SOAR Spartan Infrared Camera

E. Loh, MSU, July 2014

The Spartan Infrared Camera operates in the 1–2.4μm wavelength range. It has two focal ratios, a wide-field (WF) configuration with 66 mas/pixel a high-res (HR) configuration with 40 mas/pixel, which has not proved to be useful. The detectors are four HAWAII-2 arrays, each with 2048 × 2048 pixels. Besides the Y, J, H, and K broad-band filters, it has 9 narrow-band filters for imaging emission lines.

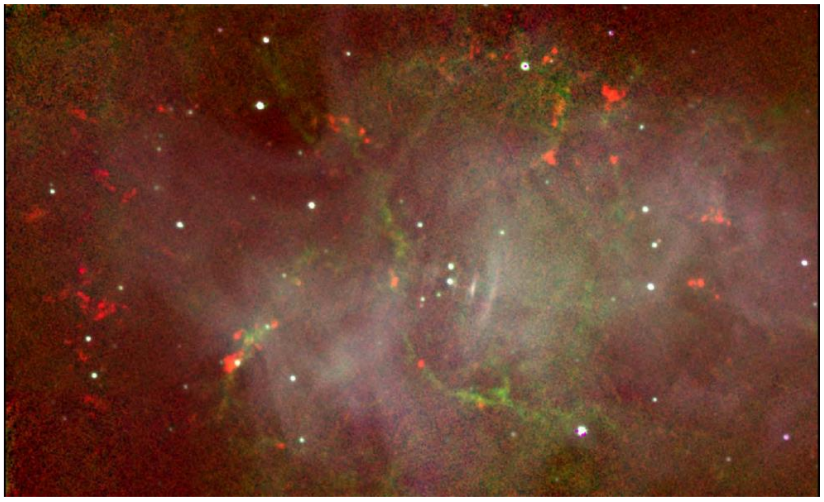
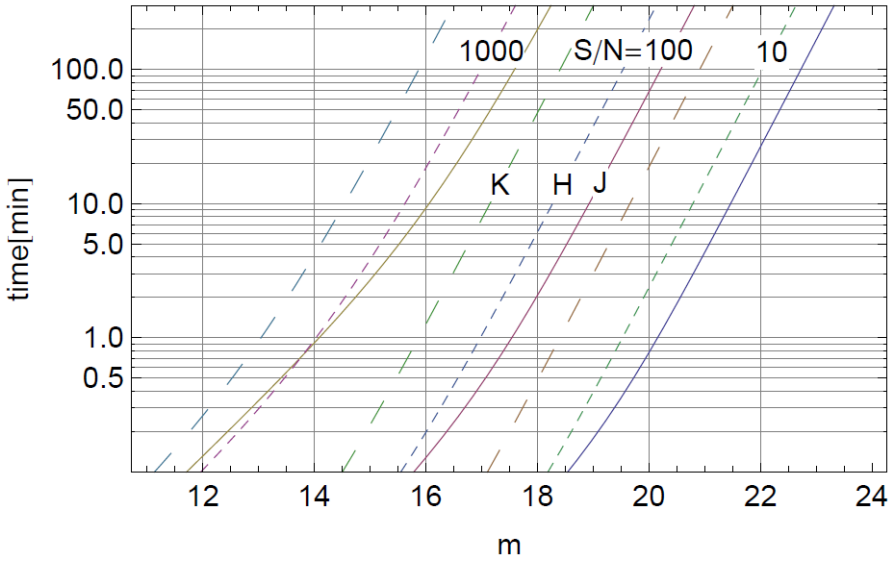
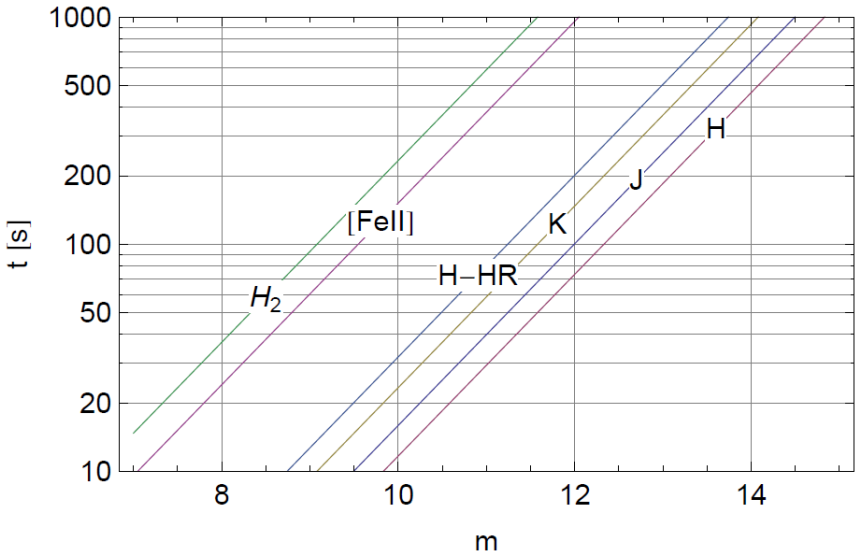


Image of the Crab Nebula taken with Spartan using the molecular hydrogen (printed as red), Brγ (printed as green), & continuum (printed as white) filters. Loh, Baldwin, Curtis, Ferland, O'Dell, Fabian, Salomé (2011, ApJS, 194, 30) discovered 55 arcsec-sized knots of molecular hydrogen. The continuum is synchrotron radiation.



Exposure time to reach a given S/N ratio for a star of magnitude *m* for the J (solid line), H (dashed line), and K band (long dashed line). The seeing is 0.7arcsec(FWHM), and the diameter of the aperture is 1.0arcsec. The temperature, which affects the K band, was 13C. For the narrow-band filters, the approximate factors by which to increase the exposure time are 22 for HeI λ10830 (J band), 13 for [FeII] λ16400 (H band), 11 for HeI/CIV λ20650 (K band for this and the rest), 10 for H2 λ21170, 19 for Bγ λ21620, and 4.3 for CO λ23310.



Saturating exposure time for a star of magnitude m. The cases are the J, H, K, H_2, and [FeII] λI16400 filters for the wide-field mode and the H filter for the high-resolution mode. The seeing is 0.7arcsec FWHM. Saturation is 30kDU (120ke$^-$).

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Detector parameters			
Parameter[1] \ Filter	*J*	*H*	*K*
QE: photons above atmosphere to electrons	0.35	0.41	0.41
Rate for 15th mag star [ke$^-$s^{-1}]	11	15	7.5
Sky [ke$^-$ s^{-1}arcsec^{-2}]	3.5	23	46

[1]for detector 0. The values for detectors 1-3 are similar.

Parameter \ Detector	*0*	*1*	*2*	*3*
Gain [e/DU]	4.9	3.6	3.8	4.6
Detector noise [e]	15	11	14	16
Saturation [kDU]	30	33	33	26

Filters

Filter	*Wavelength [μm]*	*Width [μm, (km/s)]*
HeI	1.082	0.092 (2570)
[FeII]	1.640	0.014 (2630)
Cont1	2.040	0.032 (4660)
HeI/CIV	2.065	0.029 (4150)
H2	2.116	0.031 (4380)
Cont2	2.140	0.030 (4260)
Brγ	2.162	0.021 (2870)
Cont3	2.208	0.032 (4310)
CO	2.331	0.071 (9100)
Y	1.020	0.100
J	1.236	0.186
H	1.632	0.287
K	2.148	0.307

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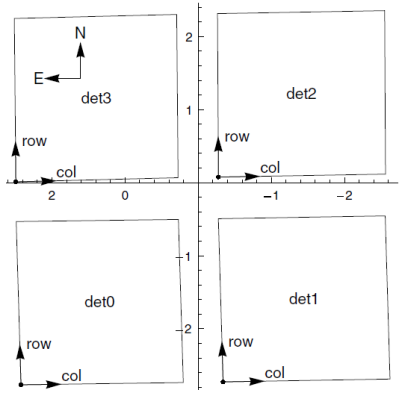
Geometrical parameters	
Pixel size	66mas
Field width, edge to edge	5.04arcmmin
Field width, single detector	2.25arcmin (2048pixel)
Blank strip (see figure below)	0.56arcmin
Minimum exposure	10s
Skew and distortion	24pixel max; 10pixel RMS
Distortion after removal of skew, quadratic terms, and barrel distortion	0.16pixel max; 0.03pixel RMS



Map of the 4 detectors on the sky. Note the gap between detectors. The scale is arcmin. The axes show the direction of increasing rows and columns. The orientation in the sky can change since the instrument is mounted at a Nasmyth port. The map is stored in the FITS header.

More information
- http://www.pa.msu.edu/~loh/SpartanIRCamera
- Loh, E., Biel, J., Davis., M., Laporte, R., Loh., O., & Verhanovitz, N., 2012, PASP, 124, 343
- Ed Loh, loh@msu.edu

NOAO staff contact for Spartan:
- Karianne Holhjem, kholhjem@ctio.noao.edu

Queries about SOAR:
- Horacio Dottori, hdottori@ctio.noao.edu
- Sean Points, spoints@ctio.noao.edu

Optical design. The base design for the optics is a pair of off-axis parabolas. The first mirror collimates the light emanating from its focus. The second mirror refocuses the light to form an image. By using an off-axis segment, the incoming and outgoing light beams do not interfere. There is a real image of the entrance pupil for the Lyot stop. This design also allows for a change in focal ratio by making the focal lengths of the two mirrors different.
The actual design adds several components to the base design. Two flat fold mirrors separate the telescope and instrument images, which are nearly coincident in the base design. A CaF2 plano-convex lens removes the net field curvature of the SOAR Telescope and the mirrors of the instrument.

Mechanical design. The mirrors have an aluminum substrate. The cryo-optical box in which the optics are mounted is aluminum. Since the mirrors and cryo-optical box are both aluminum, the optics are aligned and tested at room temperature, and the focus does not change at 77K.

Cryogenic design. The instrument is cooled with liquid nitrogen, which is filled once per day. There is a charcoal getter, which absorbs permeation through the o-rings. The instrument has been cold for 2.5 years.

Software is written in LabView.

Spartan revealed. The beam enters at the upper left, passes through a mask wheel, becomes collimated by the wide-field (WF) collimator (upper right), goes through fold mirrors, a filter wheel and Lyot stop (hidden by the large shiny plate), becomes focused by WF focusing mirror at the lower right onto the 4-eye detector assembly (lower left) which tilts the detectors when changing between the WF and high-res (HR) configurations. Shown is the WF configuration; in the HR mode, the HR collimator is rotated into the beam and the WF focusing mirror is rotated out. The circular object at the top is the reservoir for liquid nitrogen.