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74" optics Kottamia

Carl Zeiss Jena GmbH/ Spot s.r.l Milano, Italy
NRIAG Helwan/ Cairo

Test certificate

CZJ/ Kott-Contract AG 13 95702
KOTTECE5/czj

5

Test certificate

Test at the Kottamia observatory on the sky

This document contains 30 pages

confirmed

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M. G. S. P.

Date:
Jena
10.06.1998

PM/ Astronomical Instruments Division

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1 Scope

The test will confirm that the mirror is functional and has not received any form of damage in transit or during integration. The aim of the test is to check the optimal alignment of the mirror system.

The main task of the test is to reduce the coma coefficient.

2 Applicable documents

- CALL OF AN INTERNATIONAL TENDER FOR THE SUPPLY OF THE BLANK OF THE PRIMARY MIRROR FOR ITS OPTICAL FIGURING AND COATING
November 1993
- The Supply Of The Blank Of The Primary Mirror
Its Optical Figuring, Polishing And Coating
Technical proposal
Carl Zeiss Jena GmbH
January 94
- The Supply Of The Blank Of The Primary Mirror
Its Optical Figuring, Polishing And Coating
Commercial and Administrative Section
Carl Zeiss Jena GmbH
January 94
- Contract No. 7 Year 1994
Supply and Installation of the Main mirror and Subsidiary mirror for the Kottamia
Astronomical Observatory
- Test plan for the 74" optics Kottamia issue 04/ May 1997



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3 Test definition

The test will confirm that the mirror is functional and has not received any form of damage in transit or during integration. The aim of the test is to check the alignment of the mirror system.

4 Test procedure

The test procedure will be a test with a SHACK-HARTMANN tester.

Before the start of the test the telescope was adjusted with optical means. (autocollimation telescope). The ZERNIKE terms was analyzed.

For the optimization of the adjustment state the reducing of following coefficients are necessary:

1. Coma
2. Spherical aberations
3. Triangle Coma
4. Astigmatismus

4.1 Test Equipment

- SHACK-HARTMANN tester
- Balanced and tracked telescope
- PC for evaluation of the measuring data
- Evaluation software"
- Wavefront sensor system with lenslet array (used lens matrix 20x20)
- CCD sensor

5 Test description:

The telescope will be tracked on the sky. On the end of the tube the wavefront sensor is mounted. Light source is a star on the sky.

The SHACK-HARTMANN method measures the positions of star images arising from sub-apertures. Those positions determine the local gradient of the wavefront, and the overall phase profile is reconstructed from these slope data.

The test results will be describe

- the wavefront,
- the ZERNIKE coefficients
- and the spot concentration

Note:

The evaluation of the results is dependent of the seeing conditions

This process will be repeated for variation of :

- the seeing conditions (more nights)
- the position of the secondary mirror (focussing position)
- the adjustment state (optimisation process)

This method is an on-line procedure.

The distance between the mirror support flange and the optimum focal plane will be investigated

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Because the seeing conditions prevents a directly measurement, the spot concentration will be extrapolated by a statistical way.

6 Test criteria

The accuracy of the adjustment state of the optical elements will be tested.

The criterion is the extrapolated spot concentration 80% in a diameter of 0.35 arcsec.

7 Test results:

RESULTS FROM THE SHACK-HARTMANN TEST ON THE 1.9M KOTTAMIA TELESCOPE PERFORMED IN APRIL-MAY 1998 USING A NATURAL STAR

7.1 Introduction

In this document we present the results of the Shack-Hartmann test done on the 1.9m Kottamia telescope during April-May 1998 using the Shack-Hartmann sensor Puntino of Spot s.r.l.

The tests were done in a joint effort between Spot s.r.l. and Zeiss, the aim being to optimize the performance of the telescope optics by aligning the primary and secondary mirrors (by reducing coma), as well as by adjusting the supports of the two mirrors to reduce aberrations like triangular coma and astigmatism. It was also aimed to determine the correct focal plane using the coefficient of 3rd order spherical aberration.

A sampling of 21x21 spots was used.

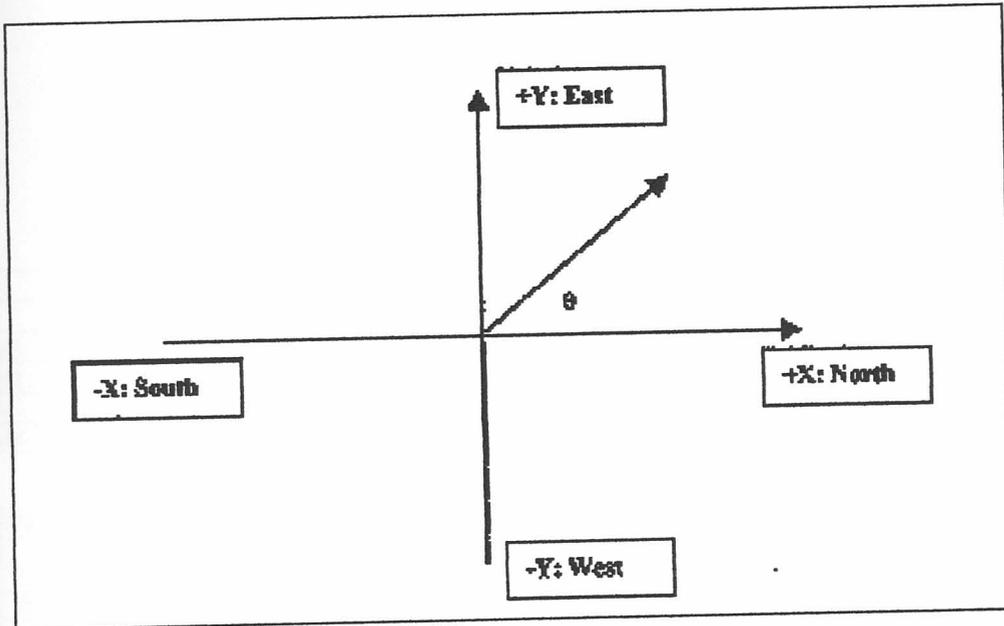
The various steps in the adjustment of the telescope have been reported in the respective tables for the days when the tests were conducted. In most cases, the steps are reported in the table for average frames.

Explanation of terms used in the document:

1. **Coma:** Coefficient of coma.
2. **SA3:** Third order spherical aberration.
3. **Ast:** Third order astigmatism.
4. **Tcoma:** Triangular coma.
5. **Qast:** Quadratic astigmatism.
6. The values for the coefficients are given in arcsecs, and denote the diameter in the focal plane containing 100% of the encircled energy due to that aberration alone.
7. **AQ: Actual Quality:** Residuals remaining after subtracting out **defocus** and **tilt**. In some tables it is abbreviated as (A) instead of (AQ).
8. **PQ: Potential Quality:** Residuals after subtracting out 7 Zernike terms: defocus, tilt, coma, Ast, SA3, Tcoma and Qast. In some tables it is abbreviated as (P) instead of (PQ).
9. **D50:** Diameter containing 50% of the Encircled Energy.
10. **D80:** Diameter containing 80% of the Encircled Energy.

7.2 . Orientation of the contour plots of the mirror surface and the Zernike coefficients

The angles are measured counterclockwise, from the +x direction. The coordinate system is related to the direction on the sky (as determined from orientation frames taken with Puntino):



The orientation frames were taken after the first night: thus for the data of 27-28 April the angles do not correspond to the above directions.

7.3 Results of Shack-Hartmann analysis for single frames and average of multiple frames

In the following pages we give the results for different nights in terms of the Zernike coefficients (in arc sec) as well as the diameter containing the 80% EE as well as the 50% EE, both for the AQ and PQ.

27-28 April - Single frames

Frame	Time	Coma		SA3	Ast		Tcoma		Qast	
		C(")	Angle	C(")	C(")	Angle	C(")	Angle	C(")	Angle
K30M1	00:59:05	1.27	44.0	-0.87	0.89	-62.7	0.69	16.8	0.18	-35.7
K60M2	01:02:37	0.97	38.5	-0.88	0.72	-58.3	0.74	32.0	0.69	44.5
K60M3	01:51:41	1.39	37.6	-0.30	0.91	68.3	0.96	50.3	1.12	-20.4
K60M4	02:02:11	1.11	49.8	-0.24	0.64	-56.9	0.86	17.0	0.24	37.1

Frame	Time	D50(A)	D80(A)	rmsx	rmsy	rms	D50(P)	D80(P)	rmsx	rmsy	rms
		"	"	"	"	"	"	"	"	"	"
K30M1	00:59:05	1.15	1.67	0.71	0.50	0.51	0.87	1.32	0.54	0.35	0.40
K60M2	01:02:37	1.13	1.81	1.06	0.96	0.44	0.88	1.45	0.94	0.84	0.40
K60M3	01:51:41	1.18	1.74	1.37	1.31	0.38	0.95	1.84	1.23	1.13	0.50
K60M4	02:02:11	0.96	1.56	0.62	0.47	0.41	0.63	1.01	0.44	0.28	0.34

Comments for the night of 27-28 April 1998:

1. Triangular coma seen: the visual image is triangular, and the value of Tcoma from the SH analysis confirms this.
2. A high value of astigmatism is also seen, and is probably correlated with that for Tcoma.
3. The value of coma is also high, indicating misalignment of mirrors.
4. The frames were taken in bad seeing conditions.
5. The orientation for the frames was not determined, but is approximately turned clockwise by 30 degrees with respect to the frames taken on subsequent nights.



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28-29 April - Single frames

Frame	Time	Coma		SA3	Ast		Tcoma		Qast	
		C(")	Angle	C(")	C(")	Angle	C(")	Angle	C(")	Angle
K25M1	22:09:46	0.89	91.1	-0.46	0.54	3.9	0.89	-37.0	0.32	0.6
K25M2	22:34:54	1.51	108.7	-0.51	0.41	31.0	0.86	-34.0	0.48	-15.5
3 fixed points of M2 adjusted to correct Tcoma.										
K30M3	00:01:04	1.11	94.2	-0.29	0.48	-16.5	0.24	-41.2	0.34	0.8
Tcoma reduced in above frame after adjustment. M2 adjusted again.										
K15M4	01:15:41	0.65	55.6	-0.41	0.50	-1.6	0.38	-40.4	0.32	5.6
Not much improvement in Tcoma. Puntino moved inwards by 2cm										
K15M5	02:42:46	1.44	75.4	-0.18	0.48	-25.0	0.06	19.4	0.14	31.3
K15M6	02:48:23	1.24	103.3	0.04	0.31	21.5	0.12	32.2	0.53	-1.8
K15M7	02:49:52	1.23	70.0	-0.06	0.39	-5.4	0.07	-20.0	0.28	-9.8
K15M8	02:51:09	1.03	97.7	-0.08	0.38	-29.7	0.29	-29.4	0.09	-7.9
SA3 decreases significantly.										
K15M9	03:06:35	0.85	85.1	-0.13	0.40	0.7	0.04	-35.1	0.03	14.7
K15M10	03:07:56	1.27	103.0	-0.29	0.54	21.3	0.02	5.4	0.23	-8.9
K15M11	03:09:07	0.73	75.0	0.06	0.28	-21.6	0.20	-38.7	0.17	-28.8
K15M12	03:10:31	1.00	106.1	-0.09	0.32	-12.4	0.19	-54.9	0.14	16.5

Frame	Time	D50(A)	D80(A)	rmsx	rmsy	rms	D50(P)	D80(P)	rmsx	rmsy	rms
		"	"	"	"	"	"	"	"	"	"
K25M1	22:09:46	0.82	1.38	0.57	0.33	0.47	0.56	0.95	0.43	0.27	0.33
K25M2	22:34:54	1.00	1.56	0.68	0.41	0.54	0.62	1.11	0.47	0.34	0.33
K30M3	00:01:04	0.69	1.17	0.54	0.33	0.43	0.53	0.89	0.43	0.28	0.33
K15M4	01:15:41	0.76	1.28	0.52	0.34	0.39	0.66	1.04	0.43	0.29	0.32
K15M5	02:42:46	0.95	1.53	0.63	0.43	0.46	0.72	1.17	0.49	0.35	0.34
K15M6	02:48:23	0.82	1.34	0.56	0.36	0.43	0.62	0.96	0.43	0.30	0.31
K15M7	02:49:52	0.76	1.26	0.55	0.34	0.43	0.62	1.01	0.44	0.28	0.34
K15M8	02:51:09	0.69	1.08	0.51	0.30	0.41	0.57	0.92	0.42	0.27	0.31
K15M9	03:06:35	0.70	1.26	0.51	0.32	0.40	0.60	1.07	0.45	0.29	0.34
K15M10	03:07:56	0.84	1.29	0.56	0.35	0.43	0.60	1.01	0.42	0.27	0.33
K15M11	03:09:07	0.61	1.08	0.45	0.27	0.36	0.59	0.95	0.40	0.26	0.31
K15M12	03:10:31	0.67	1.11	0.50	0.30	0.40	0.59	0.93	0.42	0.26	0.33



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28-29 April - Average

Frame	Time	Coma		SA3	Ast		Tcoma		Qast	
		C(")	Angle	C(")	C(")	Angle	C(")	Angle	C(")	Angle
3 fixed points of M2 adjusted to correct Tcoma.										
K25M1- K25M2	22:09:46	1.20	99.9	-0.49	0.47	17.5	0.88	-35.5	0.40	-7.4
Puntino moved inwards by 2cm										
K15M5- K15M8	02:42:46	1.24	86.6	-0.07	0.39	-9.6	0.14	0.6	0.26	3.0
SA3 decreases significantly.										
K15M9- K15M12	03:07:56	0.96	92.3	-0.11	0.38	-3.0	0.11	-30.8	0.14	-1.6

Frame	Time	D50(A)	D80(A)	rmsx	rmsy	rms	D50(P)	D80(P)	rmsx	rmsy	rms
		"	"	"	"	"	"	"	"	"	"
K25M1- K25M2	22:09:46	0.90	1.40	0.62	0.36	0.51	0.53	0.94	0.44	0.30	0.32
K15M5- K15M8	02:42:46	0.69	1.13	0.48	0.29	0.38	0.47	0.81	0.34	0.23	0.25
K15M9- K15M12	03:07:56	0.58	1.04	0.45	0.27	0.36	0.48	0.78	0.34	0.22	0.26



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29-30 April - Single frames

Frame	Time	Coma		SA3	Ast		Tcoma		Qast	
		C(")	Angle	C(")	C(")	Angle	C(")	Angle	C(")	Angle
K3M1	00:47:16	0.67	100.9	-0.02	0.47	39.2	0.10	54.4	0.29	14.0
K3M2	00:48:36	0.63	132.5	-0.17	0.31	27.1	0.10	-38.2	0.25	-7.6
K30M3	02:59:06	0.21	144.6	0.10	0.36	23.1	0.28	-53.1	0.10	-3.9
K30M4	03:02:54	0.36	126.1	0.16	0.26	5.9	0.23	-51.2	0.20	-4.3
K30M5	03:05:28	0.15	124.4	0.12	0.46	3.4	0.28	-45.8	0.10	-6.7
K30M6	03:13:45	0.29	90.1	0.07	0.34	4.4	0.17	-54.1	0.14	-5.4
K30M7	03:20:05	0.15	25.8	0.32	0.45	5.3	0.16	-34.9	0.27	-6.1

Frame	Time	D50(A)	D80(A)	rmsx	rmsy	rms	D50(P)	D80(P)	rmsx	rmsy	rms
		"	"	"	"	"	"	"	"	"	"
K3M1	00:47:16	0.73	1.24	0.53	0.37	0.38	0.67	1.12	0.47	0.33	0.34
K3M2	00:48:36	0.67	1.14	0.47	0.33	0.34	0.64	1.01	0.43	0.30	0.31
K30M3	02:59:06	0.59	0.95	0.39	0.26	0.29	0.48	0.83	0.35	0.22	0.27
K30M4	03:02:54	0.55	0.91	0.37	0.24	0.28	0.45	0.79	0.33	0.20	0.26
K30M5	03:05:28	0.60	0.96	0.39	0.26	0.29	0.50	0.85	0.33	0.22	0.25
K30M6	03:13:45	0.54	0.96	0.38	0.23	0.31	0.44	0.83	0.35	0.21	0.28
K30M7	03:20:05	0.62	1.12	0.43	0.27	0.34	0.49	0.90	0.38	0.23	0.30



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29-30 April - Average

Frame	Time	Coma		SA3	Ast		Tcoma		Qast	
		C(")	Angle	C(")	C(")	Angle	C(")	Angle	C(")	Angle
Spiders adjusted to correct coma										
K3M1- K3M2	00:47:16	0.65	116.7	-0.09	0.39	33.2	0.10	8.1	0.27	3.2
Spiders adjusted again to correct coma										
K30M3- K30M7	02:59:06	0.23	102.2	0.15	0.37	8.4	0.22	-47.8	0.16	-5.3

Frame	Time	D50(A)	D80(A)	rmsx	rmsy	rms	D50(P)	D80(P)	rmsx	rmsy	rms
		"	"	"	"	"	"	"	"	"	"
K3M1- K3M2	00:47:16	0.66	1.11	0.47	0.32	0.34	0.58	1.01	0.42	0.30	0.30
K30M3- K30M7	02:59:06	0.47	0.75	0.30	0.19	0.23	0.35	0.57	0.25	0.16	0.20



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2-3 May - Single frames

Frame	Time	Coma		SA3	Ast		Tcoma		Qast	
		C(")	Angle	C(")	C(")	Angle	C(")	Angle	C(")	Angle
K20M1	07:59:20	0.90	75.6	-0.23	0.32	77.1	0.05	-13.7	0.15	-2.0
K10M2	08:18:00	0.76	104.8	-0.20	1.05	23.1	0.21	-30.2	0.16	-12.6
K10M3	08:19:46	0.45	134.5	-0.14	0.63	49.4	0.32	-42.2	0.23	-7.3
K10M4	08:21:32	0.69	157.4	-0.32	0.65	27.7	0.47	-29.6	0.30	-14.7
K10M6	08:27:47	0.56	124.3	-0.40	0.26	85.3	0.36	-42.6	0.32	1.8
K10M8	08:49:12	0.53	80.5	-0.31	0.77	40.4	0.25	-37.4	0.25	-5.9
K10M9	08:50:52	0.35	104.9	-0.15	0.79	25.3	0.11	-22.5	0.36	-11.6
K10M10	08:52:16	0.23	58.4	-0.27	0.39	48.9	0.31	-36.4	0.14	-27.6
K2M11	10:37:59	0.26	125.1	-0.14	0.48	28.9	0.30	-36.3	0.27	-2.1
K2M12	10:47:39	0.44	162.5	0.22	0.43	35.8	0.28	-30.5	0.22	-6.7
K2M13	10:50:04	0.39	72.6	0.13	0.35	50.5	0.19	47.9	0.19	-6.1
K2M14	10:52:18	0.44	-152.9	0.00	0.51	8.9	0.10	-48.1	0.20	22.0
K2M15	00:23:45	0.47	34.2	0.20	0.24	38.0	0.23	-38.1	0.31	-31.6
K2M16	00:26:20	0.23	29.7	-0.11	0.23	54.3	0.32	14.8	0.48	-3.0
K2M17	00:27:48	0.19	73.8	-0.15	0.65	18.6	0.34	43.3	0.37	-11.4
K2M18	00:29:27	0.40	16.3	-0.25	0.40	9.7	0.27	0.7	0.15	33.6
K5M19	01:08:45	0.28	56.0	0.27	0.43	36.6	0.28	-30.1	0.10	-9.4
K5M20	01:10:52	0.43	28.1	0.27	0.42	25.7	0.25	-34.4	0.15	-20.9
K5M21	01:12:40	0.30	31.7	0.29	0.34	34.9	0.24	-32.0	0.15	-30.2
K5M22	01:14:21	0.39	51.4	0.27	0.33	30.8	0.24	-35.8	0.11	-19.8
K5M23	02:01:22	0.23	39.6	0.21	0.40	31.8	0.19	-37.9	0.08	-10.5
K5M24	02:03:08	0.09	-33.0	0.29	0.37	27.3	0.26	-38.8	0.02	12.9
K5M25	02:05:15	0.17	-16.0	0.33	0.40	30.5	0.28	-35.7	0.11	-20.5
K5M26	02:06:33	0.27	13.5	0.35	0.36	33.8	0.26	-34.8	0.14	-26.4



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2-3 May (continued) - Single frames

Frame	Time	D50(A)	D80(A)	rmsx	rmsy	rms	D50(P)	D80(P)	rmsx	rmsy	rms
		"	"	"	"	"	"	"	"	"	"
K20M1	07:59:20	0.74	1.20	0.52	0.34	0.39	0.57	0.99	0.45	0.30	0.33
K10M2	08:18:00	0.90	1.41	0.59	0.41	0.42	0.60	0.96	0.44	0.33	0.29
K10M3	08:19:46	0.79	1.21	0.54	0.38	0.39	0.56	1.05	0.46	0.34	0.32
K10M4	08:21:32	0.86	1.31	0.57	0.40	0.41	0.60	1.07	0.45	0.33	0.31
K10M6	08:27:47	0.71	1.21	0.50	0.36	0.35	0.68	1.08	0.44	0.32	0.30
K10M8	08:49:12	0.84	1.28	0.55	0.36	0.41	0.57	1.00	0.43	0.30	0.30
K10M9	08:50:52	0.88	1.27	0.52	0.37	0.37	0.59	0.97	0.40	0.30	0.27
K10M10	08:52:16	0.67	1.08	0.47	0.35	0.31	0.59	0.94	0.43	0.33	0.27
K2M11	10:37:59	0.78	1.21	0.51	0.35	0.37	0.64	1.11	0.46	0.32	0.33
K2M12	10:47:39	0.78	1.36	0.55	0.38	0.40	0.73	1.17	0.50	0.33	0.37
K2M13	10:50:04	0.74	1.28	0.55	0.37	0.41	0.70	1.19	0.53	0.36	0.39
K2M14	10:52:18	0.74	1.16	0.50	0.35	0.36	0.69	1.03	0.46	0.31	0.33
K2M15	00:23:45	0.81	1.29	0.54	0.33	0.42	0.75	1.23	0.50	0.31	0.39
K2M16	00:26:20	0.76	1.23	0.53	0.38	0.37	0.75	1.07	0.50	0.36	0.35
K2M17	00:27:48	0.82	1.35	0.56	0.35	0.44	0.71	1.13	0.49	0.30	0.39
K2M18	00:29:27	0.85	1.28	0.57	0.40	0.40	0.75	1.16	0.52	0.35	0.38
K5M19	01:08:45	0.63	0.93	0.41	0.27	0.31	0.47	0.81	0.35	0.25	0.25
K5M20	01:10:52	0.61	0.97	0.41	0.27	0.31	0.50	0.82	0.35	0.24	0.25
K5M21	01:12:40	0.57	0.91	0.36	0.25	0.26	0.46	0.76	0.31	0.22	0.22
K5M22	01:14:21	0.58	0.91	0.40	0.25	0.31	0.51	0.83	0.35	0.24	0.26
K5M23	02:01:22	0.48	0.81	0.33	0.22	0.25	0.37	0.68	0.28	0.19	0.20
K5M24	02:03:08	0.51	0.86	0.35	0.23	0.27	0.42	0.70	0.31	0.21	0.22
K5M25	02:05:15	0.60	0.97	0.39	0.26	0.30	0.47	0.77	0.33	0.22	0.25
K5M26	02:06:33	0.57	0.93	0.40	0.26	0.31	0.46	0.75	0.35	0.23	0.26



74" optics Kottamia

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2-3 May - Average

Frame	Time	Coma		SA3	Ast		Tcoma		Qast	
		C(")	Angle	C(")	C(")	Angle	C(")	Angle	C(")	Angle
M2 rotated 120 counterclockwise (i.e. North through East) to correct Ast.										
K10M2- K10M6	08:18:00	0.62	130.3	-0.26	0.65	46.4	0.34	-36.2	0.25	-8.2
K10M8- K10M10	08:52:16	0.37	81.3	-0.24	0.65	38.2	0.22	-32.1	0.25	-15.0
The above rows show that Ast has increased from 0.38 to 0.65". So M2 is again rotated counterclockwise by 120 (i.e. North through East)										
K2M11- K2M14	10:37:59	0.38	51.8	0.05	0.44	31.0	0.22	-16.8	0.22	1.8
There is some reduction in Ast. Now M2 is rotated within its cell clockwise (i.e. North through West) by 60.										
K2M15- K2M18	00:23:45	0.32	38.5	-0.08	0.38	30.1	0.29	5.2	0.33	-3.1
K5M19- K5M22	01:08:45	0.35	41.8	0.28	0.38	32.0	0.25	-33.1	0.13	-20.1
Spiders adjusted to correct coma										
K5M23- K5M26	02:01:22	0.19	1.0	0.29	0.38	30.9	0.25	-36.8	0.09	-11.1

Frame	Time	D50(A)	D80(A)	rmsx	rmsy	rms	D50(P)	D80(P)	rmsx	rmsy	rms
		"	"	"	"	"	"	"	"	"	"
K10M2- K10M6	08:18:00	0.71	1.18	0.51	0.36	0.36	0.53	0.95	0.42	0.31	0.27
K10M8- K10M10	08:52:16	0.72	1.12	0.48	0.34	0.34	0.55	0.91	0.39	0.29	0.26
K2M11- K2M14	10:37:59	0.57	0.88	0.38	0.26	0.27	0.50	0.79	0.34	0.24	0.24
K2M15- K2M18	00:23:45	0.57	0.90	0.44	0.28	0.34	0.50	0.78	0.40	0.25	0.31
K5M19- K5M22	01:08:45	0.58	0.87	0.38	0.25	0.28	0.45	0.71	0.32	0.23	0.23
K5M23- K5M26	02:01:22	0.52	0.84	0.35	0.23	0.27	0.40	0.69	0.30	0.20	0.22



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3-4 May - Single frames

Frame	Time	Coma		SA3	Ast		Tcoma		Qast	
		C(")	Angle	C(")	C(")	Angle	C(")	Angle	C(")	Angle
K10M1	21:45:46	0.79	127.4	-0.14	0.25	0.1	0.28	-27.7	0.23	-6.9
K10M2	21:52:59	0.84	124.9	-0.10	0.67	9.1	0.29	-46.8	0.32	-1.0
K10M3	21:54:16	0.60	99.8	-0.28	0.95	7.2	0.44	30.9	0.15	-39.7
K15M4	23:23:13	1.00	38.1	-0.42	0.40	73.3	0.17	51.2	0.34	-15.3
K15M5	23:27:02	0.93	76.3	0.04	0.55	15.6	0.07	22.1	0.08	5.9
K15M6	23:29:38	1.00	76.5	-0.25	0.45	-78.2	0.20	-0.7	0.18	16.1
K15M7	00:17:09	1.13	53.8	-0.22	0.69	30.6	0.14	-26.4	0.34	-15.7
K15M8	00:19:18	0.69	41.6	-0.08	0.63	34.1	0.27	-30.2	0.15	-1.9
K15M9	00:20:53	0.81	53.7	-0.27	0.76	37.0	0.33	-36.2	0.25	-2.9
K2M10	01:13:25	0.80	57.2	-0.03	0.27	42.3	0.21	-23.1	0.16	0.9
K2M11	01:26:08	0.59	67.3	0.01	0.24	23.5	0.17	-35.1	0.22	15.0
K2M12	01:25:03	0.88	59.5	0.11	0.26	-4.4	0.04	-57.3	0.32	-4.2
K5M13	02:25:22	0.90	57.9	0.02	0.40	24.7	0.27	-33.6	0.16	-11.9
K5M14	02:29:40	0.91	61.4	0.06	0.40	20.9	0.20	-41.5	0.01	7.6
K5M15	02:31:19	1.07	52.5	-0.02	0.46	22.7	0.18	-40.0	0.04	-2.7
K5M16	03:37:16	0.41	9.4	0.40	0.20	12.6	0.22	-44.7	0.09	34.4
K5M17	03:41:52	0.51	27.3	0.34	0.56	9.5	0.24	-40.0	0.10	6.6
K25M18	04:15:26	0.27	-40.1	0.21	0.62	32.5	0.12	-31.3	0.06	-11.5
K25M19	04:19:17	0.38	-25.8	0.32	0.50	37.5	0.21	-28.0	0.08	-19.3
K25M20	04:21:42	0.28	-20.5	0.27	0.58	31.4	0.17	-21.8	0.01	-34.0

Frame	Time	D50(A)	D80(A)	rmsx	rmsy	rms	D50(P)	D80(P)	rmsx	rmsy	rms
K10M1	21:45:46	0.66	1.17	0.48	0.32	0.36	0.61	0.95	0.42	0.29	0.30
K10M2	21:52:59	0.87	1.40	0.55	0.36	0.42	0.67	1.09	0.44	0.29	0.33
K10M3	21:54:16	1.10	1.59	0.64	0.45	0.46	0.78	1.23	0.50	0.32	0.38
K15M4	23:23:13	0.86	1.37	0.58	0.38	0.43	0.71	1.11	0.48	0.32	0.36
K15M5	23:27:02	0.87	1.34	0.54	0.36	0.40	0.66	1.09	0.44	0.29	0.32
K15M6	23:29:38	0.85	1.37	0.56	0.39	0.41	0.69	1.16	0.47	0.33	0.33
K15M7	00:17:09	0.87	1.29	0.56	0.35	0.43	0.56	0.88	0.40	0.27	0.29
K15M8	00:19:18	0.72	1.18	0.46	0.29	0.36	0.52	0.82	0.36	0.22	0.28
K15M9	00:20:53	0.79	1.29	0.55	0.33	0.43	0.55	0.88	0.41	0.27	0.31
K2M10	01:13:25	0.65	1.13	0.46	0.30	0.35	0.50	0.96	0.39	0.27	0.29
K2M11	01:26:08	0.65	1.12	0.45	0.27	0.36	0.60	0.96	0.41	0.25	0.33
K2M12	01:25:03	0.81	1.25	0.52	0.33	0.40	0.66	1.03	0.45	0.28	0.35
K5M13	02:25:22	0.68	1.06	0.43	0.26	0.35	0.46	0.81	0.33	0.22	0.26
K5M14	02:29:40	0.69	1.09	0.46	0.27	0.38	0.48	0.79	0.36	0.22	0.29
K5M15	02:31:19	0.74	1.18	0.48	0.30	0.37	0.49	0.82	0.36	0.23	0.27
K5M16	03:37:16	0.50	0.85	0.34	0.26	0.22	0.43	0.72	0.29	0.23	0.19
K5M17	03:41:52	0.60	1.02	0.40	0.28	0.28	0.47	0.75	0.30	0.23	0.20
K25M18	04:15:26	0.60	0.92	0.38	0.27	0.27	0.42	0.69	0.29	0.20	0.21
K25M19	04:19:17	0.54	0.94	0.37	0.27	0.25	0.43	0.73	0.29	0.21	0.20
K25M20	04:21:42	0.61	0.93	0.38	0.28	0.26	0.43	0.72	0.29	0.21	0.20



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3-4 May - Average

Frame	Time	Coma		SA3	Ast		Tcoma		Qast	
		C(")	Angle	C(")	C(")	Angle	C(")	Angle	C(")	Angle
Spiders moved towards North for correcting coma										
K10M1-K10M3	21:45:46	0.74	117.4	-0.17	0.62	5.5	0.34	-14.5	0.23	-15.9
Spiders now moved towards South for correcting coma										
K15M4-K15M6	23:23:13	0.98	63.6	-0.21	0.47	3.6	0.15	24.2	0.20	2.2
Another set of 3 frames taken.										
K15M7-K15M9	00:17:09	0.88	49.7	-0.19	0.69	33.9	0.25	-30.9	0.25	-6.8
Spiders now moved East for correcting coma										
K2M10-K2M12	01:13:25	0.76	61.3	0.03	0.26	20.5	0.14	-38.5	0.23	3.9
Coma has decreased above. M2 again moved East										
K5M13-K5M15	02:25:22	0.96	57.3	0.02	0.42	22.8	0.22	-38.4	0.07	-2.3
Coma increases, probably due to the very simple way in which the mounting of M2 can be adjusted. Further adjustment done										
K5M16-K5M17	03:37:16	0.46	18.4	0.37	0.38	11.1	0.23	-42.3	0.09	20.5
Coma reduced. Further adjustment done.										
K25M18-K25M20	04:15:26	0.31	-28.8	0.27	0.57	33.8	0.17	-27.0	0.05	-21.6
Coma reduced further.										

Frame	Time	D50(A)	D80(A)	rmsx	rmsy	rms	D50(P)	D80(P)	rmsx	rmsy	rms
		"	"	"	"	"	"	"	"	"	"
K10M1-K10M3	21:45:46	0.72	1.14	0.48	0.33	0.35	0.52	0.87	0.37	0.26	0.27
K15M4-K15M6	23:23:13	0.63	1.05	0.44	0.30	0.32	0.49	0.88	0.36	0.24	0.26
K15M7-K15M9	00:17:09	0.70	1.13	0.48	0.29	0.39	0.43	0.66	0.31	0.20	0.24
K2M10-K2M12	01:13:25	0.57	0.92	0.38	0.24	0.30	0.46	0.74	0.32	0.21	0.24
K5M13-K5M15	02:25:22	0.68	1.08	0.45	0.27	0.36	0.44	0.75	0.34	0.21	0.26
K5M16-K5M17	03:37:16	0.53	0.89	0.35	0.25	0.24	0.43	0.72	0.28	0.21	0.19
K25M18-K25M20	04:15:26	0.57	0.93	0.37	0.27	0.26	0.43	0.71	0.28	0.20	0.20

5-6 May - Single frames

Frame	Time	Coma		SA3	Ast		Tcoma		Qast	
		C(")	Angle	C(")	C(")	Angle	C(")	Angle	C(")	Angle
K15M1	22:35:52	0.44	12.7	-0.14	0.23	34.8	0.22	-46.8	0.15	4.9
K15M2	22:41:02	0.53	-11.9	-0.06	0.27	52.1	0.24	-42.5	0.14	-11.6
K15M3	22:53:28	0.49	-1.9	-0.14	0.38	55.4	0.19	-32.7	0.02	-28.7
K15M4	22:57:10	0.46	-11.7	-0.20	0.37	43.4	0.15	-42.7	0.14	5.6
K15M5	23:19:10	0.42	-7.4	-0.27	0.37	42.3	0.23	-18.0	0.08	-11.1
K15M6	23:20:47	0.49	-12.7	-0.21	0.53	44.2	0.05	-18.8	0.19	0.6
K15M7	23:24:21	0.56	-3.2	-0.06	0.43	38.1	0.20	-0.2	0.24	6.9
K15M8	23:25:44	0.29	-151.9	-0.50	0.16	-64.8	0.81	-33.2	0.74	-16.1
K15M9	23:27:16	0.56	-17.5	-0.20	0.49	48.6	0.18	-31.0	0.28	7.5
K15M10	01:00:57	0.58	15.6	-0.02	0.38	3.4	0.27	-14.8	0.16	1.7
K15M11	01:05:46	0.56	21.0	0.03	0.57	24.1	0.27	-25.8	0.12	0.3
K15M12	01:07:17	0.60	36.6	0.07	0.58	16.2	0.22	-9.2	0.16	-6.1
K15M13	01:14:48	1.11	42.9	-0.07	0.54	28.7	0.15	-23.2	0.25	1.1
K15M14	01:16:35	0.70	27.8	0.12	0.51	29.0	0.14	-22.1	0.11	6.2
K15M15	01:58:45	0.62	12.5	0.10	0.35	8.8	0.20	-38.0	0.07	11.2
K15M16	02:00:04	0.51	26.9	0.11	0.22	9.8	0.18	-33.4	0.08	-5.3
K15M17	02:01:21	0.58	12.1	0.14	0.21	25.2	0.16	-30.5	0.11	4.2
K15M18	02:02:39	0.52	19.0	0.13	0.25	7.2	0.17	-35.0	0.14	-2.1
K3M19	02:31:48	0.49	34.9	0.08	0.38	22.6	0.26	-41.2	0.08	-16.2
K3M20	02:33:28	0.53	32.4	0.04	0.38	20.6	0.35	-33.1	0.02	-11.1
K3M21	02:34:39	0.50	27.2	0.03	0.31	30.4	0.25	-23.0	0.17	-18.5
K3M22	02:35:43	0.47	22.7	0.05	0.28	18.8	0.25	-36.6	0.12	-4.3

Frame	Time	D50(A)	D80(A)	rmsx	rmsy	rms	D50(P)	D80(P)	rmsx	rmsy	rms
		"	"	"	"	"	"	"	"	"	"
K15M1	22:35:52	0.53	0.83	0.37	0.25	0.28	0.46	0.74	0.33	0.22	0.24
K15M2	22:41:02	0.54	0.93	0.38	0.26	0.28	0.47	0.80	0.33	0.22	0.25
K15M3	22:53:28	0.52	0.92	0.38	0.25	0.28	0.44	0.78	0.33	0.21	0.25
K15M4	22:57:10	0.51	0.96	0.39	0.27	0.28	0.47	0.86	0.34	0.23	0.25
K15M5	23:19:10	0.58	1.05	0.43	0.30	0.31	0.50	0.87	0.37	0.25	0.27
K15M6	23:20:47	0.62	1.07	0.47	0.31	0.35	0.52	0.83	0.40	0.25	0.31
K15M7	23:24:21	0.66	1.05	0.44	0.31	0.31	0.53	0.90	0.37	0.24	0.29
K15M8	23:25:44	0.83	1.29	1.05	0.99	0.35	0.82	1.38	0.99	0.91	0.37
K15M9	23:27:16	0.63	1.08	0.48	0.34	0.35	0.55	0.85	0.41	0.27	0.31
K15M10	01:00:57	0.60	1.04	0.42	0.29	0.30	0.50	0.81	0.36	0.23	0.27
K15M11	01:05:46	0.72	1.06	0.47	0.30	0.37	0.56	0.85	0.39	0.24	0.31
K15M12	01:07:17	0.73	1.10	0.48	0.32	0.35	0.52	0.90	0.40	0.26	0.30
K15M13	01:14:48	0.85	1.37	0.56	0.37	0.42	0.56	0.95	0.42	0.27	0.32
K15M14	01:16:35	0.68	1.10	0.46	0.30	0.35	0.53	0.89	0.38	0.24	0.30
K15M15	01:58:45	0.60	1.00	0.39	0.26	0.29	0.50	0.75	0.32	0.21	0.25
K15M16	02:00:04	0.56	0.89	0.37	0.25	0.28	0.52	0.82	0.34	0.22	0.26
K15M17	02:01:21	0.57	0.88	0.37	0.25	0.27	0.49	0.78	0.33	0.21	0.25
K15M18	02:02:39	0.57	0.90	0.37	0.24	0.28	0.49	0.79	0.32	0.21	0.25
K3M19	02:31:48	0.56	0.94	0.37	0.24	0.29	0.43	0.75	0.31	0.20	0.24
K3M20	02:33:28	0.62	1.00	0.44	0.26	0.35	0.49	0.85	0.38	0.23	0.30
K3M21	02:34:39	0.60	0.94	0.39	0.26	0.29	0.46	0.76	0.33	0.22	0.25
K3M22	02:35:43	0.54	0.89	0.36	0.24	0.27	0.45	0.72	0.31	0.20	0.23



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5-6 May - Average

Frame	Time	Coma		SA3	Ast		Tcoma		Qast	
		C(")	Angle	C(")	C(")	Angle	C(")	Angle	C(")	Angle
Very bright star. Exposure 0.01 sec.										
K15M1- K15M4	22:35:52	0.48	-3.2	-0.14	0.31	46.4	0.20	-41.2	0.11	-7.4
Further exposures taken of 0.01 sec.										
K15M5- K15M9	23:19:10	0.46	-38.5	-0.25	0.40	21.7	0.29	-20.2	0.31	-2.4
The presence of coma is confirmed by the 9 frames. Spiders moved south to correct coma										
K15M10- K15M14	01:00:57	0.71	28.8	0.03	0.52	20.3	0.21	-19.0	0.16	0.6
Coma actually increases, due to the very simple arrangement for adjusting the spiders.										
K15M15- K15M18	01:58:45	0.56	17.6	0.12	0.26	12.8	0.18	-34.2	0.10	2.0
To test the stability of the telescope, the telescope is moved W-Zenith-N-Zenith-E-star										
K3M19- K3M22	02:31:48	0.50	29.3	0.05	0.34	23.1	0.28	-33.5	0.10	-12.5
There is a small change in the value of coma. At this point, it was decided to take direct images.										

Frame	Time	D50(A)	D80(A)	rmsx	rmsy	rms	D50(P)	D80(P)	rmsx	rmsy	rms
		"	"	"	"	"	"	"	"	"	"
K15M1- K15M4	22:35:52	0.45	0.75	0.33	0.23	0.23	0.37	0.62	0.27	0.19	0.19
K15M5- K15M9	23:19:10	0.58	0.97	0.56	0.48	0.29	0.47	0.87	0.47	0.40	0.25
K15M10 - K15M14	01:00:57	0.61	1.00	0.41	0.27	0.30	0.40	0.69	0.31	0.20	0.24
K15M15- M18	01:58:45	0.55	0.89	0.36	0.24	0.27	0.47	0.75	0.31	0.20	0.24
K3M19- K3M22	02:31:48	0.57	0.87	0.40	0.24	0.31	0.42	0.72	0.34	0.21	0.27



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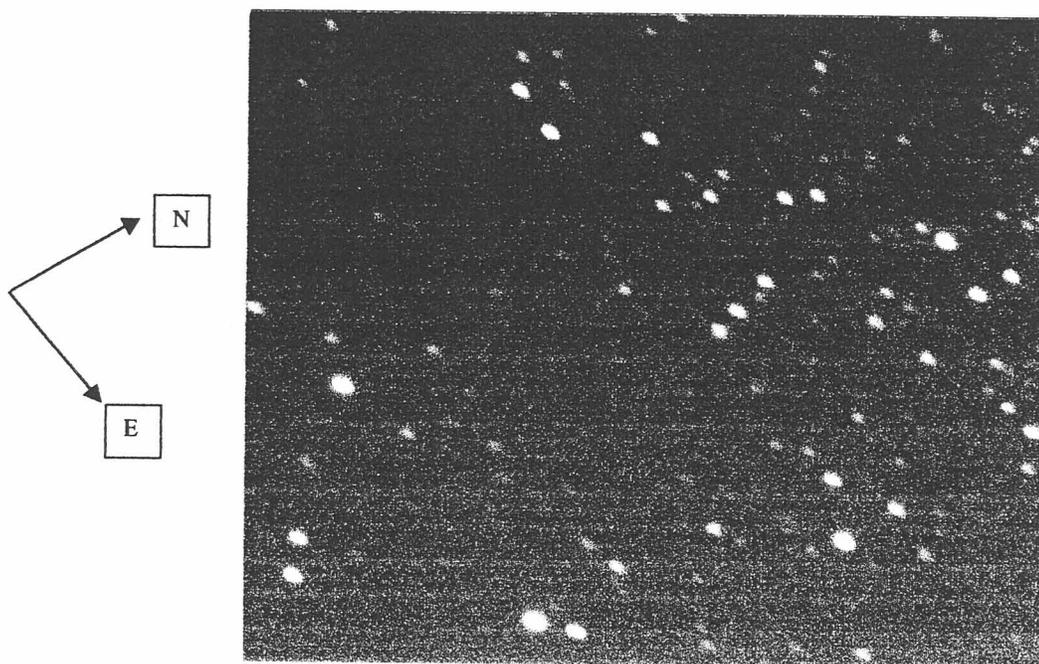
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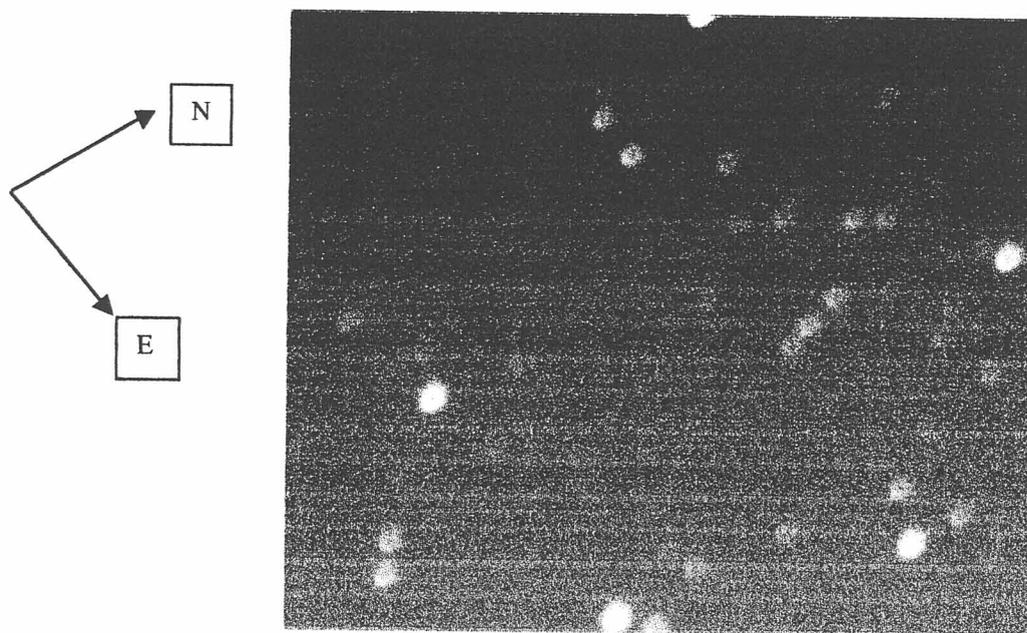
7.4 Direct images

The following images were taken after replacing Puntino with the CCD camera at the Cassegrain focus. The images are of a star cluster. Exposure time was 40 seconds. The scale of the telescope is $6.1''/\text{mm}$, and the scale on the CCD is $0.096''/\text{pixel}$.

Direct image - intra focal



40 sec exposure. Intra focal. Note the elongation of the image. The elongation of the image is approximately along the E-W direction. To check if the elongation was caused by tracking, a short exposure frame of 1 sec was taken, and the elongation persisted, as was evident from the bright stars.

Direct image- extra focal

40 sec exposure. Extra focal. Now the image is elongated approximately N-S due to the astigmatism. The comatic nature of the image is also seen (the coma had not been corrected fully, and had a value of 0.5" - see Table).



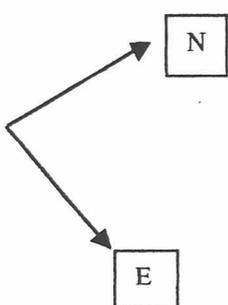
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Direct image- correct focus



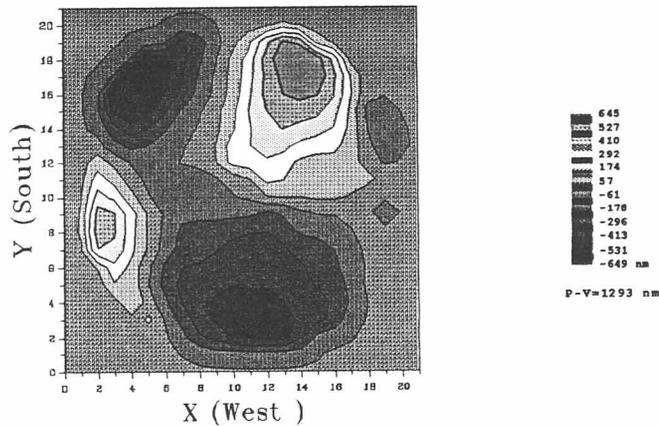
The image very near the correct focus.

1. Contour plots

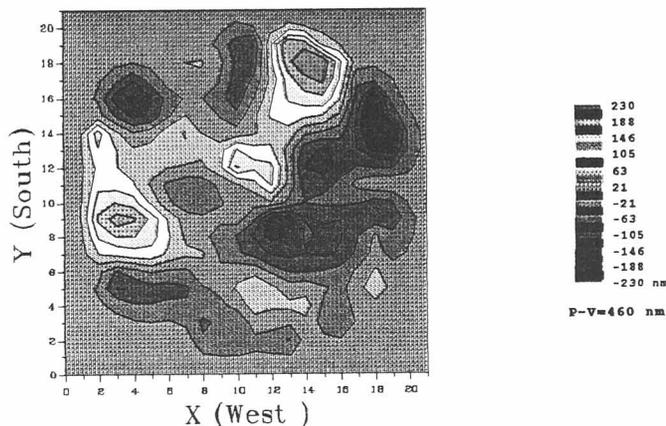
In this section we present the contour plots for different nights for AQ and PQ.

Contour plots of mirror surface: 27-28 April

Frame: K60M4-28/04/98:02:02:11-Surface-AQ



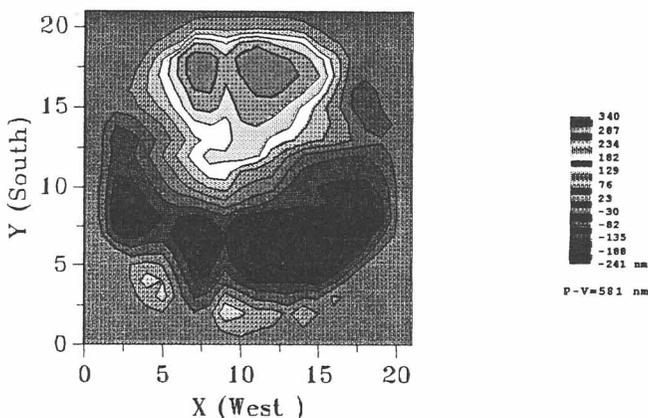
Frame: K60M4-28/04/98-02:02:11-Surface-PQ



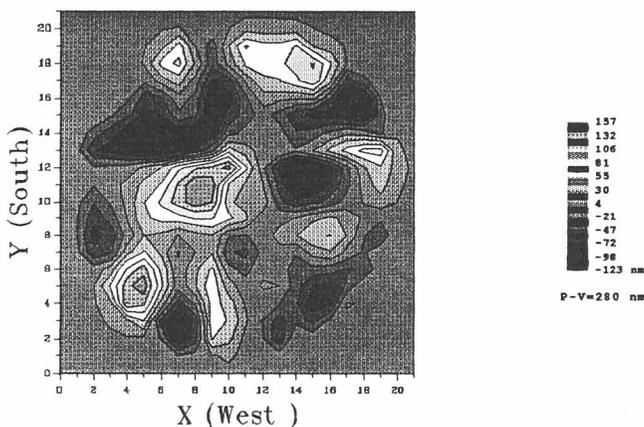
Frame Km60M4: First night (27/28 April 1998). Contour plots for Actual Quality (top) and Potential Quality (bottom). The presence of astigmatism (top) and support errors is clearly seen. The orientation of the frames is not the same as for the rest of the contour plots shown below, but is rotated clockwise by about 30°.

Contour plots of mirror surface: 28-29 April

Ave. of K15M9 to K15M10-Surface-AQ

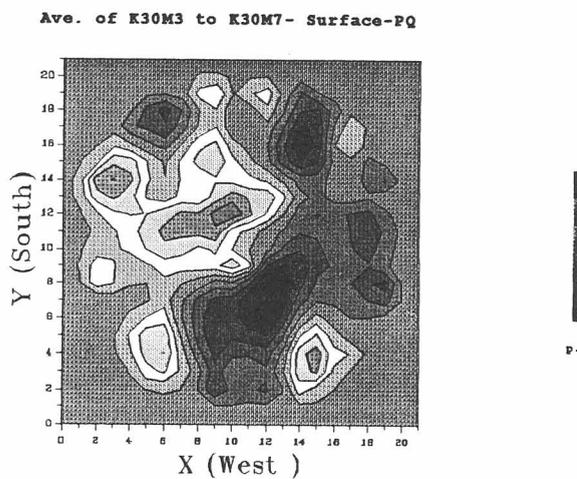
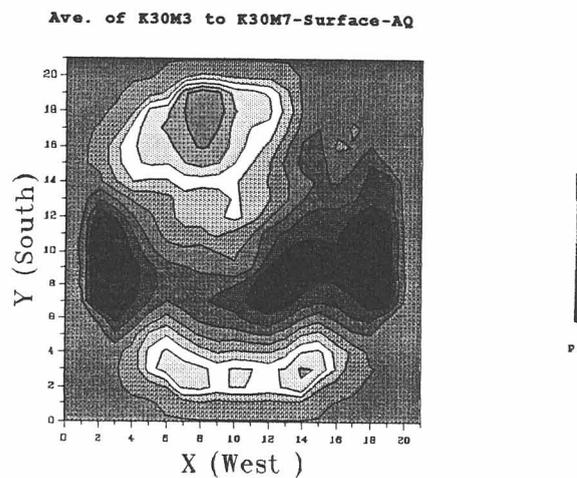


Ave. of K15M10 to K15M9-Surface-PQ



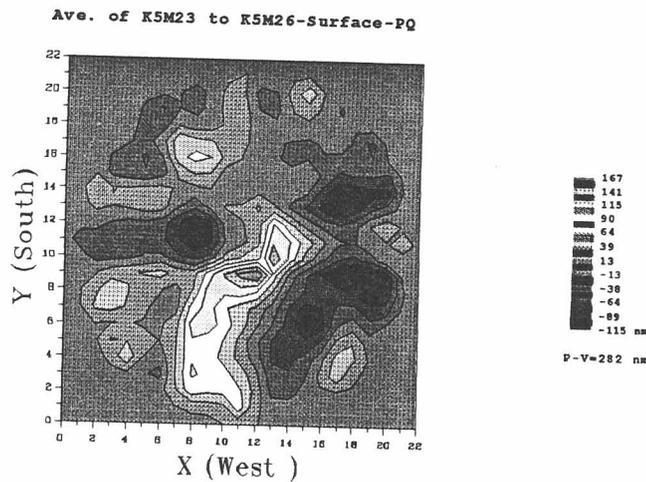
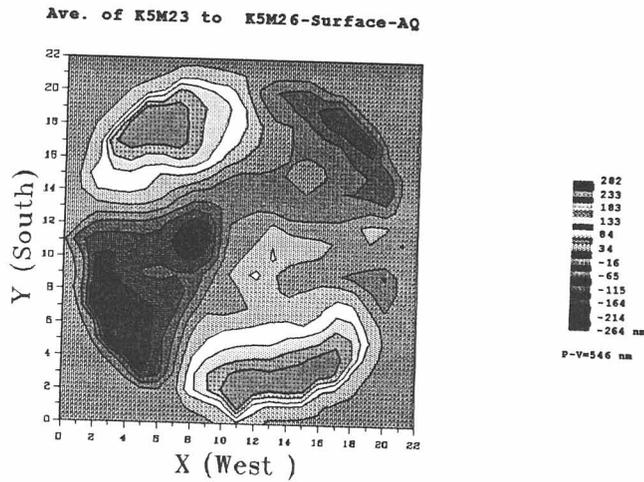
Frames K15M9-K15M12 the night: (28/29 April 1998). Contour plots for Actual Quality (top) and Potential Quality (bottom).

Contour plots of mirror surface: 29-30 April



Frames K30M3-K30M7. Night: (29/30 April 1998). Contour plots for Actual Quality (top) and Potential Quality (bottom).

Contour plots of mirror surface: 2-3 May



Frames K5M23-K5M26. Night: (2/3 May 1998). Contour plots for Actual Quality (top) and Potential Quality (bottom).



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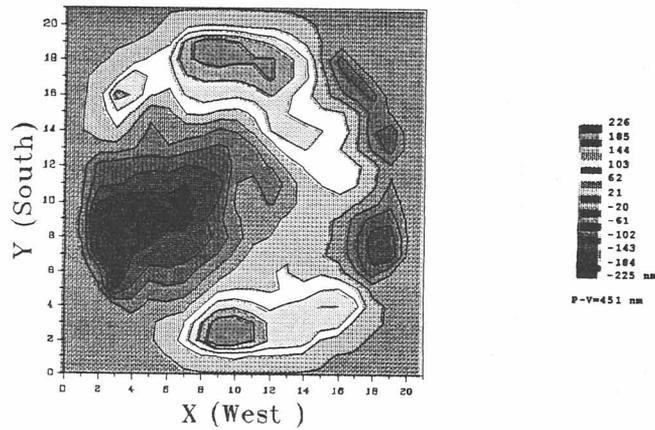
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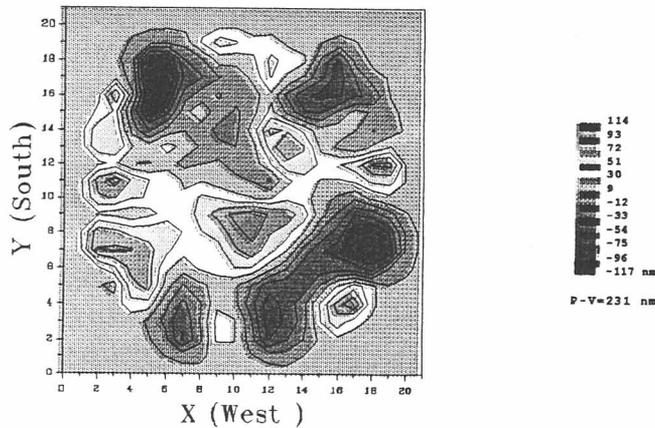
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Contour plots of mirror surface: 3-4 May

Ave. of K5M16 to K5M17- Surface-AQ



Ave. of K5M16 to K5M17-Surface-PQ



Frames K5M16-K5M17 the night: (3/4 May 1998). Contour plots for Actual Quality (top) and Potential Quality (bottom).



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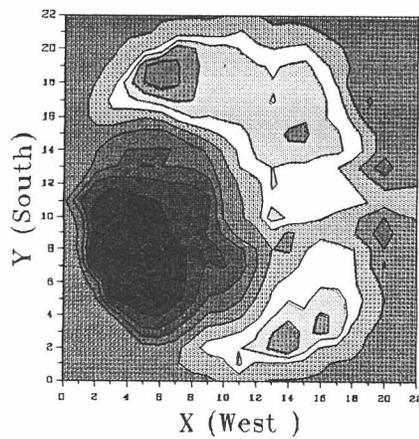
Test certificate

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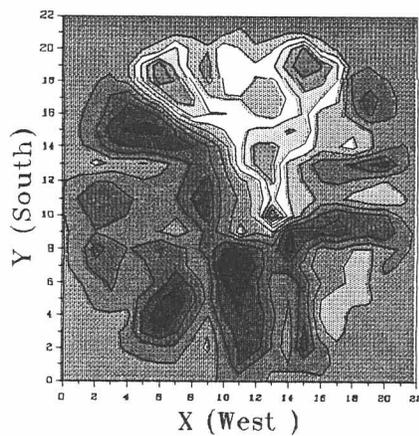
KOTTECE5/c

Contour plots of mirror surface: 5-6 May

Ave. of K3M19 to K3M22-Surface-AQ



Ave. of K3M19 to K3M22-Surface-PQ



Frames K3M19-K3M22. Night: (5/6 May 1998). Contour plots for Actual Quality (top) and Potential Quality (bottom).



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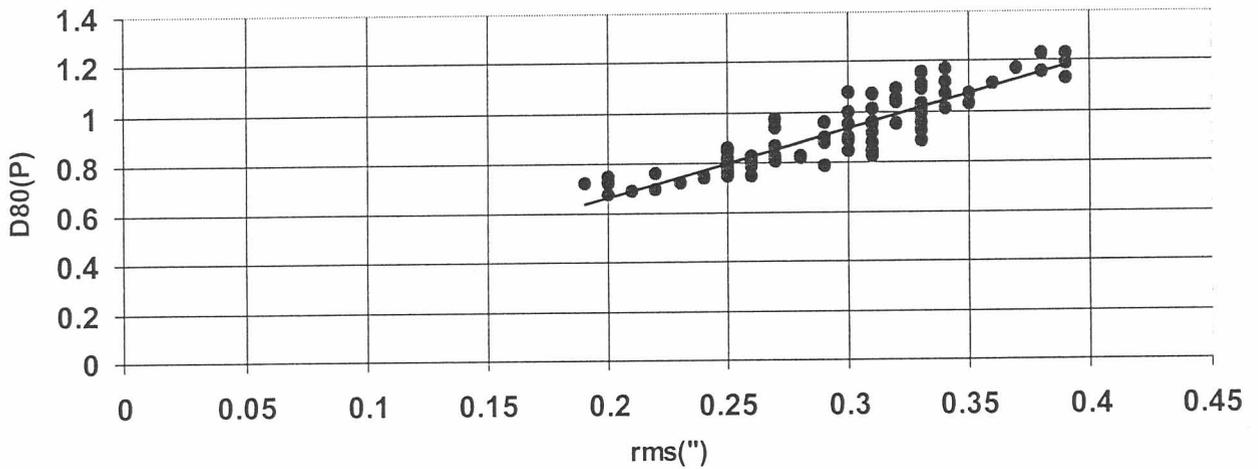
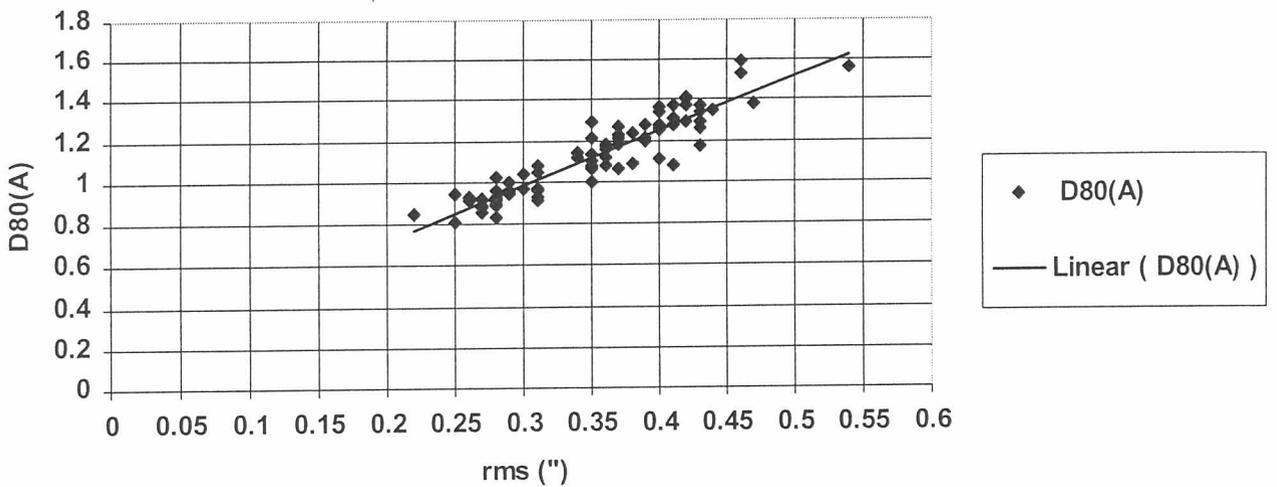
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8 The dependence of D80 on seeing

The value of seeing affects not only the estimation of the Zernike coefficients, but also that of the D80. For the Zernike coefficients, we can reduce the effects of seeing by longer integration times as well as by averaging the results from many frames. However, for the D80, we have to use statistical arguments.





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9 Summary

The above graphs show the variation of D80 as a function of rms of the residuals: it is seen that there is a linear trend, both for AQ and PQ. **Indeed, if we extrapolate the linear fit for PQ, we get a value of 0.35" for a value of rms of about 0.08".** It is our experience that under the best seeing conditions, it is possible to obtain a value of 0.08" for the rms.

Thus, we can conclude that the telescope is capable of satisfying the contractual value of D80 within 0.35" if we are able to bring the aberrations down to a negligible level, of the order of 0.1". This can be done for coma (alignment of M1 and M2) as well as SA3 (shifting of focal plane). In our opinion an attempt should be made to correct astigmatism by adjusting the supports. The contour plots clearly show that some of the supports need a final adjustment.

1.