

# INFORMATION BULLETIN

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## MODIFIED F/8 SECONDARY GIVES EXCELLENT IMAGES

The vacuum support system of the cassegrain secondary has been modified to allow bending the mirror in its cell in order to remove the 0.7" residual spherical aberration. The structural analysis of this attractive solution to a much debated problem was carried out by CFHT's Chief Engineer P.Y. Bely in consultation with A. Tournaire (INAG) and G. Lemaître (Obs. de Marseille). D. Salmon and P. Wizinowich implemented and tested the solution whose engineering details were presented at the London conference on Advanced Technology Optical Telescopes II in mid-September 1983.

The mirror bending system is illustrated in Fig. 1. The pressure in the inner bag ( $R_0/A = 0.5$ ) and the vacuum in the outer annulus are adjusted to float the mirror and generate the bending forces required to adequately modify the asphericity - and the radius of curvature - of the optical surface. These forces are quite modest. The pressure in the bag is 0.085 bars and the vacuum at the periphery -0.028 bars. A 0.03  $\cos^2 z$  bars vacuum is added to both volumes to support the mirror against gravity.

The system was sky-tested on the telescope in late July, 1983. Analysis of one dimensional (orthogonal diameters) Hartmann data yield the following results:

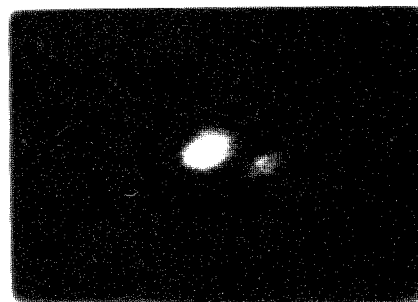
**Coma:** the coma length, due to slight miscollimation, was 0.4".

**Astigmatism:** the astigmatism between the two sampled diameters is unmeasurably small (least confusion diameter  $< 0.02''$ ). However the data suggest a very small (least confusion dia.  $< 0.09''$ ) difference in the spherical aberration compensation between the two diameters.

**Encircled Energy:** The encircled energy factor as a function of image diameter was measured (Figure 2). The image produced by the cassegrain system has FWHM = 0.15". Characteristic figures of merits are

image dia. (sec. of arc)	% energy
0.1	34
0.2	63
0.4	94

No corrections of any kind - except for coma - were applied to the data to obtain these figures. The optical quality of the system is remarkably good indeed!



The image of the double star 4 Aqu (0.5 sec exposure) after bending of the f/8 cassegrain secondary. The separation is 0.9 arc sec.

Bending the secondary mirror in its cell has very successfully removed the spherical aberration of the cassegrain optics. The method proved to be fairly simple and rapid to implement at a relatively modest cost. It introduces no additional optical elements and has the

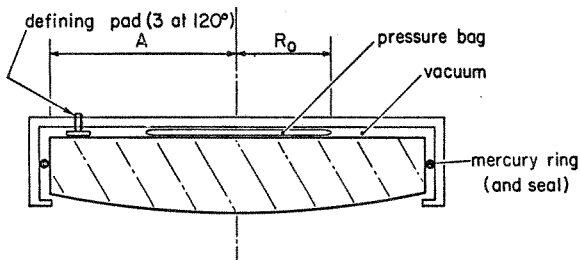


Figure 1: Schematic of the mirror bending system.

further advantage that, by trimming the regulators, a specified amount of spherical aberration can be introduced. Returning to the "unbent" figure, for instance, is almost trivial. This option can be used to optimize the performance of wide field coma correctors for our classical cassegrain system.

After corrective bending of the secondary, the wavefront aberration is dominated by two broad, shallow zones of  $\sim 0.1\lambda$  amplitude. A "zone corrector" could conceivably be figured to remove these zones for near-axis imaging. The CFH telescope would then be completely diffraction limited (FWHM  $<0.05''$ ) at its

cassegrain focus. But before some benefits could be derived from this property, considerable efforts must be devoted to the elimination of local seeing and to the perfection of the optical alignment. It is already noteworthy that to take full advantage of the cassegrain system the collimation of the optics must be set and maintained within tolerances comparable to those required by the Space Telescope.

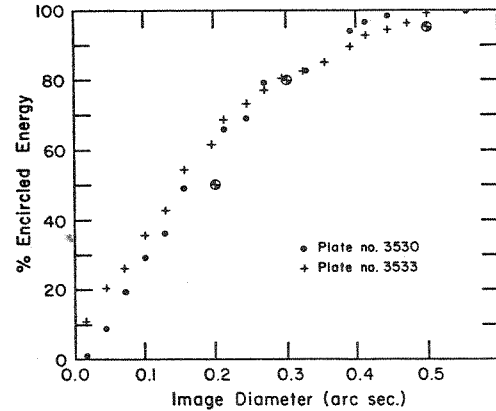


Figure 2: Encircled energy at the best focus after bending the cassegrain mirror, derived from each of the two Hartmann plates.

# LATEST NEWS ON INSTRUMENTATION -- LATEST NEWS

## WORK ON CCD+FOCAS:

Although the official commissioning of the CCD camera and its adaptor the Faint Object Camera And Spectrograph (FOCAS) took place in June, work has continued in order to characterize and improve the instrument performance. The device is a RCA CCD 512 x 320. Major problems with the CCD amplifier glow, which caused a considerable amount of charge to be deposited on the chip during integrations, and with the relatively poor transfer efficiency have been solved. Basically, adjustments to clock voltages and overlap times have helped a great deal. Amplifier glow has been reduced by tying the reset drain and output drain voltages together: this is a common technique used with RCA chips.

Instability in "bias" frames, well known to early users, was traced to a faulty analog card. After the initial modifications were complete (December) preliminary engineering data indicated the gain of the system is 25 to 30  $e^-$ /ADCU with a read noise,  $R_n$ , of  $\sim 80e^-$  and a dynamic range near  $10^5$ . Test exposures show that 21st mag objects are detectable without image processing in about 30 sec in the V or R bands (direct mode). The scale of the detector is 30  $\mu\text{m}/\text{pixel}$ , or about 0.41 arcsec/pixel at prime focus. The quantum efficiency for this imaging device is very high, particularly from the blue to the red (70% at 4500Å, 75% at 6500Å) but still 35% at 3500Å and 30% at 8500Å.

FOCAS also has received considerable attention in the last few months. A complete rework of the slit assemblies and focal plane optics is in progress to insure that all slits (72  $\mu\text{m}$ , 98  $\mu\text{m}$  and 144  $\mu\text{m}$ ) are in focus at the same position, and that the focal planes in direct and spectroscopic modes are flat. New baffling has been installed. New mounting plates for the CCD and the VARO microchannel plate intensifier (used for faint object spectroscopy) are being fabricated.

Test results show that the resolution of the spectrograph is about 12Å (4.8 Å/pixel), with the 72  $\mu\text{m}$  slit and the bare CCD. The spectral range available is 4500Å to 6650Å. The microchannel plate degrades the resolution by about a factor of two. Then, the overall resolution is about 25Å. Using the microchannel plate, 18th magnitude objects can be detected in spectroscopic mode, with S/N about 1 in 10 minutes.

The software for instrument control and data acquisition, developed entirely at CFH, has been incorporated into the "DILOG" command structure. Features of the system include image display, basic image arithmetic, picture storage and frame retrieval. Although there are many facilities at the user's disposal, a subset of commands for basic data acquisition and display can be learned in a short time. The most tedious aspect of the observing procedure is obtaining a