BIMONTHLY SUMMARY

May - June 2002

Installing the f/15 secondary. Image by S. West.

Personnel

Philip Ritz was hired as General Maintenance Mechanic, Lead, in late May.

UA undergrad Creighton Chute was hired as a student engineer in late May.

Development

F/15 Adaptive Secondary Commissioning

The following is courtesy of F. Wildi and M. Lloyd-Hart (CAAO, Steward Observatory):

For those who are interested - a brief report on the outcome of the first visit of the MMT adaptive optics system to the telescope, which took place between 6/18 and 7/1.

The prelude to the run was several months of very hard work by the AO team in the Mirror Lab, which resulted in the whole system being successfully demonstrated in closed loop at full speed, correcting simulated atmospheric turbulence to the diffraction limit in H band. Behavior was robust to assorted intentional and unintentional additional perturbations, such as faculty jumping onto the test tower from the adjacent staircase (!), cables being deliberately unplugged and switches thrown á la John Hill, etc.

The run itself began a week before scheduled telescope time, with transport of the whole system to the mountain followed by installation and checkout of everything that could be done without telescope access.

Once on the telescope, the real-world problems began to appear. Chief amongst these were a contamination problem that initially prevented active mirror operation, and a leak in the mirror's liquid cooling system. Dust particles found their way into a critical 40-micron air gap right behind the deformable optical surface. The contamination was understood to arise from inadequate shrouding of the mirror during installation in the very dirty telescope environment. It took us a while to get the mirror clean again, but once it was, and the whole thing (*except* the optical surface!) encapsulated in Saran Wrap, that problem was solved. The mirror then went through a full night in operation on the telescope, exposed to the elements.

The leaks were a surprise. The cooling system has operated flawlessly for two years, and survived shipment from Italy to Arizona intact. Nevertheless, it wasn't a fluke. At least two separate leaks were found (the hard way) in the actuator cooling plate. The problem was finessed in the end by simply bypassing that part of the cooling circuit, after various experiments with radiator sealant were tried (that stuff never works!).

Finally, we found an error in the manufacture of the secondary mechanical structure - as delivered to us, it is too long and the required motion to focus it correctly is outside the range of the active hexapod that holds it to the telescope. This prevented us from actually closing the loop during the run and repeating the diffraction limited imaging we saw in the lab.

All these issues are now being addressed. We hope to go back to the telescope in the fall, when there will be one additional new element - the cold. To anticipate problems there, we'll be running the mirror in a big fridge for a while.

On the bright side, one concern has been addressed head-on: with the secondary commanded to behave like a normal rigid mirror, it does so in the face of wind at 30 kph. Measurements using the mirror's internal sensors showed stability of the optical surface of 20 nm rms or better over periods of ten minutes. This is true regardless of elevation angle (to 30 degrees) and orientation with respect to the wind.

Procedures for installation of the wavefront sensing topbox and the secondary, and alignment of the two with respect to each other and the telescope are now well established. Boding well for future maintainability, these procedures are not significantly more complex than current normal MMT operations.

The full closed-loop software was exercised and worked fine. We just had to set the gain to zero....

We invite you to browse the blow-by-blow account compiled at the time at:

http://athene.as.arizona.edu/~fwildi/work/1st_light/

We'd like to say a HUGE thank-you to all the staff of MMTO, who went well above and beyond to accommodate us and our quite extraordinary requirements.

Primary Mirror Support

P. Spencer built a simple hardpoint stepper driver test board that enables movement of the hardpoint and test proximity switches. The test board consists of a momentary enable switch and a forward/reverse switch. He also tested reducing hardpoint motor torque by changing the current set resistor (R1) on the motor driver card. Motor torque was reduced from 6.5 oz-in to 2.3 oz-in by increasing the resistor value from 68.9K to 91K. Since this resistor value is outside the manufacturer's specifications, it should not be considered a reliable/repeatable value without verification with other hardpoint motors and driver cards. Another spare hardpoint driver card was built with printed circuit board cards supplied by K. Duffek.

S. Callahan and R. James met with Matt Johns and Charlie Hull from the Magellan project to discuss safety mechanisms to limit the extension of the primary mirror support hardpoints.

Thermal System

S. Callahan, R. James, S. Bauman, and the rest of the mechanical team began the design and modeling of a new heat exchanger cabinet in the pit to increase the capacity of the primary mirror ventilation system. The Neslab chiller will be relocated to the pit as well.

F/9 Topbox Wavefront Sensor

In early May the wavefront sensor was more carefully aligned to the topbox mechanical axis using B. Kindred's laser alignment fixture. This resulted in significant improvement of alignment. Topbox rotation now results in very little pupil motion on the detector.

The Apogee CCD has developed contamination on the surface of the detector. It was replaced with the spare. The contaminated detector will be sent back to Apogee for cleaning.

Much work was performed on the wavefront sensor GUI to make it simpler to use by the telescope operators, although further refinement is required.

Although scheduled for several nights of testing, integration, and debugging, poor weather and more critical engineering tasks precluded all but a couple partial nights of observation.

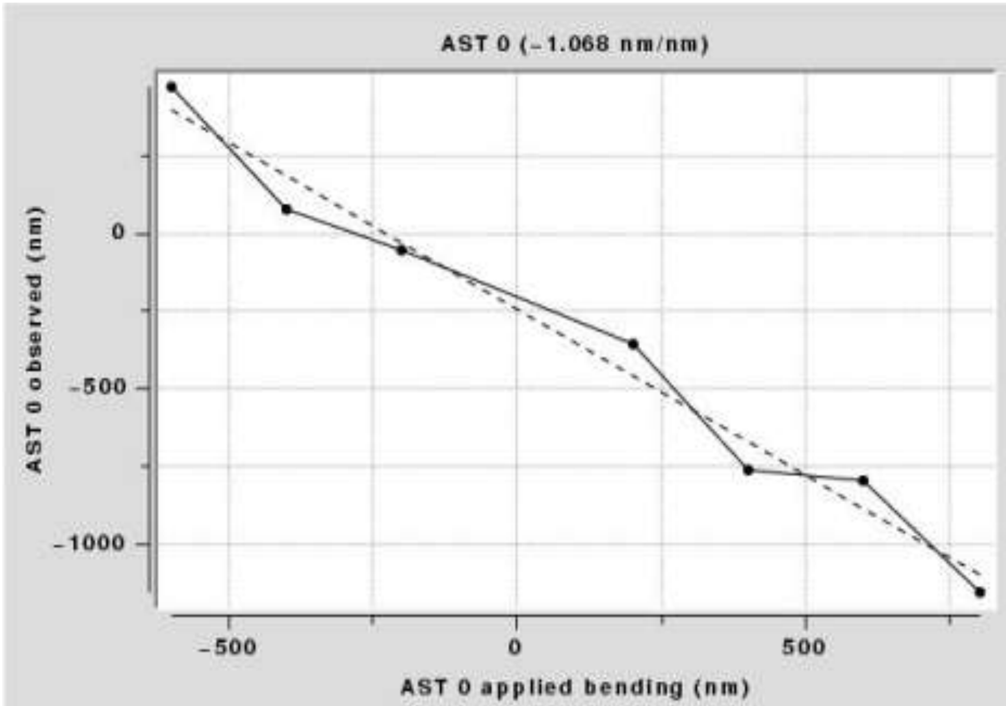
These few observations helped verify proper operation. The data were used to test the effectiveness of the new centroid and data reduction routines, and were found to work well. The Zernike response was measured for: 1) bending the primary in a few low-order modes, 2) misaligning the f/9 secondary mirror, and 3) preliminary elevation dependences.

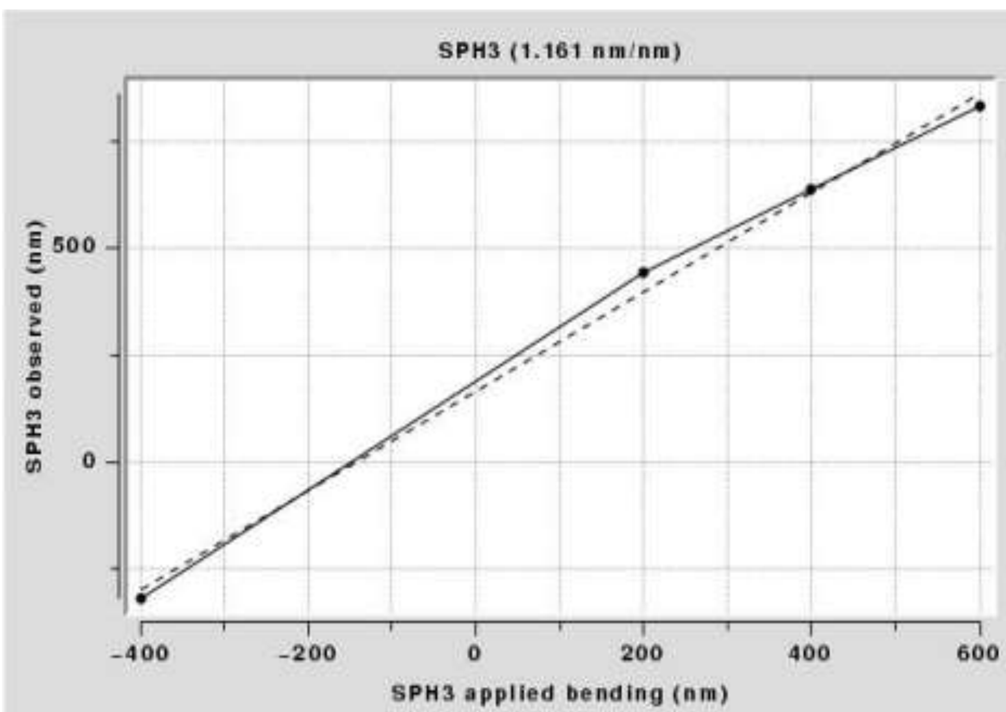
The preliminary response wavefront aberrations are summarized in the following table:

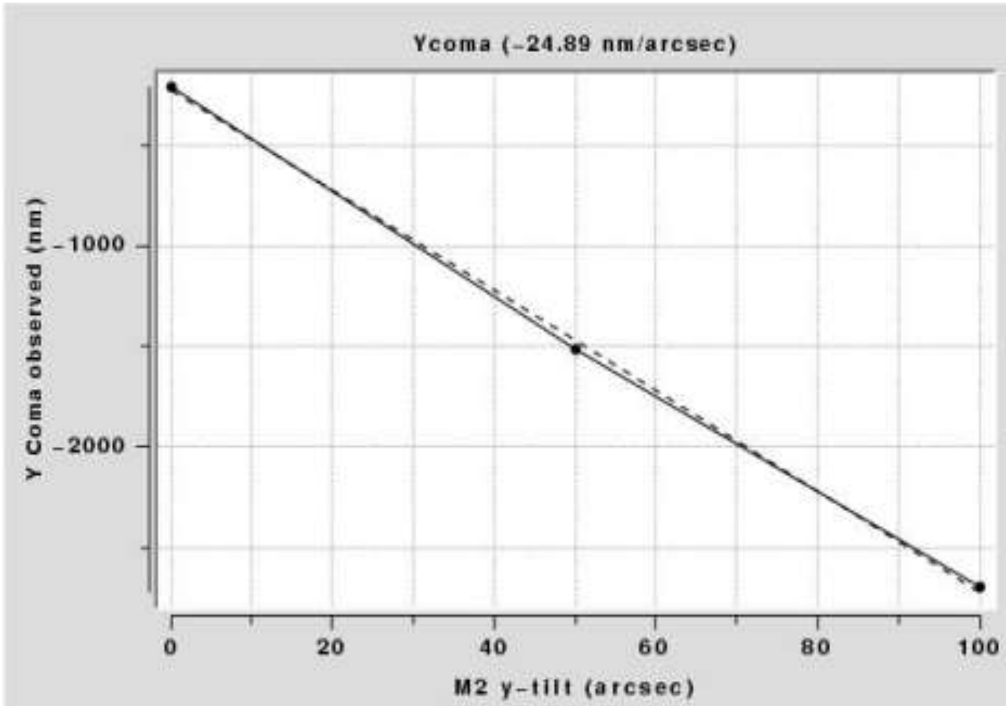
Description	**Measured Response**
Astig @ 0	1nm/nm (measured wavefront/bending
Astig @ 45	1 nm/nm
Trefoil X	0.95 nm/nm
Trefoil Y	0.95 nm/nm
Spherical (3rd)	1 nm/nm
Defocus	39nm/µm (wavefront/M2 piston)
Coma X	26 nm/arcsec (wavefront/M@ vertex tilt)
Coma Y	25 nm/arcsec

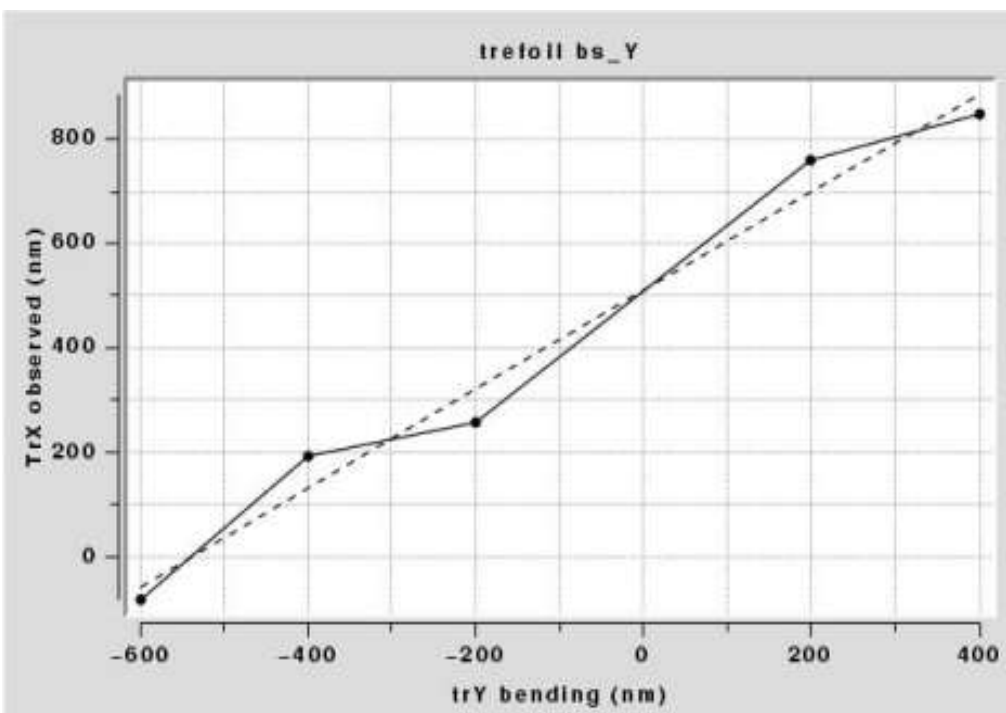
The bending responses are the observed Zernike wavefront errors measured after bending the primary into Zernike modes. Defocus and coma were measured after misaligning the secondary mirror. In each case, several data points were measured in the span of a micron of aberration, and the slope of the best-fit line is shown in the above table.

Typical responses are shown in the following four figures (best-fit lines are dashed):

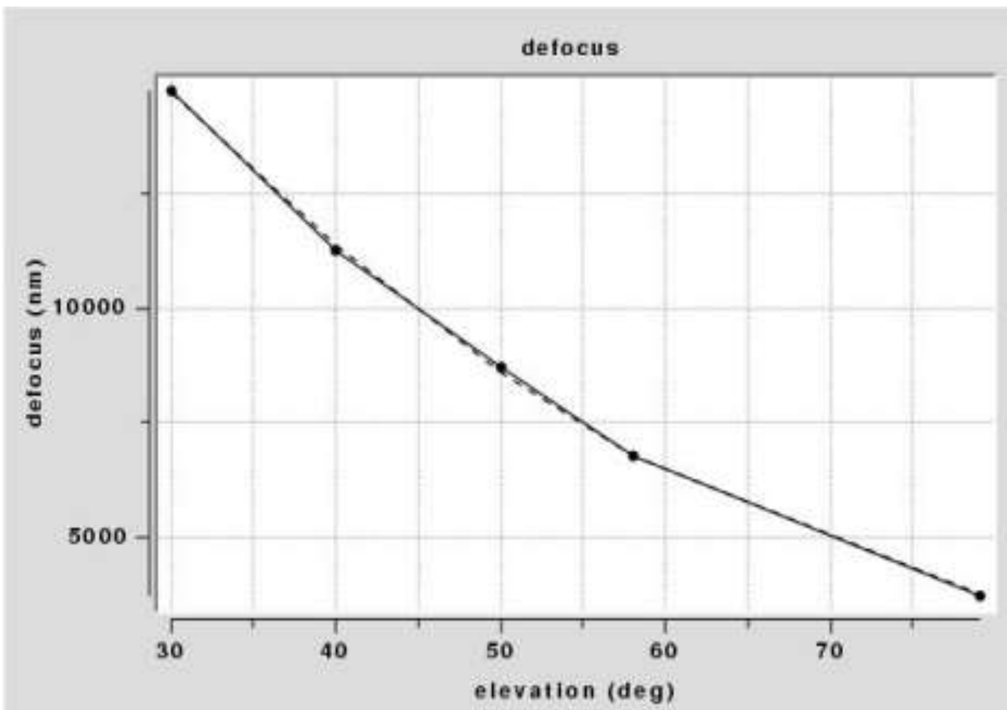

AST 0 (-1.068 nm/nm)
AST 0 observed (nm)
0
-500
-1000
-500
0
500
AST 0 applied bending (nm)

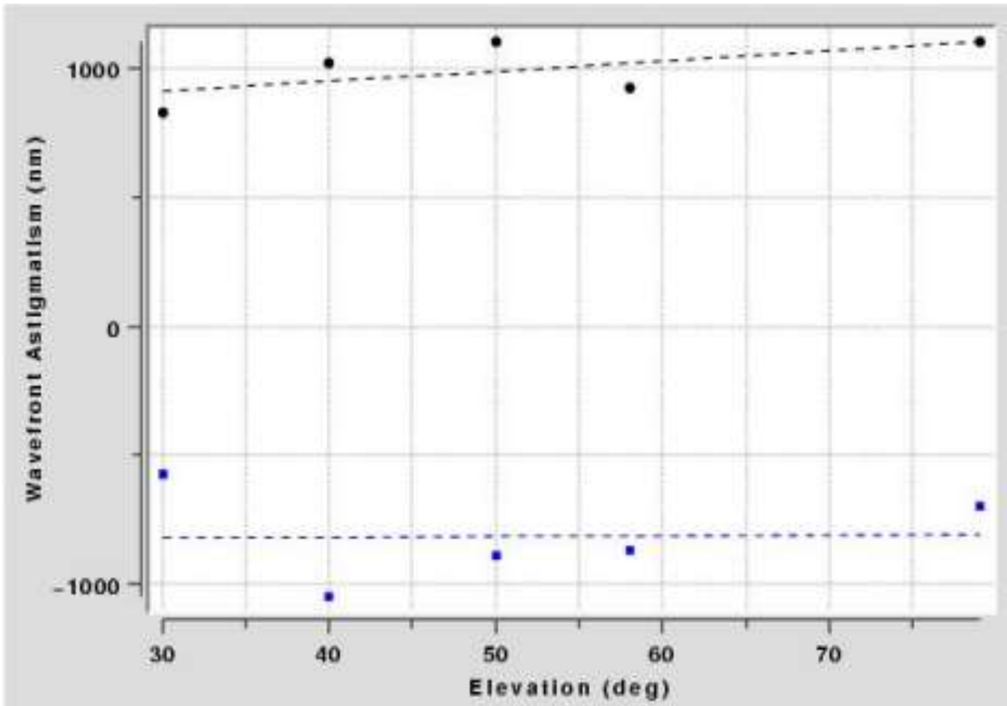

SPH3 (1.161 nm/nm)
SPH3 observed (nm)
500
0
-400
-200
0
200
400
600
SPH3 applied bending (nm)


Ycoma (-24.89 nm/arcsec)
Y Coma observed (nm)
-1000
-2000
0
20
40
60
80
100
M2 y-tilt (arcsec)


trefoil bs_Y
TrX observed (nm)
800
600
400
200
0
-600
-400
-200
0
200
400
trY bending (nm)

The preliminary elevation dependence was measured during partly cloudy conditions. Only a single span of elevation was measured before observations became impossible, so repeatability remains untested. The data do, however, give an indication of the magnitude of elevation-dependent aberrations that are present without any corrections to the primary or secondary mirrors. The M2 piston sag is about 250 μm from 30-80 degrees elevation. The changes in astigmatism are shown for both modes and have been intentionally offset by 1μm on the graph for clarity. The observing conditions precluded obtaining elevation data for other modes.



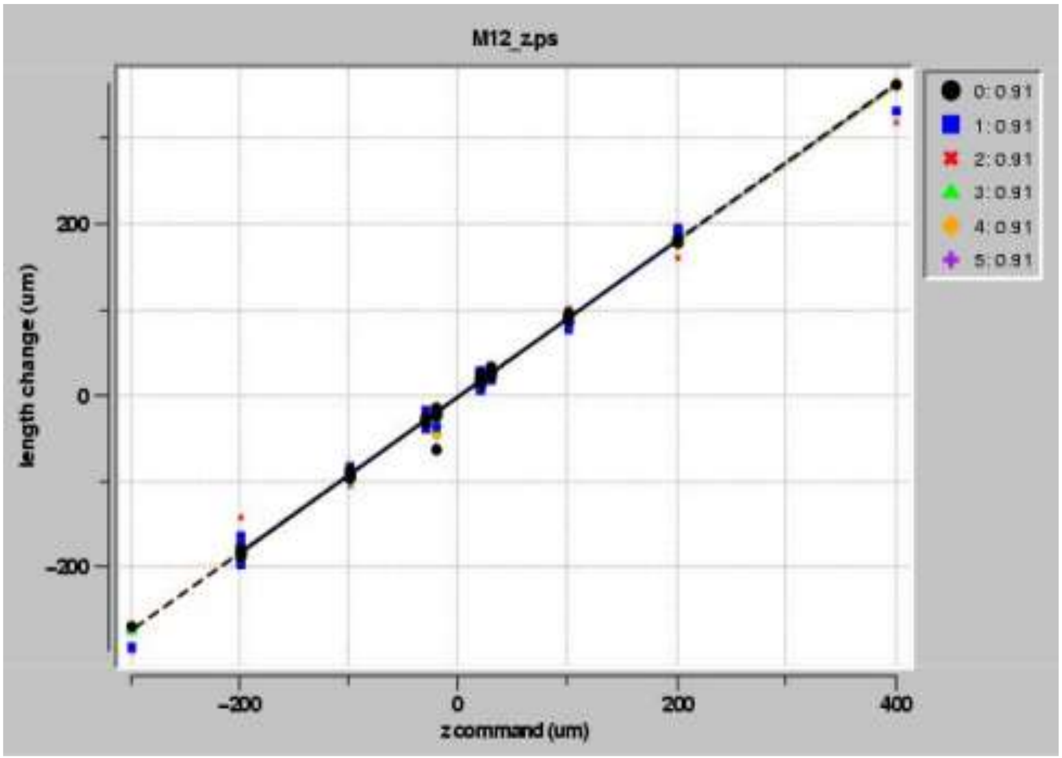


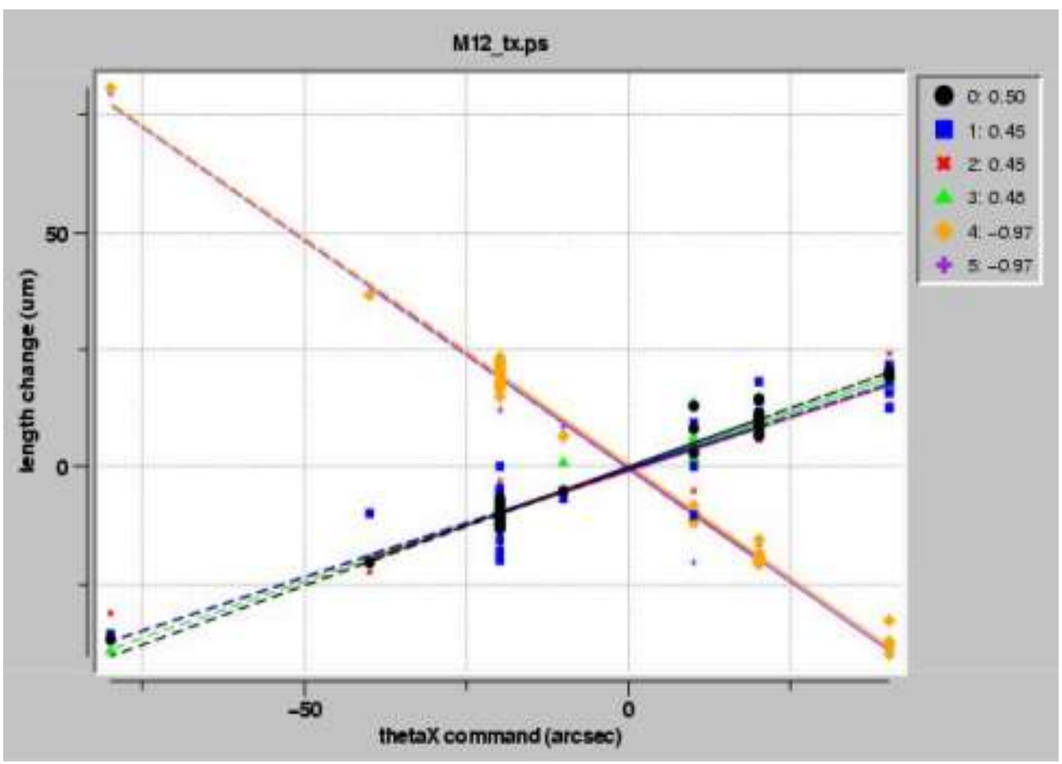
F/9 Hexapod

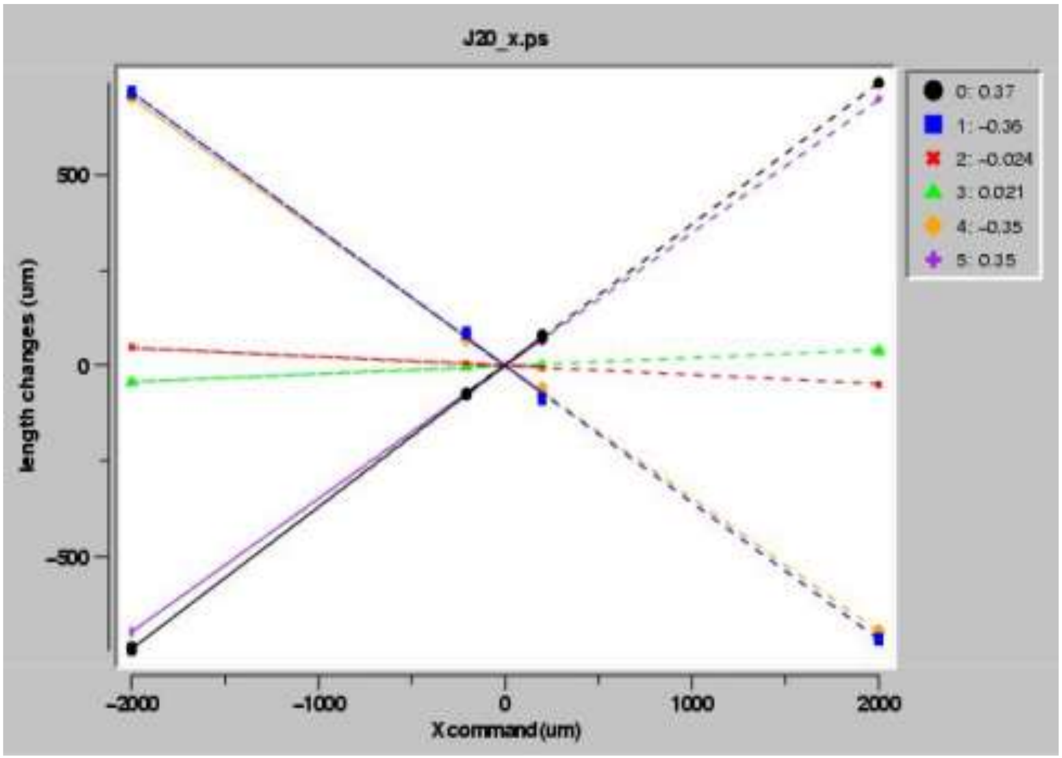
Routine Maintenance

As part of routine maintenance, the inverse kinematics of the hexapod struts was re-measured. Moving the mobile platform in Cartesian coordinates and comparing the resulting individual strut motions with the theoretical values accomplishes this. Noise on the LVDT electronics prohibits a finely detailed analysis, but the procedure works well enough to verify proper operation of all the components. The test results indicate that the hexapod is working to within its designed specifications. We saw no indication of the occasional/rare positioning glitches that the operators report.

The following three figures illustrate the results of the test for the mobile plate moved in Z, θ_X, and X motions. The response of each strut is shown vs. the commanded platform motion.


M12_z.ps
length change (um)
z command (um)
0: 0.91
1: 0.91
2: 0.91
3: 0.91
4: 0.91
5: 0.91


M12_tx.ps
length change (um)
thetaX command (arcsec)
0: 0.50
1: 0.45
2: 0.45
3: 0.48
4: -0.97
5: -0.97



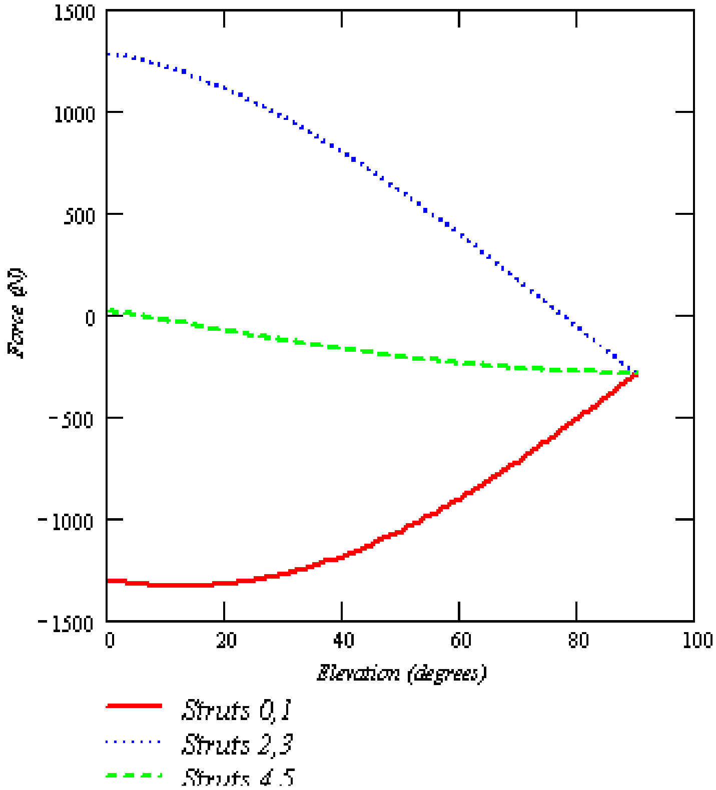
The following table shows the theoretical strut motions vs. those measured (in parenthesis, NM = not measured) in this test. Each column shows the response of each strut to a given motion (X, Y, Z, θ_Z, θ_Y, θ_X respectively with the first three columns having units of μm of strut motion/μm of platform displacement; the last three columns have units of μm of strut motion/arcsec of platform rotation about the mirror vertex).

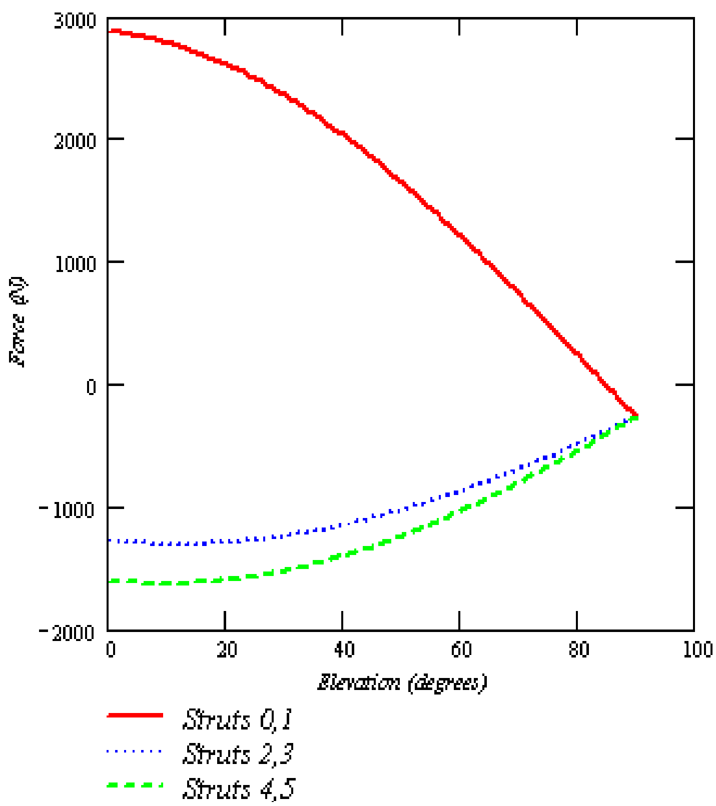
0.375 (0.37)	0.191 (0.19)	0.907 (0.91)	-0.383 (NM)	0.852 (0.87)	0.492 (0.50)
-0.375 (-0.36)	0.191 (0.19)	0.907 (0.91)	0.383 (NM)	-0.852 (-0.87)	0.492 (0.45)
-0.021 (-0.02)	-0.420 (-0.42)	0.907 (0.91)	-0.383 (NM)	-0.852 (-0.83)	0.492 (0.45)
0.022 (0.02)	-0.420 (-0.42)	0.907 (0.91)	0.383 (NM)	0.852 (0.86)	0.492 (0.48)
-0.353 (-0.35)	0.229 (0.23)	0.907 (0.91)	-0.382 (NM)	-0.002 (0.0)	-0.984 (-0.97)
0.353 (0.35)	0.229 (0.23)	0.907 (0.91)	0.383 (NM)	-0.000 (0.0)	-0.984 (-0.97)

To the level of measurement that the LVDT electronics allow, the hexapod appears to be functioning properly.

Usage for F/15

During the end of July, the f/9 hexapod was adapted for use with the f/15 adaptive optics system. Although the payload weights are nearly identical, the f/15 load has a longer cantilever, and the hexapod is rotated in θ_Z by 180 degrees. This has two effects: 1) the struts see larger forces, and 2) the two neutral f/9 struts now take substantial load. The following figures show the strut load vs. elevation for each package (f/9 load shown on top).


1500
1000
500
0
-500
-1000
-1500
0
20
40
60
80
100
Force (N)
Elevation (degrees)
Struts 0,1
Struts 2,3
Struts 4,5


3000
2000
1000
0
-1000
-2000
0
20
40
60
80
100
Force (N)
Elevation (degrees)
Struts 0,1
Struts 2,3
Struts 4,5

During the f/15 run, occasional problems were reported with strut #5. As seen in the graphs, struts 4 and 5 remain essentially neutral in the f/9 configuration, but are heavily loaded in the f/15 configuration (due to the rotation of the hexapod by 180 degrees). We may have an intermittent problem for strut 5 under load. However, there was too little time for further diagnosis during the AO engineering run.

Prior to the f/15 run, new transformation matrices were calculated by the MMTO for the hexapod, and a new hexapod GUI was written for its control. Additionally, the AO group can control the hexapod independent of the telescope operator GUI.

P. Spencer worked on the f/15 secondary-to-hub collision detection electronics. The system consists of a ribbon switch or contact switch that is installed either on the f/9-f/15 hexapod mobile ring or on the secondary hub-stiffening ring. When the switch is squeezed (shorted) between the hub and the AO secondary it will detect a collision and halt hexapod movement. The switch is connected at the secondary with a BNC connector and "T'd" with an 820-ohm resistor for detecting a connection/power failure (a K. Van Horn contribution). The signal is fed through an RG180 coaxial cable to the hexapod electronics. Triggering the switch will disconnect the hexapod amplifier power and enable the actuator brakes if a collision is detected or if there is a connection/power failure. The signal will also be interfaced to a GUI and indicator LEDs for alerting staff.

Another hexapod change was the remounting of the single board computer to the back of the hub midplate. This placement works well for both the f/9 and the f/15 secondaries while permitting easy service access. This task was performed with P. Ritz.

F/5 Hexapod

Work continued on the testing and control hardware and software for the new f/5 secondary. This work included PID servo hardware control through a serial port interface, and a GUI of hardware and servo parameters that updates at approximately 10 Hz.

The initial testing of the new Ruby GUI and control electronics began during the reporting period, with less-than-satisfactory results. The control script communication over the RS-232 link proved to be too slow to provide good servo control at higher motor speeds. The servo amplifier was retuned according to the Copley application procedure (resulting in ~16 Hz bandwidth), while the motor top speed was reduced to accommodate the slow digital update rate. At this point it was discovered that the roller nut friction is highly non-linear, with lower stiction in one direction than the other. Application of integral gains in the digital loop to deal with this resulted in unstable "hunting" due to the concomitant overshoot in the servo demand. It was decided at this point that the servo amplifier tuning had to be optimized to get more linearity; extensive modeling and verification with a MATLAB servo amplifier model led to an increase in bandwidth to 34 Hz. Even with this improvement, however, accurate, smooth control over the strut length was an elusive goal.

More testing then ensued to determine what items could be improved in the hardware to improve the situation. We found that the roller nut shaft preload was improperly shimmed to preload the shaft axially. With R. James' help, this was repaired (on the spare actuator) with the installation of a 0.006" shim in the shaft bearing housing. We elected not to disassemble the hexapod units until gravity loading tests can be done to verify this axial movement. During this period, testing of the electronics using the HP dynamic signal analyzer in spectrum analysis mode revealed a major problem: the servo amplifier PWM frequency is close to an integer multiple of the LVDT's carrier frequency. The lack of magnetic shielding in the LVDT unit (due to its stainless-steel housing) results in the LVDT voltage becoming corrupted with interference from the amplifier output.

It is clear from the above that extensive re-design of the electronics is necessary. Testing the spare actuator using a linear amplifier and analog servo control loop (with the computer providing only a target position to the servo electronics) gave gratifying results: smooth, fast motion to positions repeatable within four microns. With these results in hand, re-design and construction of new hardware to run the hexapod began. We will build a new linear amplifier stack, new controller card, and new link electronics to pass the LVDT values down to the controller; results will be reported in the next Bimonthly Summary.

F/5 Mirror Support

Initial testing and setup of the support servo board have led to some minor changes to the axial support servo, and the addition of more analog-to-digital channels to provide more diagnostic information (i.e., air pressure sensor outputs) to the control GUI. No additional testing has been done due to other time commitments and ongoing mechanical work on the cell.

The mechanical team mounted the f/5 dummy mirror into the cell and completed a wide variety of tasks to prepare the mirror for testing.

F/5 Instrument Preparation

J.T. Williams worked with Mark Ordway, Jack Barberis, and Michael Honsa (SAO) May 20-22, 2002. The fiber derotator for the Hectospec and Hectochelle was installed and tested on the telescope. A prototype of the energy chain for the aforementioned spectrographs and Minicam was installed on the west drive arc and tested throughout the elevation range.

The wide field corrector and its attendant handling carts were shipped in mid-June. They arrived at SOML on June 14 where the air-ride semi trailer was unloaded. The corrector was moved to Steward Observatory, and the remaining hardware went to the FLWO warehouse.

Servos

More investigation has been done on the MMT elevation axis to find the 2-Hz compliance. Extensive testing, using an accelerometer on various parts of the telescope and drive motor hardware, failed to turn up any obvious source, although we did verify the new drag link flexures on the east drive motor to be indeed stiffer (at least in the rigid-body modes) than the stock west unit. We await installation of the tape encoders to do more testing and investigation.

Computers and Software

Catalog GUI

Code was developed for loading, editing, and controlling the telescope from an MMT-format catalog. A multi-threaded approach was used for software design to optimize user response with the GUI and to perform mathematically intense calculations in the background. The Ruby programming language was used to build a class for common astronomical calculations such as altitude, azimuth, and airmass. Code for the GUI is contained in a separate class that runs in a high priority thread, facilitating user response. Current information from the mount computer is displayed in the GUI including telescope orientation, commanded positions, actual positions, and current time. Catalogs are loaded into a spreadsheet-like matrix that can be sorted by any field. A target telescope orientation can be specified in right ascension/declination or altitude/azimuth coordinates. The separation angle between this target orientation and each entry in the catalog is calculated. Finally, the GUI can be used to modify an existing catalog or to build a new catalog that conforms to the standard MMT format.

Data Server

Work was initiated on a Ruby-based data server that will serve as a data cache of "reasonably timely" parameters for the entire MMT telescope system. The concept behind the data server is to have one location for obtaining data on current telescope status via a universal network socket protocol. Data will be refreshed in the data server at variable intervals based upon the nature of the data, such as once per second for the mount system versus once per minute for the thermal system. These data can be used by GUIs or to create log files. This project will be ongoing for the next few months as Ruby classes are written for the various subsystems, e.g., cell, mount, secondary, and thermal. Initial work is on the thermal system.

VxWorks Migration

A number of VME based computers running VxWorks are used on the mountain for real-time control of the mount, hexapod, and primary mirror support. Software development and booting of these systems has long been supported from our Sun computers running Solaris. Over the past few months we moved both development and booting to our Linux computers. This has several advantages: the Linux machines are much faster, and since we administer them in-house we can more quickly resolve any issues that arise with them. This also reduces the number of computers that must be powered on up on the mountain, making things more robust and convenient in times of lightning hazards. It also essentially eliminates our dependence on our ageing Sun computers.

Mount Software

A number of pesky issues have been fixed in the software that controls telescope motion. For a long time we have been irritated by the software's deciding to perform a 360-degree slew while in the northwest part of the sky. This bug has been fixed and we are now able to use the full 540 degrees of azimuth motion in the most efficient manner. A second long-standing issue has been the presence of aberrant encoder values as strange "spikes" in the absolute encoder readouts for both elevation and azimuth. This has ultimately been traced to a settling time issue during multiple bit transitions in the digital encoder readout circuitry. A software filter has been developed that seems to be extremely effective in rejecting these erroneous values.

Terminal Server Deployment

We now use our Cyclades terminal server to access serial ports over the network. We use this to communicate with a number of devices that are part of the telescope thermal control system at the present time. Work is in progress to use this for the "instcon" serial protocol that allows legacy instruments to send commands to the mount, and to collect data from weather instruments (temperature and humidity sensors) that have been read manually up until now. A major advantage of using the terminal server is that it is a central and uniform point of access for all devices with serial interfaces. This makes it very easy, for example, to change the operator console at a moment's notice should such a need arise.

MMT Network

To reduce costs and simplify network topology and administration, all MMT machines were migrated to a new domain, mmto.arizona.edu, over the course of the month of June. Migrating the computers on the summit was simply a matter of changing their domain names and DNS configurations. The downtown machines took somewhat more effort since they needed to be assigned new network addresses, and a few needed new hostnames as well. The main snag in the process was an unforeseen limitation in the ability of the ethernet switches that are part of our microwave radio gear to handle large numbers of machines on multiple switch ports. This was worked around by having CCIT reconfigure their switch in the basement to provide more ports for our network.

Now that the migration is complete, all MMT machines share the same network address space, namely the 128.196.100.0 subnet. This improves ease of use for windows users since all MMT windows machines will now appear in one's network neighborhood. It also improves network performance by avoiding having to route through the campus core routers to go between downtown and the summit. T. Pickering has measured about a 10-15% improvement in throughput between his machine and machines on the summit. Managing our own DNS servers now allows us to maintain a DNS server on the summit as well as downtown, which should help improve network performance of summit machines at times when the radio link is down.

A second domain, mmto.org, was also activated to provide convenient e-mail and web aliases for the MMT. A new server machine was purchased to host the mmto.org domain as well as to act as the main web, mail, DNS, and file/backup server for the MMT. It has a 2 GHz processor and over 400 GB of redundant disk space, which make it a significant improvement over the aging Sun Sparcstations it replaces. The new e-mail addresses are of the form *<first initial><last name>@mmto.org*, e.g. *tpickering@mmto.org*. The main MMT home page is at *http://www.mmto.org* and users can now access their e-mail via a web-based interface at *http://www.mmto.org/webmail/* in addition to the usual methods.

Optics

No activity to report.

General Facility

A Vaisala HMP247 dewpoint transmitter was installed in July. This unit determines dewpoint to within 0.5 C in near-saturation conditions and will enable us to better protect telescope optics from condensation. The sensor head is heated, preventing condensation and allowing accurate measurements very near saturation and in rapidly changing conditions – the response time is 15 seconds. A separate sensor measures temperature with an error of ±0.1°C (+20°C). Derived quantities available are relative humidity (±3% at saturation), absolute humidity, dewpoint-temperature spread, mixing ratio, and wet-bulb temperature. Data are output via RS422 and two analog outputs.

On separate occasions the reported RH agreed exactly with that obtained by wet/dry bulb temperature tables. These numbers disagreed considerably (as much as 14%) with those reported by the Vaisala HMI36, and pointed out the need for more frequent calibration of these types of instruments. Materials to calibrate the HMI36 probes have been ordered.

The fiber link to the RUPS room is now carrying blower control signals, DAU, and Carrier control signals. A UPS is also installed in the RUPS room. A printed circuit board has been designed, but not ordered, to replace the wire wrapped boards built for this interface.

In May, C. Wainwright and S. Callahan began the design to install a new crane for secondary and fixed hub installation. This new crane will be rated for two tons. The trolley will be motorized and the rail will be replaced with a stronger, longer I-beam. C. Wainwright finished the drawings and ordered the crane and beam.

New video cables have been installed between the topbox and the GAITS rack, and another set installed from there to the control room.

A new rotator limit switch has been implemented for Minicam and other instruments that need something other than the lanyard.

The database for the 26V rack has been updated almost to the latest configuration. Some work still needs to be done.

New documentation on cabling to and from the cell and the control room has been generated and will be used to order new cable to be installed in the new energy chains.

Maintenance and Repair

P. Spencer and B. Kindred removed video noise on the I-CCD camera. To remove the noise, all components involved in the video signal chain from ground were isolated, i.e., all monitors, computers, instruments, etc. Chassis are not fully grounded, so if these components need powered servicing, one must ground the chassis externally.

C. Chute and R. James designed a replacement seal for the elevation motors. At the same time, R. Ortiz, S. Callahan, C. Wainwright, and D. Jones removed the east elevation motor. The seals were inspected and the excess grease in the bearings was removed. After a thorough cleaning, the motor mount flexures were replaced and the motor was then realigned to the elevation axis.

The Red Channel CCD detector failed on April 16. Due to an oversight, this was not reported in the last Bimonthly Summary. We intend to replace this detector with a new low-noise device from a fabrication run that will soon be in Mike Lesser's (UA Imaging Technology Lab) hands.

Visitors

May 13: A Smithsonian Associates Study Tour group of 38 visited the FLWO/MMT facilities atop Mt. Hopkins during the day. In the evening they returned to the Whipple Observatory Visitor's Center to view exhibits and videos, followed by a catered barbecue. With sunset, telescopes set up next to the Visitor's Center were used to observe the sky. After dark, observations began to view Mercury, Saturn, Mars, Venus, Jupiter, and the Moon.

June 12: Kurita Mikio (a student at Nagoya University in Japan) and an engineering colleague, accompanied by D. Brocious.

Publications

MMTO Internal Technical Memoranda

None

MMTO Technical Memoranda

None

MMTO Technical Reports

None

Scientific Publications

02-5 Continuum and Emission Line Strength Relations for a Large Active Galactic Nuclei Sample
Dietrich, M., Hamann, F., Shields, J. C., Constantin, A., Junkkarinen, V. T., Chaffee, F., Foltz, C. B.
To appear in *ApJ*

02-6 A Survey of Proper-Motion Stars. XV. Orbital Solutions for 34 Double-Lined Spectroscopic Binaries
Goldberg, D., Mazeh, T., Latham, D. W., Stefanik, R. P., Carney, B. W., Laird, J. B.
AJ, **124**, 1132

02-7 A Survey of Proper-Motion Stars. XVI. Orbital Solutions for 171 Single-Lined Spectroscopic Binaries
Mazeh, T., Carney, B. W., Laird, J. B., Morse, J. A.
AJ, **124**, 1144

02-8 LBQS 0015+0239: A Binary Quasar with Small Angular Separation
Impey, C. D., Petry, C. E., Foltz, C. B., Hewett, P. C., Chaffee, F. H.
ApJ, **574**, 623

02-9 An Extraordinary Scattered Broad Emission Line in a Type 2 QSO
Schmidt, G. D., Smith, P. S., Foltz, C. B., Hines, D. C.
Submitted to *ApJ Letters*

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 Smithsonian Institution and the University of Arizona."

Submit observing reports and publication preprints to *bruss@mmto*.org 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://www.mmto.org*. 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*.