BIMONTHLY SUMMARY

July - August 2001

Andy Szentgyorgyi stands next to the Hectochelle collimator.
(Image by S. West)

Personnel

Dr. Timothy Pickering, an Assistant Staff Scientist formerly of Steward, transferred to the MMTO in early August.

The open position of Electronic Technician, Sr. (to replace K. Harrar) generated over two dozen resumes and job applications. Of these, several candidates were identified and interviewed by D. Clark, S. West, and S. Callahan. In the end, two strong candidates with copious experience as retired USAF technicians were offered positions with MMTO. Both Cory Knop and Brian Comisso started during the reporting period, and will be heavily involved in the aluminization electronics.

Student worker Heidi Olson left the MMTO in late July to attend graduate school in Colorado.

Development

Red Channel of the MMT Spectrograph

C. Foltz and D. Smith completed the commissioning of the Red Channel, although the weather prevented any on-sky testing. The new detector is cosmetically very clean and has lower read noise (~5.5 e-) than its predecessor. Since the Red and Blue Channel CCDs now have completely separate controllers, the changeover from one to the other is simple: crank the TIRP out of the beam, reset the detector parameters in software, and begin observing. This is not a procedure that should be carried out by the astronomer, but it certainly will allow nights to be split with the two channels.

Aluminizing

During this time period work concentrated on preparing the primary mirror for re-aluminizing. Testing moved from the downtown offices to the basecamp. Six aluminizing modules consisting of a driver card, a high side and a low side power drive, with each power drive containing four parallel power MOSFETS (International Rectifier # IRFK6J054), were tested for functionality. Then each driver card was modified to incorporate the minor modifications required for the new servo control card configuration and retested for functionality. During testing with K. Van Horn it was found that the control card needed further modifications: the reduction in value of the integrating capacitor to 750 picofarads and a change in the intermediate gain-stage resistor values. Copper bar stock must be configured to connect the batteries, close attention must be paid in order to maintain good airflow around the switching modules, and the new control box must be integrated and calibrated.

Mirror Support

After removal of the primary mirror pneumatic support actuators, a procedure for repairing the temperature-dependent leaks in the pneumatic cylinders was developed by R. James, S. Callahan, and S. Warner (SOML), with much support from J.T. Williams, R. Ortiz, R. Teachout (SOML), and R. Murray (SOML). This procedure was checked by testing ten actuators at temperatures below the coldest night ever recorded on Mt. Hopkins. R. James, S. Callahan, S. Bauman, and a large crew of technicians and engineers from the Mirror Lab including R. Lopez, R. Perry, D. Sakacs, S. Brunetti, and S. Warner then began to disassemble and repair the nearly 200 pneumatic cylinders. With R. James conducting quality control, nearly half the actuators were modified, adjusted, relubricated, reassembled, and calibrated by the end of August.

Thermal System

New software was written to implement a proportional-integral (PI) control loop for the entire MMT thermal system. The software was tested on a modified thermal system to see how effective a PI control loop would be in producing conditioned air for the mirror system and how responsive the thermal system would be to varying thermal conditions, such as rapid changes in ambient air temperature. Initial preparations for mirror maintenance and aluminizing were underway at the time of the testing (August 9-10, 2001). Because of these preparations, air was blown directly into the pit beneath the telescope rather than into the mirror cell as would be the case during normal telescope operation. PI control loop parameters will need to be modified to better match normal telescope operating conditions. In addition, software for remote control of the Carrier cooler was not available. Both the Neslab chiller and Carrier cooler will be under direct control of the PI control loop in future versions of the software. During these tests, only the Neslab chiller was under software control.

Results for thermal system testing include:

- A total of 16.5 hours of detailed (i.e., every 10 seconds) thermal data were collected on August 9-10, 2001. New thermocouple sensors were placed upstream of the Carrier and Neslab heat exchangers, between the two heat exchangers, and downstream of the two heat exchangers.

- A PI control loop was shown to effectively control the overall thermal system. This control loop is wrapped around a PID control for the Neslab chiller and an unknown control algorithm for the Carrier cooler.

- In the steady-state, the PI loop, controlling only the Neslab setpoint, can condition air to within 0.1°C of a desired target setpoint.

- Preliminary values of Kp = 0.75 (the PI loop proportional coefficient) and Ki = 0.3 (the PI loop integral coefficient) were found. These values will need to be modified for the final thermal system configuration (e.g., with the mirror).

- The PI loop responds to a temperature-change input step function with a 9-minute-period, dampened sine curve response. Overshoot of the target setpoint is ~25-30 percent. At least two cycles (i.e., 18 minutes) are required for the temperature of the conditioned air to closely match the target setpoint.

- The thermal system, particularly the blower, takes at least one hour to reach a steady-state running temperature after initial start-up.

A sample of the data is presented in the figure above. These data are from the morning to early afternoon of August 10, 2001. Five different data series are plotted in the figure:

- The "tc_pre" thermocouple ("pre" heat exchangers), which measured the air temperature (in degrees C) after the air has left the blower and before hitting either of the two heat exchangers. The tc_pre thermocouple was located about 8-12 inches upstream of the Carrier heat exchanger. This thermocouple was placed on the side of the heat exchanger unit.

- The "tc_mid" thermocouple ("mid" heat exchangers), which measures the air temperature (in degrees C) between the upstream Carrier and the downstream Neslab heat exchangers. These heat exchangers were spaced approximately 8-12 inches apart. A new hole was drilled into the side of the heat exchanger for the tc_mid thermocouple. This new location prevented direct contact of the thermocouple with a heat exchanger and reduced the possibility of water directly flowing over the device.

- The "tc_post" thermocouple ("post" heat exchangers), which reads the air temperature (in degrees C) a few inches downstream of the Neslab heat exchanger. The tc_post thermocouple sampled temperatures in the air stream downstream of both the Carrier and Neslab heat exchangers. As with the tc_mid thermocouple, a new hole was drilled in the side of the heat exchanger to improve data quality.

- A "target" temperature was calculated by continuously subtracting 20.5°C from the tc_pre temperature. This target temperature was used to mimic ambient air temperature. Temperatures measured by tc_pre thermocouple varied from 15 to 20 degrees C above the ambient temperature. This target temperature represented values with a maximum amount of adiabatic heating by the blower system.

- The "command" data series represents the temperature setpoints sent to the Neslab unit by the PI control loop. These commands caused the Neslab to change its internal bath temperature and the temperature within the Neslab heat exchanger. Variations within the Neslab heat exchanger, in turn, caused the tc_post temperature to closely track the target temperatures. The result is a conditioning of air that is delivered to the telescope.

Parameters, such as Kp, Ki, and target setpoint, were systematically varied during the day. The results of this parametric variation are summarized above.

Top Box f/9 Shack-Hartmann Wavefront Sensor

The optical design for the in-situ f/9 Shack-Hartmann wavefront is complete. The unit will be installed at the "seeing" camera location in the top box. Because it uses the bare f/9 focus (rather than the re-imaged Beseler pupil), the device can be removed from the top box and mounted to f/9 instruments that do not use the top box. We will also include a 1:1 re-imager option for acquisition and autoguiding. Because of top box constraints, the unit will be fixed on-axis.

We chose an Adaptive Optics Associates 625-45-H 13x13 lenslet array from their standard selection. Although we'd eventually like a longer focal length lenslet, at this time we do not want to pay for a custom lenslet setup ($12K). However, the 45 mm lenslet we selected should provide plenty of dynamic range for debugging the thermal system (or performing wavefront sensing in its absence). We use an 80 mm doublet collimator to produce a ~9 mm diameter pupil, which is a good fit to the Apogee KX-260 camera that we have on hand. The following two figures show the pupil and image geometry.

Standard 625-45-h lenslet array with the re-imaged telescope pupil superimposed (hex apertures approximated with circles).

Estimated detector spot pattern. Dots show lenslet diffraction image sizes.

Using the OSLO CCL, we modeled spot motions for various aberrations and M2 motions for this collimator/lenslet geometry. The spot motions for smaller aberrations scale directly.

Estimated spot motions that result from tilting M2 by 50 arcsec about its vertex (top) and decentering M2 by 100 microns.

Estimated spot motions for typical aberrations present when the thermal control is not functioning. We have sufficient dynamic range to sense these aberrations if needed.

The full report is available as MMTO Tech Memo #01-1 at URL *http://nemo.as.arizona.edu/~swest/pdfs/sh_wfs_tb.pdf*

F/5 Wavefront Sensor Package

A preliminary design for the f/5 Shack-Hartmann wavefront sensors was performed by the MMTO and taken to CfA in early September for discussion. We will make another design iteration taking their comments into consideration.

We agreed that the f/5 wavefront sensor package would be mounted on a movable stage and would incorporate a high quality re-imager that produces excellent images over a 2k x 2k CCD throughout UV-visible wavelengths. CfA will fabricate the movable stages and possibly subcontract the re-imager design to Harland Epps.

Servos and Telescope Control

Some data were taken of the control loop history (a 4-second snapshot of the servo error and demands to the inner loop) to verify and characterize the behavior of the servo loop in and out of the wind. The data remain to be analyzed as time permits.

The telescope instrument rotator has an absolute encoder tape that was brought on line during this period. Interestingly, we used the encoder input sections of a pair of National Semiconductor LM628 motion control chips to read the encoder tape signals, and we are very pleased with the result. The LM628 has a very nice encoder input section with the ability to capture position and interrupt upon traversing an index mark, and this is just ideal for reading the encoder tape.

Now, when we turn on the rotator drives, the rotator makes a short excursion first one way and then the other (moving 2.5 degrees in each direction), as it needs to see a pair of index marks on the tape in order to determine its starting position. The tape has been entirely robust and reliable, and has been incorporated into the telescope control system. Having the tape functional has made it possible to simplify procedures followed by the operators, and the operator software interfaces have been streamlined accordingly. The servo control for the rotator axis has been modified to use the encoder tape to provide servo feedback.

Other minor changes have been made to the control software. Apart from a few internal bug fixes, the operator GUI interfaces have been modified to detect and recover from loss of communication with the control computer. Changes were made to the network server in the control computer to enforce access restrictions (enhancing security). In particular, a number of ports were restricted to access only by the operator's control GUI, so that other access will not compete or conflict with their ability to control the telescope. Finally, a catalog search facility was added to make it easier to select objects from very large catalogs.

Work was initiated on modifying the software and related GUI that controls the f9 hexapod. This software modification has several objectives: 1) to simplify the GUI and make it more focused towards the needs of the telescope operators, 2) to redesign the GUI so that it has a similar "look-and-feel" to other MMT software, 3) to separate server and client software functionality into separate programs, 4) to implement the SAO "msg" messaging protocol between client and server as is being used in other MMT software, and 5) to serve as a basis for software development for future secondary units. It is envisioned that these modifications will facilitate f9 hexapod control by the operators and will ease future software maintenance. In addition, migration of much of the server code, currently written in Tcl, into the C programming language is also planned so that the code can be run under VxWorks.

F/9 Secondary

C. Wainwright and S. Callahan modified the f/9 hardpoint and tangent rods to remove free play that was causing secondary collimation errors. The parts were detailed by C. Wainwright and are currently in fabrication.

K. Van Horn has inspected and documented the f/9 mirror support servo card component values and has begun reworking the power distribution wiring, as well as remounting the power distribution card on the inside of the mirror cell shroud.

F/5 Hexapod

A test card was built and tested during the reporting period to evaluate the operation of the spare f/5 hexapod strut, mounted in a test fixture constructed of scrap parts by D. Clark. This test card incorporates a PIC16F877 microprocessor, a 24-bit analog-to-digital converter, a 16-bit DAC, and a bit of glue logic to talk to the electronics on the strut. Initial measurements of the A-to-D converter resulted in a std of 180 microvolts on any measurement, well under the 400 microvolt measurement target needed to digitize the actuator LVDT. The LVDT output was then scanned at 50 Hz from limit to limit with a constant motion in one direction to determine the measurement accuracy of the LVDT over the ~50 mm stroke range. It was discovered that the straight-line nonlinearity of the LVDT output was in fact within the manufacturer tolerance of +/- 0.25%. Unfortunately, if this is expressed in microns, it leads to a measured deviation of 120 microns peak to peak. The measurement confirms the results reported by ADS in their final integration test report on the hexapod. Since this nonlinearity has unknown temporal and temperature variation, it is clear that an LVDT will not measure the strut length to the necessary submicron accuracy needed to hold the optical tilt and decenter tolerance. Accordingly, a candidate digital length gauge made by Heidenhain was ordered as a test article. It will be mounted on the test fixture and tested during the next reporting period.

S. Callahan finished the design of the f/5 cell attachment to the fixed hub. The design uses a modification to the unused f/9 removable hub and a new weldment. The design is now ready for detailing for fabrication.

C. Wainwright and S. Callahan finished the conceptual design of the f/5 dummy mirror. Detailed fabrication drawings were started at the end of August.

C. Wainwright and S. Bauman completed the final detail drawings of the many parts required for the f/5 secondary ventilation system, and submitted most of the parts to various machine shops for fabrication.

F/15 Secondary

At the beginning of summer shutdown R. Ortiz and S. Callahan removed the fixed hub and spider arms from the telescope for modification. The fixed hub is being modified to accommodate cable feedthroughs. In addition, a rail system that attaches to the fixed hub is being implemented to facilitate installation of the f/15 secondary. The spider turnbuckles were brought to the University Research Instrumentation Center shop for machining and repair.

In response to the requirements expressed by CAAO vis-à-vis the f/15 secondary configuration, the cable system designed for use in the f/9 and f/5 configuration was revisited and several changes were made to the cable type and mechanical attachments on secondary spider arms. The current design would have the existing flat cables replaced with a few runs of separate flat cables that can all fit on top of or below the spider vane shadow to a connector panel mounted on the interior surface of the secondary hub. There will need to be a transition box mounted strategically on the top of the OSS to convert to round cables to go through the cable drape to the electronics racks. The MMTO mechanical group will be handling major cutouts and other changes to the hub to accommodate the new design.

CAAO also has serious motion limitations with the f/15 configuration, which will make it necessary to sense any motion of the hexapod that may bring it into contact with the internal bracing or electronic boxes on the inside of the hub. We will add a tape switch around the entire periphery of the moving plate of the hexapod to detect any collision that causes the tape switch to activate (at approximately 3N of force over a 4.5 mm area) and to immediately shut down the hexapod. We also plan to physically disconnect the control cables at the hexapod whenever the optical test doublet optics are attached in order to forestall any possibility of uncommanded motion.

Computers and Software

Efforts have been made to enhance security on the summit computers. Updated versions of operating system software have been installed on our linux computers that allow per-host firewalling. In addition we are taking steps towards establishing a firewall on the off-mountain network link.

B. Russ has begun an effort to migrate our 'Observers Preparation Forms' and 'Confidential Observers Reports' to the web. The on-line forms should be ready for use when observing resumes.

Optics

No activity to report.

General Facility

As the primary mirror thermal control system nears completion, we find that a fair number of I/O points, both analog and digital, are needed to monitor and control the system components in the summit support building. K. Van Horn and D. Clark researched available commercial solutions to this problem and identified a Koyo ethernet-based I/O unit with various I/O modules that will fulfill our needs. This system can be configured with pluggable I/O units that are industrial-rated for digital and analog functions with a fair amount of noise and lightning immunity. With attachment to the MMT network over optical fiber, we can monitor and control the system with any computer without danger of lightning-induced damage. This unit and appropriate modules were ordered during the reporting period and should be installed sometime in the fall.

K. Van Horn completed a purchase request for hardware to interconnect the RUPS room with the network for RS-232 and discrete signal handling. However, this effort has been shelved for the time being as the HP DAU seems to work and should do the job for a while. Four temperature monitors have been installed in the mirror air control system, and D. Gibson has been able to start controlling the Neslab.

The fiber link to the comm room has been reconnected and is functional.

Maintenance and Repair

The Carrier interface module is on order but K. Van Horn has been unable to get them to schedule delivery and installation.

D. Smith performed annual preventive maintenance on the Mattei compressors (models 511 and 515). He also repaired the unit servos and offload valves, which were preventing the units' reaching their high pressures. Faulty o-rings were the cause, and he is checking to see whether a different material can be used.

Visitors

July 24: Dr. Richard Davies and Mr. Sebastian Rabien of Max-Planck-Institut für extraterrestrische Physik, Garching, accompanied by J.T. Williams and Roger Angel. They are involved with the development of the PARSEC laser, which will be used for the VLT Laser Guide Star Facility.

Publications

MMTO Internal Technical Memoranda

None

MMTO Technical Memoranda

01-1 Baseline Shack Hartmann Design for the 6.5m MMT f/9 Focus
S. C. West, H. Olson

MMTO Technical Reports

None

Scientific Publications

01-14 A Survey of Proper Motion Stars. XIV. Spectroscopic Binaries Among Metal-Poor Field Blue Stragglers
Carney, B. W., Latham, D. W., Laird, J. B., Grant, C. E., Morse, J. A.
Submitted to *AJ*

01-15 The First Bright Quasar Survey. III. The South Galactic Cap
Becker, R. H., White, R. L., Gregg, M. D., Laurent-Muehleisen, S. A., Brotherton, M. S., Impey, C. D., Chaffee, F. H., Richards, G. T., Helfand, D. J., Lacy, M., Courbin, F., Proctor, D. D.
ApJ Supp, **135**, 227

Observing Reports

Copies of these publications are available from the MMTO office. We remind MMT observers to submit observers' reports, as well as preprints of publications based on MMT research, to the MMTO office. Such publications should have the standard MMTO credit line: "Observations reported here were obtained at the MMT Observatory, a facility operated jointly by the University of Arizona and the Smithsonian Institution."

Submit publication preprints to *bruss@as.arizona.edu* or to the following address:

MMT Observatory

P.O. Box 210065
University of Arizona
Tucson, AZ 85721-0065

MMTO in the Media

No activity to report.

MMTO Home Page

The MMTO maintains a World Wide Web site (the MMT Home Page) which includes a diverse set of information about the MMT and its use. Documents that are linked include:

1. General information about the MMT and Mt. Hopkins.

2. Telescope schedule.

3. User documentation, including instrument manuals, detector specifications, and observer's almanac.

4. A photo gallery of the Conversion Project as well as specifications and mechanical drawings related to the Conversion.

5. Information for visiting astronomers, including maps to the site and observing time request forms.

6. The MMTO staff directory.

The page can be accessed in two ways. First, it can be loaded via URL *http://sculptor.as. arizona.edu*. Second, it can be accessed via a link from the OIR's MMT page at URL *http://cfa -www /cfa/oir/ MMT/mmt/foltz/mmt.html*. The former should be used by interested parties west of the Continental Divide; the latter is a copy, which is locally mirrored at SAO and is much faster for East Coast access.