DEROTATORS AT THE WHT

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Purpose: The purpose of this document is to provide information on the available derotators of the WHT

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Overview

Available derotators

Table 1 The four available derotators at the WHT.

No.	New name	Old name	Notes
1	Optical 1 (wide-field)	GHRIL optical	Formerly used by SCAM
2	Optical 2 (wide-field)	UES old	No longer used. Similar to 1.
3	UV/optical (30" field)	UES new, or UV	Used by SCAM 7/04
4	IR	GHRIL IR	Permanently in GRACE

Derotators 1 and 4 were originally used mainly at the GHRIL Nasmyth focus, while 2 and 3 were for the Utrech Echelle Spectrograph, formerly mounted at the opposite Nasmyth focus (now hosting the AO enclosure GRACE). The GHRIL and GRACE mounting flanges are identical, and lie at the same distance along the optical path.

Derotators can only be changed during the day (crane required). The correct focal-station name must be selected in TCS when a derotator is changed.

Summary of flange-focal plane distances

In March 2005, KMD/MFB measured the focal distances from the GHRIL rotator flange (on which the derotator is mounted) as follows. After the Zemax models were created from the drawings the correct distances could be checked in Zemax as well. This was done by Tibor Agocs in December, 2009. The below focus values are for monochromatic 550nm wavelength. Also the focal distances for the best image quality are presented for 330nm (only for the UV derotator), 440nm, 550nm and 660nm.

GHRIL rotator flange – focal plane distances for Optical 2 derotator

Rotator flange – derotator flange distance for Optical 2 derotator: 9.8mm.

There is some discrepancy regarding the focus position for the Optical 2 derotator regarding the focal distances between the measured values and the values from the Zemax models. It can only be verified with on-sky measurements.

Table 2 GHRIL rotator flange – focal plane distances for Optical 2 derotator.

Derotator	Nasmyth Station	Tel. Focus (mm)	Focal distance from **rotator** flange (mm) KMD/MFB	Focal distance from **rotator** flange (mm) TIBOR (ZEMAX)
Optical 2	GHRIL	97.8	485	569.6 (for 550nm)
Optical 2	GHRIL	98.2		577.4 (for 550nm)
Optical 2 (Best focus for 440nm)	GHRIL	99.76		608.2 (for 440nm)
Optical 2 (Best focus for 550nm)	GHRIL	99.87		610.2 (for 550nm)
Optical 2 (Best focus for 660nm)	GHRIL	99.93		611.2 (for 660nm)
Optical 2	GHRIL	103.76	615	686.9 (for 550nm)

GHRIL rotator flange – focal plane distances for UV derotator

Rotator flange – derotator flange distance for UV derotator: 9.1mm

Table 3 GHRIL rotator flange – focal plane distances for UV derotator

Derotator	Nasmyth Station	Tel. Focus (mm)	Focal distance from **rotator** flange (mm) KMD/MFB	Focal distance from **rotator** flange (mm) TIBOR (ZEMAX)
UV (Best for 330nm)	GHRIL	95.71		595.2 (for 330nm)
UV (Best for 440nm)	GHRIL	95.89		598.0 (for 440nm)
UV (Best for 550nm)	GHRIL	95.97		599.2 (for 550nm)
UV (Best for 660nm)	GHRIL	96.01		599.8 (for 660nm)
UV	GHRIL	97.8	~630	633.8 (for 550nm)
UV	GHRIL	98.2	640	641.4 (for 550nm)
UV	GHRIL	103.76	768	747.9 (for 550nm)

GRACE rotator flange – focal plane distances for IR derotator

Rotator flange – derotator flange distance for IR derotator: 10mm

Table 4 GRACE rotator flange – focal plane distances for IR derotator

Derotator	Nasmyth Station	Tel. Focus (mm)	Focal distance from **rotator** flange (mm) KMD/MFB	Focal distance from **rotator** flange (mm) TIBOR (ZEMAX)
IR	GRACE	98.4		463.9

Rotator flange – focal plane distances for GRACE and GHRIL without derotator

Table 5 Rotator flange – focal plane distances for GRACE and GHRIL without derotator

Derotator	Nasmyth Station	Tel. Focus (mm)	Focal distance from **rotator** flange (mm) KMD/MFB	Focal distance from **rotator** flange (mm) TIBOR (ZEMAX)
None	GHRIL	98.2		585.6
None	GRACE	98.4		596.3

Optical derotator 1

Introduction

The optics are similar to those of Optical derotator 2. It comprises a flat mirror and a pair of fused silica prisms + 5 mm of BK7, and is described in La Palma Technical Note 9. Prisms of fused silica (Heraeus Homosil) with total internal reflection are used. Lens surfaces on these prisms also extend the optical path as is necessary and maintain good image quality. The final element is a lens of UBK7 glass which is 1.5 mm thick on axis and is cemented to one of the fused silica prisms. The following information is based on the Zemax model of the derotator, which was built up from the specifications/drawings of the components.

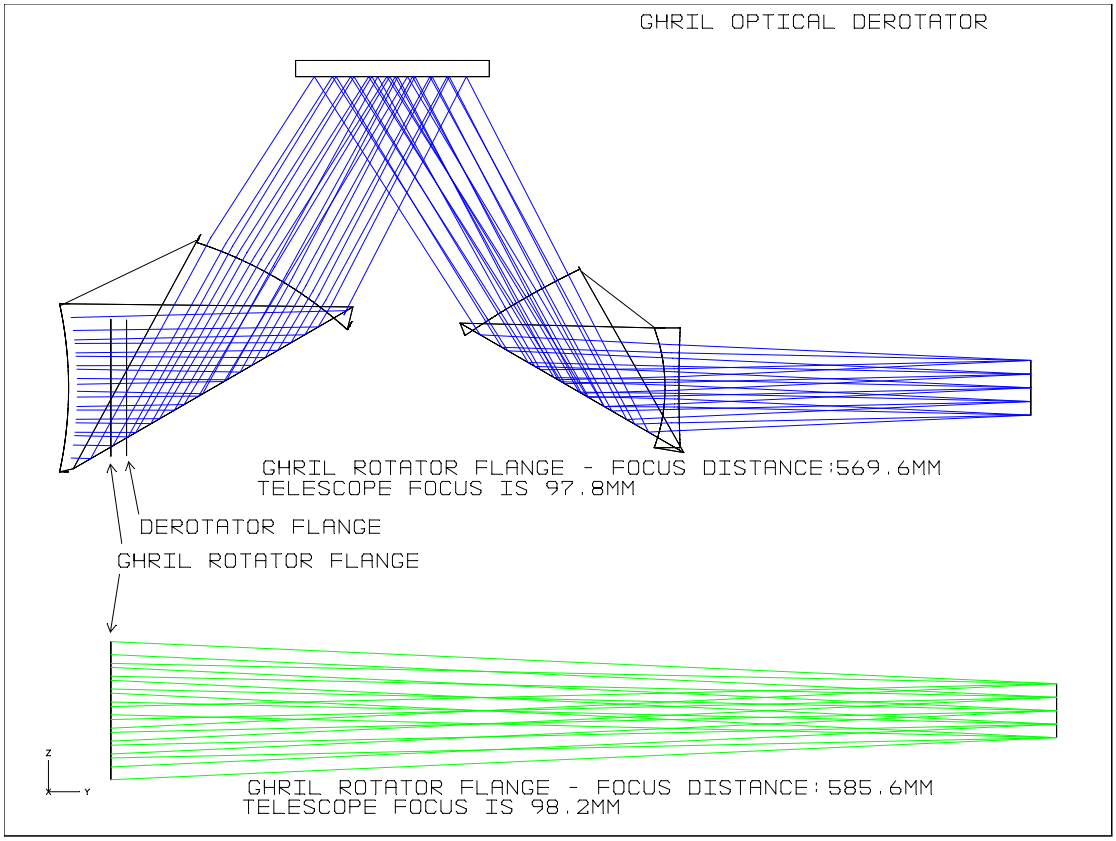
This is the derotator usually used by visiting instruments mounted at the Nasmyth focus, e.g. ESA SCAM/STJ, or Rafael Rebolo's FASTCAM.

Layout

The following layout shows two configurations. The upper one shows that the distance from GHRIL rotator flange to the focal plane is 569.6mm, when the optical derotator is used and the secondary focus is set to 97.8mm. The lower layout shows that the distance from the GHRIL rotator flange to the focal plane is 585.6mm, when no derotator is used and the secondary focus is set to 98.2mm. These are the findings from the Zemax models.

On the derotator it is labelled: Focus from derotator flange is 485mm, when telescope focus is set to 97.8mm, which is not matching with the Zemax models. It has to be checked.

Figure 1 Layout of the Optical derotator 1



Field size

2.5 arcmin unvignetted field with the Optical derotator

5 arcmin 50% vignette with the Optical derotator

(7 arcmin unvignetted field without a derotator)

Image quality

At nominal focus < 0.5 arcsec over 5 arcmin field

Image scale

At nominal focus 4.44 arcsec/mm, 225 um/arcsec

Theoretical throughput

We don't have any information whether the prism pairs are coated or not. Also we don't have information on the coating of the mirror. If the prism surfaces are AR coated (presume a wide-band AR coating for the visible spectral range) and the mirror is aluminium, the throughput of the derotator should be:

T>70% across the 380 nm-1 micron range

And without AR coating on the prism surfaces it should be:

T>60% across the 380 nm-1 micron range

Derotator history (measured throughput, realignment, recoating, etc)

In July, 2009 cleaning and on-axis measurement was done by Tibor Agocs. The results of the measurement are the following.

T=50% at 543nm before cleaning of entrance and exit surfaces

T=55% at 543nm after cleaning

T=64% is the theoretical throughput at 543nm for circularly polarized light (the measurement laser was circularly polarized

T=56-72% is the theoretical throughput at 543nm for linearly polarized light

Optical derotator 2

Introduction

The optics is similar to those of derotator 1. It comprises a flat mirror and a pair of fused silica prisms + 5 mm of BK7, and is described in La Palma Technical Note 9.

The unvignetted field of view 2.5 arc minutes, throughput is believed to be ~ 75%, probably declining to ~ 65% in the UV (3000 A) ad IR (1 micron).

As of 12/09, Juerg believes this to be in its case, marked 'do not use'.

UV derotator

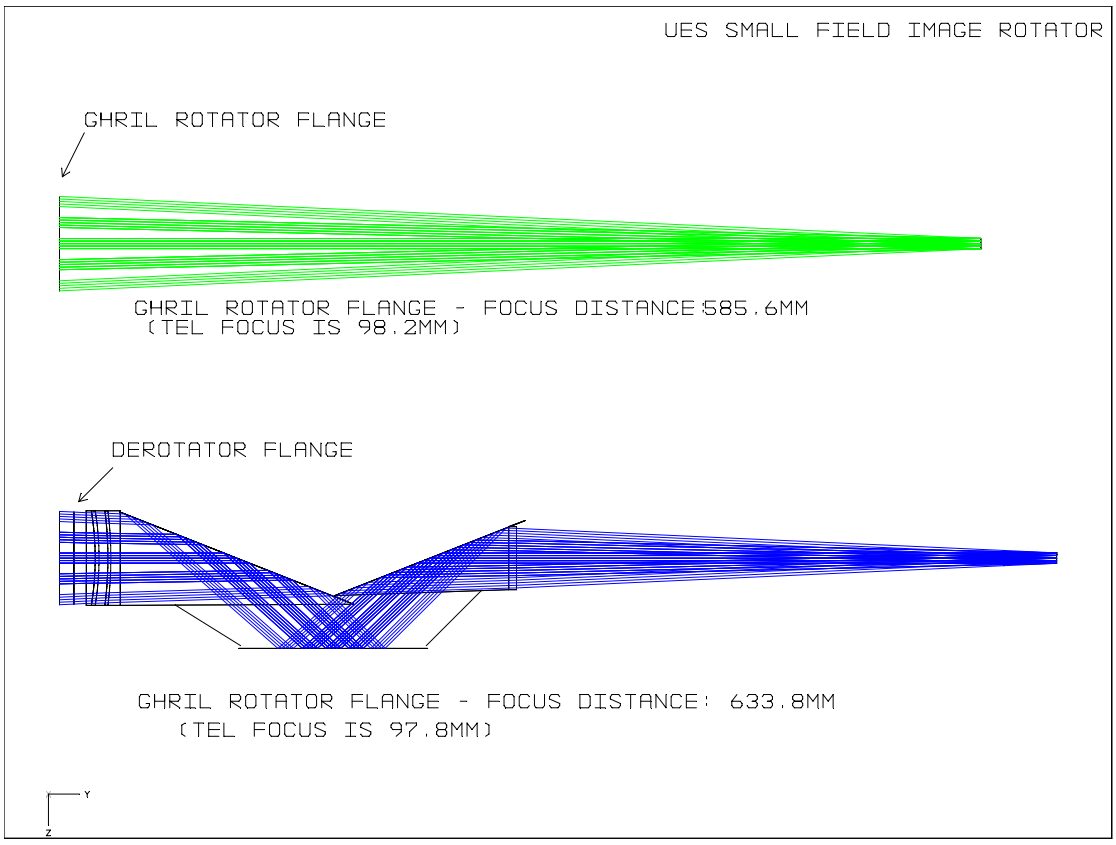
This is also referred to as UES Small Field Image Rotator. There are only two air-glass surfaces in the derotator, and the derotator optics themselves are all-reflecting. The derotator was commissioned with UES in Dec 1997. The following information is based on the Zemax model of the derotator, which was built up from the specifications/drawings that was found at the ORM archives.

Layout

The following layout shows two configurations. The upper layout shows that the distance from the GHRIL rotator flange to the focal plane is 585.6mm, when no derotator is used and the secondary focus is set to 98.2mm. The lower one shows that the distance from the GHRIL rotator flange to the focal plane is 633.8mm, when the UV derotator is used and the secondary focus is set to 97.8mm. These are the findings from the Zemax models.

On the derotator it is labelled: Focus from derotator flange 630mm, when telescope focus is set to 97.8mm, which is close but not matching with the Zemax models. It has to be checked.

Figure 2 Layout of the UV derotator



Field size

30 arcsec unvignetted field with the UV derotator

(7 arcmin unvignetted field without the derotator)

The central 30 arcsec of the slit are unvignetted, vignetting increases slowly outside this region. With a telescope focus of 97.8 mm, MFB/KMD found the unvignetted field of view to be circular, and of radius 50 arcsec, with partial vignetting out to 75 arcsec, where the image disappears completely. At a focus 103.8 mm, the unvignetted radius is again 50 arcsec, and the image disappears completely at radius 85 arcsec. It is 50% at radius 1.2 arcmin, 25% at radius 1.55 arcmin. These measurements made by John Telting in March, 2000.

Image quality

At nominal focus < 0.5 arcsec over 5 arcmin field

On-axis image degradation is < 0.15 arcsec over the wavelength range 300 - 1000 nm.

Image degradation is < 0.15 arcsec over range 3000 - 11000 A.

Image scale

At nominal focus 4.44 arcsec/mm, 225 um/arcsec

Theoretical throughput

From the Zemax model:

We don’t have any information whether the prism is AR coated on the entrance and exit or not. If the prism surfaces are AR coated (presume a wide-band AR coating for the visible spectral range) the throughput of the derotator should be:

T>85% across the 330 nm-1 micron range

And without AR coating on the prism surfaces it should be:

T>80% across the 330 nm-1 micron range

Derotator history (measured throughput, realignment, recoating, etc)

Throughput measured in the lab (April 1997) to be 93 - 95% over the wavelength range 3000 - 11000 A.

Throughput measured by MFB in August, 2004 and reflectivity found to be 93% at 633nm and 91% at 543nm.

Throughput measured by Tibor Agocs in December, 2009 and reflectivity found to be 91% at 633nm and 90% at 543nm.

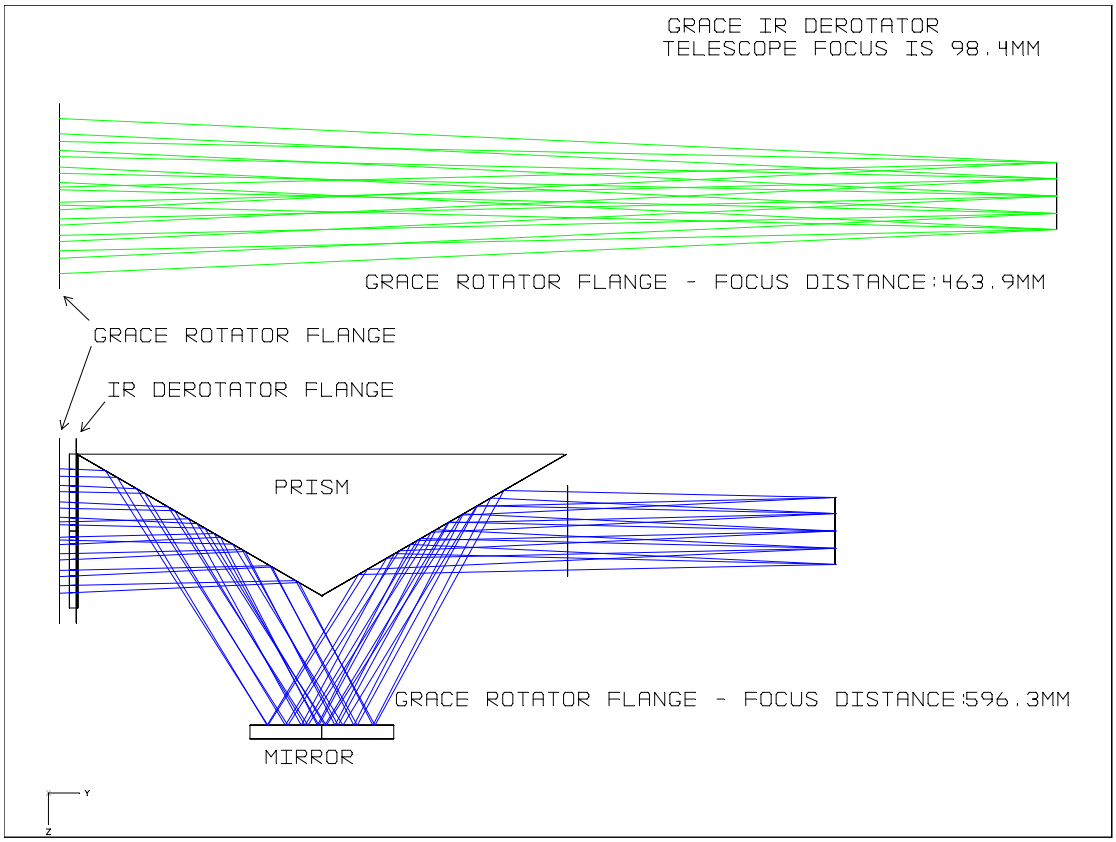
IR derotator

This component is also called K-mirror, and it is containing a prism and a mirror. They both have silver coatings. Currently this IR-derotator is used with GRACE.

Layout

The following layout shows the distance from the GRACE rotator flange to the focal plane, when the secondary focus is set to 98.4mm (focus for GRACE). The distance is 463.9mm with the IR derotator, and it is 596.3mm without.

Figure 3 Layout of the IR derotator



Field size

3 arcmin unvignetted field with the IR derotator

(7 arcmin unvignetted field without a derotator)

Image quality

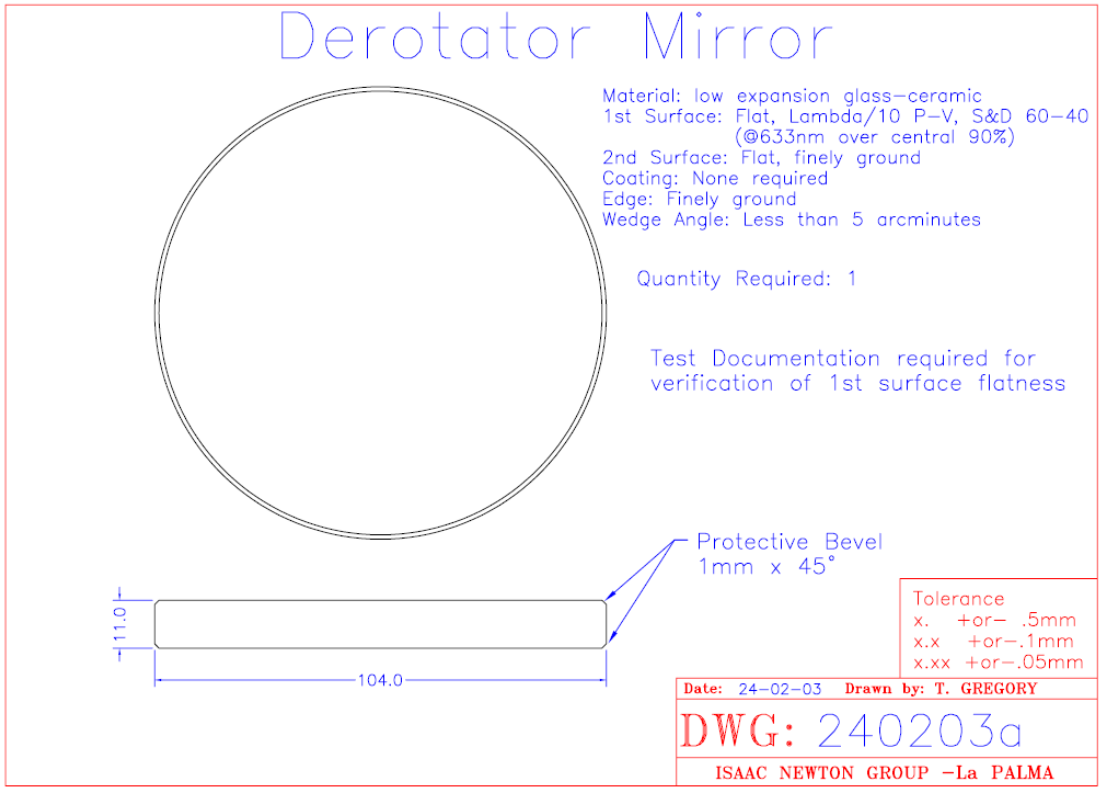
At nominal focus < 0.5 arcsec over 5 arcmin field

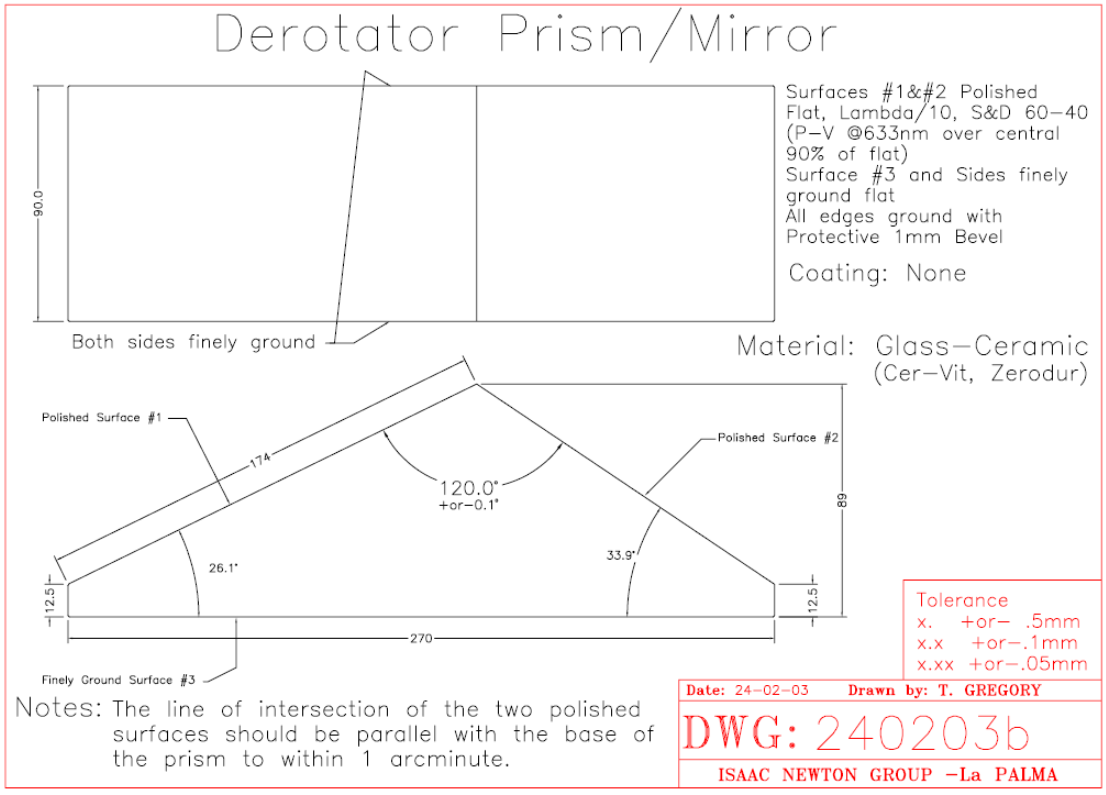
Image scale

At nominal focus 4.44 arcsec/mm, 225 um/arcsec

Drawings

Figure 4 Drawings of the IR derotator components





Coating specifications for the IR derotator components

The coating would be broad band protected silver coating, with the following performance:

>95% over 400nm - 500nm

>97% over 500nm - 800nm

>98% over 800nm - 4000nm

At the following incidence angles:

- for the #1 polished surface of the prism 63.9 degree

- for the #2 polished surface of the prism 56.1 degree

- for the mirror 30 degree

Drawings:

Mirror specification as per 24203a Model (1).pdf

Prism specification as per 24203b Model (1).pdf

Theoretical throughput of the derotator

Poor in the ultra-violet, since the components are protected silver coated.

T>84% over 400nm - 500nm

T>90% over 500nm - 800nm

T>93% over 800nm - 4000nm

Derotator history (measured throughput, realignment, recoating, etc)

The 3 Ag (over-coated) surfaces are all reflecting, and were recoated by Dave Jackson (RGO Cambridge) mid 1998. It was than realigned at May, 1998 (?), before the ELECTRA run.

The throughput was measured by Tom Gregory in August, 1999 (by comparing counts from a star with and without derotator): 0.56 in B, 0.64 in V, 0.64 in R, +- 0.02, implying reflectivity of each surface 0.85.

In ~ May 2000, Tom Gregory had the surfaces recoated and sealed the two apertures with CaF2 windows to protect the silvered surfaces and to cut down airflow through the derotator (which was degrading seeing). The throughput was measured again May 2000, with a 633-nm laser to be 79+-1%, and on-sky in V band to be 75% (measurement error probably dominated by transparency variations). The throughput will be even better in the near-IR, since the windows are coated for minimum reflectance at 1.2 microns. As of Jun 2006, there have been no changes to this optics since the derotator was installed in GRACE in 2003.

The GRACE side CaF2 window was removed sometime between 2003 and 2006 (Tibor Agocs).

It was realigned in Oct-Nov, 2007 by Tibor Agocs.

References

The following references were used:

- Astronomy webpage: http://www.ing.iac.es/Astronomy/telescopes/wht/derot.html
- La Palma Technical Note 9.
- Drawings from ORM archives

Zemax – the derotator models were created from the drawings; these models then were analysed with the ray tracing program.