Filling out the SOAR Instrument Complement

Steve Heathcote & Chris Smith

The year 2009 will be a seminal year for SOAR. As one of the two southern 4-meter-class telescopes available to the US community through NOAO (NOAO has 30% time), SOAR plays a critical role in providing community access to the rich scientific opportunities in the skies of the Southern Hemisphere.

In semester 2009A, the fraction of time on SOAR scheduled for science has increased to 80% (from 60% in 2008B), significantly increasing the number of nights available at this telescope through NOAO.

The remaining engineering time is being used for instrument commissioning, with completion of work on the fourth of SOAR's first-generation instruments anticipated during 2009. This initial instrument suite provides work-horse capabilities for optical imaging (SOI), optical spectroscopy (Goodman High Throughput Spectrograph), infrared (IR) spectroscopy (OSIRIS), and IR imaging (currently OSIRIS, very soon Spartan IR Camera). During 2009-2010, the SOAR instrument suite will be expanded with two instruments, augmenting both spatial resolution (with adaptive optics (AO)) and spectral resolution.

To help the community prepare proposals for the 2009B semester, and plan science programs for future proposals, we briefly present below the current and planned instrumentation at SOAR.

Current Instrumentation

SOI: The SOAR Optical Imager, built at CTIO, has been in regular use since 2004, initially for commissioning and subsequently for science activities. It routinely delivers images comparable to, or better than, the prevailing seeing, while the blue optimized optics provide excellent transmission, even down to the atmospheric cutoff.

OSIRIS: The Ohio State Infrared Imager and Spectrometer, fitted with a 1K × 1K Rockwell HgCdTe array purchased by CTIO, was moved to SOAR after several years of use on the Blanco 4.0-meter and CTIO 1.5-meter telescopes, becoming available for science on SOAR in the 2005B semester. It provides both an imaging and a modest-resolution, near-infrared spectroscopic capability (up to R = 3000).

Goodman HTS: The Goodman High Throughput Spectrograph, built at the University of North Carolina, supports low- to medium-resolution (R ~ 1400–6000) spectroscopy, achieving high throughput in the 320–800 nanometer region through the use of Volume Phase Holographic gratings and an all-transmissive optical design. The imaging and single-slit spectroscopic modes came into regular science operation for the 2008B semester. Work to implement its multi-slit capabilities will proceed during 2009.

Spartan IRC: The Sparten Infrared Camera was designed and built by Michigan State University. This 4K × 4K near-IR imager saw first light in November 2008 and is currently undergoing commissioning. It produces outstanding J, H, and K broadband images exploiting SOAR's excellent image quality. Science verification testing, with community involvement, will be carried out during 2009B, and regular science use starting with the 2010A semester. (Related article in this section.)

Future Instrumentation

SAM: The SOAR Adaptive Module is designed to enhance the telescope-delivered image quality by correcting the turbulence in the first 5–10 kilometers of atmosphere, halving the image size during appropriate atmospheric conditions, expected to occur about half the time. SAM will incorporate an ultraviolet (UV) laser guide star (LGS) working in Rayleigh backscatter mode, with laser pulses and shutter timings coordinated to select the altitude of the reflection used for the wavefront correction. It is expected that commissioning of the SAM in natural guide star mode will begin in the 2009B semester. Full availability, including use of the (LGS) is expected by the end of 2010. (Related article in this section.)

SIFS: The Brazilian-built SOAR Integral Field Unit Spectrograph is entering its final phases of assembly and testing, and it is expected to be delivered to SOAR in early 2010. SIFS employs a 1300-element microlens array coupled to a fiber-optic bundle to dissect a small patch in the SOAR focal plane, feeding the light to a bench-mounted spectrograph. SIFS will produce moderate dispersion (R ~ 1000–30,000) spatially resolved optical spectra. Initially, SIFS will be mounted on a direct port producing seeing-limited spectral images. However, it is expected to achieve its maximum potential when mounted on SAM, allowing it to exploit the AO-corrected images delivered by the LGS.

STELES: The SOAR Telescope Echelle Spectrograph is a beam-fed, high-resolution spectrograph, optimized for work at blue/UV wavelengths. The design work on this second-generation instrument is well advanced, and fabrication work is slated to begin once SIFS is completed.

BTFI: The Brazilian Tunable Filter Imager employs a novel tunable filter based on Volume-Phase Holographic gratings to perform low-resolution spectral imaging, as well as a more conventional Fabry-Perot etalon for higher spectral resolution. Although BTFI can be used stand-alone, using natural seeing images, it will primarily be used in conjunction with SAM to produce AO-corrected spectral images. BTFI is being developed and funded entirely by Brazil for the use of its own community. However, if demand is sufficient, it is our intention to negotiate with Brazil concerning access for the NOAO community, once BTFI has been successfully commissioned.

Spartan Commissioning

Jayadev Rajagopal, Steve Heathcote, Sean Points (NOAO) & Ed Loh (Michigan State University)

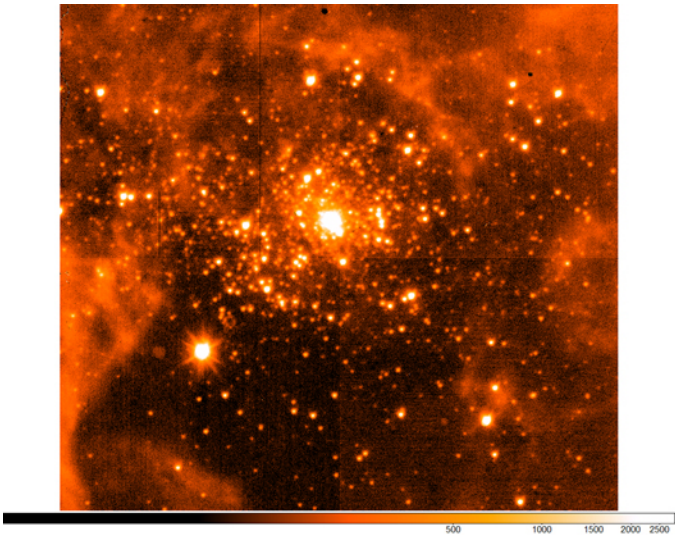
The Spartan Infrared Camera had a successful first light on the Southern Astrophysical Research (SOAR) 4.1-meter telescope in mid-November.

Built at Michigan State University under the direction of Ed Loh, Spartan has two plate scales, 43 milliarcseconds per pixel with a 3 × 3-arcminute field and 68 milliarcseconds per pixel with a 5 × 5-arcminute field, with a spectral range of 0.9–2.5 microns.

Following delivery to SOAR in early October, the instrument underwent a series of laboratory tests to ensure its health on arrival, before mounting it on the telescope to prepare for its first use. The instrument is now in the process of being commissioned, with three engineering runs carried out to date. These have focused mainly on characterizing the detectors and exploring the on-sky performance of the imaging optics and tip-tilt guider. The accompanying figure shows an image of the 30 Doradus nebula taken during the second of these runs and attests to the good progress being made. Commissioning activity will continue during the remainder of this (2009A) semester.

Spartan has a focal plane consisting of four "HAWAII2" 2048 × 2048-pixel HgCdTe detectors. Currently, two of these are Engineering grade, but they will be replaced with new Science grade arrays when those are delivered in the next few months. At the same time, the present compliment of broadband Y, J, H, and K filters will be supplemented with a set of narrowband filters (purchased by Cassio Leandro Barbosa of UNIVAP, Brazil) recently received in Chile.

Spartan has not yet been characterized to allow it to be offered through the regular 2009B call for proposals, especially given the upcoming detector and filter upgrades. However, we anticipate inviting the NOAO community to participate in Science Verification Testing during that semester through a special call for proposals (stay tuned for further information in the NOAO e-newsletter *Currents*!). In addition, during the scheduling process, we will evaluate successful imaging proposals for the Ohio State Infrared Imager and Spectrometer (OSIRIS) and will offer Spartan as an alternative if, at that time, it appears to be better matched to the science program.



Spartan Infrared Camera image of R136, the massive star cluster at the center of the 30 Doradus nebula in the Large Magellanic Cloud. Thousands of stars, crowded together in the recently-formed central cluster, illuminate the surrounding remnants of the giant molecular gas cloud from which they formed. This K-band (2.2-micron wavelength) image was taken on Spartan's second commissioning run on the SOAR telescope. The area shown is 150 arcseconds across and is only 1/4 of Spartan's full field of view. Picture credits: E. Loh & J. Baldwin, MSU

The 2009 CTIO REU/PIA Program

Ryan Campbell

Monday, 12 January 2009 was the start of CTIO's 14th Research Experiences for Undergraduates (REU) and Practica de Investigación en Astronomía (PIA) program. During this 10-week program, six US students and two Chilean students spend the Chilean summer working and living at the CTIO compound in La Serena. And, not only do the students work on research projects with CTIO, SOAR, and Gemini staff, they also have the chance to visit Cerro Tololo, Cerro Pachón, and Cerro Paranal, observe at Cerro Tololo, attend seminars, and sample the social and cultural life of the CTIO compound and Chile. This year the REU students are: Tracy Becker (Lehigh University), Will Flanagan (University of Colorado-Boulder), Danielle Nielsen (Colby College), Jordan Mirocha (Drake University), Ben Moore (Xavier University of Louisiana), and Shannon Dealman (Clemson University). The PIA

continued

The 2009 REU and PIA students and CTIO REU Director Ryan Campbell. From left to right: Will Flanagan, Jacqueline Seron, Ryan Campbell, Shannon Dealman, Marcela Espinoza, Danielle Nielsen, Ben Moore, Tracy Becker, and Jordan Mirocha.

The 2009 CTIO REU/PIA Program continued

students for 2009 are Jacqueline Seron (Universidad de Concepción) and Marcela Espinoza (Universidad de La Serena).

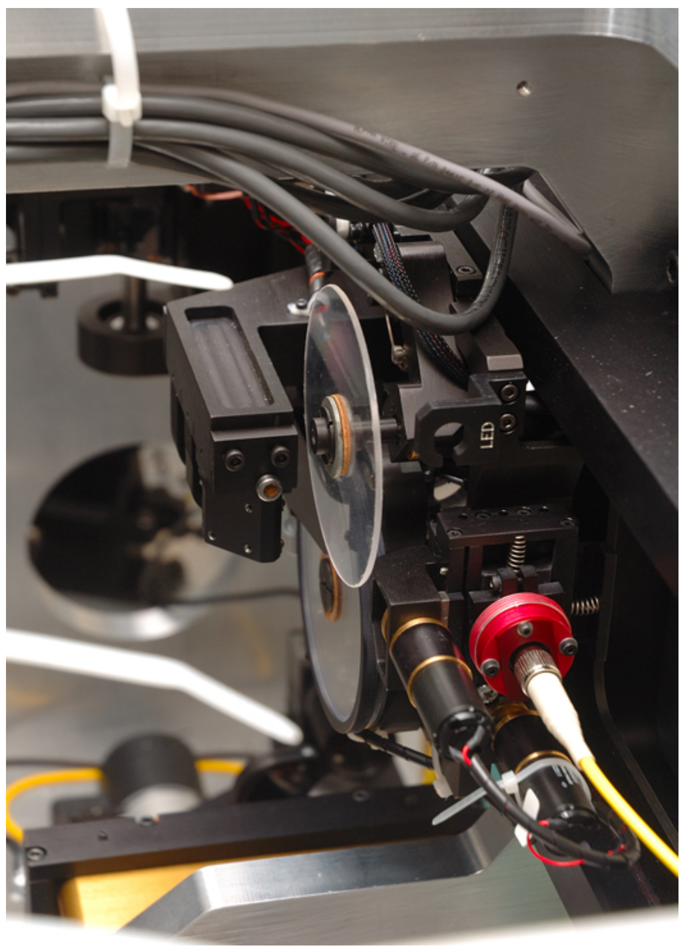
Mentors for the students are an integral part of the program. As such, Ryan Campbell, the new REU/PIA director, would like to thank this year's participating mentors: Tim Abbott, Roberto De Propris, Jayadev Rajagopal, Susan Ridgway, and Nicole van der Bliek from CTIO; Luciano Fraga and Steve Heathcote from SOAR; and Bryan Miller, Gelys Trancho, and Bernadette Rodgers from Gemini.

First Integration, Alignment & Testing of Complete SOAR Adaptive Module

The SAM Team

As reported in the December 2008 *NOAO/NSO Newsletter*, integration, alignment, and testing of the SOAR Adaptive Module (SAM) was taking place during the second half of 2008. On the evening of Thursday, December 18, integration and alignment of the last subsystem, the built-in turbulence simulator (TurSim), was completed (see figure, below). TurSim was mounted into the SAM Main Module in its designed location and at nominal focusing position of its dovetail rail (see figure, right). Image and pupil were almost aligned and in correct location in Z, the focus position. The next morning, December 19, the TurSim electronics were connected, the engineering graphical user interface was set up, and we were able to control all of the TurSim functions. Note that there are seven motors plus light sources to control in TurSim alone.

That same afternoon, we were able to close the loop on turbulence generated by TurSim. The loop is robust and the closed-loop image at the SAM Imager focal plane is clearly corrected to the near-diffraction limit as measured by Wavescope.



TurSim mounted into the SAM Main Module (left), and Optical Engineer Roberto Tighe working on the integration and alignment of TurSim.

Congratulations to the whole SAM team, especially everyone from the design, drafting, instrument shop, electronics, and optics groups for making this happen.

Meanwhile, the instrument has been taken completely apart. After making some modifications to the main module, the instrument will be anodized and painted before being reassembled. The achievements of late 2008 put SAM well on track for first light at the telescope later this year.