NOTES ON OPTICAL ALIGNMENT AT GHRIL

Peter Gray, Isabel Escudero December 18^{th} 1996

Background

The combination of the WHT's ALT–AZ mounting and the versatility of its computer control system provide a range of possibilities in the alignment of GHRIL optics with the telescope. The alignment of optics at GHRIL has three main aspects:

1. **Pointing Alignment**: To enable a star to be acquired onto the instrument aperture and then tracked for extended periods.
2. **Internal Alignment**: To align the various optical components within the GHRIL optical experiment with each other.
3. **Vignetting Alignment**:To ensure the telescope beam once acquired onto the instrument aperture passes through the optical system with minimum vignetting and aberration.

In respect of the first requirement, the CALIBRATE procedure in the control system allows the part telescope pointing to be temporarily adjusted to cope with slight changes in telescope collimation. This procedure is usually carried out using a TV camera mounted on the instrument rotator where the reference mark to which the calibration is done is the centre of rotation of the instrument rotator (found by tracking a star and rotating by 180°). When the GHRIL focus is used without any form of instrument rotation or derotator optics, no such rotator centre can be established. However, if instead a nominal reference mark is established on a TV and the CALIBRATE procedure run, the telescope pointing and tracking is adjusted such that subsequent objects will be acquired onto this mark and tracked with the field rotating about this point. Note that, if instead, the default GHRIL pointing model was used and no CALIBRATE done, a star could be moved onto the instrument aperture with a BEAM beamswitch command, however because the field rotation would occur about some other point (the true instrument rotator centre), an on–axis star would not be tracked because of rotation. The axis about which a GHRIL optical system should be assembled can therefore be any arbitrary axis on the GHRIL table as long a CALIBRATE procedure is carried out using the optical system's axis as the TV reference. This will enable a star to be acquired and tracked.

To satisfy the last 2 criteria, GHRIL system's optical axis needs to be aligned with the telescope pupil so as to minimise vignetting and aberrations due to offaxis rays. However, this vignetting alignment is somewhat less critical than the pointing alignment since most optical systems will have optical components which are slightly oversized and can tolerate some degree of misalignment of the beam passing through them.

Suggested Alignment Methods

As described above, the alignment procedure does not necessarily require the optical system axis to be exactly coincident with the telescope axes. However some sort of repeatable reference is helpful. The telescope defines an number of axes which can, but need not necessarily, be coincident.

1. **Secondary Mirror Optical Axis**:

The optical axis of the secondary mirror is commonly used as an optical reference, however it is the combination of the primary and secondary mirrors which actually forms the optical axis of the complete telescope (ie a translation misalignment of primary and secondary can be cancelled out by a tilt of secondary with respect to primary). A laser beam can be aligned aimed at the centre of the secondary can be adjusted in translation and tilt to reflect back on itself. This beam then defines the axes of the secondary mirror and can be used as a reference, however since it is not necessarily coincident with the defined pointing axis, it is important also to perform a CALIBRATE at this position.

2. **Altitude Mechanical Axis**:

Alternatively, the mechanical axes of the telescope can be used. The most convenient to use is the altitude axis. The Nasmyth instrument rotator axes have been adjusted to be coincident with the altitude axis and since the default pointing centre has been defined to lie on the rotator axis centre, it is the most convenient axis to work from.

A pair of alignment plates can be accurately fitted to dowel locations on the centre section inside the altitude bearings. They have been pre–aligned to coincide with the altitude axis and repeat to ± 0.25mm. Each plate has a central glass alignment target with accurately concentric rings which can be sighted with the alignment telescope or aligned with a laser beam (less accurate). The targets are only aligned in translation to the altitude axis centre, they are NOT adjusted in tilt to be square to the axis.

Whilst it is possible to remove and replace the glass targets from their holders and retain the alignment setting, NONE of the other adjustments or clamping screws should be disturbed. With the Nasmyth flat in the stowed CASS position it is possible to sight through the entire altitude axis through a hole in the side web of the Nasmyth flat support.

*** Isa, Check this section and add your experiences of doing it. I haven't done it anyway! *** A laser mounted on the GHRIL table can be adjusted in tilt and translation to pass through the centre of both targets. The best method of doing this is to arrange a white screen (piece of paper) behind the second target on the far side. The shadow of the concentric rings can then be seen, the aim is to get the laser beam centred on the ring pattern AND the pair of ring shadows coincident. The advantage of using a laser is that once it is aligned with the altitude axis, it can be used to square–on the optical components on the GHRIL table by aligning the back reflections. The disadvantage is that the relatively large diameter of the laser beam makes it difficult to accurately align translation. The present mounting for the GHRIL alignment laser also makes it difficult to precisely translate and tilt the laser to achieve exact alignment.

An alternative to the laser is the Rank Taylor–Hobson alignment telescope (MAT). The MAT is mounted on a precision base which positions it at the correct height and enables fine tilt adjustment. With the MAT at the back of the table at the approximate position of the altitude axis, the base can be moved by hand to align the MAT with the altitude targets, then clamped. The final tilt alignment can be done with the MAT's tilt screws and the final translation alignment with the cross–hair micrometers. Once set up this way, the MAT can be used to align the remainder of the GHRIL optical components, assembling them from the front of the table backwards.

A problem common to both the laser and MAT alignment techniques from the BACK of the table, is that the alignment of each component must be done from the REAR. This is especially a problem with the alignment of the detector since it is probably to view a suitable reference mark from the back.

2. **Alignment of GHRIL Components**:

*** Isa, Can you do this section. Describe how you go about setting up the alignment of the lens, etc using the laser. ***