Electro-Optics:

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Yoonchan Jeong
School of Electrical Engineering, Seoul National University
Tel: +82 (0)2 880 1623, Fax: +82 (0)2 873 9953
Email: yoonchan@snu.ac.kr

Quadratic Electro-Optic Effect

$$\rightarrow s_{ij} = \begin{pmatrix} s_{11} & s_{12} & s_{13} & s_{14} & s_{15} & s_{16} \\ s_{21} & s_{22} & s_{23} & s_{24} & s_{25} & s_{26} \\ s_{31} & s_{22} & s_{33} & s_{34} & s_{35} & s_{36} \\ s_{41} & s_{22} & s_{43} & s_{44} & s_{45} & s_{46} \\ s_{51} & s_{22} & s_{53} & s_{54} & s_{55} & s_{56} \\ s_{61} & s_{22} & s_{53} & s_{64} & s_{65} & s_{66} \end{pmatrix}$$

Permutation symmetries:

$$\rightarrow s_{ijkl} = s_{jikl}$$

$$\rightarrow s_{ijkl} = s_{ijlk} \qquad \rightarrow 1 = (11),\ 2 = (22),\ 3 = (33),$$

$$4 = (23) = (32),\ 5 = (13) = (31),\ 6 = (12) = (21)$$

Index ellipsoid:

$$\rightarrow \eta_{ij}(\mathbf{E}) = \eta_{ij}(0) + r_{ijk}E_k + s_{ijkl}E_kE_l$$

$$\rightarrow x^2\left(\frac{1}{n_x^2} + s_{11}E_x^2 + s_{12}E_y^2 + s_{13}E_z^2 + 2s_{14}E_yE_z + 2s_{15}E_zE_x + 2s_{16}E_xE_y\right)$$

$$+ y^2\left(\frac{1}{n_y^2} + s_{21}E_x^2 + s_{22}E_y^2 + s_{23}E_z^2 + 2s_{24}E_yE_z + 2s_{25}E_zE_x + 2s_{26}E_xE_y\right)$$

$$+ z^2\left(\frac{1}{n_z^2} + s_{31}E_x^2 + s_{32}E_y^2 + s_{33}E_z^2 + 2s_{34}E_yE_z + 2s_{35}E_zE_x + 2s_{36}E_xE_y\right)$$

$$+ 2yz\left(s_{41}E_x^2 + s_{42}E_y^2 + s_{43}E_z^2 + 2s_{44}E_yE_z + 2s_{45}E_zE_x + 2s_{46}E_xE_y\right)$$

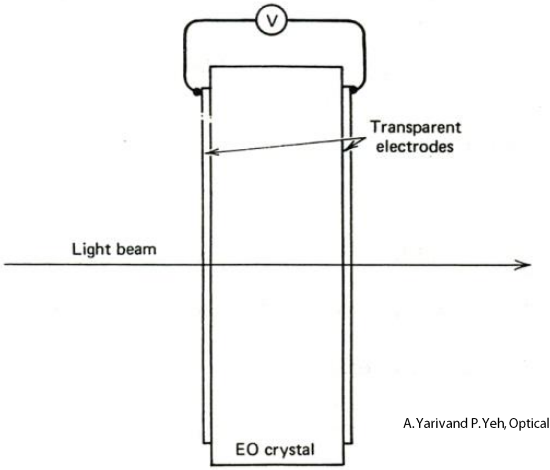
$$+ 2zx\left(s_{51}E_x^2 + s_{52}E_y^2 + s_{53}E_z^2 + 2s_{54}E_yE_z + 2s_{55}E_zE_x + 2s_{56}E_xE_y\right)$$

$$+ 2xy\left(s_{61}E_x^2 + s_{62}E_y^2 + s_{63}E_z^2 + 2s_{64}E_yE_z + 2s_{65}E_zE_x + 2s_{66}E_xE_y\right) = 1$$

Electro-Optic Light Modulators

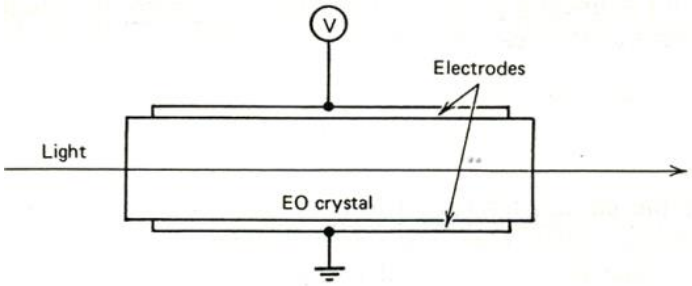
Longitudinal electro-optic modulation:

→ Large acceptance area with a thin EO crystal plate



A. Yarivand P. Yeh, Optical Waves in Crystals, John Wiley & Sons, 1984.

Transverse electro-optic modulation:

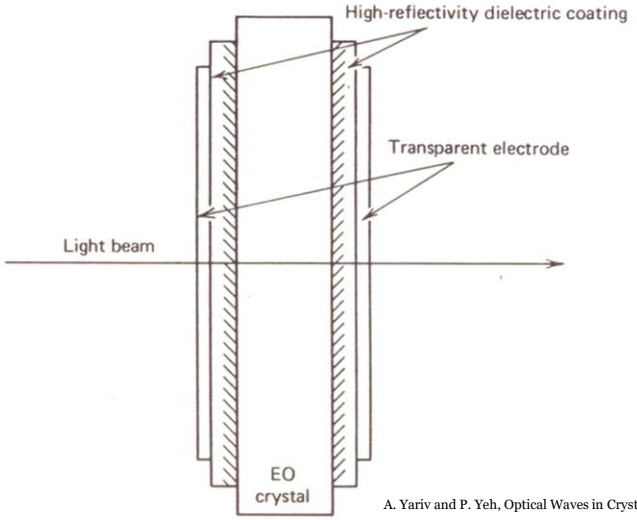


A. Yariv and P. Yeh, Optical Waves in Crystals, John Wiley & Sons, 1984.

→ Long interaction length at a given field strength

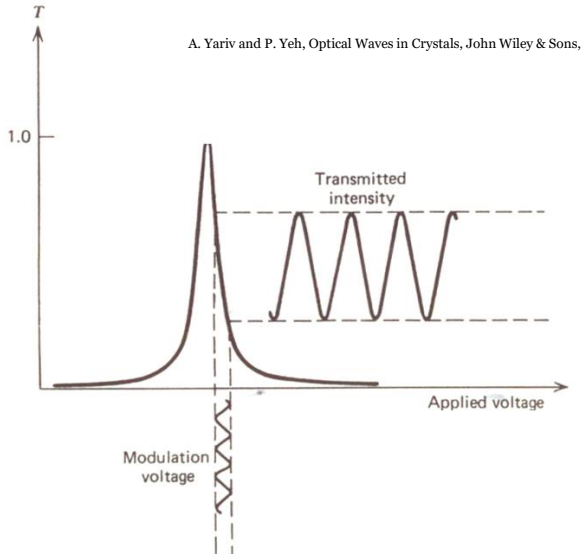
Electro-Optic Fabry-Perot Modulators

Electro-optic amplitude modulator:



A. Yariv and P. Yeh, Optical Waves in Crystals, John Wiley & Sons, 1984.

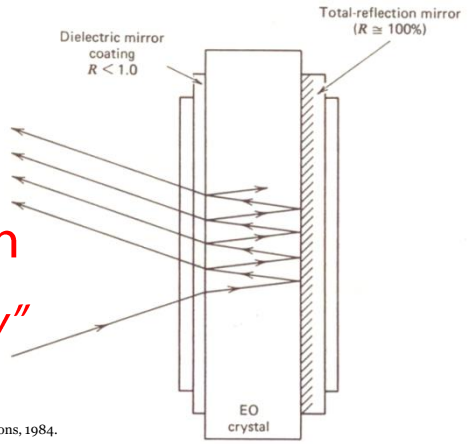
Transmission as a function of applied voltage:



A. Yariv and P. Yeh, Optical Waves in Crystals, John Wiley & Sons, 1984.

→ Gires-Tournois eltalon

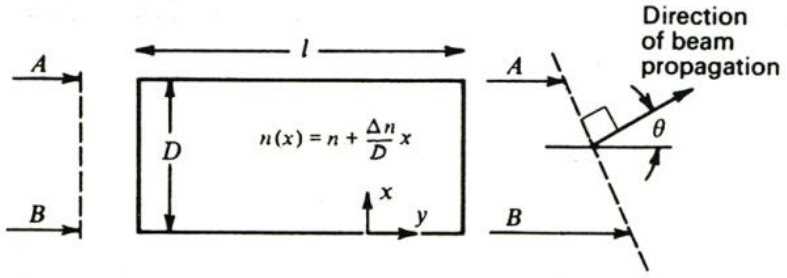
"Phase modulation only"



A. Yariv and P. Yeh, Optical Waves in Crystals, John Wiley & Sons, 1984.

Electro-Optic Beam Deflectors

Double-prism KDP beam deflectors:



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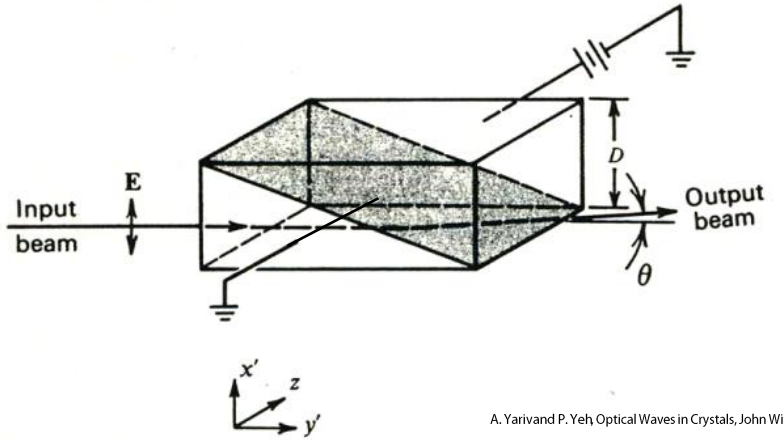

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Electro-Optic Property of Liquid Crystal

Liquid crystals:

Liquid crystal phases: smectic, nematic, and cholesteric
Nematic LC: uniaxial dipole moment
$\rightarrow$ Dynamic director alignment along the applied electric field
$\rightarrow$ Switching time: ~msec

Twisted nematic LC in liquid crystal displays (LCDs)