Optical fiber interferometry

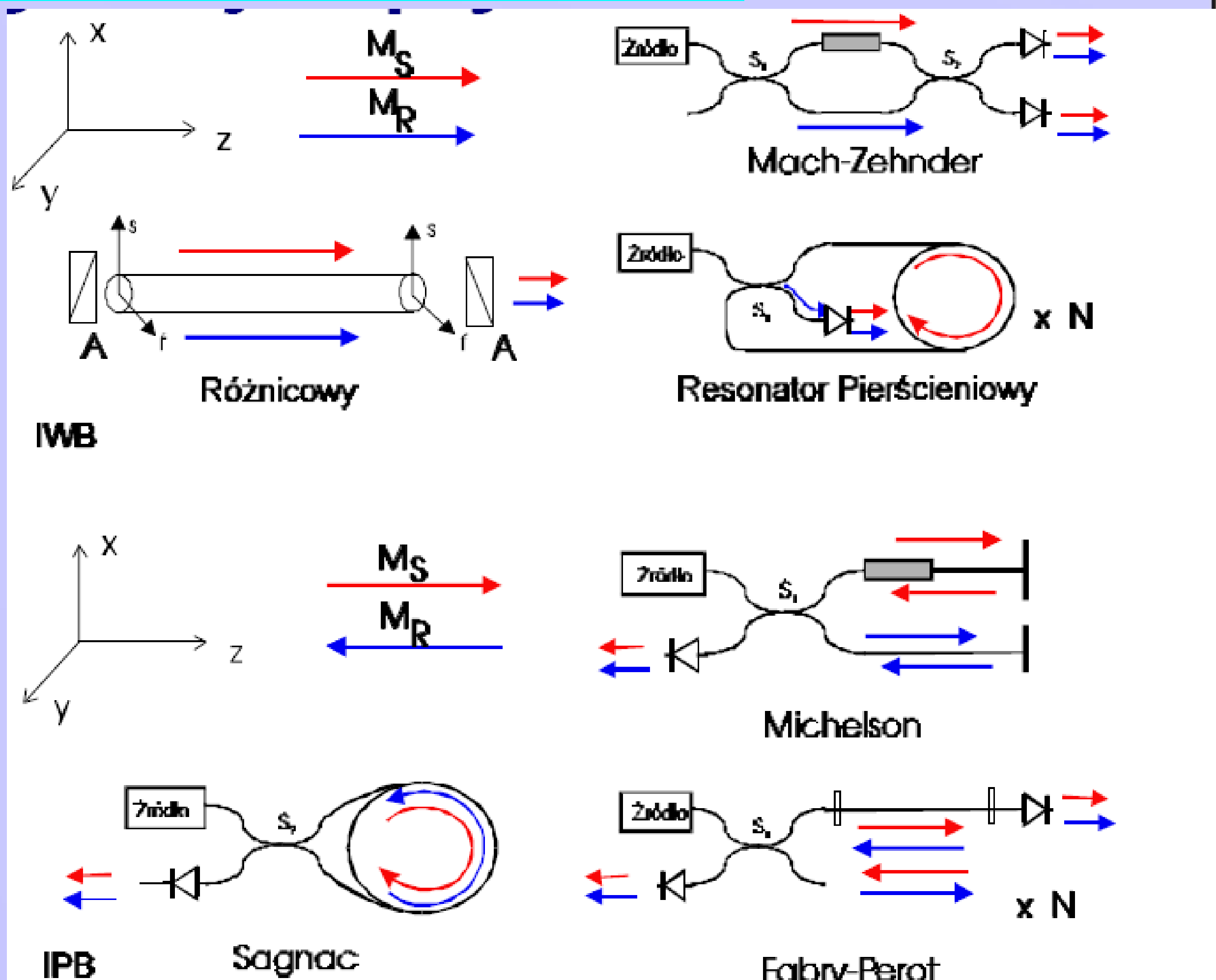
- Signal processing
  - optical considerations

Optical processing

The phase or polarization demodulation optical carrier is obtained by interefrometer system application, futher siganl processing on useful form is realized by electronics processing.

IWB (CMW) – Common–way interferometer
IPB (CCW) – Conter-way interferometer
ANALYSE:

1. Coupler influence
2. PT localisation influence
3. Configuration influence



With polarisation – ideal construction: the Kapron law about an optical system equivalence:

$$\mathbf{M}_s \equiv \mathbf{R}(\Omega)\mathbf{G}(\delta)\mathbf{M}(\Phi)$$

The Jones vector for the optical source:

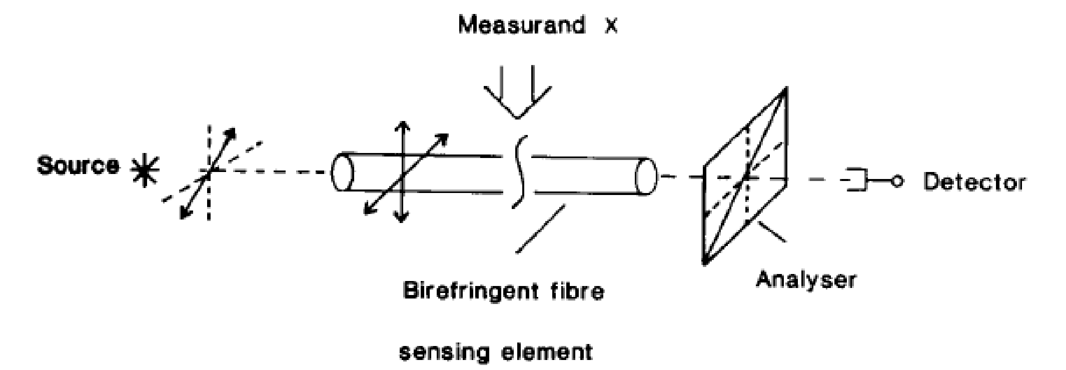
$$\mathbf{E} = e^{i\omega t}\begin{bmatrix} E_x \\ E_y e^{i\Delta} \end{bmatrix} = \ldots = \begin{bmatrix} E_x \\ E_y e^{i\Delta} \end{bmatrix} = \ldots = \begin{bmatrix} \cos\beta \\ \sin\beta e^{i\Delta} \end{bmatrix}$$

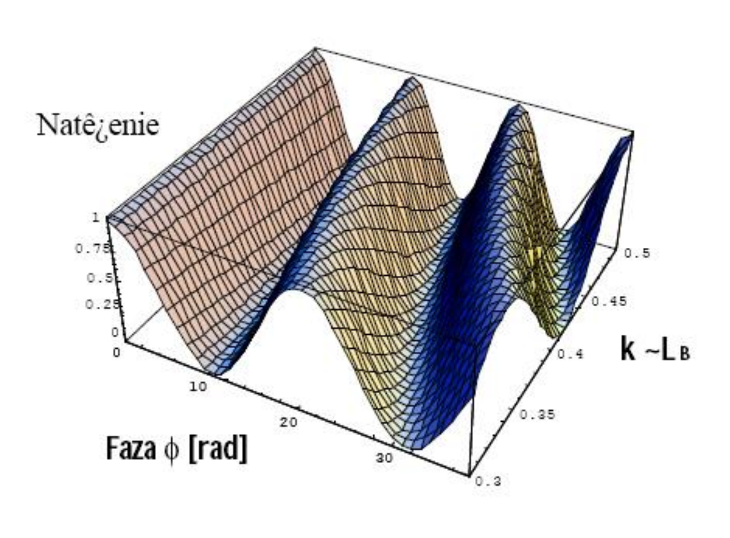
General matrix of system: $m = \mathbf{E}_{we}^{+}\mathbf{M}_{R}^{+}\mathbf{M}_{S}\mathbf{E}_{we} \in C$

Transfer function: $I = 0.5\{1 \pm V\cos[\phi' + \phi_0]\}$

V=Abs(m)	$\phi'=f(\phi)$	ϕ_0 =arg(m)
Scale factor Responsitivity	Configuration Dynamic range	Bias Drift

Linear polarimeter:





Transfer function:

$$E_1 = A(\alpha) F E_0$$

$$A = \begin{pmatrix} \cos^2\alpha & \sin\alpha\cos\alpha \\ \sin\alpha\cos\alpha & \sin^2\alpha \end{pmatrix}$$

$$F = \begin{pmatrix} e^{i(\phi_1 + 1/2\phi_2)} & 0 \\ 0 & e^{i(\phi_1 - 1/2\phi_2)} \end{pmatrix}$$

$$E_0 = \begin{pmatrix} \cos\delta \\ e^{i\beta}\sin\delta \end{pmatrix}$$

$$I = \frac{1}{2} I_0 (1 + \cos 2\alpha \cos 2\delta)[1 + V\cos(\phi_2 - \beta)]$$

$$V = \sin 2\alpha \sin 2\delta / (1 + \cos 2\alpha \cos 2\delta)$$

for $\delta=\alpha=\pi/4$

$$I_1 = \frac{1}{2} I_0 [1 + \cos(\phi_2 - \beta)]$$

The polarisation properties change has influence only on dynamic range

Circular polarimeter:

$$F = \begin{pmatrix} \cos\phi_3 & \sin\phi_3 \\ -\sin\phi_3 & \cos\phi_3 \end{pmatrix}$$

$$E_0 = \begin{bmatrix} \cos\delta \\ \sin\delta \end{bmatrix}$$

$$I_1 = \frac{1}{2} I_0 [1 + \cos 2(\phi_3 + \delta - \alpha)]$$

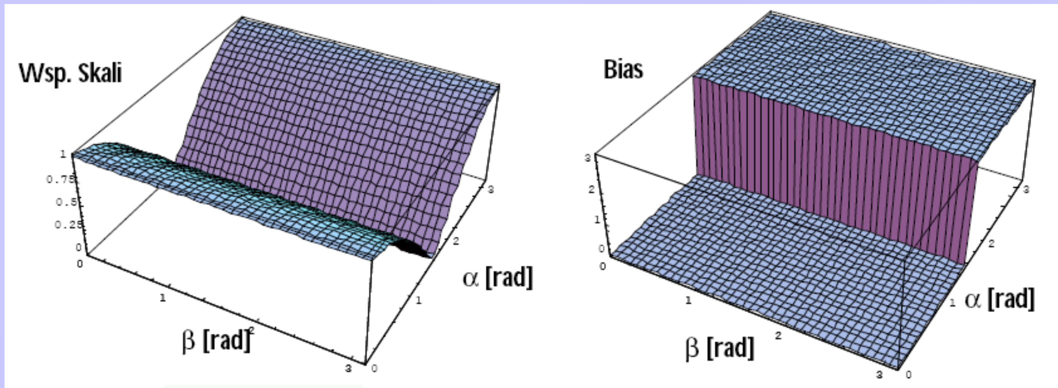
Mach-Zehnder interferometer:

$$m = \mathbf{E}^{+}_{we}\mathbf{R}(\Omega)\mathbf{G}(\delta)\mathbf{R}(\Phi)\mathbf{E}_{we}$$

a. Only twist: $\mathbf{M}_S = \mathbf{R}(\alpha)$

$$V = \sqrt{\cos^2\alpha + \sin^2\alpha \sin^2(2\beta)\sin^2\Delta}$$

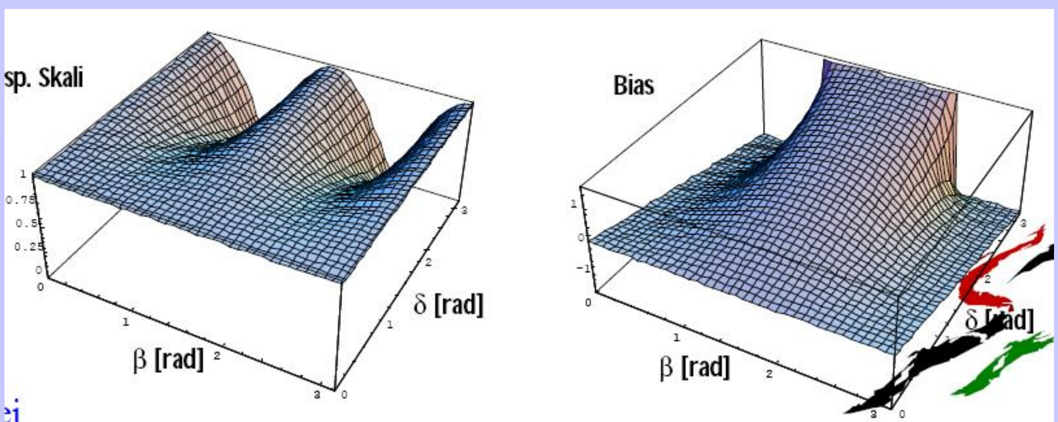
$$\phi_0 = arctg[-tg\alpha \sin(2\beta)\sin\Delta]$$



b. Only birefringence: $\mathbf{M}_S = \mathbf{G}(\delta)$

$$V = \sqrt{\cos^2(\delta/2) + \sin^2(\delta/2)\cos(2\beta)}$$

$$\phi_0 = arctg[-tg(\delta/2)\cos(2\beta)]$$



MZ (Ring Interferometer) is very sensitive on input SOP changes as well as polarisation properties of the optical fiber

Michelson (Fabry-Perot) interferometer:

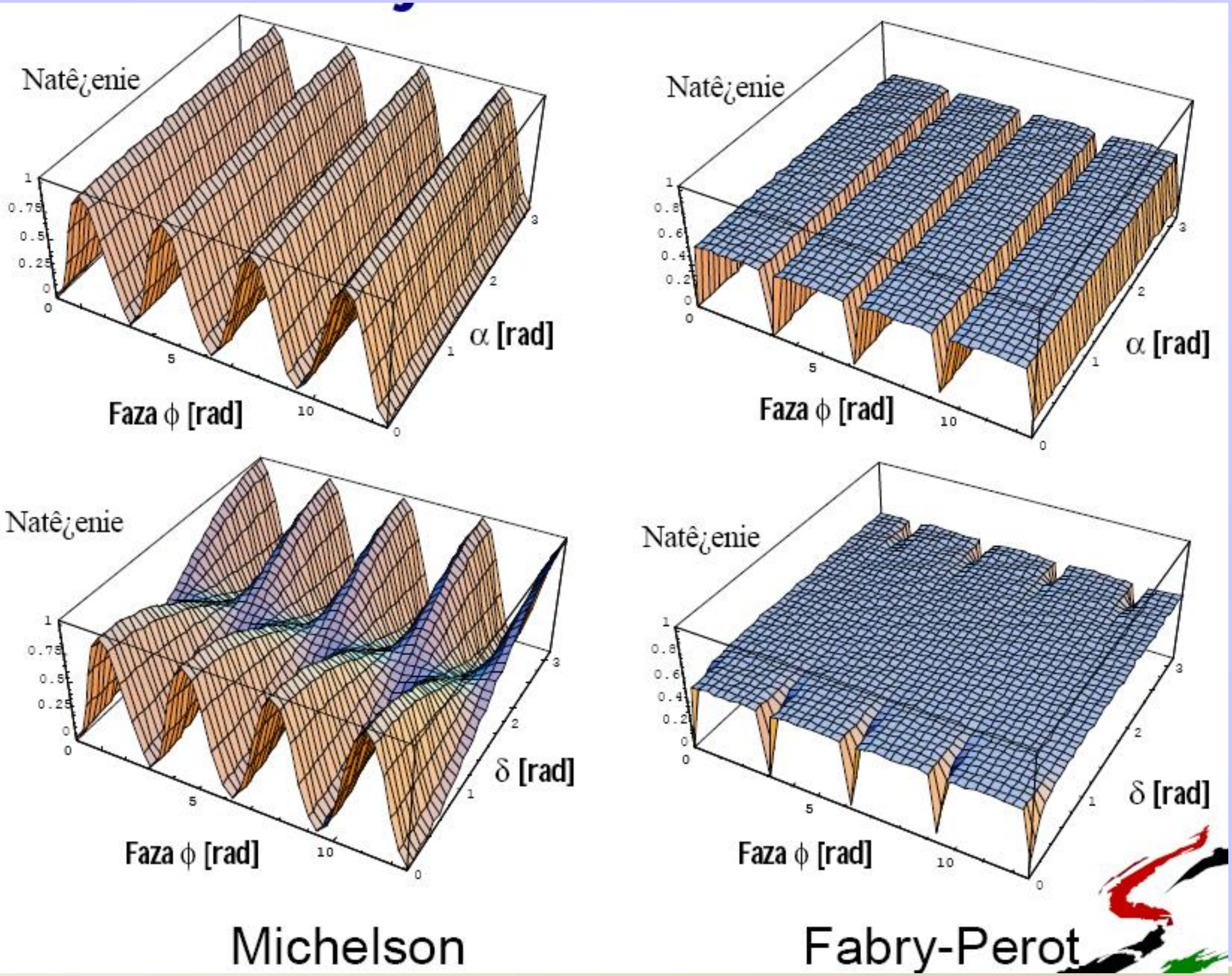
Input beam with linear SOP ($\beta=\pi/4$)

$$I = \frac{I_0}{1 + F\sin^2\phi/2}$$

$$F = 4R/(1 - R)^2$$

IM (FP) is more polarisation stabile.

Noninfluence of fiber twist, but twice bigger influence of fiber birefringence.

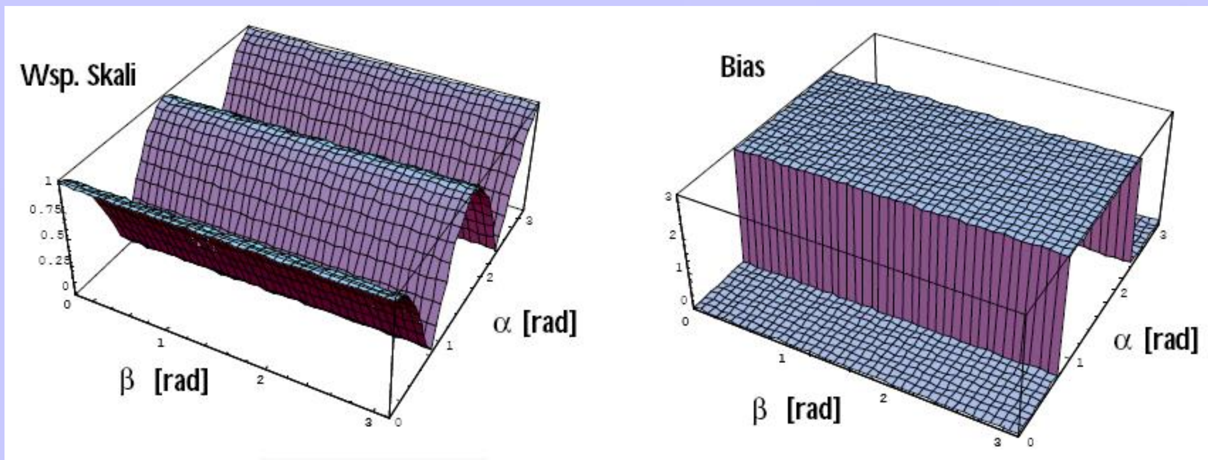


Sagnac interferometer:

$$m = \mathbf{E}^{+}_{we}\mathbf{R}(\Omega)\mathbf{G}(-\delta)\mathbf{R}(\Phi+\Omega)\mathbf{G}(\delta)\mathbf{R}(\Phi)\mathbf{E}_{we}$$

a. Only twist: $\mathbf{M}_S = \mathbf{R}(\alpha)$

$$V = \sqrt{\cos^2(2\alpha) + \sin^2(2\alpha)\sin^2(2\beta)\sin^2\Delta} \qquad \phi_0 = arctg[-tg(2\alpha)\sin(2\beta)\sin\Delta]$$



b. Only birefringence: $\mathbf{M}_S = \mathbf{G}(\delta)$

$$V = 1 \quad \phi_0 = 0$$

The Sagnac interferometer has nonsensitivity on clear birefringence of the optical fiber.

The polarisation influece reduction:

- application Hi-BI fiber (increase system cost 3 USD/m, the elements should be adjusted according SOP)
- polarisation correction via polarization controller
- reduction of the „freedom degrees" (Φ–δ–Ω):
    - differential – polarisation filtration (has been shown)
    - MZ and RR unstabile – active polarisation controller
    - choose the proper configuration:
        - CCW insted of CMW (more stabile)
        - SOP detection in real time (polarise-phase detection scheme)
        - reciprocal configuration of Sagnac interferometer