BIMONTHLY SUMMARY

July - August 2000

The black bears have returned to the summit of Mt. Hopkins.
(Image by Steve West)

A Note

Since the 6.5-m telescope is making the transition from an engineering project to a functioning research instrument, we return to our practice of detailing staff activities in the Bimonthly Summary starting with this issue. We also have taken this opportunity to streamline the layout of this document by simplifying the section headers and removing the confusing numbering scheme used in previous editions. – *C. Foltz and B. Russ.*

Personnel

Josh Pearson, physics undergraduate student, was hired in late July to develop a web-based operator log system.

Vijay Venkatraman and Prem Kandalu, computer science grad students, were hired in late August as research assistants to work on autoguiding software as well as centroiding applications that will aid us in analyzing telescope tracking data taken with the Apogee camera.

Temporary drafters Ricardo Ortíz and Richard Stavish were hired in late August to work on the design of the f/5 secondary mirror cell.

On August 21, the Pima County Board of Supervisors tentatively adopted the draft Outdoor Lighting Code. This code provides new and substantial protection to the Tucson area observatories by establishing "lumen caps" for development near the observatories. C. Foltz, D. Brocious (FLWO), and Mark Sykes (Steward) worked hard in support of the passage of this new code.

Development

Aluminizing

Some of the concepts implemented in the aluminizing system are seriously flawed. The use of tungsten rods in place of filaments offered several real advantages that seemed to make them worth trying, but the exorbitant current requirements (300 amp/source, 200 sources) convinced us to try running them in series. We refined this approach to its physical limit, that being the inherent instability of having heating elements in series whose resistance rises with temperature. Any imbalance that develops results in a runaway and loss of a series leg. The real prospect of losing large sections of the array during every shot is unacceptable. Further, interconnecting these sources with copper wire had placed a structural requirement on them that they could not reliably bear. Even worse, unavoidable heating of the conductors introduced unmanageable problems with film contamination and pressure control.

The decision has been made to replace the entire array. Filaments will be used in place of rods and they will attach to a 1" x 1" aluminum bus. The new array will have similar geometry with 3 concentric rings and 200 source locations, each location supporting 1 or 2 filaments. K. Harrar's power modules will drive 20 banks of 20 (or possibly 10) parallel filaments, each filament drawing about 50 amp steady-state. Film profile and structure function are qualitatively unchanged.

Although the new arrangement will reduce the pressure load on the vacuum system, a second cryopump has been bid. This should insure acceptable pressure levels. No valve will be purchased but a variable impedance device will be designed and fabricated in-house.

Telescope Control System

The venerable CSR linear amplifiers were characterized with the HP digital servo analyzer (DSA) for archival documentation, and the new design developed by D. Clark was tested and compared to the DSA data. With the new design, the quiescent current in the amplifier is much lower, with about 22 times the bandwidth (45 kHz vs. 2 kHz). J. McAfee proceeded with the construction of 4 complete units. On their first night in operation, John did 120 pointing objects with no problems.

The DSA was also used to very accurately characterize the open-loop behavior of the velocity loop of the azimuth drives with both the CSR amplifiers and the new units. Work on measurement of the servo bandwidth and performance with the DSA is ongoing.

The instrument rotator encoding tape and read heads were installed during the reporting period. We expect to get the final adjustments to the air gap for the heads and to install the read electronics in late September, with the drive servo working by October. The incremental encoder cable and amplifier were installed and connected to the mount interface chassis and tested. We await drive software to be ready to start up the rotator drive servo. Modification of our servo tuning software will be required to support the rotator as a third telescope axis.

All the hardware is on hand to install the Heidenhain tapes on the elevation drive arcs. This will be done when the personnel to install the mounting brackets are available.

J. McAfee has started fabrication of the new mount interface chassis under supervision of D. Clark and K. Van Horn.

In late July, problems starting the azimuth telescope drives were encountered, characterized by rumbling and instability of the drive servo. All of the drive hardware was extensively checked and found to be functional. We eventually corrected the problem by retuning the servo parameters and adding a "soft-start" mode to the software to sequence the servo constant loading after power-up to eliminate most of the hard "bang" when the drive amplifiers come on.

Mirror Support

The Electronics Group plans to repackage the mirror support electronics (VME crate, power supplies, etc.) into a 19" rack system located in the spectrograph lab. As part of the process, the backplane transition hardware that brings the electronic connections from the DAC cards to the backpanel CPCs will be rebuilt to enhance their reliability. At present, the lack of mechanical retention hardware on the mating connectors to the backplane make the connections occasionally unreliable. We will add a new backplane and connectors with retention feature for better reliability.

During off-hours A. Milone has been preparing the new wiring and terminating it for installation in the new back plane. The storage cabinets have been moved out of the instrumentation lab to make room for the installation of the new racks.

To fully stock up spare boards for the mirror support system, a run of new printed circuits was generated by Avanti Circuits in Phoenix. These include the preamp cards needed to add the hardpoint counterweight loadcell outputs to the cell computer.

K. Harrar worked on the spare hardpoint, assembling it for testing and doing some investigation on increasing the step rate of the hardpoint motor. This will allow us to raise the mirror faster (it currently takes ~10 minutes to raise the mirror).

The primary mirror support had for some time been unreliable, with occasional mysterious failure modes that caused the mirror support system to panic and set the mirror down in the course of observing. Careful checking and troubleshooting revealed that the cable drape to the cell connector panel was slipping and straining the cables, especially the force monitor cable. The cables were securely retied to the drive arc braces, then individually checked and any suspicious pins replaced. These efforts were rewarded by an immediate increase in support system reliability. Pointing and observing have subsequently been very successful, with few failures noted in the system. Kudos to K. Van Horn, P. Spencer, and K. Harrar for troubleshooting, building new test hardware, and fixing the system.

DAC Board Distributions

Each primary mirror actuator receives its force commands from 1 of 8 DAC boards attached to the VME bus. The signals from any one DAC board must be uniformly distributed under the mirror to insure mirror safety, should one DAC board completely fail. A discrepancy between the MMT and SO cell documentation made it appear that one DAC board failure could jeopardize mirror safety. That turned out to be an error in the MMT documentation, which was corrected. However, while investigating this, renewed attention was placed on these distributions. Instead of being uniformly distributed about the entire mirror (like the power and air systems), a single DAC board is distributed about one-half of the mirror. Although it's likely that mirror safety is insured, SO is re-analyzing this geometry for potential problems.

Thermal System

P. Spencer continued work on the layout of the primary mirror thermal readout system. The system will consist of 4 gray NEMA enclosures mounted at cell portholes for thermocouple access – one for each thermal quadrant of the mirror. Each enclosure provides the capability to program the thermocouples of that quadrant into different measurement configurations (differential, series, etc.). Ability to connect with other quadrants will also be provided. A prototype programming and breakout wiring configuration of one of the quadrant enclosures has been fabricated. Preliminary testing with the Hewlett Packard (now Agilent Technologies) data acquisition unit (DAU) indicates that some signals for measurement will be on the order of tens of microvolts. These signal levels will require careful attention to wiring and signal conditioning methods.

Pete also ran a few tests to compare microvolt measurements and temperature difference measurements. Preliminary findings indicate good correlation between the two. A computer (called *thermal*), whose primary function will be thermal system evaluation, has been installed and configured on the mountain. The computer system's primary software consists of Benchlink (HP DAU software), Orcad, and Office.

Hexapod

The hexapod was updated with the addition of a cooling fan, installation of computer control of the 30 V power supply, and installation of transient voltage suppressors and higher voltage breakdown MOSFET brake control transistors.

Actuators and Hardpoints

We have designed, fabricated, and installed a monitoring system to gather data on the hardpoint actuators. These data indicate a potential problem with at least one of the hardpoints, which is being analyzed.

K. Harrar built and tested a new hand-held device for reading both the DAC input and valve drive output to the actuator cards. This unit can be used with either single or dual actuators.

All parts for the cell spare actuators have been received. The spares soon will be assembled and calibrated.

Miscellaneous

A design problem, which made the manual paddle very dependent on the computer program, was identified in the transverse counterweight servo. This has been addressed to make the manual control independent of the software. The brake controls have been moved from the 26 V rack to the servo chassis, and this system is within one man-day of being tested.

K. Harrar added new protection circuitry to the building drive and did extensive work on the H-file.

Interferometric Hartmann Wavefront Analyzer

The adapters were made to mount the high resolution interferometric Hartmann wavefront sensor to the f/9 top box. Despite the instrument's being attached to the telescope for over a week during August, inclement weather precluded any significant results except to verify that the instrument was capable of forming excellent interference spots with a star (even without thermal control of the telescope optics). The next two figures show interferograms obtained with a laser reference source (left) and with a star through the telescope.

Computers and Software

Development of the first of a family of protocols for telescope and instrument interaction is ongoing. These are implemented using a relay process on an arbitrary computer that works by accepting commands from a serial cable in a fashion compatible (more or less) with PC_TCS protocols in use at other telescopes (e.g., the Steward 90 inch). This has allowed MIRAC, Pisces, and F-Spec to interact with the telescope. By doing things in this way, we have also come a long way in the development of a network protocol that can be offered to new generations of instruments. And, in fact, Flamingos plans to interact with the telescope using the native protocol that now exists.
Work continues on the development of a PC-VxWorks control system that may ultimately replace the existing VME mount computer (a 25Mhz 68030 with 4M of RAM) with a rack mounted PC running a 600Mhz Pentium-III with 128M of RAM. Among other things, this would allow the network to use a commodity 100Mbit ethernet card and give us flexibility in developing new servo algorithms. At this time, the setup is used for off-line software testing and has been useful in running diagnostics on ailing servo control hardware.

A web-based operator log has been developed and will soon be placed into service. Our intention is to build on this and develop a fully integrated logging system that is http accessible from any browser. (In fact, we make operator log entries now from an application that runs within a browser). Log information from the mount, cell, secondary, and other subsystems will be integrated into this system.

We continue the never-ending, time-consuming but essential work to administer and run our support computers. This included setting up two new machines for our graduate assistants, as well as a number of security measures on all of our linux machines.

Optics

Preliminary Collimation vs. Elevation

After the telescope rededication, some preliminary measurements of the elevation-dependence of collimation were made using out-of-focus images (by simply centering the spiders within the image). To the level of accuracy of this technique, we found that the collimation had very little elevation dependence except for a discontinuity that occurs between 70 and 80 degrees. The origin of this feature was searched for in the secondary hardpoints, hexapod, OSS, and primary hardpoints. Thus far, no one source adequately explains the discontinuity.

Using out-of-focus images, we calculated the zero-coma rotation point for the secondary. This was done by decentering the secondary with the hexapod and then tipping about the vertex until the spiders were again centered. We verified John Hill's 3rd order calculations quite well with this crude technique – finding that ~5.8 microns of decenter produced on-axis coma equivalent to 1 arcsec of tilt. This corresponds to the zero-coma rotation point's being 1.2-m away from the M2 vertex – again verifying Hill's 3rd order calculations.

f/9 f/15 Hexapod and Uncorrected M2 Motions

During the search for the source of the collimation discontinuity, we looked closely at the hexapod. Currently, the lengths of the actuators are adjusted using the internal incremental encoders attached to the rotary shafts. However, any length change that does not affect the rotary shaft remains undetected by the servo (e.g., axial compliance and bearing looseness). Each actuator has an externally mounted lvdt that detects all significant sources of length changes for the actuator. While leaving the hexapod actuators static, we moved the telescope in elevation while reading the lvdt's. The figures below show the hexapod platform motion that is undetected by the incremental encoder vs. elevation. Eventually, the position servo will be closed around the lvdt's and the incremental encoder will be used only for velocity. Given our other priorities, this performance is deemed adequate for now.

Uncorrected M1 Positions

While attempting to uncover the source of the collimation discontinuity, the primary mirror hardpoints got some attention. Two problems were found: 1) at levels of about 10 microns, the lengths of some of the hardpoints are dependent on elevation, and 2) for large elevation slews there is a substantial following error in the support system, causing large forces to develop on the hardpoints and, in some cases, for one hardpoint to break away. Although none of these phenomena pose a danger to the mirror, they do degrade performance and must be corrected. The figures below show both the residual force on the hardpoints (lbs.) and the hardpoint lengths (mm) vs. elevation for maximum slew rates of 1.5 deg/sec. Each graph shows two separate slews. The telescope was slewed from 90 degrees to 20 degrees at one time, rested for a minute, and then slewed back to 90 degrees. In a perfect system, all forces and lengths would remain unchanged. However, when the outer loop has a following error, forces accumulate on the hardpoints during the slew, but they quickly return to zero when the slew is completed. However, unless the spurious forces are large enough to cause the hardpoint to break away, the lengths should remain unchanged. Clearly, one hardpoint breaks away and the lengths do not completely return to zero at the slew endpoints.

Further tests were run showing that the hardpoint does not break away when the maximum elevation slew rate is reduced to 1 deg/sec or below. However, the low level lvdt non-repeatability remains. A particularly interesting test was run by leaving the maximum slew rate at 1.5 deg/sec and then slewing the telescope in 10 degree increments with a short rest between each slew. The results are shown in the following figures.

Several aspects are immediately noticeable: 1) the following error is larger near zenith, which implies that the z component of the outer loop servo needs tightening, 2) one hardpoint length appears to be strongly elevation dependent, and 3) even though the hardpoint did not break away as above, notice that there are still force ripples at the positions where it formerly broke away and re-engaged!

General Facility

An interlock system switch was added to the observing chamber instrument lift and connected to the 26 V control system. This will prevent the mirror cell's colliding with the lift if it is not fully down.

Wire baskets and ancillary hardware were ordered from B-Line to contain cables on the mirror cell, and in the instrument lab for the cell computer and hexapod control electronics. This will give us a flexible system for handling the cables wrapping around the cell and running to the instrument support drape near the rotator.

D. Smith relocated the instrument dry air system to make room for SAO instrument and cell computer racks, and installed an automatic water drain for the telescope air cabinet.

The cables for the humidity sensor unit in the telescope chamber were extended to the new control room and should be hooked up within the next week.

K. Harrar installed the new GPS amplified antenna on the outside of the building near the loading dock doors.

Maintenance and Repair

D. Smith performed preventive maintenance on both the 15hp and 20hp Mattei air compressors. This includes oil and filter change, change oil separator element, air filter, and replace return oil valves and water drain element.

M. Alegria and D. Smith replaced the bushing and coupler assembly in RUPS and verified alignment. They also greased the motors while the unit was down. During the last two months we have spent time diagnosing and repairing RUPS on three different occasions. This machine is getting very old and should be considered for replacement.

K. Harrar repaired and installed the wind speed and direction indicator on the weather station.

Visitors

July 14: Larry Lesyna and Bob Barrett, a scientist and manager from Lockheed Palo Alto, who are involved with building an IR instrument for G. Rieke.

Publications

MMTO Internal Technical Memoranda

None

MMTO Technical Memoranda

None

MMT Conversion Internal Technical Memoranda

None

MMT Conversion Technical Memoranda

None

MMTO Technical Reports

None

Scientific Publications

00-6 Kinematics and Mass Profile of AWM 7
Koranyi, D. M., Geller, M. J.
AJ, **119**, 44.

00-7 M31 Globular Clusters: Colors and Metallicities
Barmby, P., Huchra, J. P., Brodie, J. P., Forbes, D. A., Schroder, L. L., Grillmair, C. J.
AJ, **119**, 727.

00-8 Absolute Properties of the Eclipsing Binary Star FS Monocerotis
Lacy, C. H. S., Torres, G., Claret, A., Stefanik, R. P., Latham, D. W., Sabby, J. A.
AJ, **119**, 1389.

00-9 The Nature of LINERs
Alonso-Herrero, A., Rieke, M. J., Rieke, G. H., Shields, J. C.
ApJ, **530**, 688.

00-10 Absolute Dimensions of Eclipsing Binaries. XXIII. The F-Type System Ei Cephei
Torres, G., Andersen, J., Nordström, B., Latham, D. W.
AJ, **119**, 1942.

00-11 The Cessation of Eclipses in SS Lacertae: The Mystery Solved
Torres, G., Stefanik, R. P.
AJ, **119**, 1914.

00-12 Rotation Curve Measurement using Cross-Correlation
Barton, E. J., Kannappan, S. J., Kurtz, M. J., Geller, M. J.
PASP, **112**, 367.

00-13 The Distribution of Stellar Orbits in the Giant Elliptical Galaxy NGC 2320
Cretton, N., Rix, H.-W., de Zeeuw, P. T.
ApJ, **536**, 319.

00-14 Clues to Quasar Broad-Line Region Geometry and Kinematics
Vestergaard, M., Wilkes, B. J., Barthel, P. D.
ApJ Letters, **538**, L103.

00-15 Time-Resolved HST Spectroscopy of Four Eclipsing Magnetic Cataclysmic Variables
Schmidt, G. D., Stockman, H. S.

To appear in *ApJ*.

Observing Reports

P. Hinz: July 1-5, Speckle Camera

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

A photograph of the 6.5-m MMT at sunset, taken by Howard Lester on June 7, 2000, was published on page 27 of the October 2000 issue of *Sky & Telescope* magazine. A similar photo, taken the same evening, was accepted for publication in WGBH's (PBS) *NOVA Teacher's Guide* for high school instructors who show NOVA science programs in their classrooms.

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.