

Hz sampling rate). The UH system is highly optimized; although the number of degrees of freedom of the compensation (12) is much smaller than that of conventional systems, the resolution improvement is expected to be comparable.

Although the system has not yet been completed, two engineering runs have already been made at the CFH telescope. The optical set-up fits on a small 3 x 4 ft table installed in the Coudé room. The tests were made on bright stars with the low sensitivity detector used for development purpose (array of silicon diodes). We concentrated most of our efforts in recording the error signals delivered by the wavefront sensor for further statistical analysis purpose. The sensor was also used to control a fast tip/tilt mirror for atmospheric tip/tilt compensation. One minute CCD exposures were taken one immediately after the other with and without the control system.

The figures show photometric profiles of pairs of stellar images recorded with and without compensation at 0.85 μ m with the telescope aperture stopped down to one meter. In both cases the image full width at half maximum (fwhm) was divided by a factor two. Data shown in Fig. 7 were taken in April 1991. The seeing was very good (0.5" uncompensated image) but the control system was not fully optimized (the tip/tilt signal was affected by random turbulence induced coma errors). Although the compensated image fwhm is 0.25", the gain in central intensity is only by a factor 2.5. Data shown in Fig. 8 were taken in January 1992. The seeing was not as good (0.7" uncompensated image). As a result the compensated image fwhm is only 0.35". Note however the high gain by a factor of about 5 in the central intensity. It is very close to the theoretical maximum gain achievable with tip/tilt compensation only. To our knowledge, this is the first time such a performance has been demonstrated.

These results clearly demonstrate that the image fwhm is not a good performance criterion for compensated images. Experts in the field use a better criterion called the Strehl ratio. It is the ratio of the image central intensity to that of the diffraction-limited image. The absolute Strehl ratio is difficult to estimate on astronomical images but one can easily estimate the Strehl ratio improvement when the control system is on.

During the January run compensated stellar images have also been recorded with a deformable bimorph mirror of low optical quality on temporary loan from ONERA. The full telescope aperture was used in the H band. Owing to the poor quality of the mirror, the Strehl ratio improvement was only by a factor three, but the image fwhm went down to 0.1". A bimorph mirror of good optical quality is expected to be available for the next observing run in July 1992.

A new type of adaptive optics system has been successfully demonstrated. Compared to current systems, it is easier to implement and better adapted to astronomical applications. An array of very sensitive photon counting detectors is now being built. It will enable us to sense the wavefront using natural guide stars as faint as $m=16$. A complete working system is expected to be ready for astronomical observations in 1993.

The UH adaptive optics group includes Buzz Graves, Dan McKenna, and Malcolm Northcott. This development effort was made possible thanks to an initial support from ONERA provided by Marc Séchaud. Bimorph mirror technology was developed by Pascal Jagourel at Laserdot.

F. Roddier

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CFHT AO Bonnette Status

The CFHT AO Bonnette project has reached its cruising speed. Here are some of the specifications for the Bonnette as presented at the 1992 Users' Meeting in Victoria last May. The Bonnette should:

- provide median Strehl Angles <0.2 arcseconds from 0.5 to 2.3 μ m
- provide a choice of either high-order or tip/tilt-only image correction
- use modal control to drive the adaptive mirror surface and tip/tilt mirror
- offer the possible use of the science source as the wavefront reference
- feed full-sized instruments (imagers, 2-D spectrographs,...) with 2.5 pixel sampling of the diffraction core for wavelengths longer than 1.5 μ m.
- provide differential flexures under 5 μ m/hour of telescope motion
- transmit (excluding the beamsplitter) : from 0.4 to 2.3 μ m a minimum of 75% at any wavelength, with a mean value of 85%.
- readily switch between the corrected 1.5' field and a straight through uncorrected field 5' in diameter.
- be modular, reliable, user transparent, and be capable of evolution to better adaptive mirrors and wavefront sensors.
- cost < U.S. \$10⁶ on a three year development timetable.

A more detailed description of the Bonnette was given in the previous Bulletin (No 26, 1992 I)

At this stage, the design of the optical layout (wavefront sensing path included) has been completed by Dr. E.H. Richardson of the University of Victoria. The input focal ratio is f/8 and the output f/19.6. In order to keep the number of optical elements to a minimum Dr. Richardson has elected to make use of toroidal elements in the design. Two retractable flat mirrors allow the use of the direct f/8 focus with a field of view of 5

arcminutes. The beam is sent to the wavefront sensor by a beamsplitter, and brought to an f/100 focus. The wavefront sensor sample the telescope pupil with 19 sub-apertures using a lenslet array.

A mechanical design of the Bonnette has been completed by W. Grundmann of the Dominion Astrophysical Observatory. The diameter of the bonnette is slightly over one meter, and the thickness is 280 mm. At the moment, design of the mounts for the optical components is underway, and there is considerable interaction taking place between the different partners (CFHT, DAO, LASERDOT, and OPM) to ensure that all components will indeed fit in the enclosure.

DAO is also developing the Curvature Wavefront Sensor for the AO Bonnette. J. Stilburn has been involved in the realization of the components and the definition of the interfaces with the control system. The group of F. Roddier (Institute for Astronomy – U of H) is acting as a consultant to DAO for the design details of this particular component, and provides advice in general on the whole system (See the article from Dr. Roddier on the adaptive optics system of the University of Hawaii, in the section Latest News on Instrumentation).

The French company Laserdot is fabricating the 44 actuator piezo-stack mirror for our system and developing the control software of the AO Bonnette – at this stage mainly the closed-loop control of the deformable mirror using signals derived from the wavefront sensor. Many simulations have been carried out to study different aspects of the system including closed-loop bandwidth, the interactions of the curvature sensor and piezo-stack mirror, the design of the off-line Shack Hartmann sensor for flattening the deformable mirror, etc.

Meudon Observatory is studying a solution for the system's tip/tilt mirror which is a separate component from the deformable mirror. P. Gigan is designing a tip/tilt mount driven by 4 linear magnetic motors for the f/20 paraboloid mirror to be used for tip/tilt correction. Another solution also envisioned would be a commercial momentum-compensated piezo-stack tip/tilt mirror sold by the German firm Physik Instrument.

Concerning management of the project, a Kick-Off meeting took place at DAO last February to define the project and the task sharing between the various partners. On May 20-21, preliminary studies were presented to CFHT by Laserdot, Meudon Observatory, and DAO, at the Laserdot headquarters in France. Next August a Milestone 2 meeting will take place at CFHT Headquarters in Waimea to review the detailed design studies of the contracting parties. If CFHT is satisfied with the results of these studies, the contracts for fabrication will be issued shortly thereafter.

R. Arsenault, D. Salmon

Redeye Project Status

At the time of this report the infrared camera project is in a rather dynamic state, with final integration of essentially all components in progress. In late March we received the LiF and BaF₂ lenses needed to complete the cold reimaging optics, and will complete acceptance tests of the two cryostats in late May. We recently ran a bare NICMOS3 multiplexer with the new Generation III controller under development at CFH, paving the way for final tests of our engineering grade NICMOS3 array and

ultimately a science grade device. All of these efforts are being driven in the near term by a June engineering run with one of the cameras. Barring unforeseen problems that prevent us from making tests on the sky, we will distribute through e-mail to the Community the results of our engineering runs in June and August. Such performance characterization will allow future users to design observing proposals for the new cameras. We currently anticipate commissioning the cameras for use at the Cass focus by 1 January 1993, in time to support runs throughout next semester.

D. Simons & C. Clark

MOS-SIS Progress Report: Release for General Use Scheduled for 1st Semester 1993

Highlights of the Past Six Months

Since the last information bulletin a great deal of activity has been taking place around the MOS-SIS imaging spectrograph. Integration of the instrument has been completed at DAO, with frequent trips of CFH personnel to DAO for active testing. As compared to what was announced 6 months ago, we have experienced a two month delay in shipment to CFHT due essentially to two problems, one with the control software, the other with the MOS camera optics. After this first problem was solved, the MOS-SIS plus auxiliary equipment (handling cart, test bench) was shipped to CFHT. Since then the MOS-SIS has been put back together (it was shipped in sub-assemblies), and brought up to the observatory 5th floor for integration into our operations. The MOS-SIS has successfully been installed on the Cassegrain focus and successful communications between the dedicated control system and both our main control computers and the TCS has been obtained. The SIS optical train alignment was checked out and found not to have suffered from shipment. Figure 10 shows the first multi-spectra image taken on the sky in June, 1992, while Figure 9 shows one of the spectra. The last major missing optical component has at the time of this writing finally been completed: the MOS camera aspherical lenses were successfully manufactured by APS and subsequently glued.

Problems and Solutions

One serious problem discovered in the control system while testing proved difficult to track down and solve: occasional crashing of the control software was occurring at a low but definite rate of 1 motion failure over 30 requests. After much effort by DAO/CFHT and external experts, the problem was finally identified and solved. In parallel, the MOS camera optics was being redone by the Applied Physics Specialty (APS) company. Due to the unusually curved aspherics, a first attempt by another company resulted in optical elements largely out of specifications. APS efforts included several attempts at surfacing the aspheres spread over several weeks, and as of today, we are delighted (and relieved) to report that APS successfully surfaced the surfaces close to specifications and that all elements were successfully glued together at APS with DAO guidance.