The Palomar OBSERVER

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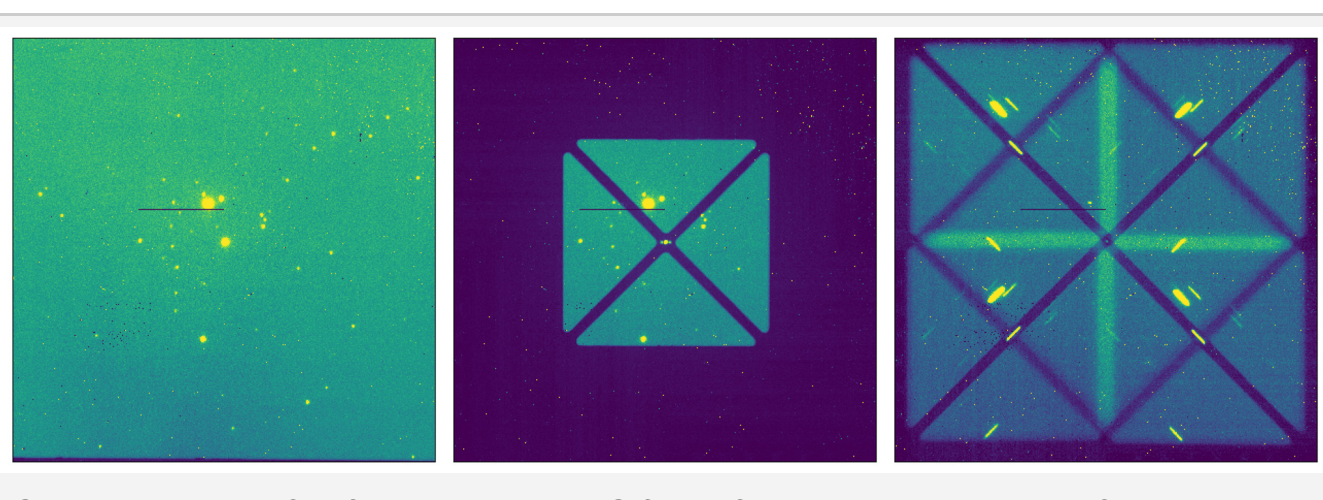
Palomar Observatory

In this issue

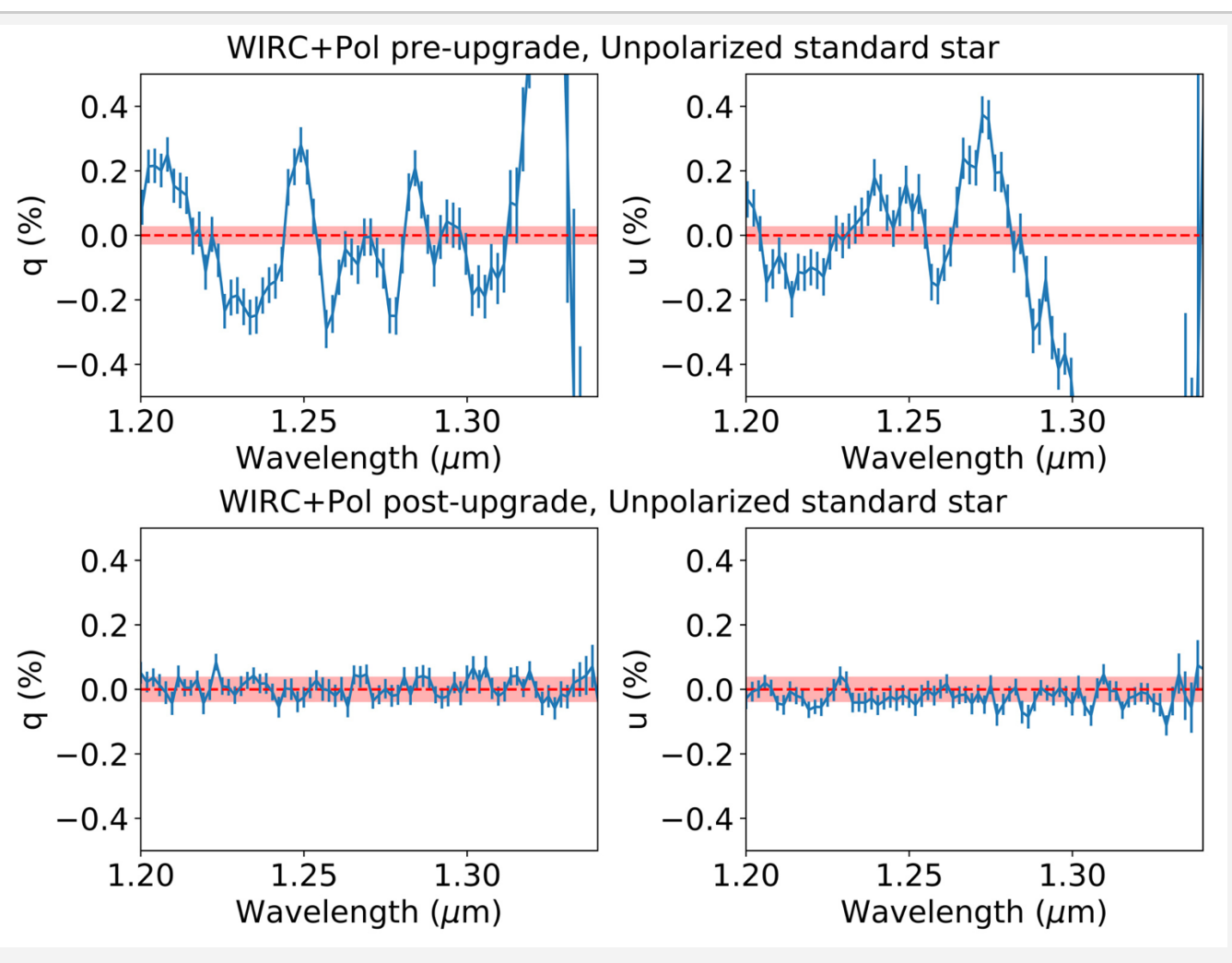
Upgraded WIRC+Pol on P200 inch

By Tinyanont Samaporn (Caltech)



Output images (left) of the normal WIRC field of view, (center) with the focal plane mask installed, and (right) with the PG inserted, dispersing a point source into four spectral traces in the four quadrants of the detector. (T.Samaporn/Caltech)

WIRC+Pol is a spectropolarimetric upgrade to the Wide field InfraRed Camera (WIRC) on the 200-inch Hale Telescope. WIRC+Pol operates in the J and H bands, and have a spectral resolving power of R ~ 100. The instrument uses a polarization grating, installed in the filter wheel, to perform polarimetric beam splitting and spectral dispersion simultaneously. Four different spectra sampling four linear polarization angles are recorded in the focal plane, allowing the instrument to measure all linear polarization states in one exposure. To minimize field overlap, we also installed a focal plane mask passing a ~4 × 4 arcmin field view with a slit in the center. The current slit dimension is 17 × 3 arcsec. WIRC+Pol has been on-sky since February 2017 and we found that the systematic errors, arising likely from flat fielding and the gravity effect on the instrument, limit our fractional polarization accuracy to ~1%. To remove these slowly varying systematic effects, we installed a half wave plate modulator in March 2019. The modulator switches the polarization angle each spectrum probes, which eliminate systematics from flat field and instrumental polarization occurring inside the instrument. In addition, we also installed a polarizer to help with calibrations. Both optics are mounted in rotation stages in front of WIRC dewar, and can be retracted from the beam.



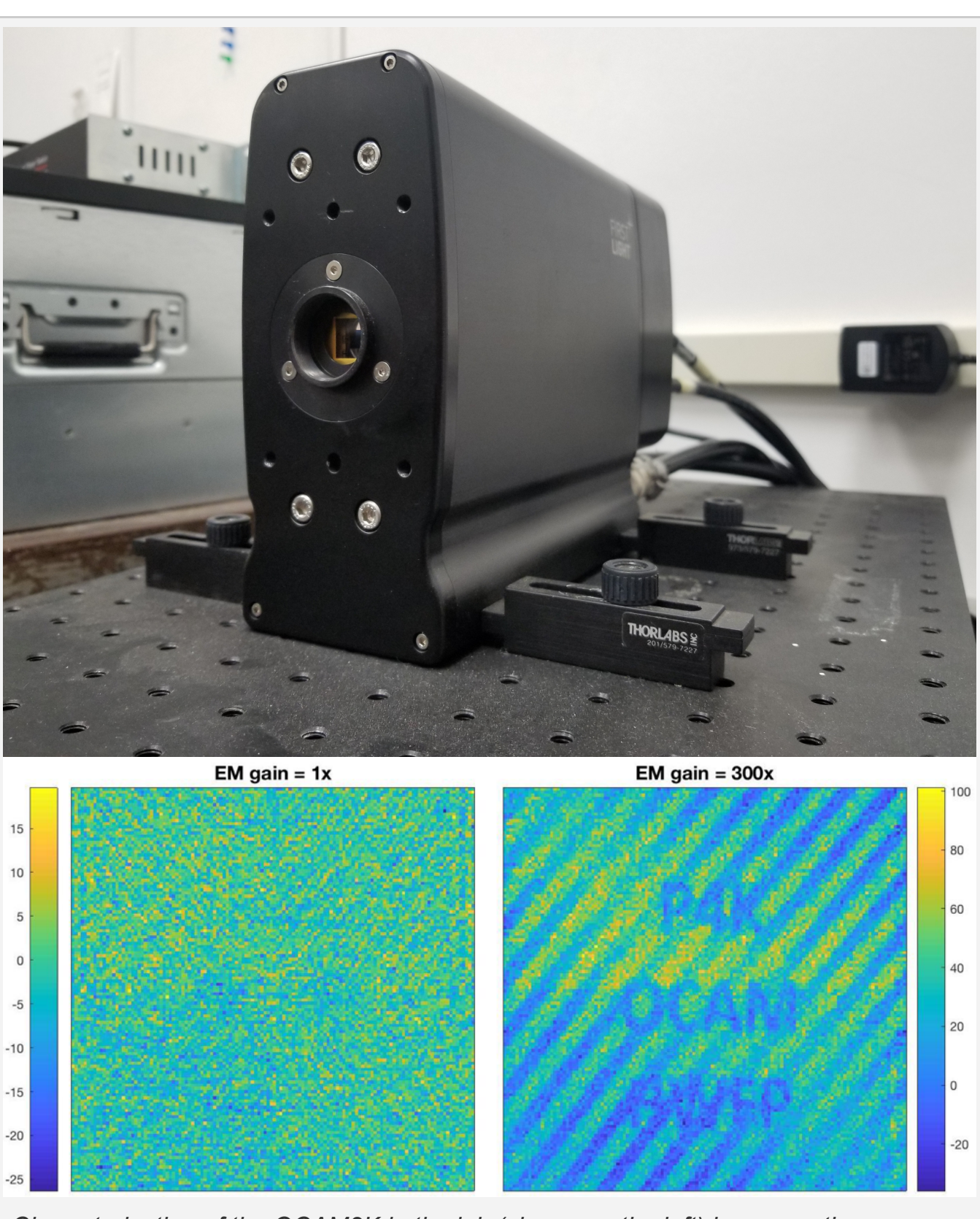
Comparison of unpolarized standard star observations from WIRC+Pol with (bottom panels) and without (upper panels) the upgraded modulator. (T.Samaporn/Caltech)

The modulator's commissioning is underway, and so far we have confirmed that the large (~1%) systematics we experienced has been eliminated, as shown in the figure. We found that the polarimetric efficiency is of order 90% (WIRC+Pol will measure 9% polarization for a source that is 10% polarized) and the polarization angle is offset by ~15 degrees. It is unclear how stable the efficiency factor and polarization angle offset are. To calibrate the polarimetric efficiency and angle offset, we recommend to observe a polarized standard, or an unpolarized standard with the polarizer, close to the science target. For the sensitivity calculation, in most cases the observations are now photon noise limited, so the sensitivity scales with sqrt(t). For 5 minute total exposure, a 3-σ polarization sensitivity for sources with J = 10, 12, 14 are 0.16%, 0.42%, and 1.9% without the slit, and 0.15%, 0.33%, and 1.0% with the slit. So we recommend using slit for sources with J > 12, since the sensitivity gain is significant. The data reduction pipeline for WIRC+Pol is publicly available from this link. Please feel free to contact WIRC+Pol team members (Tinyanont Samaporn, st [at] astro.caltech.edu; Dimitri Mawet, dimitri.mawet [at] gmail.com; and Max Millar-Blanchaear, max.a.millar-blanchaer [at] jpl.nasa.gov) if you plan to propose and have questions regarding the instrument and/or data reduction.

News on PALM-3000 (P3K) Instrument

By Seth Meeker (JPL)

Upgrades in both software and hardware for PALM-3000 (P3K) will be carried out in the summer of 2019.



Characterization of the OCAM2K in the lab (shown on the left) has recently completed, confirming the exceptional noise characteristics expected of the EM-CCD. The accompanying OCAM2K frames were taken in a dark room at 3.5 kHz while viewing a test pattern hanging on the wall. At unity gain (center) the image is dominated by readnoise. With 300x EM gain applied (right) the test pattern is clearly visible despite the faint signal. (S.Meeker/JPL)

P3K is the second-generation adaptive optics (AO) instrument for the Hale Telescope at Palomar Observatory, was released as a facility instrument in October 2011. Since commissioning, P3K has been on-sky for hundreds of nights as a workhorse science instrument and technology testbed—ushering in a new generation of extreme-AO fed exoplanet imaging systems with P1640, enabling high resolution studies of solar-system bodies, and playing a crucial role in the validation of Kepler planetary candidates to name a few applications. Continuing this heritage of technology innovation and scientific excellence, P3K will be joined by the PARVI spectrograph in the coming months, and will continue its role in validating transiting exoplanet candidates from the TESS mission. In anticipation of these future efforts, P3K is undergoing a significant upgrade this summer to reinforce its position as a state-of-the-art AO facility and improve its correction on fainter and redder targets.

The upgrade is comprised of two major components. First, the current wavefront sensor camera with an E2V frame-transfer CCD will be replaced by an OCAM2K electron-multiplying (EM) CCD camera from First-light Imaging. The OCAM2K features enhanced red sensitivity, sub-electron read-noise when operating with high EM gain, and a 3.5 kHz maximum framerate (P3K's current maximum rate is 2 kHz). Second, the real-time control (RTC) system will change from the current GPU implementation, using 16 deprecated NVIDIA graphics cards spread over 8 PCs, to a digital signal processor (DSP) based system comprised of a single PC and PCIe expansion box housing 4 DSP cards. Taken all together, the total system latency is expected to drop by half, resulting in an associated K-band contrast improvement of up to a factor of 3 on bright targets. At the faint end, P3K's performance limit will be extended by roughly one V-band magnitude, providing decent Strehl ratios on nearby low-mass stars for TESS follow-up imaging and PARVI's survey.

In July 2019, P3K will enter the AO lab to begin installation of the new camera and closed-loop performance testing. On-sky re-commissioning efforts will begin in September 2019, with a partial return to science operations scheduled for November. More information, including expected Strehl performance curves, can be found on the P3K observer's page.

Updates on Palomar High Angular Resolution Observer (PHARO)

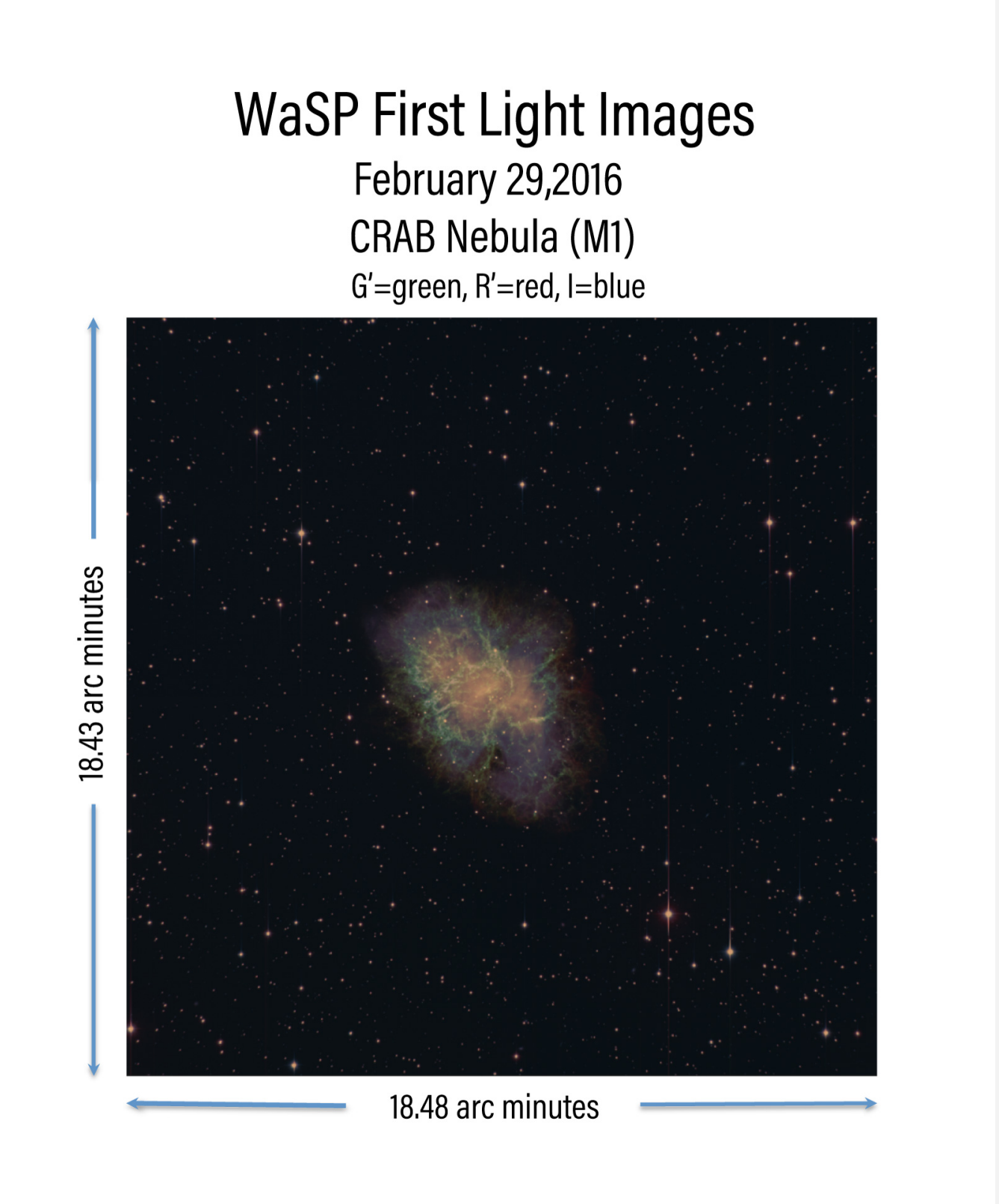
By Lin Yan (Caltech)

The observatory support team has recently provided instructions on the preliminary reduction of the data taken using the Palomar High Angular Resolution Observer (PHARO). The raw PHARO image data is stored as a FITS cube in 512x512x4 array. After processed, the full PHARO image can be put together into a 1024x1024 pixels image. The PHARO cookbook on the Palomar website describes the details.

WaSP: A New Optical Imaging Camera for the Palomar Observatory

By Jennifer Milburn (Caltech)

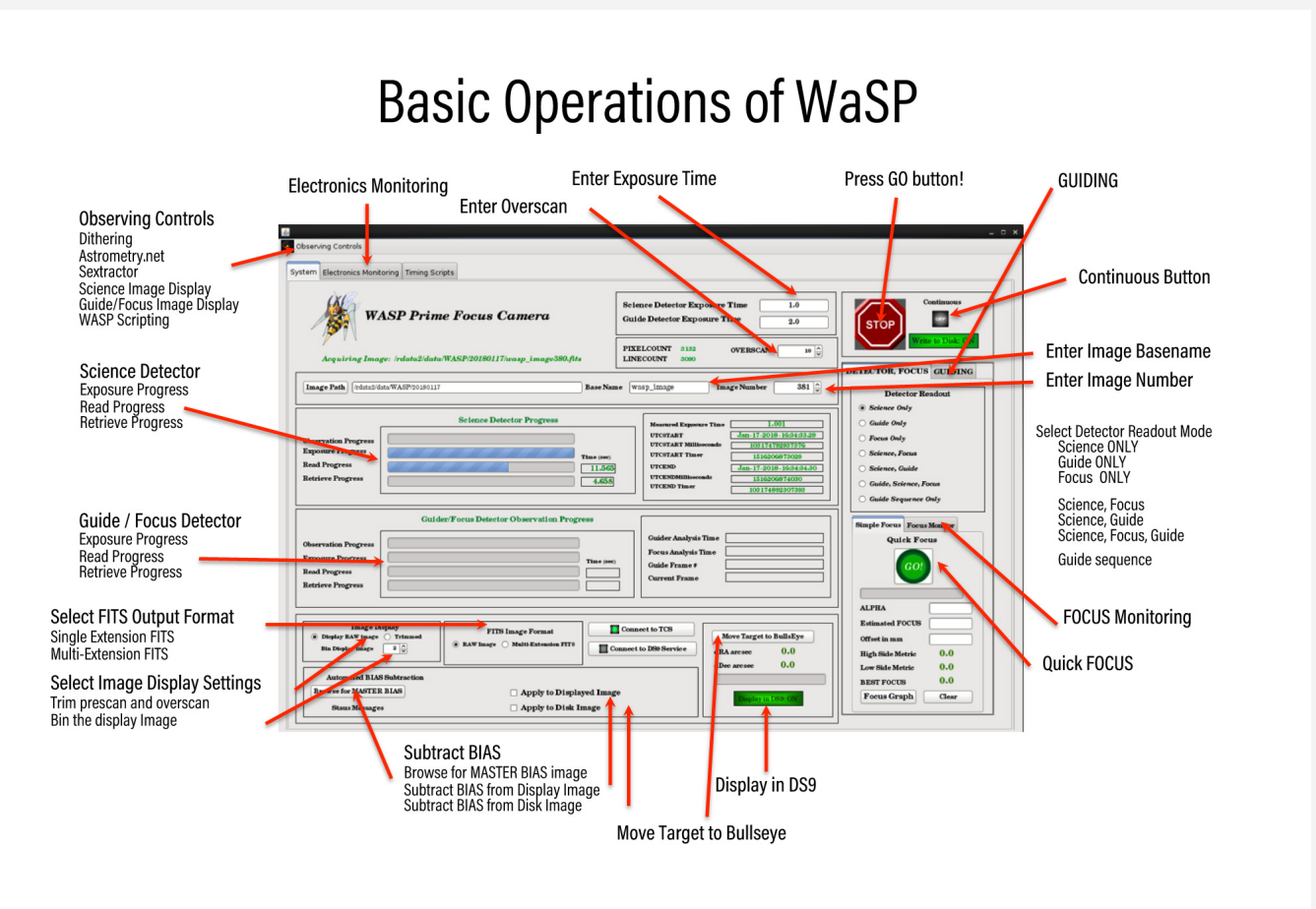
WaSP (Wafer-Scale imager for Prime) is a wide field optical imaging camera at the P200 prime focus. A quick start guide on how to use WaSP can be found in the WaSP manual on the P200 Observer website. A more extensive document on WaSP is at this location.



WaSP first light image of the Crab Nebula (M1) showing WaSP's large field of view. (J.Milburn/Caltech)

WaSP was first made available as a facility instrument at the start of the 2018A observing semester. The instrument is intended as a replacement for the Large Format Camera (LFC) that has been in use at Palomar Observatory since the early 2000's and is nearing retirement. The WaSP instrument contains an E2V CCD231-C6 back illuminated CCD with 6144x6160 pixels and two dedicated STA 3600A delta-doped guide and focus detectors. The E2V science detector images a field 18.43 x 18.48 arc minutes in size but can also be operated in Region of Interest (ROI) mode allowing faster readout when the entire field isn't required. Unlike LFC where the readout of the entire array required 120 second to readout the entire array, WaSP can readout the entire science detector in approximately 11 seconds vastly increasing the open shutter efficiency. The filter set includes all of the filters previously available for the LFC instrument.

WaSP is an entirely GUI controlled instrument and was designed to be a simple point and shot imaging camera. The GUI contains an internal image display system that allows targeting telescope moves to be carried out using the mouse. The GUI also allows images to be directly displayed simultaneously in DS9. Focusing the telescope is completely automated using analysis of out of focus donuts. The instrument control GUI incorporates a number of analytical tools including Sextractor and Astrometry.net to make rapid analysis of image easy to assure that observers are reaching their scientific goals. The instrument also contains a specialized version of the Aperture Photometry Tool (APT) that allows the creation of on-the-fly photometry curves for multiple stars. A flexible and sophisticate dither control system is also available that allows the use of preconfigured dither pattern or custom patterns imported from simple ASCII text files. The dither control system can scale any pattern to any size from simple 5-point rectangular dithers to complex maps including hundreds of images (for mapping large sections of the sky). A simple but comprehensive scripting language is also available to automate calibration tasks and to carryout complex observing scenarios. For example, a simple script can automate the execution of dither sequences in 4 filters making it possible to carry out complex observations with a single click of the mouse.



The WaSP GUI. (J.Milburn/Caltech)

WaSP has been used extensively during its first year of operation for a variety of projects. Examples include a long term project carried out by Charles Bailyn at Yale to monitor Black Holes in low mass galaxies using the instruments photometry curve capabilities. Similarly, the instrument has been used to monitor the photometry of Patroclus-Menoetius asteroids during one observing run. Recently, the instrument was used by Sophia Dai to follow up on the WISP survey (HST) to image very faint galaxies making extensive use of the dither control system. The instrument has also been used extensively for imaging supernovae discovered by the Zwicky Transient Factory (ZTF).

Plans for improving the instrument are also in the works including the deployment of a new shutter and filter wheel mechanism later this year. The original LFC shutter and filter wheel used by WaSP is aging and filter moves require 20 seconds to move from one filter to the next. JPL is currently building a replacement with the goal to decrease the time required to change filters to between 1 and 2 seconds improving the instrument open shutter efficiency during multi-filter imaging projects. The new shutter and filter wheel system will be available sometime during the 2019B semester.

LFC Decommissioning

By Andy Boden

Our new P200 prime-focus imaging camera WaSP (Wafer-Scale imager for Prime) has been in service since February 2018. WaSP feedback from the P200 user community has been highly positive. With the successful WaSP deployment, we are planning to decommission the older Large Format Camera (LFC) at the start of the 2020A Semester. Any legacy LFC project proponents that need small amounts of data to complete their dataset should contact Andy Boden in the COO Director's Office at their earliest convenience.

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