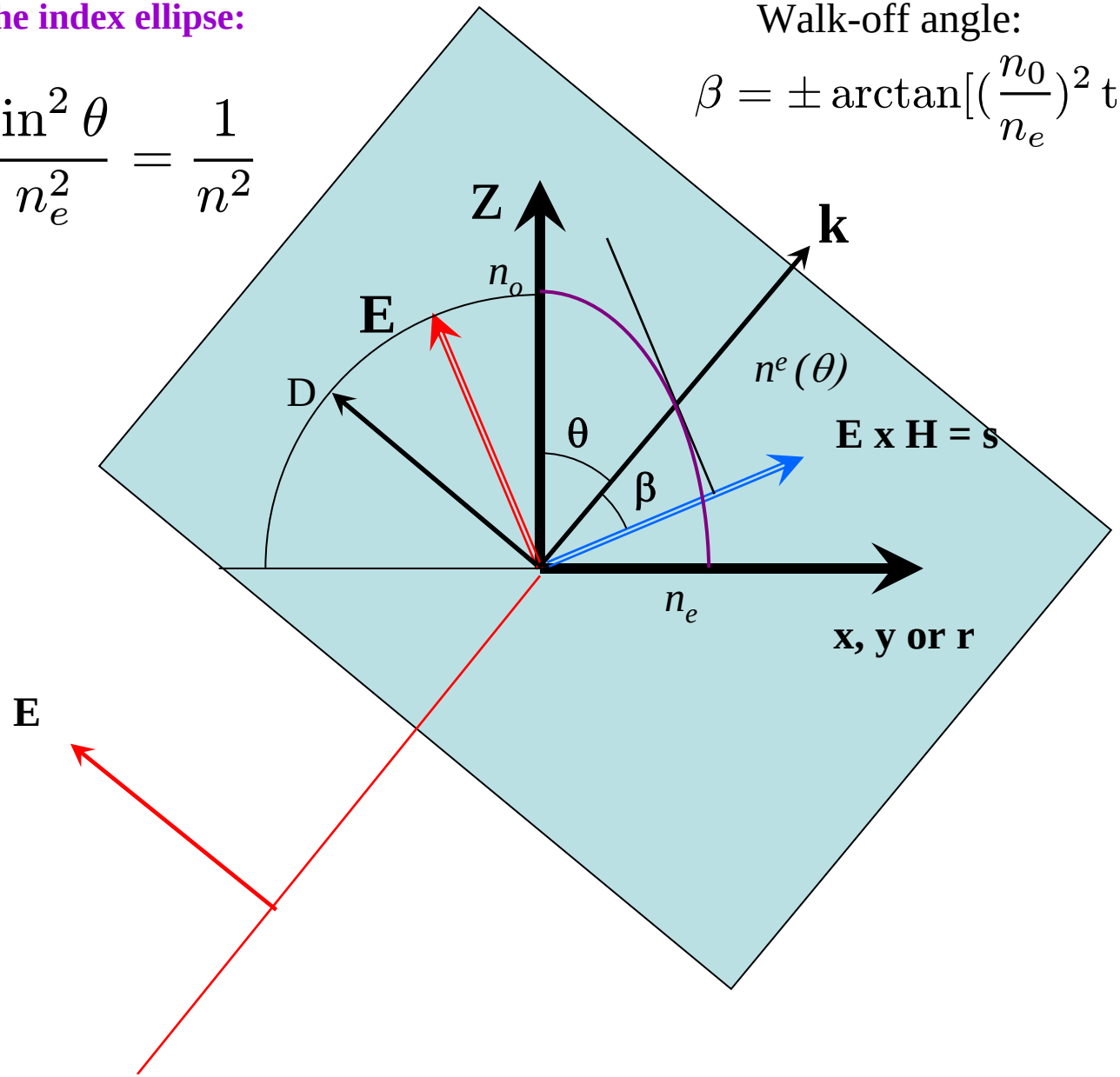
Uniaxial crystals

Equation of the index ellipse:

$$\frac{\cos^2\theta}{n_0^2} + \frac{\sin^2\theta}{n_e^2} = \frac{1}{n^2}$$

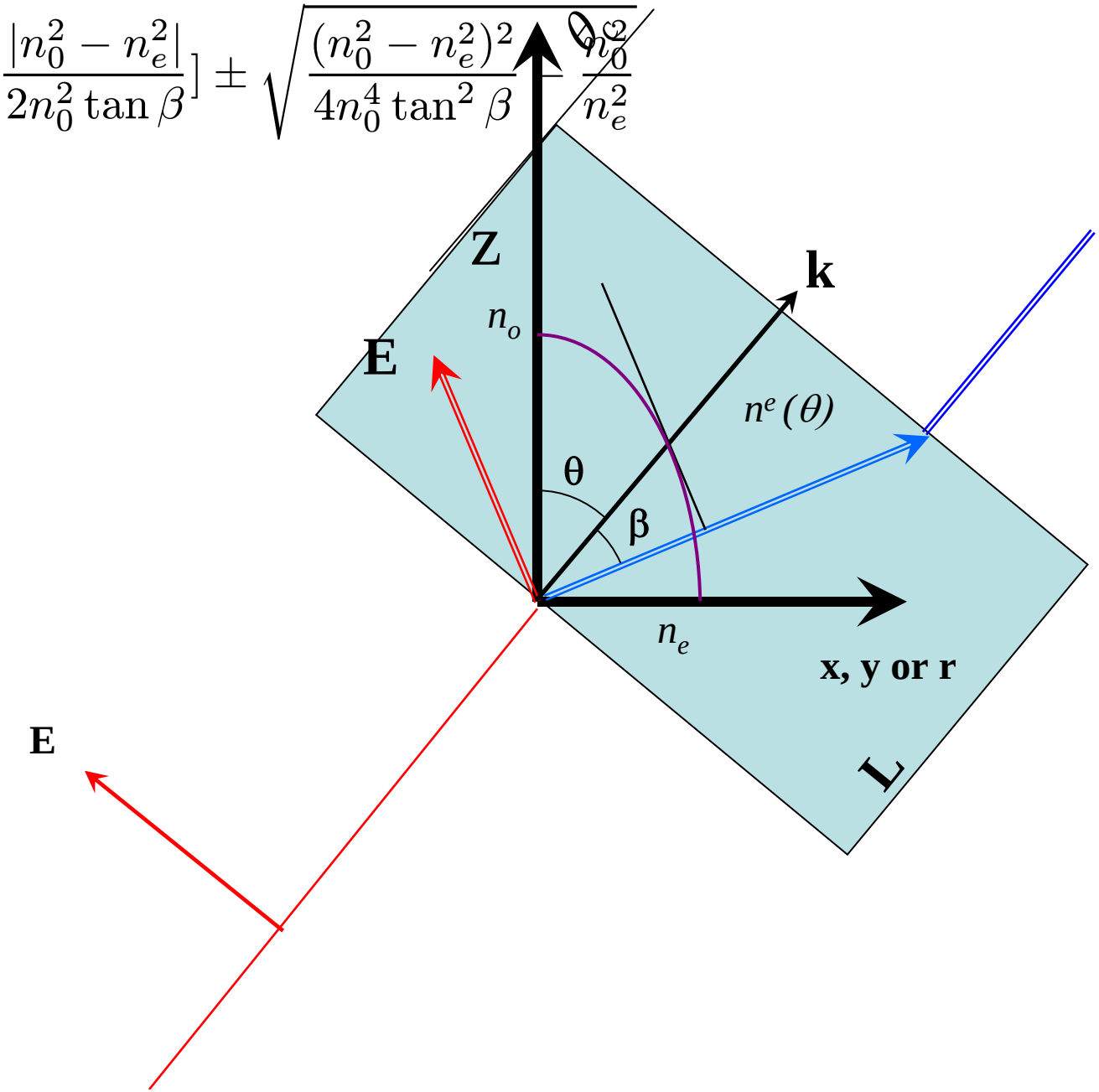
Walk-off angle:

$$\beta = \pm \arctan[(\frac{n_0}{n_e})^2 \tan\theta] \mp \theta$$

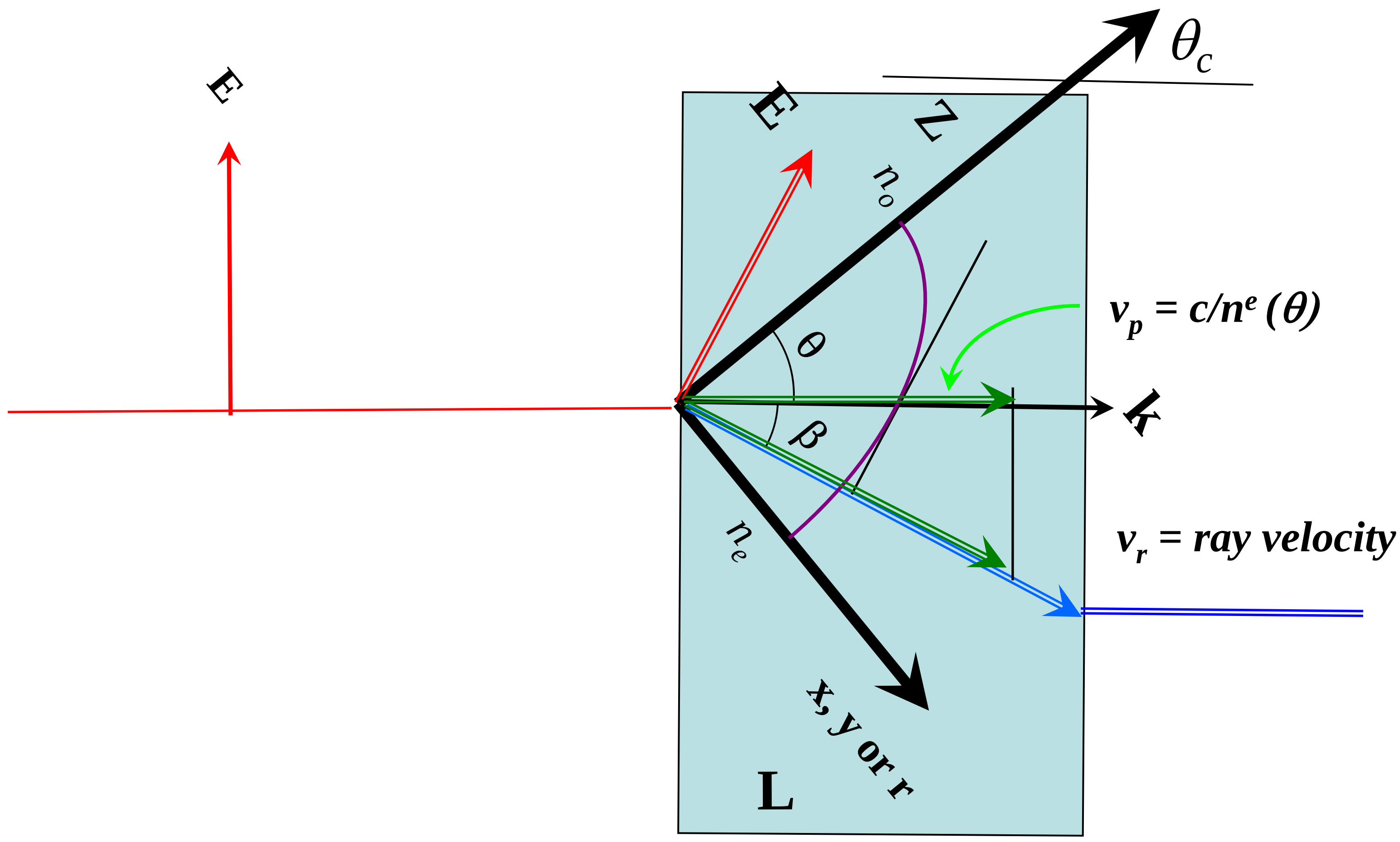


Orienting Uniaxial crystals

$$\theta_c = \arctan\left[\frac{|n_0^2 - n_e^2|}{2n_0^2 \tan\beta}\right] \pm \sqrt{\frac{(n_0^2 - n_e^2)^2}{4n_0^4 \tan^2\beta} - \frac{n_0^2}{n_e^2}}$$



Velocities in Uniaxial crystals



Quote from Born & Wolf: The ray velocity is a useful concept, although, like the phase velocity, it has no directly verifiable physical significance!!

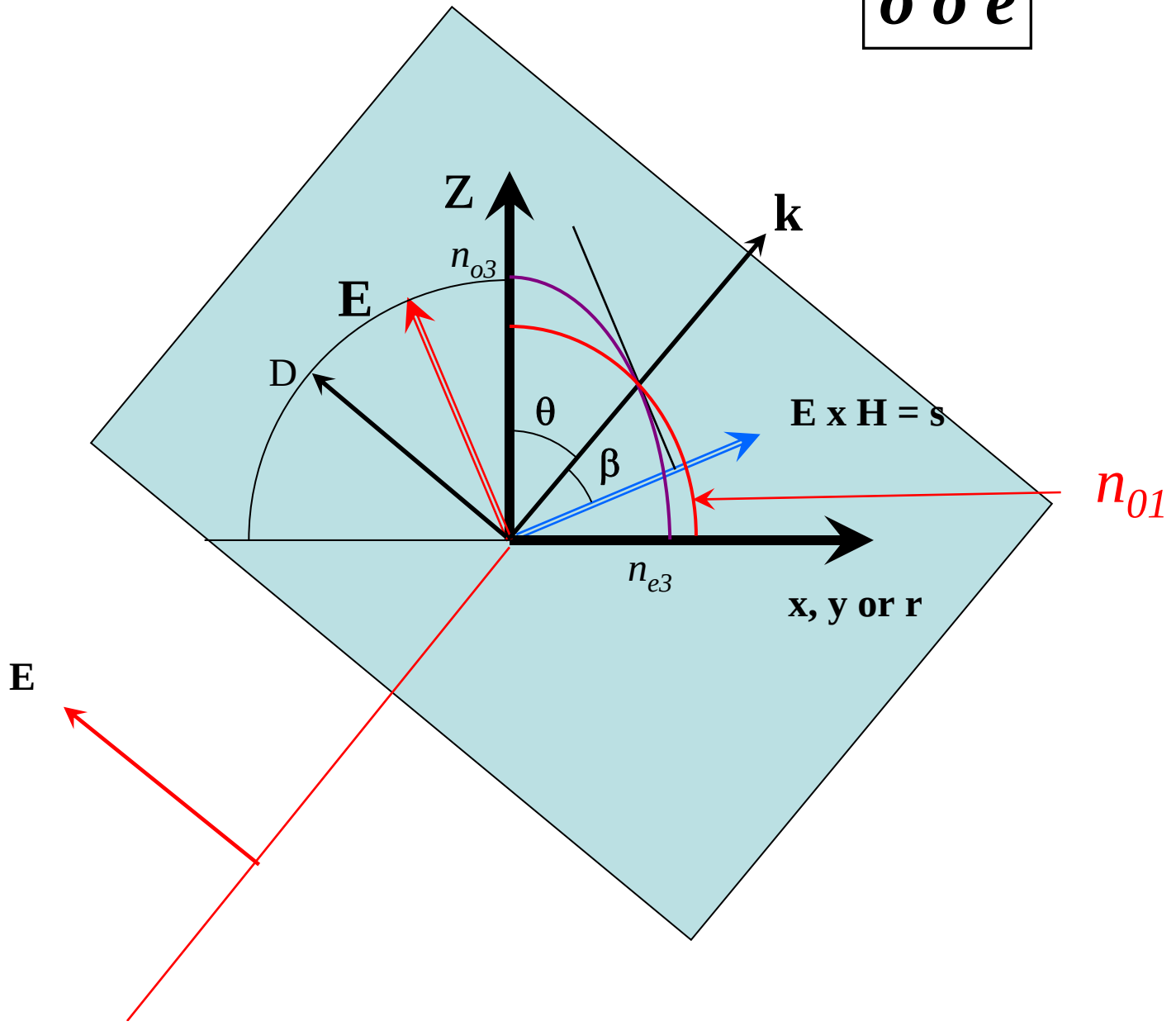
NONLINEAR OPTICS

“Handbook of nonlinear optics”
by Richard L. Sutherland

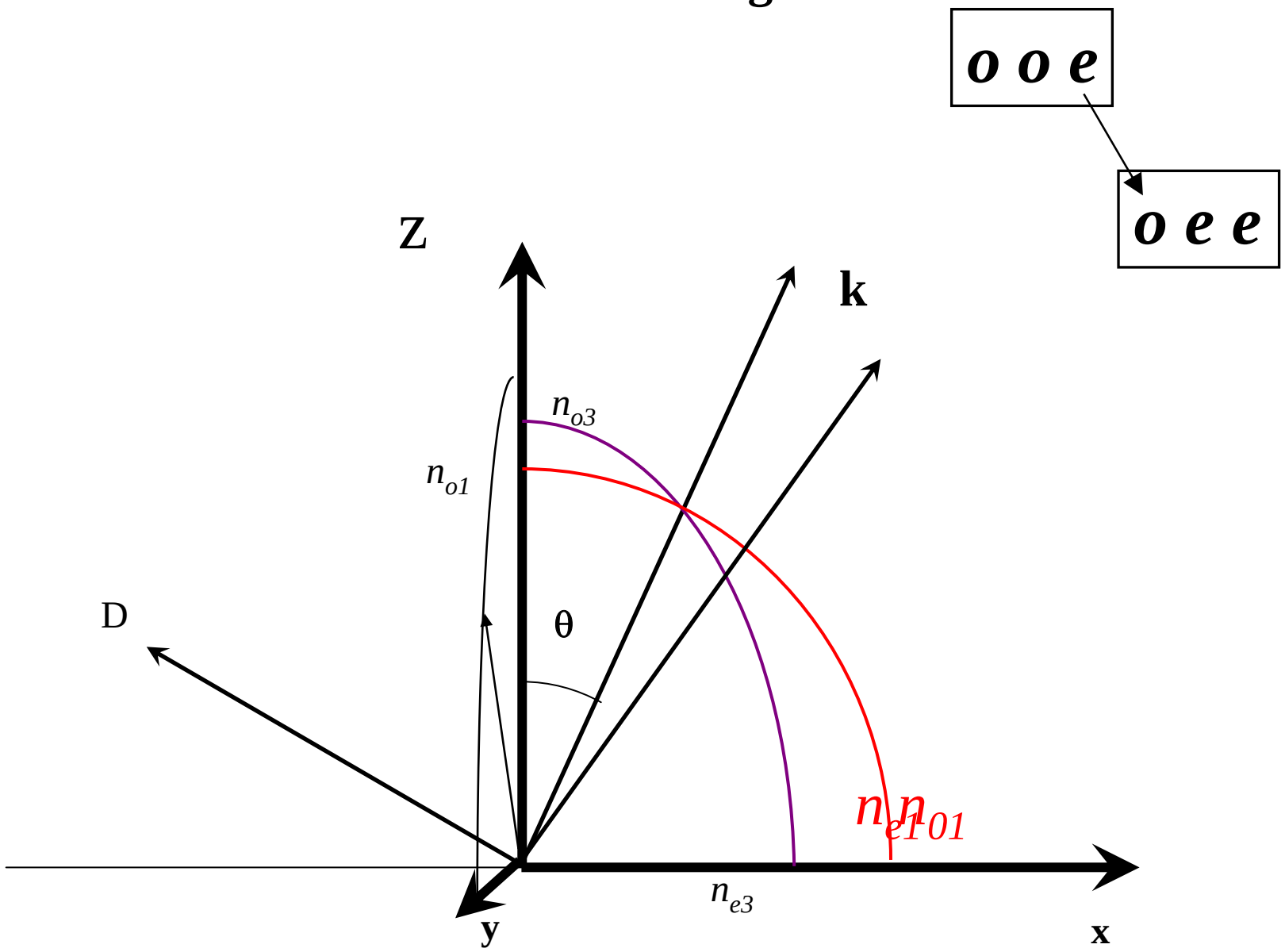
“Handbook of nonlinear optical crystals”
by Dmitriev, Gurzadyan and Nikogosyan

Phase matching

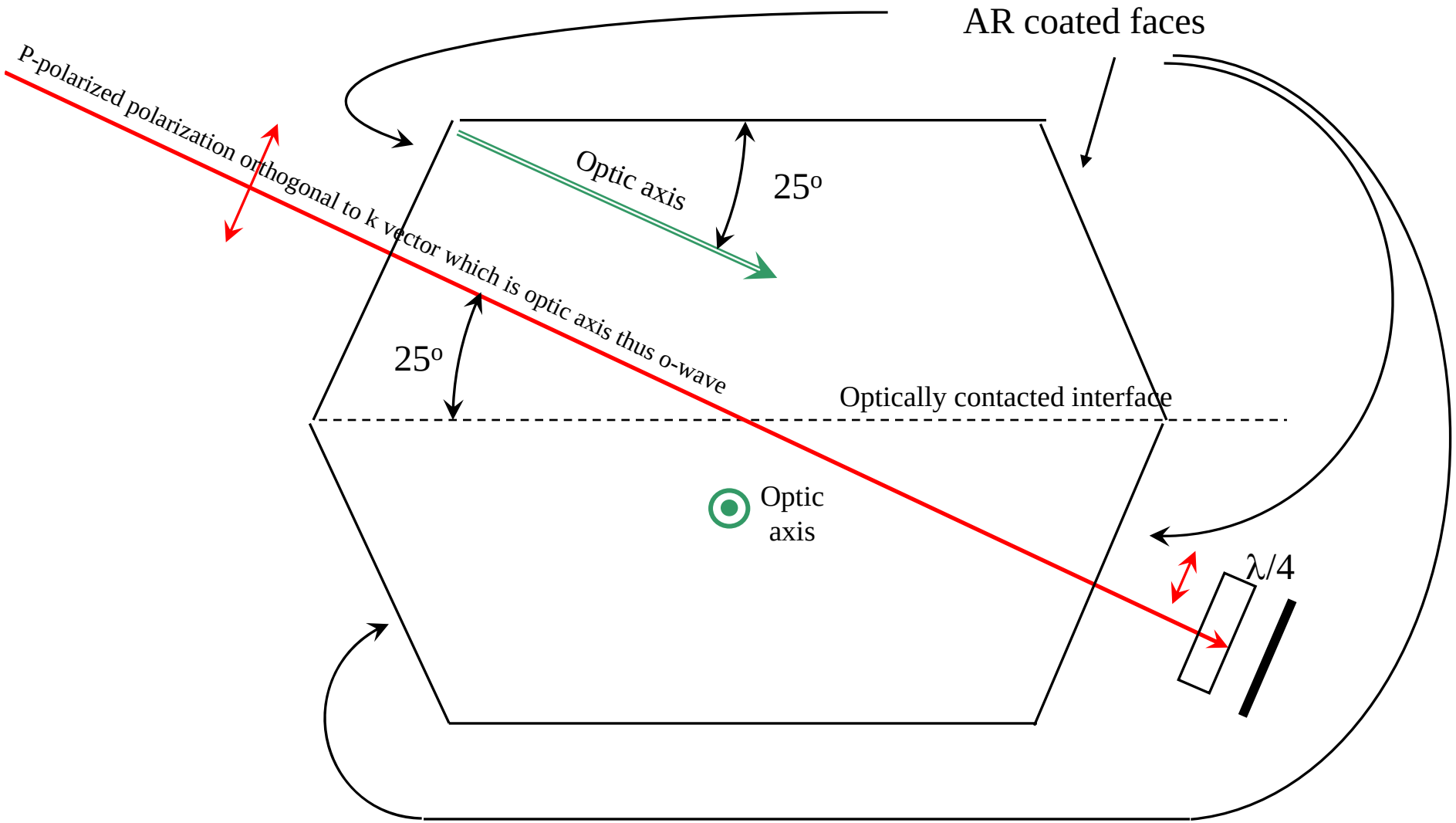
o o e



Phase matching



POSITIVE uniaxial crystals (extraordinary index> ordinary) **YVO_4**



After interface, still o-wave, since p-wave polarized in plane of paper, optic axis perpendicular to paper in second crystal

No change of index at the interface for a p-wave