SAAO 1m Optical Test Summary Report

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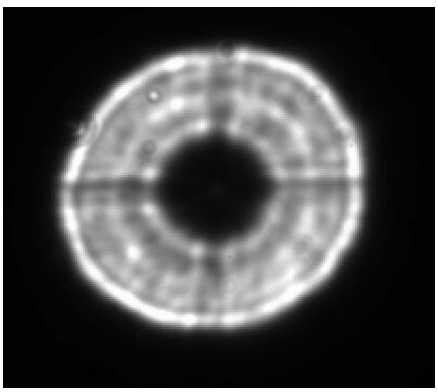
Optical tests have been performed using the curvature sensing method, one of the wavefront analysis used to check the telescope optical performances. Intra and extra focal images have been gathered using one of the available CCD at +/- 150 encoder unit of M2 focus. Both sides of the telescope focus images must be exposed in the shortest delay possible to avoid intensity variation due to the sky transparency fluctuation. The curvature sensing method is based on the intensity distribution contrast between both intra and extra images.
The defocused images have been analysed later using the EF software program.
With a pixel size of 0.02 mm the defocused images covered around 150pixels in diameter far enough from the focal plane and the telescope caustic range (For F/16 telescope). The analysis software converges in a better way within this important condition.
Due to the 1m control the time delay to shift the focus between the intra and extra focal image is quite long and on some case the sky variation induced fitting error on the EF analysis.

By looking at the defocused image symmetry and intensity distribution an early diagnostic of the telescope status could be done. The several tests performed are then sequential listed below.

Telescope Quality First Tests

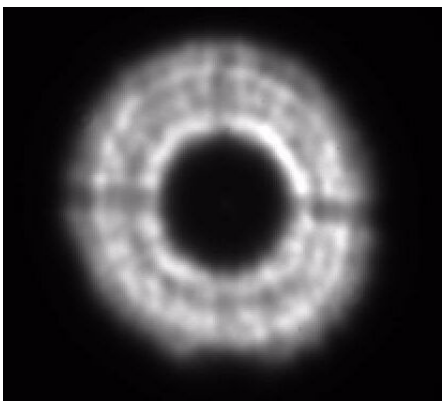
During the first test night (April 25) several images obtained with the telescope oriented sequential on Zenith, 50deg Zenithal Distance (ZD) South, 50ZD North, Zenith, 50ZD West and Zenith confirmed the following results:



Intra focal

Extra focal

South left
East down



Both images are distorted with clear elongation rotating when crossing the focus.

- Image Quality ~ **2.1 Arcsec d80%EE** (Encircled Energy) in Total
- Main Residual is Astigmatism (**1.8**) and the Triangular term (0.5) and coma (0.3)
- The triangular term decreases by 0.2 arcsec when inclining the telescope at 50ZD
- Spherical aberration too large (probably due also to deformations)

We Conclude then:

- M1 and/or M2 deformations induces the large astigmatism and triangular effects.
- M1 weight distribution over the axial pads is not correct. The Triangular term variation with the telescope inclination may be produced by a lack of force on the three axial fixed points.
- Behaviour of M1 and M2 lateral stability seems correct with the small coma variation within 0.2 arcsec.

M2 focusing check

During the M2 aluminization a check of the M2 focus move has been done as:

- One M2 focus unit corresponds to 0.0305 mm of M2 move and 0.402mm of telescope focus shift.

M2 Mounting within its cell.

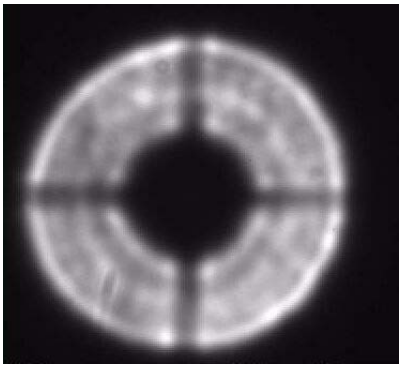
The mirror mounting was found hyperstatic. The mounting of the mirror has been modified to restore the correct static concept over three points with the corresponding 3 points facing fixation. The back surface of the M2 mirror is slightly curved. and step plastic shims have been installed on each three pads to compensate the mirror curvature and avoid triangular bending of the mirror edge when fixing the front ring.
Any forces in between the static mounts must be avoided, the risk of deforming the mirror is very high.

M1 lateral stability.

Two linear gauges have been installed on the mirror edge.
Up to 0.04 mm shift has been detected when moving the telescope on 50ZD South, North, West and East.
The corresponding coma is below 0.1 arcsec.
M1 is then laterally stable.It will have to be check again after the refurbishing of the axial pads force distribution.

New Image Quality after M2 mounting improvements

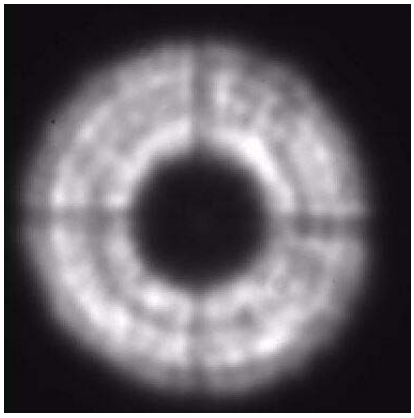
As done on the first test night the telescope has been analysed on Zenith and at 50ZD South North and West.



Intra Focal

Extra Focal

Same orientation as before



Images are much better !, only a small local distortion is seen towards the South . Elongation mainly disappeared.

The analysis of the new defocused images presents a large improvement as:

- **Image Quality ~ 0.8 Arcsec d80%EE in Total**
- Astigmatism reduces to 0.5, Triangular as well to 0.3
- Coma amounts 0.45 being then almost the main contribution ! The telescope was not collimated on-line. A new aluminization of the M2 mirror must be done to replace the plastic shims with a better mirror supporting system. Stains on M2 front will be then also removed.
- Spherical aberration is now below 0.2 arcsec
- When inclining the telescope the triangular variation was also detected still within 0.2 arcsec range.
- Residual coma vector is oriented North East. And a small tilt correction of M2 moving the North East side towards M1 will compensate the defect. A tilt of 0.05deg will be enough.

Some Test on changing the M1 axial pad forces

The axial pad close to the South part (named Pad#2) has been modified by increasing slightly the force applied on the mirror back.
The image analysis shown then:

- increasing by almost 4 kg it was possible to reduce the Triangular contribution to 0.1 arcsec with only 0.3 arcsec Astigmatism with the telescope at Zenith.
- The pad#2 counterweight was then moved to increase the force, the IQ measure was not possible to achieve as sky variation at that time affected the CCD images.

Conclusion

The telescope is now in a better shape. The pad#2 has been modified by moving the counterweight expecting then a better compensation of the residual aberrations.
With a proper overhaul of the M1 cell with a verified axial force distribution we can estimate the astigmatism being the higher residual with 0.3 arcsec. Coma, triangular and spherical terms being below 0.2 arcsec. The telescope should deliver an IQ total around 0.6 arcsec d80%EE.
Images for science have been obtained on the next nights with seeing below 0.7 arcsec of a very good 0.8 arcsec FWHM !!

To be done:

- Improve the M2 fixation.
- Improve the M1 cell force distribution on axial pads taking in account the radial pad belt weight. The M1 cell use two axial pad ring. Mirror deformation analysis done on our 1m shown a correct weight compensation with 0.27 of the total weight on the inner ring with 6 pads and 0.73 on the outer ring with 9 pads (including the 3 fixed ones)
- A device to measure the force for each pad must be foreseen. At zenith the correct force with the counterweight horizontal must be considered to minimize the M1 deformations
- An online Software reduction as EF should be restored to allow precise IQ analysis and corresponding correction (coma improvement)