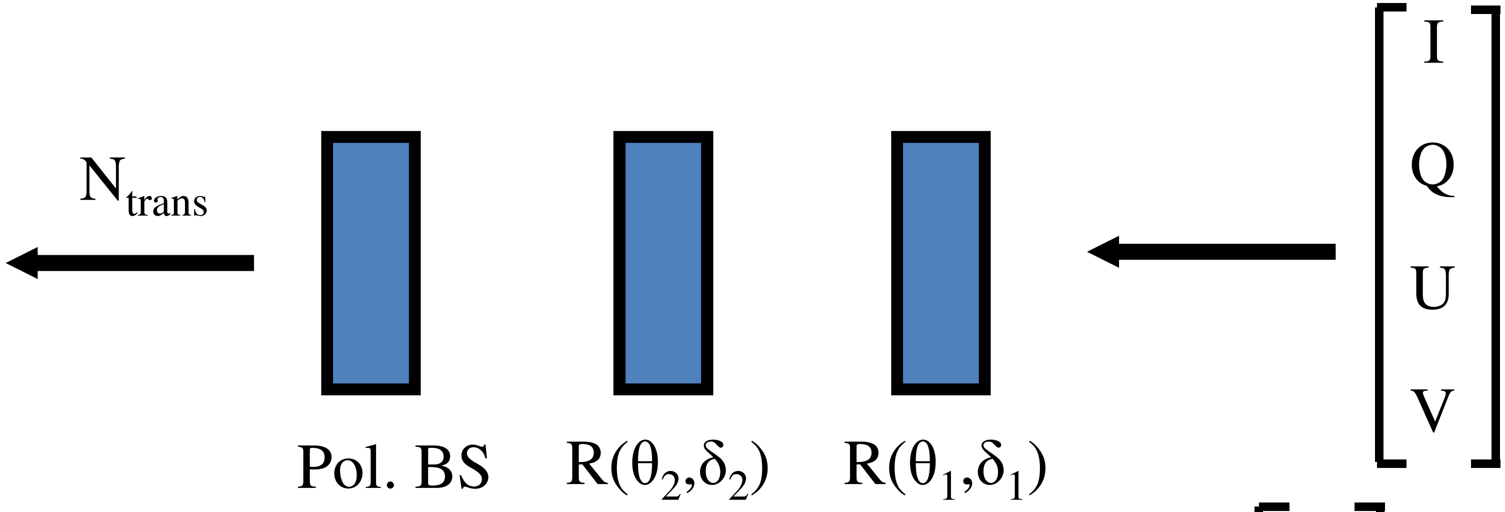
S.4.1 Polarization contamination

- Which polarimetric sensitivity is required?
- Better Q,U signal at expense of V?
- Spectral resolution vs SNR. Optimum trade-off?

Polarimetric techniques



$$N_{trans} = [1 \;\; \pm 1 \;\; 0 \;\; 0]\, R\,(\theta_2\,,\,\delta_2)\, R\,(\theta_1\,,\,\delta_1) \begin{bmatrix} I \\ Q \\ U \\ V \end{bmatrix} \longrightarrow$$

$$\longrightarrow \;\; \vec{N} = \boldsymbol{M}\,\vec{I} \longrightarrow \vec{I} = \boldsymbol{D}\,\vec{N} \quad // \;\; \boldsymbol{D\,M = 1}$$

Polarimetric techniques

Modulation efficiency

$$\vec{N} = \boldsymbol{M}\,\vec{I} \longrightarrow \vec{I} = \boldsymbol{D}\,\vec{N} \quad // \;\; \boldsymbol{D\,M = 1}$$

$$\epsilon_i = \left(n \sum_{j=1}^{n} {D_{ij}}^2 \right)^{-1/2} \qquad \epsilon_1 \leq 1, \qquad \sum_{i=2}^{4} {\epsilon_i}^2 \leq 1$$

$$\sigma_i = \frac{\sigma}{\epsilon_i}$$ Larger efficiencies mean lower noise

Optimum efficiencies

Equal efficiency for Q,U, and V

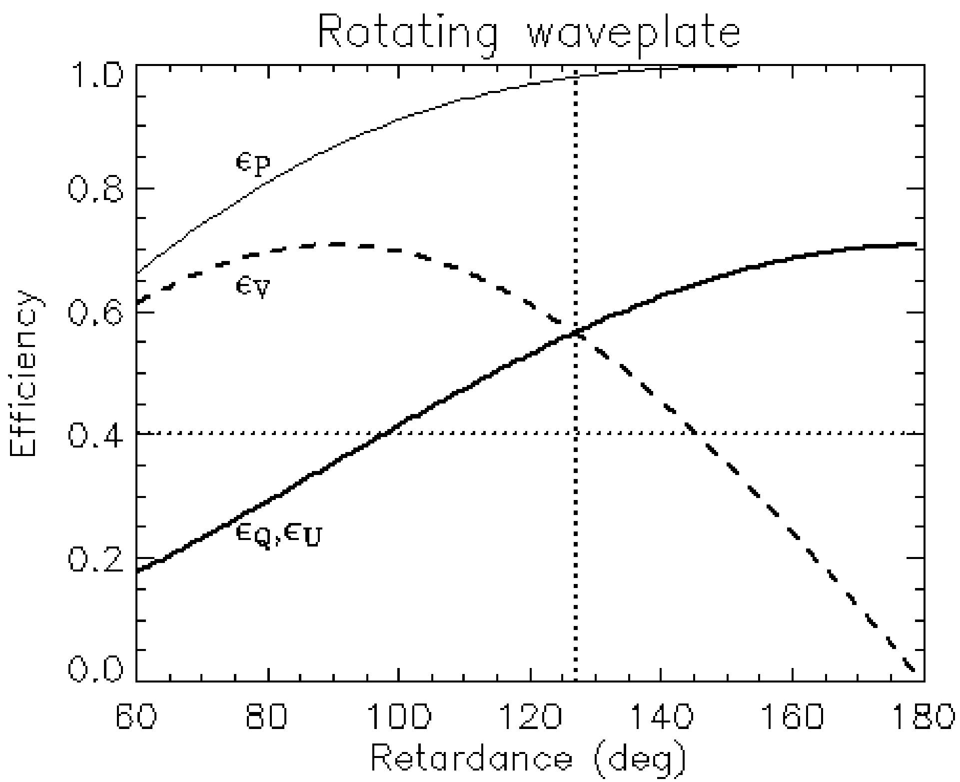
} $\epsilon_{Q,U,V} = 1/\sqrt{3} = 0.577$

Polarimetric techniques

- 1 rotating waveplate (ASP, POLIS, SPINOR)
- 2 retarders with discrete orientations (THEMIS)
- 2 nematic liquid crystals (ViSP, IMaX, SST)
- 2 ferroelectric liquid crystals (TIP, LPSP)
- 2 piezoelastic modulators (ZIMPOL)

Polarimetric techniques

1 rotating waveplate (ASP, POLIS, SPINOR)



Optimum retardance : 127º

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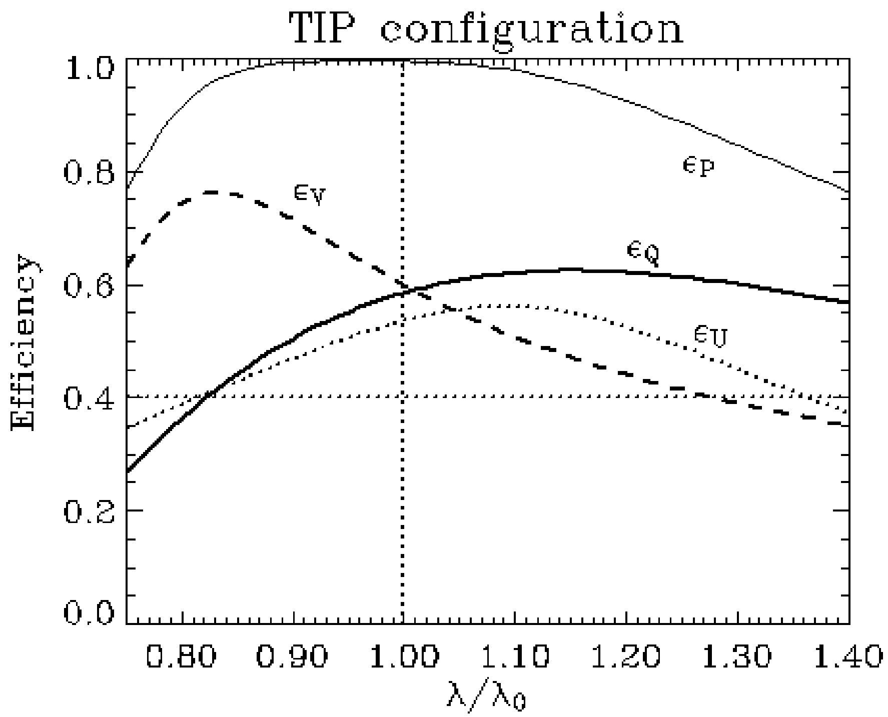
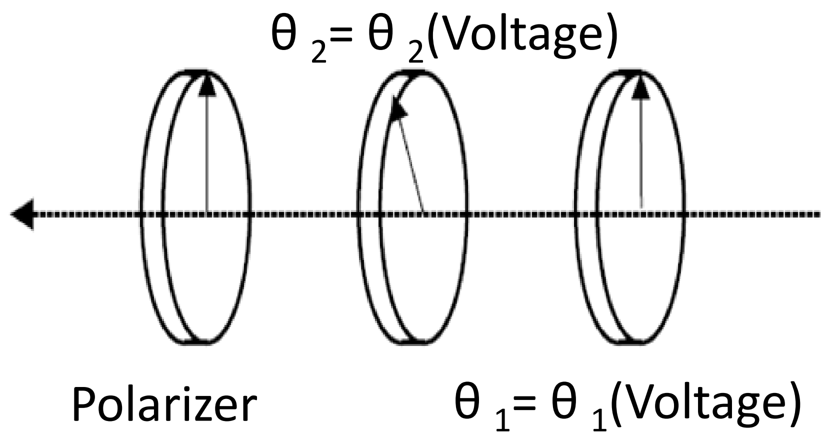
Polarimetric techniques

2 ferroelectric liquid crystals (TIP)





Fixed retardances

δ_1 = 155º δ_2 = 75º

θ_1 = 70º θ_2 = 155º $\Delta\theta$ = 50º

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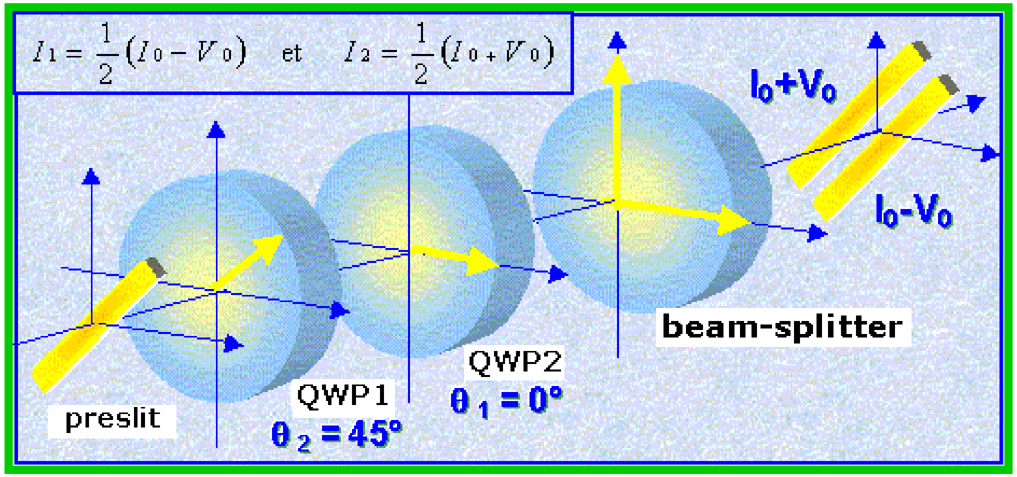
Polarimetric techniques

2 retarders with discrete orientations (THEMIS)



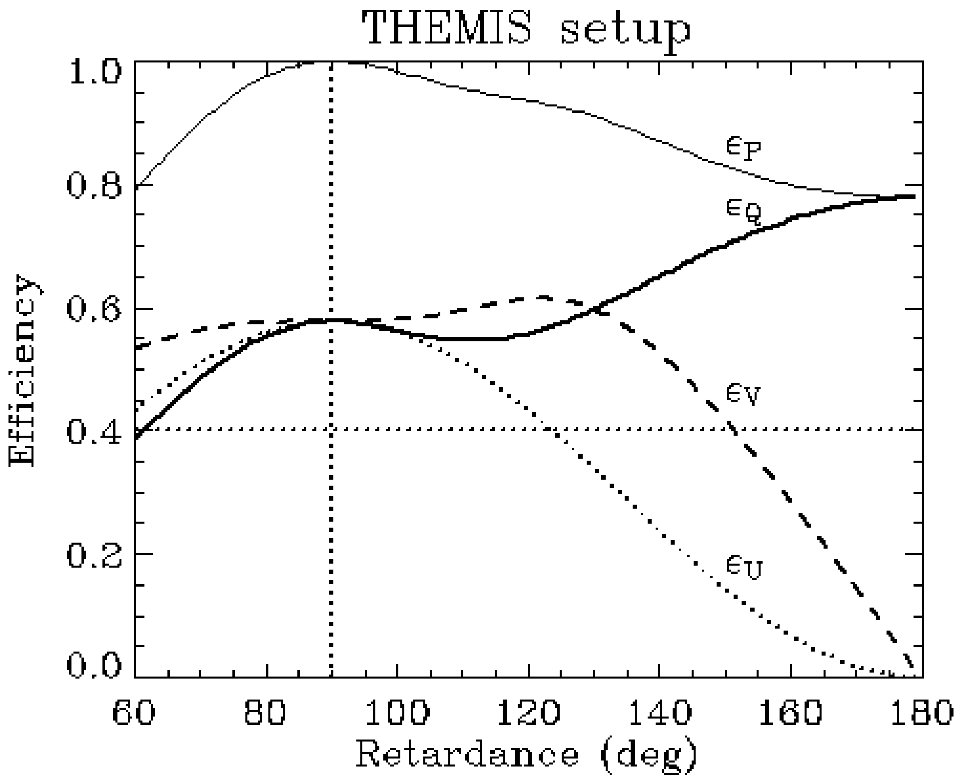
$\delta_1 = \delta_2 = 90º$

θ_1	θ_2	Stokes
0º	0º	I+Q
45º	45º	I-Q
22.5º / 45º	22.5º / 0º	I+U
67.5º / -45º	67.5º/ 0º	I-U
0º	-45º	I+V
0º	45º	I-V

- Pure Stokes parameters
- Maximum efficiencies: $\epsilon_{Q,U,V} = 0.577$

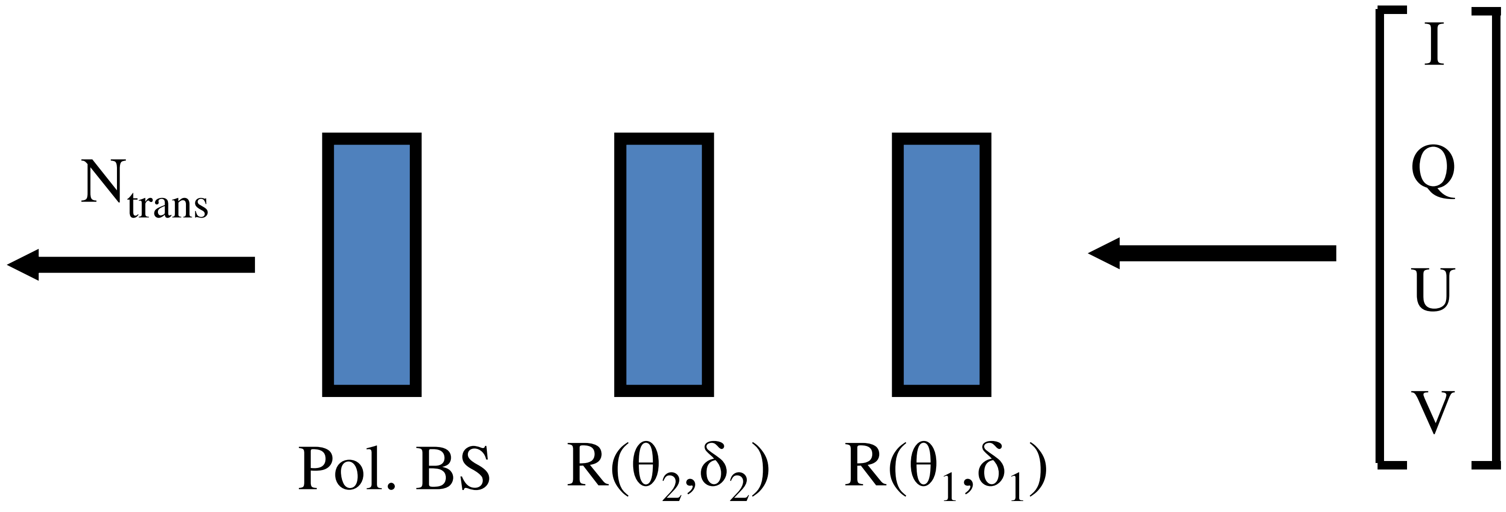
Polarimetric techniques

2 retarders with discrete orientations (THEMIS)



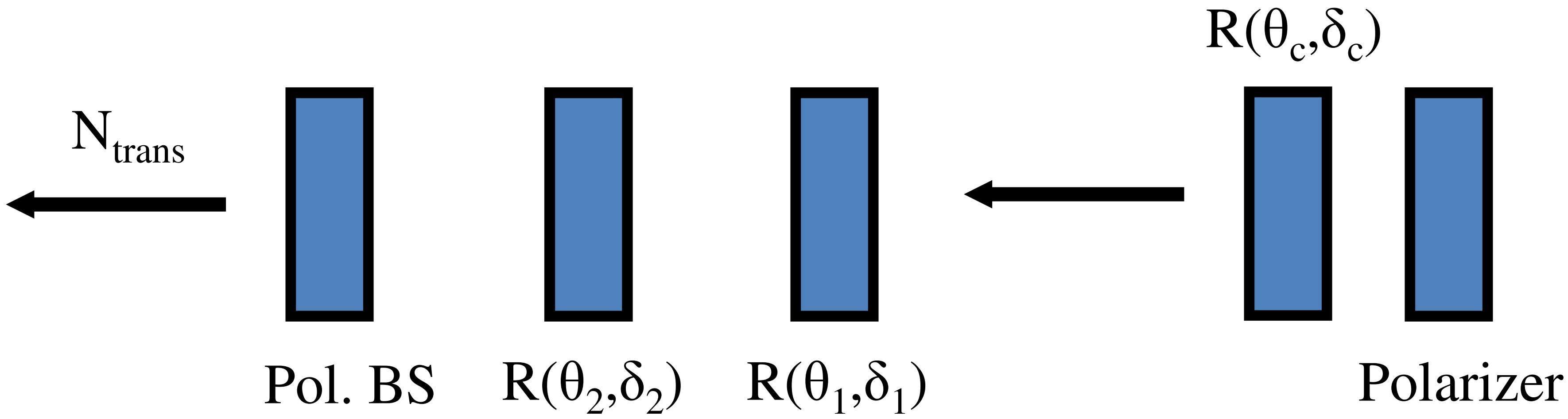
Polarimetric techniques

Calibration procedure



Polarimetric techniques

Calibration procedure



$$\vec{N} = \boldsymbol{M}\,\vec{I} \longrightarrow \vec{I} = \boldsymbol{D}\,\vec{N} \quad // \; \boldsymbol{D}\,\boldsymbol{M} = \boldsymbol{1}$$

$\sigma_D \sim 10^{-3}$

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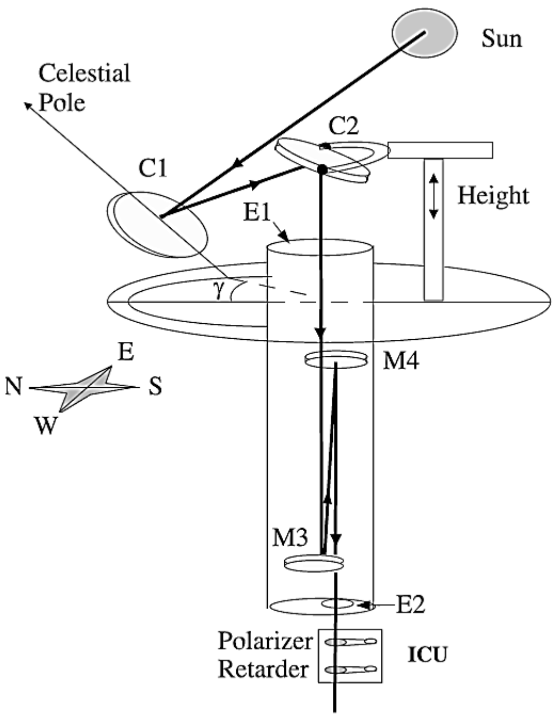
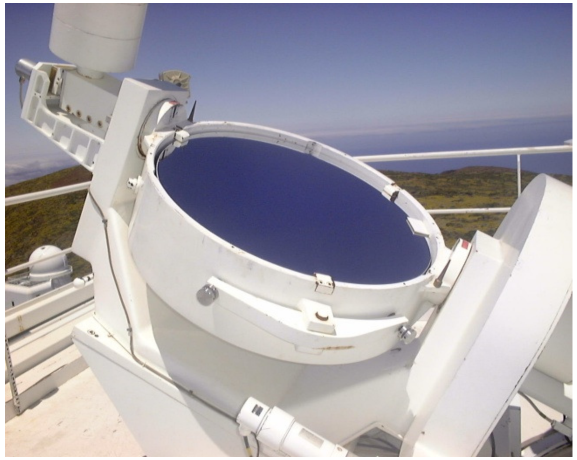
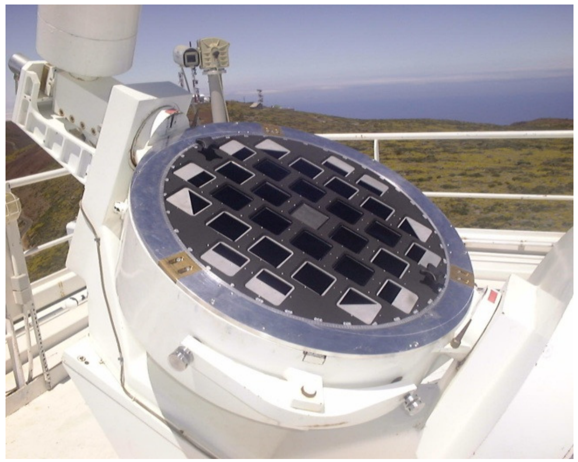
Polarimetric techniques

Telescope Calibration



VTT





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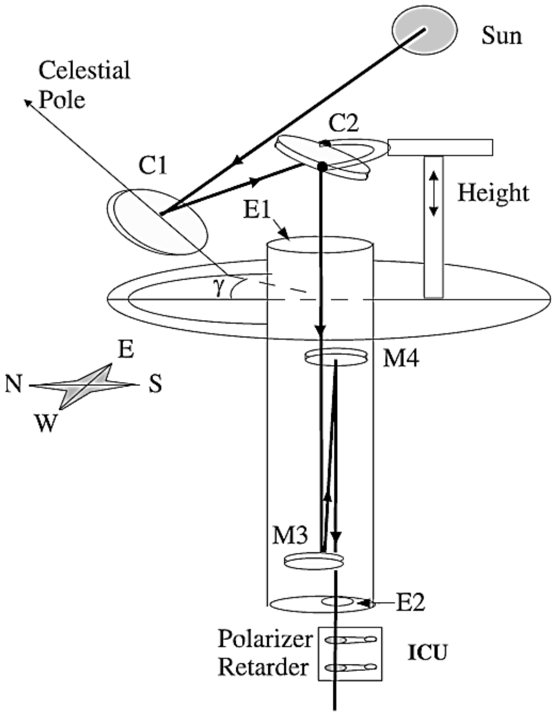
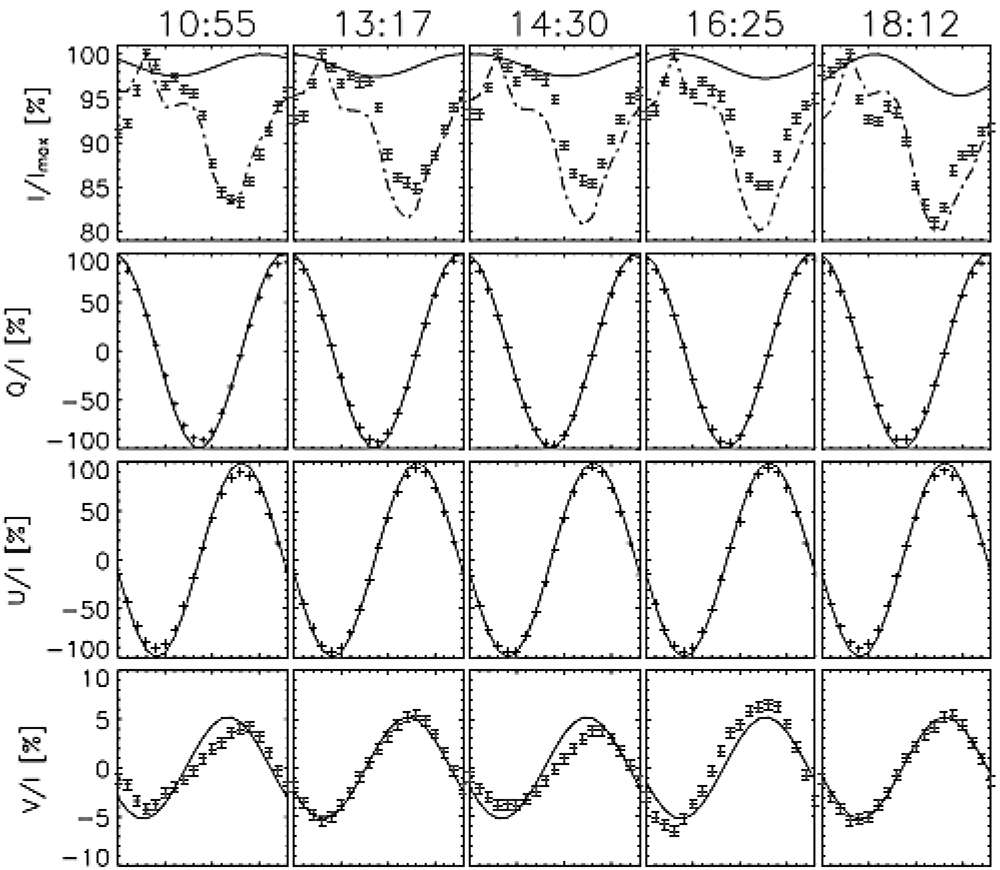
Polarimetric techniques

Telescope Calibration



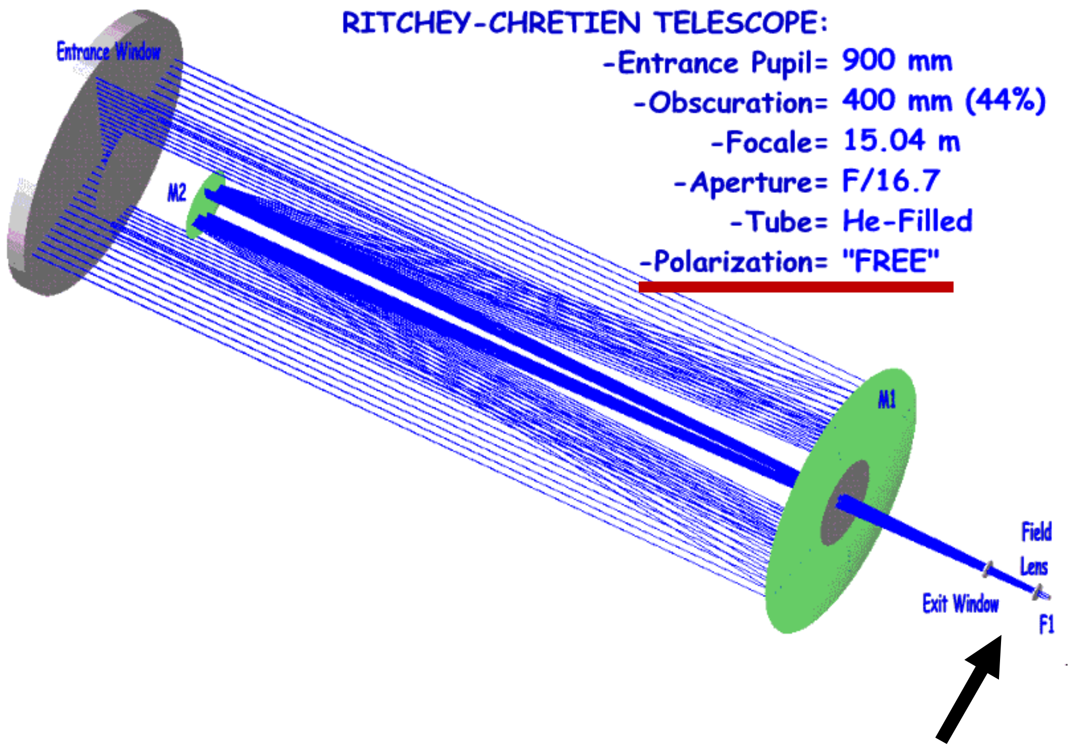
VTT



Beck et al. (2005)

Polarimetric techniques

Telescope Calibration



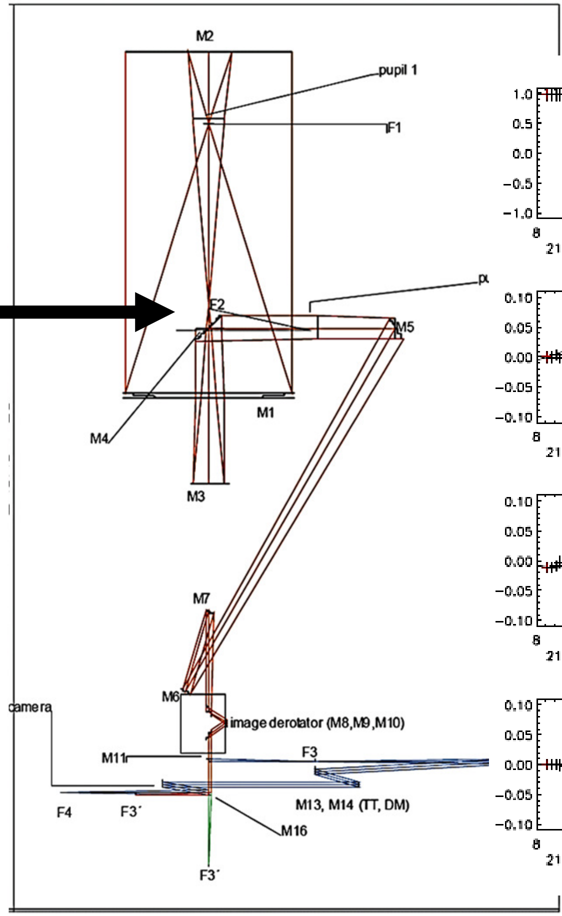
THEMIS

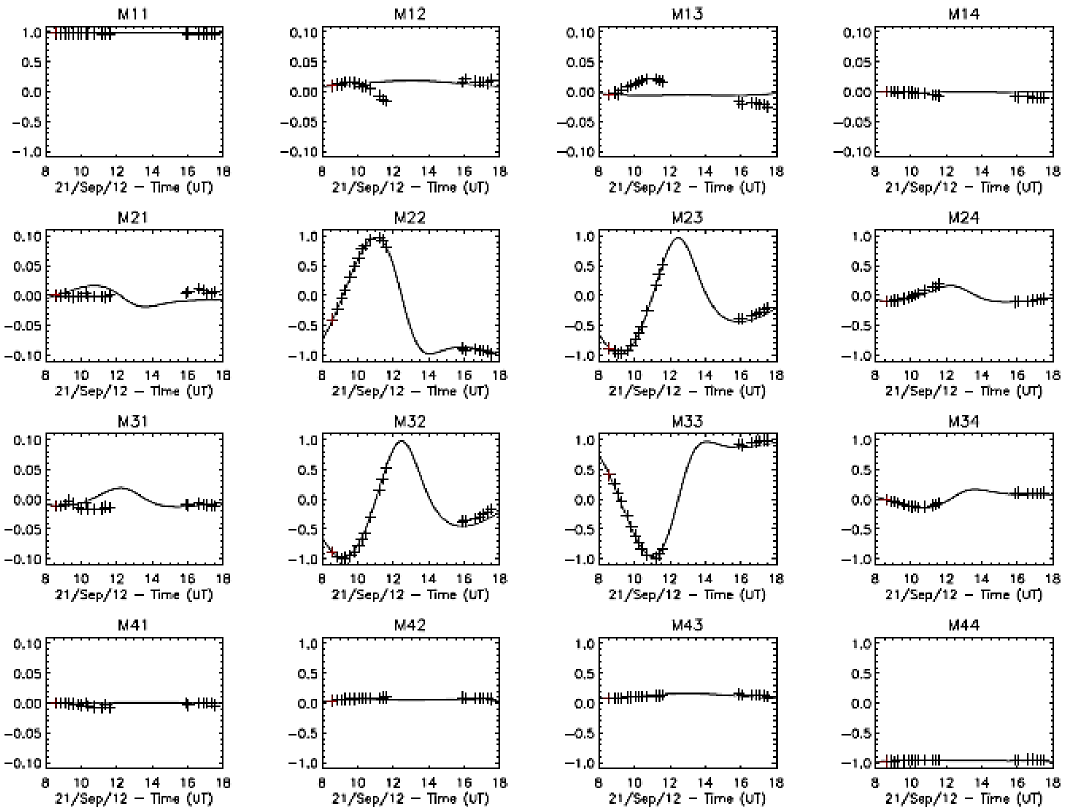
Polarimeter

Polarimetric techniques

Telescope Calibration

Calibration Optics





GREGOR

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Polarimetric techniques

Calibration

Sensitivities ~10^{-3} and

crosstalk between Q, U, V < 10^{-2}

are routinely obtained

Beyond that, careful specific reduction is required

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- Spectral resolution vs SNR. Optimum trade-off?

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Better Q,U signal at expense of V?

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Better Q,U signal at expense of V?

<u>Modulation efficiency</u>

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Larger efficiencies mean lower noise $\qquad \sigma_i = \dfrac{\sigma}{\epsilon_i}$

Optimum efficiencies
Equal efficiency for Q,U

} $\epsilon_{Q,U} = 1/\sqrt{2} = 0.7$

Better Q,U signal at expense of V?

Modulation efficiency

Optimum efficiencies
Equal efficiency for Q,U, and V } $\epsilon_{Q,U,V} = 1/\sqrt{3} = 0.577$

Optimum efficiencies
Equal efficiency for Q,U } $\epsilon_{Q,U} = 1/\sqrt{2} = 0.7$

Gain factor = $\sqrt{3}/\sqrt{2} = 1.22$ Eq. to Exposure time x 1.5

Spectral resolution vs SNR. Optimum trade-off?

$$N_{phot} \propto \Delta t\, \Delta\Omega\, \Delta\lambda = \Delta t\, \Delta x\, \Delta y\, \Delta\lambda = \Delta t\, \Delta x^2 \Delta\lambda$$

$$\text{SNR} = \sqrt{N_{phot}} \propto \Delta x \sqrt{\Delta t}\, \sqrt{\Delta\lambda}$$

$$\text{SNR x 2} \equiv \begin{cases} \Delta t \times 4 \\ \Delta\lambda \times 4 \\ \Delta x \times 2 \end{cases}$$

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