Pupil rotation compensation for LINC-NIRVANA

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ABSTRACT

The interferometric imager LINC-NIRVANA will use pyramid wavefront-sensors for mulri-conjugated adaptive optics (MCAO). A derotator will produce a static field on the pyramids, but a rotating pupil image on the CCD. For long exposure times, we have to take into account this effect to command the deformable mirror properly by changing the command matrix on the fly. We reproduce in a laboratory set-up this configuration to test different methods for compensating for this effect. We present the results obtained and the optimal solution we have selected.

Keywords: adaptive optics

1. INTRODUCTION

LINC-NIRVANA[1] for the Large Binocular Telescope is an infrared interferometric imager, which include a multi-conjucated adaptive optics (MCAO) system for the two optical paths. This instrument will be commissioned in a few years, after a *pathfinder*[2] version planned for 2013, and the different components are currently being tested at Max-Planck-Institut fuer Astronomie (MPIA) in Heidelberg. The four wavefront sensors use 8 to 12 pyramids[3] aligned to different stars, and these sensors must remain fixed with respect to the field to keep the alignment during the exposure. In the case of the 12-pyramid sensor, the derotator is a large bearing and the entire constellation of sensors is rotated (see figure 1).

In the case of the 8-pyramid sensor this operation is performed by a K-mirror derotator, currently being tested in the laboratory set-up. In this configuration, the pupil image on the CCD rotates with the K-mirror and the reconstructor must be changed regularly to properly command the deformable mirror.

Although the results presented here were produced from data collected using a test set-up for the 8-pyramid sensor, they will first be used for the *pathfinder* which makes use of one of the 12-pyramid systems for wave front sensing. Because this system controls the adaptive secondary at LBT, closed loop pupil rotation tests could not be conducted in a laboratory set-up. Instead we used the 8-pyramid sensor and its K-mirror for these tests and the results will be adapted to the 12-pyramid system. Althouth the derotation mechanism, a large bearing instead of a K-mirror, differs, we anticipate that the general techniques developed in the laboratory will be applicable to the 12-pyramid system in its control of the adaptive secondary for *pathfinder*.

2. EXPERIMENTAL SETUP

The LINC-NIRVANA optical bench[4] is currently set up for middle high altitude sensing, using the devoted wavefront-sensor with 8 pyramids. We use a single phase screen ($r_0 = 30cm$ at $500nm$) conjugated in altitude and the correction is performed by a Xinetics deformable mirror with 349 actuators. The sources (we use 4 of them to illuminate almost the whole pupil) are installed on a rotating fiber plate, allowing us to simulate the sky field rotation. As on-sky, the K-mirror (see figure 2) is used to derotate the field and keep the sources aligned with the star enlargers of the wavefront sensor.

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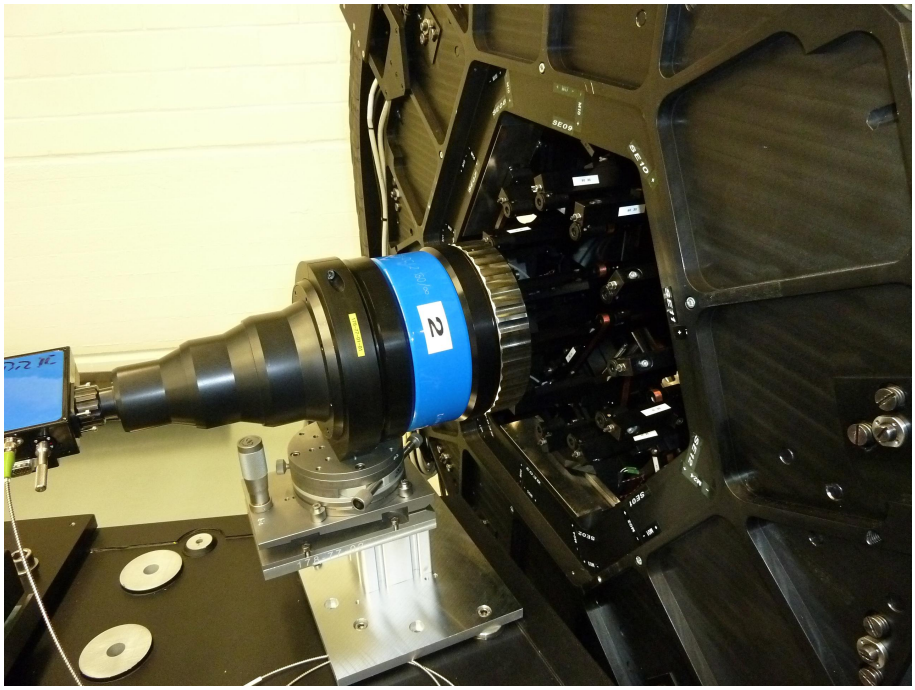

Figure 1. Wavefronsensor (on the right) with 12 pyramids on individual stages. The whole mount is able to rotate to compensate the field rotation during the exposure.

Figure 2. The K-mirror of LINC-NIRVANA, currently used on optical testbench.

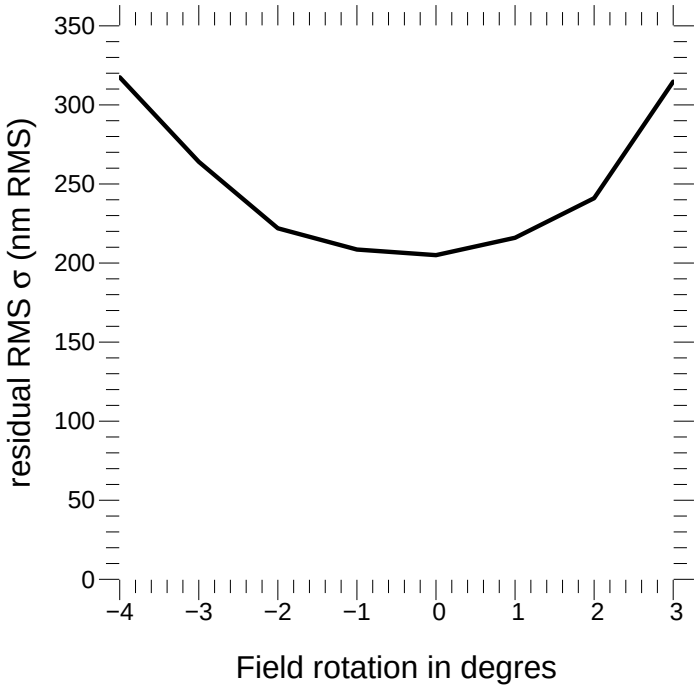

Figure 3. Residual variance after correction with 320 modes, for different field rotations

3. PERFORMANCES

The correction is performed on the illuminated part of the pupil with 320 modes. We attempt to close the loop with a given reconstructor for different field rotation angles, to determine the influence of this error in the correction. The 8 measurements were taken with 1000 samples each in closed loop, and the residual variances are estimated by projection on the first 320 Zernikes. Figure 3 shows this variance versus the rotation angle in degrees.

Out angle values beyond those shown in the graph, the loop is no longer stable, which means that in our configuration, the error must be lower than 3 degrees (which is consistent with the 7.5 degrees period of the last Zernikes used here). More interesting, we can see from this result that the effect of a miscorrection of field rotation is not critical, and this graph gives information to determine the angle variation before a new reconstructor must be uploaded, depending on the error budget allowed for this. The error reached here for example is 50nm RMS for a deviation of 1 degree.

4. FIRST ATTEMPTS FOR RECONSTRUCTOR ROTATION

The next step was to update the reconstructor according to the previous results, to reach the best performance during long exposure acquisitions. An algorithm allowing us to perform the rotation operation as well as dealing with non-illuminated subapertures was realized and tested in June on our bench. Unfortunately, we did not succeed in obtaining a stable loop while the field was rotating. Our last investigations showed that the pupil does not only rotate, but is also significantly translated. For example, a rotation of 25 degrees leads to a translation of the pupil of 0.8 subaperture.

This same problem was in particular already studied at Keck Observatory,[5] and we have now to calibrate this translation to update our algorithm to take into account this effect.

5. CONCLUSION

We have presented here the first results obtained with the K-mirror of LINC-NIRVANA on a test bench, with the aim of being able to keep the loop closed with the best performances during long-acquisitions with a rotating field.

The error due to a miscorrection was measured and first attempts to rotate the reconstructor have been described. The next step will be to take into account the pupil translation observed on the bench in the computation of the new reconstructor, in order to be ready to operate the LINC-NIRVANA pathfinder in early 2013.

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