BIMONTHLY SUMMARY

November - December 2001

The summit of Mt. Wrightson reflected in the newly-realuminized primary.
(Image by S. West)

Personnel

Student office worker Christina Pease graduated and left the MMTO in December. Due to the availability of voice mail and its installation on a number of our phones, we have decided against hiring a replacement for Christina.

T. Pickering traveled to Washington, DC to participate in the review of proposals for NASA Applied Information Systems Research Program (AISRP) December 10-13.

C. Foltz served on the Pre-Ship review panel for the DEIMOS spectrograph at Lick Observatory on November 13-14. The august panel also included G. Schmidt (UAO) and was chaired by D. Fabricant (SAO).

Development

Aluminizing

In early November system testing was completed, and successful aluminization was accomplished. Final aluminizing power system testing required simulating a probable power profile to gain insight as to how the system will behave during aluminizing. This consisted of using a test setup similar to the system used to simulate the belljar. The power profile is the desired current or power output vs. time of power modules during an aluminizing shot. This profile is an idealized waveform generated from observations of previous aluminizing shots. The first part of the ideal profile is a steep rise in output to about 60% power, where it is maintained for about 20 seconds, then another rise in output to 80% power is reached in about 20 seconds. Power then drops to about 70% where it is maintained for about 30 seconds, after which the shot is complete. An important consideration for system operation is to be absolutely certain that the power MOSFETs do not exceed their temperature ratings (125 degree C) during an aluminizing run. A simulation of the power profile was accomplished by adjusting a remote control with a digital readout calibrated to read percent duty cycle. System parameters monitored were output waveform duty cycle on an oscilloscope, and module heat sink temperature rise with an HP DAU. An example of temperature rise of the power MOSFETs is illustrated in Figure 1 below.

Figure 1: Thermal response plot depicting temperature rise of power MOSFETs.

After running several profiles, the system was connected to the belljar to aluminize the primary mirror. During aluminization the HP DAU was used to monitor command voltage on each of the five modules. The command voltage mirrors the load voltage, which provides for a good approximation of the power to the load and the performance of the system. A graph of the aluminizing run follows (Figure 2).

Figure 2: Aluminizing power profile.

The power profile plot in Figure 2 above shows that the power modules performed the actual aluminizing operation well below their tested operating parameters. The power and time required for each stage of the power profile was much less than anticipated. For example, the tested power profile anticipated peak power levels of 80% for about 20 seconds, whereas actual operation required only 60% peak power for about 5 seconds (60% power corresponds to command voltage of 3 volts, 100% power would be 5 volts).

A prototype design was begun using IGBTs, and the transient suppression network was simulated using PSPICE to replace the current MOSFET based design. During the reporting period, parts were delivered for construction of the snubber circuit (for flyback pulse protection) and a new gate-drive circuit. In addition, a new copper-plate arrangement was designed and fabrication was started. This came to an end, however, when the campus milling machine x-y tables came loose. Thanks to R. James for cleaning and re-assembling the machine.

Thermal System

Considerable effort was spent resolving hardware and hardware/software issues related to the Carrier chiller. Additional functionality was added to the thermal system software and GUI to convey system status, including equipment failure, to the telescope operators. New GUI functionality also included options for servo and non-servo automated control of the thermal system. Additional problems were encountered in socket programming between different computers and messaging protocols. Resolution of these problems continues.

Initial tests of a PID control loop for thermal control of the primary mirror are quite promising. Several nights' data have been collected that help determine the characteristics of the thermal system, including the primary mirror. These data emphasize the importance of pre-cooling the mirror for up to two hours prior to observing, and the slow response of mirror temperature to varying ventilation air temperatures. Software limits were set for the Carrier and Neslab chillers to allow maximum cooling within safe operating conditions for this equipment. Refinement was made to the parameters used for the PID control loop.

Towards the end of December the entire primary mirror cell ventilation system was reinstalled by a team that included S. Callahan, R. James, R. Ortiz, D. Smith, J. McAfee, C. Wainwright, J. Ludeke, and S. Bauman.

Top End

In December S. Callahan, with help from R. Ortiz and R. James, installed the fixed hub with modified spider arms and new turnbuckles. The hub was aligned with help from J.T. Williams and B. Kindred. The fixed hub is concentric to the optical axis to 1 mm.

F/9 Secondary

Axial and Lateral Hardpoint Assembly Modifications

Work on the f/9 secondary addressed two problems: 1) tangent arm connections that steadily loosened due to wind vibration, and 2) mirror position discontinuity between 70 and 80 degrees elevation present in the system since installation of May 2000.

Figure 3 shows the modifications to the tangent and axial hardpoint assemblies. These modifications replace rod end connections with flexures, reduce the number of threaded series connections, and strengthen the column components.

Figure 3: Before and after modifications to the tangent arms (top) and the axial hardpoints (bottom).

Elevation-Dependent Collimation

After installation of the new hardpoints, the lateral motion of the mirror vs. elevation was carefully measured using a Mitutoyo Mu-checker and a (nearly) gravity-invariant mount (black in Figure 4 below). As shown in Figure 4, the position discontinuity at high elevation was still present (but presumably the hardpoint positions will be more immune to wind vibration in the future). Additionally, we noticed that the lateral support servo became unstable in the region of the discontinuity. Extensive testing of the electronics failed to show an electronic problem.

Figure 4: Recent progress in improving the f/9 secondary mirror position vs. elevation.

The hardpoint breakaway mechanisms were taken to the SO mirror lab for stiffness characterization with the Instron. These tests showed that the breakaways were behaving as designed.

After close inspection, we discovered a single point contact of an axial earthquake pad with the mirror backplate. After fixing this, the mirror position discontinuity was apparently lessened (blue in Figure 4 above). However, the lateral servo was still unstable over the region of the original discontinuity. Further testing showed that the mirror's lateral position was never stiffly defined at any elevation, which was the cause of the servo oscillations.

The cause of the position discontinuity turned out to be the three linear bearings that are in the direct load path from the tangent arm connection to the mirror frontplate. The bearings accommodate the CTE mismatch between aluminum and glass. When these bearings were clamped, the mirror position (red in Figure 4) was well behaved and the servo oscillations were eliminated. Note that the simple beam flexure of the aluminum post that connects the tangent arm to the bearing naturally flexes by 30μm, so the displacement shown in the graph is near the theoretical mechanical flexure for the geometry.

Blade flexures were designed to be radially stiff (to provide a stiff load path from the tangent arm to the glass) but axially compliant (to accommodate the CTE mismatch between the post and glass). One was placed in parallel with each linear bearing (shown in Figure 5 below). The mirror deflection (green in Figure 4) is quite flat vs. elevation, and is not significantly softer than outright clamping the bearings.

Figure 5: Top view of one of the three new blade flexures that improve the stiffness between the tangent arm and mirror substrate.

The secondary was reinstalled. Tests on the sky proved that the long-standing collimation discontinuity was indeed eliminated. However, the collimation still suffered from erratic elevation dependencies. The origin was traced to one of the primary mirror hardpoints that was positionally unstable. After removal and inspection of the hardpoint, it was determined that the problem was with an occasional interference in the external counterweight system, which caused the force on the hardpoint to slightly exceed the breakaway force. Figure 6 shows the hardpoint length vs. elevation before and after the counterweight collision modification.

Subsequent sky tests (though not yet official) show flat and stable optical collimation from elevation 40-90 degrees. Lower elevations cannot yet be tested due to a problem with the primary mirror actuator air system.

Figure 6: Hardpoint length vs. elevation before (black) and after (blue) correcting a collision in the hardpoint's counterweight system.

F/9 Top Box Shack-Hartmann Wavefront Sensor

All of the optics and X-26 rail components have been received. Space for the system has been identified and cleared in the top box, and assembly has begun.

F/5 Secondary

During the month of November, S. Bauman and S. Callahan detailed a variety of seals and covers for the f/5 ventilation system.

J. Ludeke and S. Callahan finished detailing the connection of the f/5 cell to the teststand cart.

Recent experience with the f/9 demonstrated the need for position feedback for diagnostics. Six LVDTs have been designed into the f/5 support system. S. Bauman and J. Ludeke have detailed the connections of three LVDTs that are approximately parallel to the tangent rods. Construction of the prototype mirror support card began, with the addition of the LVDT circuits that will report the hexapod struts, plus a set of six LVDTs on the mirror cell for metrology of the support system in real time. We expect to install and test the electronics as soon as the cell and dummy mirror are assembled.

F/5 Hexapod

The hexapod amplifier and its controller were completed during the reporting period. We now have to finish writing the controller firmware and debug any problems that will appear during testing on the actual hardware. Tests were also done with a high-accuracy optical linear length gauge in parallel with the existing LVDT devices on the spare hexapod strut to verify that the LVDT accuracy is good enough for the application. The data confirm that the LVDT measurement with a 24-bit ADC is accurate to the tolerance specified. Still unknown is how much, if any, look-up table or linear fitting is needed to remove mechanical inaccuracies (pitch variation, bearing tolerance, etc.) from the measurements to determine the actual hexapod position.

F/9-F/15 Hexapod

Extensive testing of the f/9 hexapod system was done primarily to test repeatability of movements, consistency between encoder and LVDT readings, and communication between the new Tcl/Tk-based GUI and the hexapod VxWorks software. In general, excellent correlation between encoder and LVDT readings were found, with differences of a few microns to tens of microns across the allowed range of movement for the actuators. Empirical reference LVDT voltages were determined and were used to set an arbitrary “zero” location for each actuator. Use of these empirical voltages improved correlation between encoder and LVDT readings.

Some difficulties were found in direct communication between the GUI and the newly developed msg task that run on the VxWorks hexapod crate. Further work is needed to resolve errors in communication, process synchronization, and hexapod system response between these two sets of code.

F/15 Secondary

C. Wainwright, with support from S. Callahan and M. Rascon (CAAO), headed up the design of a rail support system for safely mounting and installing the f/15 system to the hexapod. This design was fabricated in the University Research Instrumentation Center, and was successfully tested with a dummy weight at the telescope in December.

Mount Servos

More work was done on the collection of performance data on the servos, and in attempting to understand the weak wind-rejection of the elevation axis. Using the HP DSA to develop closed-loop disturbance rejection measurements of the telescope while tracking proved to be helpful in measuring the actual servo bandwidth under different tuning parameters. In addition, D. McKenna (UAO) performed some step-response measurements using a DSP-based PC card and MatLab software. The data suggested that a low-frequency resonance is present in the elevation drivetrain, which makes higher servo bandwidths difficult to achieve due to the loss of servo stability when the servo gains are set high for increasing stiffness (i.e., better disturbance rejection). Much testing was then done using the DSA and an accelerometer to detect the source of the low-frequency resonance, but without much success. More testing is therefore planned with the LBT tools to reproduce and better understand the results.

A failure mode, in which the telescope was able to runaway in elevation, was discovered and was eliminated by interlocking all the power supplies to the encoders within the 26 volt system. An issue has been raised as to whether or not the blower needs to be brought inside the emergency stop shutdown procedure. K. Van Horn welcomes input on this.

Computers and Software

Cell System Software Development and Testing

A new cell VME computer user interface is being implemented using Tcl/Tk, similar to other user interfaces currently used in the telescope computer system. Work will continue on migrating the cell system user interface from WindX on the VME crate to a Tk-based user interface on a Linux platform.

Work continued with new actuator calibration data, and the current primary cell support software is using the new set of calibrations taken this summer. This software has been carefully tested in full operation on the telescope.

Cyclades Terminal Server

Work continued on replacing a number of serial cables and connections with network socket connections through a Cyclades terminal server. When in place, this terminal server will be a central point of access for all devices that communicate with control software via serial links. It will also provide a central hookup point for an ever proliferating collection of serial cables that are now being connected in an ad-hoc fashion to random computers.

A serial isolation card that provides a degree of lightning protection for serial cables that originate outside of the telescope building has been designed, built, and tested.

Because of difficulties with embedded software provided with the new Cyclades terminal server, we designed a network to serial server program (in Python) that makes a serial port on one computer accessible to any other computer on the network. This presently acts as a handy workaround until the problems with the Cyclades are resolved.

SAO Guider

After much reworking by B. McLeod and J. Roll, the latest revision of the SAO Guider was brought to the mountain. It was built and is working on the computers both in town and on the mountain in preparation for testing and engineering during the first week of January 2002.

Mountain Computer Upgrades

To better handle the rigors of real-time video display and autoguiding—and to get around the fact that the framegrabber cards that we use do not work well with multiple CPUs—the main operator computer, hacksaw, was upgraded to a 1.4 GHz Athlon processor. In the process, it also gained a 40 Gbyte disk in order to alleviate disk space constraints. A new machine, alewife, was added to the control room. It is a 1 GHz Athlon with 40 Gbyte of mirrored RAID disk space and its own framegrabber card. It is the eventual replacement for ringo as the primary observer's machine. hacksaw, hoseclamp, and alewife were all upgraded to the latest version of Red Hat Linux during this time. These new systems and software upgrades have been tested, and minor issues they introduced have been resolved.

GPS Clock and NTP Time

We successfully got the Garmin 25 GPS clock to work with the Linux NTP (Network Time Protocol) server. Unfortunately, it was much less accurate than using other network time servers such as those run by the UA campus. Part of the problem was a 0.4 sec offset due to serial port and other latencies. However, even after calibrating that out, the noise was 20-50 ms, about an order of magnitude noisier than either the campus or any other network time servers. It might be possible to improve that by using the PPS (pulse per second) output, though getting the Linux NTP server to utilize it would require the construction of a pulse stretching circuit and the application of non-standard patches to the Linux kernel. The Garmin 25 also has the undesirable feature of requiring multiple satellites in order to get a time lock, and will not output time or PPS signals without a lock. Thus, during long building slews, it could lose lock due to the antenna's facing a different area of sky. These issues prompted us to investigate procurement of a dedicated NTP server box with integrated GPS and oven-controlled local oscillator.

Mount Control Software

Work has begun on improving the mount software's ability to detect and quickly respond to runaway telescope motion. The first line of defense falls into the domain of hardware interlocks, and improvements have been made in this area. Software can detect and cope with a number of scenarios. Excessive acceleration indicates a servo system that is not in control, as does excessive velocity (although acceleration monitoring promises to allow us to really nip these sorts of things in the bud). This work is ongoing and needs further efforts.

An improved logging facility has been added to the mount software, and it is our intention to develop this into a comprehensive system that will log important events from other subsystems (such as the primary support software and the hexapod). At present, it logs and timestamps events such as drive enable/disable commands and telescope slews (both for engineering and slews to observed objects). As a safeguard, pointing data are written to this log as well as to the usual pointing data log. An ever expanding set of exceptional conditions are also logged, and it is our intention to periodically log normal conditions as well.

Optics

No activity to report.

General Facility

No activity to report.

Maintenance and Repair

The Carrier cabling has been completed and is functional. The same cannot be said about the Carrier itself. It seems there are at least three problems:

- The system as sold did not meet the requirement for operation at low ambient temperature conditions. This shows up as low head pressure on the compressors when the cooling fans take out too much heat from the condensers. The present operation is done by timed relays and has no feedback of ambient conditions. An option exists that controls the fan speeds based on feedback of the head pressures. We have asked for a quotation from Carrier but do not yet have one we are comfortable with. In the interim we have turned off one of the two fans, and that has helped.

- The original system was not specified to operate with a cooling fluid (brine) that would work below freezing. Since that is the case, the system complains when the demanded temperature is brought below 32 degrees F. A firmware change could enable the system to operate down to 14 degrees F. Part of this change would also normally require a change of the expansion valves to a different type. We have been told, but not by anyone with the authority to do so, that we might try not changing the valves. Our track record with Carrier makes it difficult to expect any cooperation from them.

- The second compressor has been shut down because of a leak in the expansion valve. This may or may not be valid. The valve will not close all the way, but the techs feel that this might not be an issue if they could maintain head pressure. This valve was changed during our last go-round with Carrier and they are reluctant to change it again. For the time being the second compressor will remain shut down.

The shutter on the top box ICCD camera has quit working reliably. K. Van Horn contacted the manufacturer but has gotten no response to date. The next time the top box is down, the other shutter should be swapped into this position and the original shutter repaired (cleaned and lubed).

D. Smith sent the Balzers turbo pump out for repair to a company, Orbit, in Chandler, AZ that rebuilds equipment mainly for semiconductor companies. The pump was received back the last week of December with a one-year warranty, and seems to be working well.

Visitors

December 18: Lori Stiles (UA), Dan Brocious, Howard Lester, and Larry DeVoto (Green Valley News) photographed the freshly aluminized mirror. Video Workshop did sound and video recording.

Publications

MMTO Internal Technical Memoranda

None

MMTO Technical Memoranda

None

MMTO Technical Reports

None

Scientific Publications

01-22 The Masses of White Dwarfs in the Praesepe Open Cluster
Claver, C. F., Liebert, J., Bergeron, P., Koester, D.
ApJ, **563**, 987

01-23 AAS Annual Report
Foltz, C. B.
BAAS, **35**

01-24 Redshifts for 2410 Galaxies in the Century Survey Region
Wegner, G., Thorstensen, J. R., Kurtz, M. J., Brown, W. R., Fabricant, D. G., Geller, M. J., Huchra, J. P., Marzke, R. O., Sakai, S.
AJ, **122**, 2893

01-25 Spectroscopy and Photometry of Stellar Objects from the Second Byurakan Survey
Stepanian, J. A., Green, R. F., Foltz, C. B., Chaffee, F. ,Chavushyan, V. H., Lipovetsky, V. A., Erastova, L. K.
AJ, **122**, 3361

Observing Reports

Copies of these publications are available from the MMTO office. We remind MMT observers to submit observing 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 observing reports and 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

The successful aluminization of the primary mirror was featured in an article in UA newspaper publication *Lo Que Pasa*.

MMTO Web Site

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 via URL *http://mmt.as.arizona.edu*. This site is mirrored at URL *http://cfa-www/cfa/oir/ MMT/mmt/foltz/mmt.html.*