GREGOR – the calibration unit

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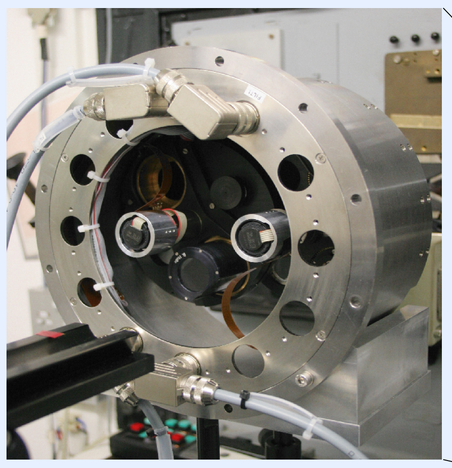
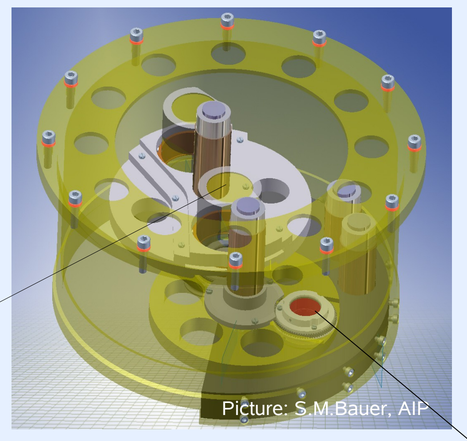
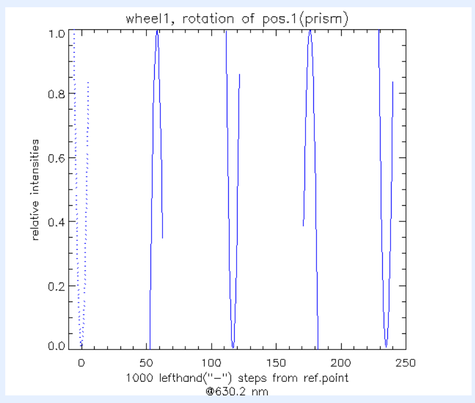
GREGOR is designed to observe small-scale dynamic magnetic structures below a size of 70 km on the Sun with high spectral resolution and high polarimetric accuracy. For this purpose, the polarimetric concept of ***GREGOR*** is based on a combination of post-focus polarimeters with a pre-focus unit for high-precision calibration. This unit will be placed in the shadow of the Nasmyth mirror M4 using the narrow beam close to the secondary focus F2. So far the telescope can be regarded as polarization free at a level of 10^{-4}. The GREGOR calibration unit was designed and built in the AIP. The development of controlling software and an extensive program of test measurements have been performed in the Solar Observatory ***Einsteinturm***.





Linear polarizer

aperture	24.5 mm
acceptance angle	±5° (symmetric) for 350nm < λ < 2000nm
movability	rotatable with 0.1° pos. acc.

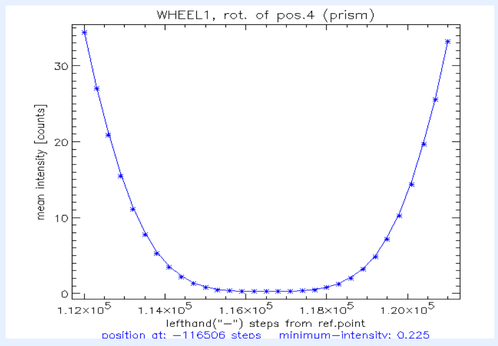


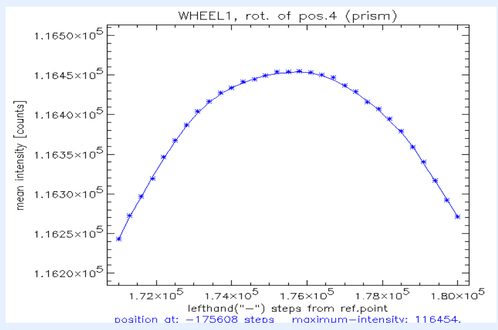
k1= 116454 counts
k2= 0.225 counts

open transmission
$H0 = (k1^2+k2^2)/2$
$= 6.78 \cdot 10^9$

closed transmission
$H90 = k1 \cdot k2 = 26283$

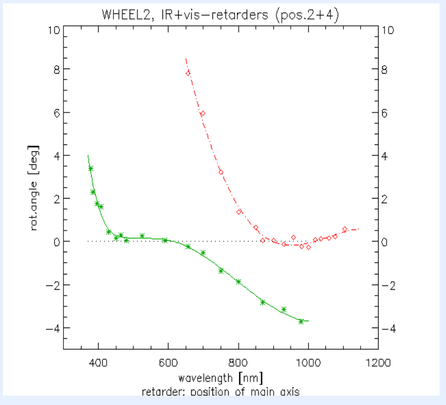
extinction ratio
$ER = k2/k1 = 1.938\ 10^{-6}$

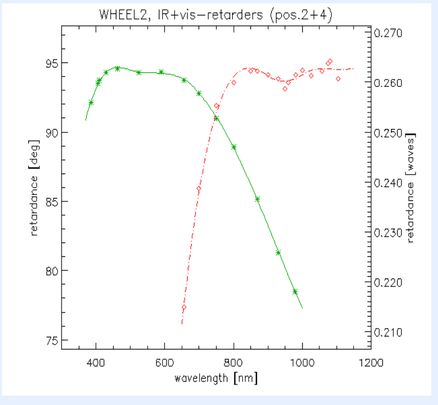




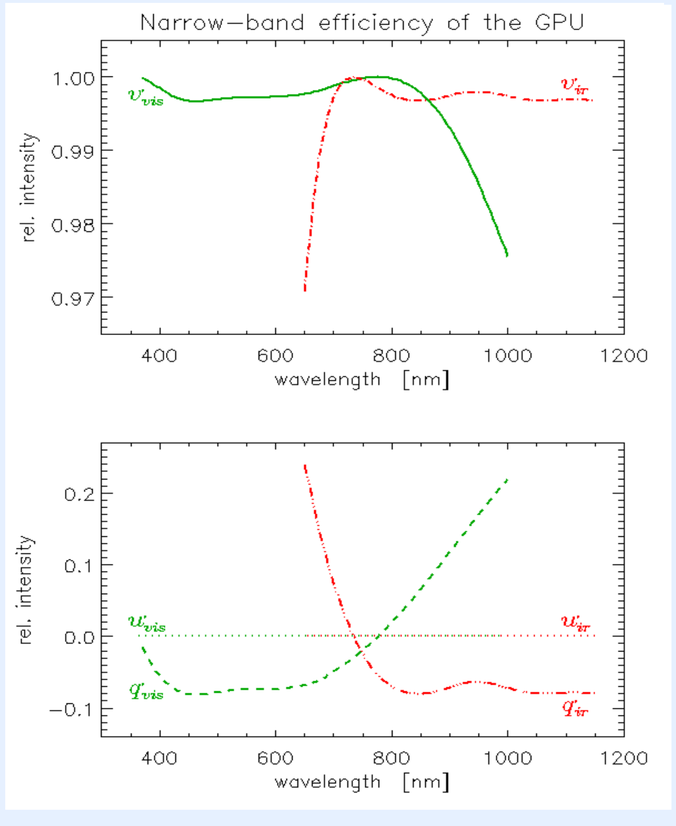
Retarders (R=λ/4, vis + IR)

aperture	19.5 mm
spectral range	380-800 / 750-1800 nm
angular accept.	$\Delta R/R = 8.5 \cdot 10^{-3}$ for ±5°
movability	rotatable with 0.1° pos. acc.





Polarimetric efficiency



The polarimetric throughput of the unit depends on the parameters of the individual components and is described by:

$$\text{Input} : \vec{S} = (I, Q, U, V)$$
$$\text{Output: } \vec{S}' = (I', Q', U', V') = \vec{S}'(\varphi_1, k_1, k_2, \varphi_2, \delta)$$
$$= \mathbf{G}(\varphi_2, \delta)\ \mathbf{P}(\varphi_1, k_1, k_2) \cdot \vec{S}$$

If the coordinate system is related to the transmisson axis of the polarizer(ϕ_1=0) we obtain:

$$I' = 0.5\ \{(k^+\ I + k^-\ Q\}$$

$$Q' = 0.5\ \{(C_2^2 + S_2^2 \cos\delta)\ (k^-\ I + k^+\ Q) + 2k^*\ [S_2 C_2 (1 - \cos\delta)\ U - S_2 \sin\delta\ V]\}$$

$$U' = 0.5\ \{S_2 C_2 (1 - \cos\delta)\ (k^-\ I + k^+\ Q) + 2k^*\ [(S_2^2 + C_2^2 \cos\delta)\ U + C_2 \sin\delta\ V]\}$$

$$V' = 0.5\ \{S_2 \sin\delta (k^-\ I + k^+\ Q) - 2k^*\ [C_2 \sin\delta\ U + \cos\delta\ V]\}$$

where:

$$k^+ = k_1 + k_2,\ k^- = k_1 - k_2,\ k^* = k_1 \cdot k_2,$$
$$\text{and}\ \ S_2 = \sin 2\varphi_2,\ C_2 = \cos 2\varphi_2$$

This is used to calculate the polarimetric efficiency of the unit, which is shown for the case that circular polarized light is generated (left). The alternative use of two retarders ensures that it is higher than 99.7% over the whole wavelength range from the visible to the infrared. Thus the calibration unit will become an essential component for high resolution spectro-polarimetry with ***GREGOR.***

GREGOR is a common project of the KIS (Freiburg), the AIP (Potsdam), the IAG (Göttingen), and the MPS (Lindau) in cooperation with the AU AVČR (Ondřejov) and the IAC (Tenerife).