# Astrophysical Research Consortium
## Apache Point Observatory
*Sunspot, New Mexico 88349*

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This report covers the period from November 1, 1996, to October 31, 1997.

## 1. CHARTER, AFFILIATE INSTITUTIONS, AND PERSONNEL

The Astrophysical Research Consortium (ARC) was chartered in 1984 to build and operate observatory facilities at Apache Point for the shared use of consortium astronomers and students. The major projects at the site are the 3.5-meter telescope which has been in operation since 1994, and the Sloan Digital Sky Survey (SDSS) telescope whose installation is near completion. ARC Consortium members are the University of Chicago (UC), the Institute for Advanced Study (IAS), Johns Hopkins University (JHU), New Mexico State University (NMSU), Princeton University (PU), the University of Washington (UW), and Washington State University (WSU). Additional support and contributing institutional partnerships for the SDSS are provided by the Alfred P. Sloan Foundation, the Fermi National Accelerator Laboratory (FNAL), the Japanese Participation Group (JPG), the US Naval Observatory (USNO), and the National Science Foundation (NSF).

Chairperson of the ARC Board of Governors is T. Heckman (JHU). D. York (UC) is Observatory Director and Director of the SDSS. E. Turner (PU) is Director of the 3.5-meter Telescope, and C. Stubbs (UW) is 3.5-meter Telescope Scientist. R. Kron (UC) is Survey Director for the SDSS, J. Pier (USNO) is SDSS Project Manager, and J. Gunn (PU) is SDSS Project Scientist. J. Peoples (FNAL) is chair of the SDSS Advisory Council, and A. Szalay (JHU) heads the SDSS Scientific Advisory Committee.

NMSU operates the observatory under contract to ARC. K. Anderson is Site Director; B. Gillespie is Site Operations Manager; M. Klaene is Deputy Site Manager and Observatory Engineer; C. Loomis is Observatory Computer Systems and Network Manager; K. Gloria, C. Corson, and T. Hoyes are 3.5-meter Observing Specialists; D. Long and R. McMillan are SDSS Observers; G. Van Doren is a Technical Writer; J. Davis is Telescope Systems Engineer; J. Brinkmann is SDSS Instruments Engineer; D. Woods is an Electronic Technician; M. Reyero and N. Blythe are Data Aides/Housekeepers; and J. Wagner maintains the site grounds. D. Pacheco and others at the NMSU Las Cruces campus provide administrative support to the site.

## 2. FACILITIES

APO is located in the Sacramento Mountains at 2800 meters elevation near Sunspot, New Mexico. Observing facilities at APO include a 3.5-meter telescope used for general visible and IR imaging and spectroscopy, the SDSS 2.5-meter survey telescope, a 0.6-meter telescope which is used to calibrate survey photometry, and a 1-meter telescope owned by NMSU. The site also contains operations and support buildings, plus dormitories. Additional temporary housing and workspace have been provided to accommodate SDSS installation and commissioning activities.

## 3. 3.5-METER TELESCOPE AND OPERATIONS

The 3.5-meter telescope is completing its third year of scientific operation. Scientific observations were taken during 37% of the year, the balance given to inclement weather (33%) and scheduled and unscheduled engineering time (30%). As reported elsewhere, a growing volume of published scientific results based on data taken with the telescope continues to appear in refereed journals.

Our early experience with the telescope has uncovered various deficiencies which prevent users from benefiting from the full performance and efficiency capabilities inherent in the telescope design. A consensus was reached this year to adopt an aggressive engineering improvements and enhancement strategy, called ''The 3-year Plan.'' Extra funds were earmarked to accomplish a substantial list of improvements to the observatory, including the replacement of the secondary mirror, upgrading the guider, enabling automatic tertiary mirror rotation and mirror covers, improving instrument capabilities, modernization of operational software, etc.

Two major engineering shutdowns were conducted in late 1996 and mid-1997. The telescope optics were realuminized which yielded a substantial improvement in telescope throughput. Defective enclosure wheels were replaced. The primary mirror pneumatic support system was redesigned and implemented. Improved primary ventilation hardware was installed. A larger, more sensitive guide camera was integrated into the off-axis Nasmyth instrument port. Advanced means of aligning the optics were devised and used to improve image quality. Computer and network systems were maintained and upgraded to give higher capacity and better reliability for operations.

The telescope regularly uses an infrared imager and spectrometer, a medium-resolution visible-light spectrograph and imager, and a large-format visible-light CCD imager. A high-speed infrared CCD imager, and an adaptive optics system have also been integrated with the telescope. Also, a number of visitor-supplied instruments have been used with the telescope for limited observing runs. An echelle spectrograph is scheduled for delivery at APO in the coming year. Technical details for these instruments is available from the world wide web server for APO; the URL is given below. Planning for next-generation facility instrumentation has been initiated.

Provided by and for the SDSS project, a prototype all-sky 10-micron scanner is in regular use to monitor and archive sky conditions, producing an image of the sky in the thermal infra-red each few minutes at half-degree resolution. Clouds that are otherwise undetectable by eye are easily seen in the images during dark time, and this system has become very popular with the remote and on-site observers. New this year, a commercial dust measuring device has been added to the suite of meteorological transducers that are integrated into a user facility for monitoring and archiving the weather conditions at the site.

Visits to the site by astronomers are mainly for installation and testing of new instruments, or for training purposes. Observing functions, which include complete telescope control, instrument control, quick-look quality assurance, and data retrieval, are all accomplished by the remote observer. APO has a dedicated T1 circuit to NMSU enabling remote operation of the 3.5-meter telescope through the Internet, nominally at about 10% of T1 data rates due to Internet bottlenecks. A modem backup system is in place. Roughly two-thirds of all observing is done remotely, which continues to be the same ratio as in previous years. Because new instruments with larger CCDs have begun to tax the existing network systems, plans for increasing the data bandwidth to the site are in progress. Many of the ARC institutions already have or have proposed to acquire vBNS network capability.

The telescope is scheduled roughly two months in advance by quarters, with two to three programs frequently scheduled for separate time intervals in the same night. These science programs often involve different instruments, observers, and institutional affiliations. Multiple remote users can also connect simultaneously from several geographical locations, allowing ''eavesdropping'' or even active collaboration at a distance. Routine remote operation of the telescope has been conducted by ARC astronomers from Israel, Canada, the United Kingdom, and once via satellite from the South Pole. Several rapid-response opportunities to observe the optical afterglow of Gamma-Ray Bursts (GRBs) this year were supported, possible in part by the rapid instrument change capability of the telescope.

Monthly telephone meetings of the 3.5-meter Users Committee were held during the year. In September 1997, NMSU organized a workshop of 3.5-meter users held in the newly-opened Visitor's Center at the National Solar Observatory at Sunspot. Two days of discussion of science programs and observatory projects led to a deeper understanding of observatory issues and priorities for engineering improvements and upgrades.

As part of APO's support to public outreach programs, the Adler Planetarium in Chicago continued its regular Friday evening program that demonstrates the use of APO's remote observing system to the public. Astronomers at the planetarium control the telescope and instruments during evening twilight and transfer images for public viewing. Also, APO is a partner in the Sunspot Astronomy Center, located nearby at the National Solar Observatory, which was completed and opened to the public this year.

## 4. SLOAN DIGITAL SKY SURVEY (SDSS)

The SDSS is a project to map $\pi$ steradians at the North Galactic Pole in five broadband filters, for use in selecting a magnitude-limited sample of galaxies and QSOs. Redshifts for a million objects will be obtained in the selected range. The goals of the project are unchanged from previous reports, as is the list of participating institutions. A small control sample will be obtained in small regions near the South Galactic Pole.

During the past year, notable progress has been made. The 0.6-meter Monitor Telescope was in commissioning, a process that pointed up several performance deficiencies that were fixed. Following delivery of all five large optical parts for the 2.5-meter telescope (the two mirrors and three correctors), a detailed model using the as-built surfaces was defined to aid in collimation and alignment. The entire camera, electronics, conveyance mechanisms, and utility systems were delivered to the site. One of the two identical spectrographs as well as the CCD camera were mounted on the telescope and fit-checked. The electronics for both types of instruments were mated to the data acquisition system and interface tests and debugging were completed. The eight CCD dewars of the camera (54 CCDs total, 144 square inches of silicon) individually assembled and tested and were made ready to mount in the telescope focal plane.

Instrument handling equipment was installed and tested. Of all 6800 optical fibers required, 80% were delivered. Ten plug plate cartridges were completed. The telescope motion control system was installed. All utilities and supporting infrastructure were installed.

The telescope optics and the mirror control system will be inserted early in 1998 and first light with the camera is expected shortly thereafter. Software for reducing images is ready for sky testing, based on which final changes will be made. The main imaging survey will start in January of 2000 AD and the spectroscopic survey will start one year later.

*Additional information about Apache Point Observatory and the Sloan Digital Sky Survey is available on the world wide web at http://www.apo.nmsu.edu.*

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