appear to solve this problem. A series of short exposures with the ESO 3.6 m telescope have revealed that the central star of NGC 3132 is in fact a double star and that the faint companion in all likelihood has the necessary characteristics to excite the nebula. It has a visual, apparent magnitude of about 16.5 and a luminosity 110 times that of the Sun. The star is extremely blue. It is therefore a subluminous, blue star, a stellar type that is typical for the central star of an evolved planetary nebula.

Drs. Kohoutek and Laustsen have submitted their detailed results to the journal *Astronomy and Astrophysics*.

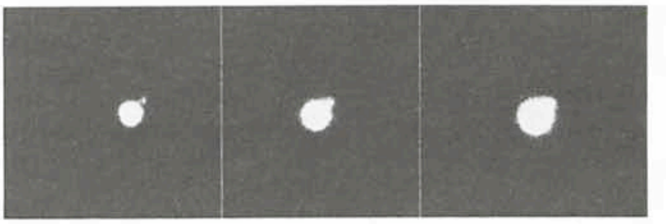


Fig. 2. — *Short-exposure images of visual binary HD 87892. 5, 10 and 20 seconds on IIIa-J + UG 1. The distance between the centres of the two components is 1.65 arcsecond.*

3.6 m Telescope: Excellent Optical Quality

The preliminary tests of the optical quality of the 3.6 m prime and Cassegrain foci optics have now been analyzed. They show that the large ESO telescope is optically nearly perfect and that the design specifications have been met, probably even significantly surpassed. The tests were carried out by the ESO Optics Section (in particular Daniel Enard, Francis Franza, Maurice Le Luyer, Patrick Monnerat and Raymond Wilson) and the present report was compiled by the leader, Dr. R. N. Wilson:

Prime Focus

In *The Messenger* No. 7 a brief summary was given of the alignment and test of the prime focus optics of the 3.6 m telescope (prime mirror with Gascoigne plate correctors). The preliminary analysis of the test results (mainly computer analysis of Hartmann test plates) was based on measurements with the modified Blink Microscope whose measuring precision is insufficient for establishing the formal energy concentration, although adequate for providing information on the important, low spatial frequency error residuals such as third-order spherical aberration, coma and astigmatism. In spite of these limitations, there was clear evidence that the specification (75 % of the geometrical energy to be within a circle of 0.4 arcsec diameter) had been met, perhaps by a clear margin.

Since this report, about 50 Hartmann plates for the prime focus have been measured on the "Galaxy" measuring machine at Herstmonceux in England. "Galaxy" has the necessary measuring precision of the order of 1μ. We consider that errors due to the photographic processing conditions (the dark-rooms were not finished at that time) and non-random (dome) turbulence giving asymmetries in some spots are probably more serious sources of error than residual measuring errors on "Galaxy".

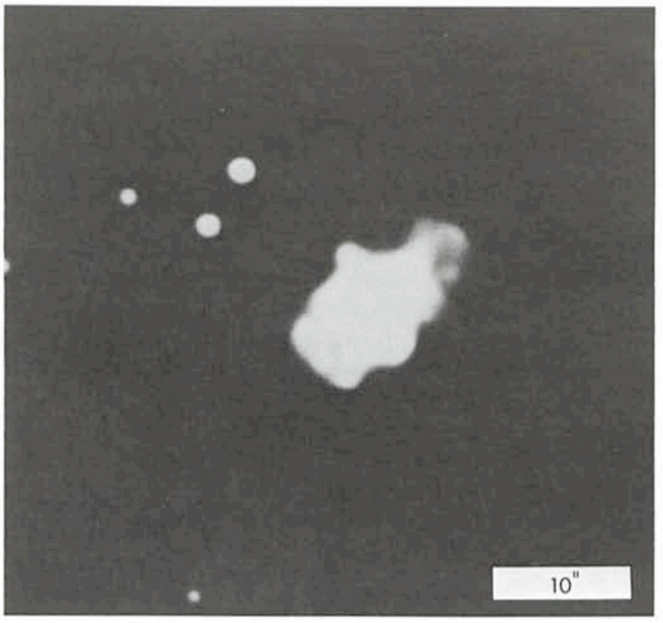
The computer analysis of the "Galaxy" measurements is now almost complete and it is hoped to produce a final report on the prime focus (with Gascoigne plates) within the next few weeks. However, it is already fully confirmed that the specification has been met with 80 % of the geometrical energy within 0.42 arcsec for the zenith position and only minor variations for the inclined telescope (between 0.46 arcsec southwards to 0.35 arcsec eastwards). These figures correspond, of course, to the state of the telescope after the removal of the very small decentring coma error present after the alignment. We believe that even this excellent result is too pessimistic; for the residual astigmatism is probably largely due to dome turbulence. Furthermore, the small residual in spherical aberration can be removed by a further axial adjustment of the corrector and any genuine residual astigmatic effects present in the primary can be removed by a small adjustment of the axial support system.

Our calculations show that removal of third-order astigmatism alone would give a geometrical energy concentration of 80 % within 0.35 arcsec diameter, while further removal of the residual spherical aberration and triangular astigmatism would give 80 % within 0.27 arcsec diameter. It should be remembered further that energy concentration values, although an apparently simple means of specification, are the most difficult values to prove formally with the Hartmann method and tend to be pessimistic because of the high spatial frequency residual statistical and systematic errors entering as background noise with a relatively large effect on the concentration values.

Our work on the prime focus had convinced us that the dome seeing was probably the major limiting factor—we wondered what the Cassegrain focus would reveal in this respect!

Cassegrain Focus

The Cassegrain focus (CF) alignment and test was a relatively simple process compared with the prime focus—it took only 3 weeks for three staff members from Geneva, compared with 11 weeks for the prime focus (PF). The main reason for this was that the PF operation represented the first use of the telescope. All the basic alignment had to be done from scratch and many general "teething problems" overcome. The initial part of the CF alignment was simply a repetition of the PF procedure—establishing a sighting line perpendicular to the δ-axis and passing through the centre of the prime mirror. (This requirement stems from the need for accessibility to the south pole and means that the δ-axis is the starting point of the optical alignment.) This sighting line was lined up with a cross-hair defining the centre of the top unit of the telescope, this cross-hair having been lined up with the centre of the prime mirror during the previous PF adjustment. On our telescope there is no possibility of translating laterally the secondary mirror within its top unit—it can only be tilted. With this single degree of freedom, only one condition can be fulfilled, and this must be imagery free from decentring coma. This is possible even if the optical axes of the primary and secondary are not exactly coincident, for a residual translation error can be compensated by a tilt. But this will incline the pointing direction (effective optical axis) so that the tolerance on perpendicularity with the δ-axis may not be met.



An interesting illustration of the use of the Cassegrain focus at the ESO 3.6 m telescope is this photo of the central part of the famous southern nebula, Eta Carinae. It shows the so-called "Homunculus" nebula surrounding the star Eta Carinae. This nebula is expanding after having been thrown out during an outburst in 1843. At that time, the apparent magnitude was brighter than −1, i.e. about the same as Sirius, but it is now around 6^m. Exposure 30 seconds on IIa-O emulsion through a GG 385 filter by S. Laustsen. Seeing around 1 arcsecond. Original scale 7 arcsec/mm. Scale on reproduction indicated by bar. North is up and east to the left.

In our present case, the initial arbitrary setting of the secondary tilt gave marked coma, easily visible on the TV screen. Hartmann analysis revealed 3.2 arcsec of coma. The tilt of the secondary is varied by 2 variable supports driven by motors and a fixed point. The position of the motor drives is given to a high precision by encoders. This arrangement is far more precise and easy to manipulate than was the PF—modifications are in progress here. The first iteration of adjustment reduced the coma to about 0.3 arcsec, the second to about 0.24 arcsec. This is about the limit for a small number of plate measurements on the Blink. More accurate centring will be possible from the "Galaxy" plate measurements. Two top unit exchanges resulted in comparable coma values. Thus the preliminary result of the reproducibility of centring after top-unit exchange seems favourable, although further confirmation will be necessary from "Galaxy" measurements.

It remained to determine the "pointing error" in perpendicularity (E-W) with the δ-axis for the Cassegrain system thus centred. This was done by a three-stage process, noting the telescope coordinates at each stage:

(a) the sighting telescope at the CF was lined on a star through the hole in the PF plate-holder,

(b) the star was then centred in the PF eyepiece,

(c) the top units were exchanged while maintaining initialization of coordinates, and the star centred in the Cassegrain plate-holder.

From the 3 sets of telescope coordinates, the CF pointing error was established as 163 arcsec in E-W. It may be necessary to improve this in future but this would involve translating the primary in its cell. At this stage, the pointing error was judged acceptable.

The remainder of the time was spent on Hartmann analysis in or near the zenith position (45 plates taken, ten plate measurements on the Blink). The operation was made difficult by two factors—repair operations on the dome severely restricting telescope and dome movement, and very bad dome turbulence giving serious disturbance of the Hartmann plate spots. The doubled optical path compared with the PF demonstrated even more cogently the present limitations of dome seeing and the need for systematic investigation as soon as time and more sophisticated test equipment are available.

In spite of this, the Blink measurements gave clear indication that the quality in the Cassegrain focus is comparable with that in the PF. The only significant aberrations detected were spherical aberration and third-order astigmatism, both with maximum wavefront slopes corresponding to 100 % of the geometrical energy in a diameter of about 0.65 arcsec, which would probably give an 80 % concentration in the order of 0.45 arcsec. The origin of the spherical aberration residual is still under investigation and may well be removable. It is believed that the astigmatism is largely caused by *dome seeing,* as in the PF. If these two defects are removed, the resulting quality should be well within the specification (75 % within 0.4 arcsec diameter). The "Galaxy" measurements will be necessary for final confirmation and will be made within the next few months.

Cassegrain Adapter

Within the framework of these tests the Cassegrain adapter (see *The Messenger* No. 8, March 1977, p. 14) was put into use and final adjustments performed. All its facilities functioned well and proved to be practical and convenient in use. Particularly impressive was the sensitivity of the TV. ESO astronomer André Muller estimated that the limiting magnitude of acquisition (centre field) was 20^m–21^m; that for guiding 19^m–20^m. Confirmation was given by the large number of guide stars found with ease, even well away from the galactic plane. The pupil observation and knife-edge on TV were extremely impressive. Above all, this provides a wonderful means of studying dome turbulence effects, perhaps by filming.

First Photos

On 19 April the Hartmann screen was removed and the first photos taken at the Cassegrain in cooperation with Svend Laustsen. In the next three nights the best plate obtained was a 2-minute exposure (guided) on a baked 2AO plate. The seeing was the best we had had, estimated at about 1 to $1^1/_2$ arcsec, and the smallest star images were about 140 μ ($\equiv$ 1.0 arcsec) and perfectly round. This, of course, is no measure of the telescope quality, which is vastly better, but provided rough confirmation with the best seeing we had.

Conclusion

We may legitimately conclude that the telescope optics is as successful in the Cassegrain as in the prime focus. Much further analysis is necessary, however, to extract the maximum potential quality—above all with respect to dome seeing.

We would like to express our acknowledgement and thanks to all those at La Silla who gave us excellent cooperation; also to our colleagues at Kitt Peak National Observatory who kindly supplied us with the basic Hartmann programme (subsequently heavily modified and extended), and to the Royal Greenwich Observatory for their excellent help and cooperation in the "Galaxy" measurements of the plates.