SCExAO/CHARIS: Near-IR spectro-imaging optimized for high contrast imaging

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AVAILABLE FOR OPEN USE

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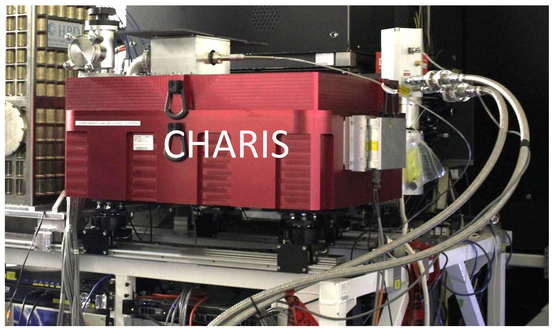
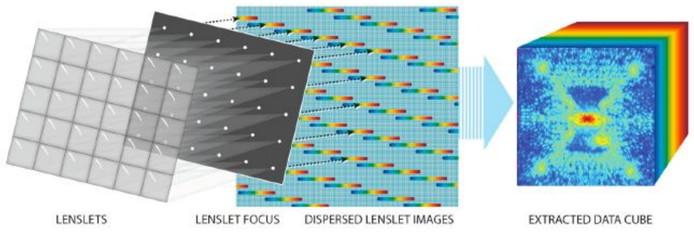
OVERVIEW

Original PI: Jeremy Kasdin (University of San Francisco, formerly Princeton University)
Current CHARIS team: Tyler Groff (NASA Goddard), Jeffrey Chilcote (university of Notre-Dame), Olivier Guyon & Julien Lozi (Subaru Telescope)

The Coronagraphic High Angular Resolution Imaging Spectrograph (CHARIS) is an IFS for the Subaru telescope. It sits behind the SCExAO coronagraphic and extreme AO system and AO188 adaptive optics systems at the Subaru telescope.

- 2.07”x2.07” FOV
- **LOW RESOLUTION MODE**:
  - R~19, J+H+K Band
  - 65-70% instrument throughput
  - 10-15% from atmosphere to detector
- **HIGH RESOLUTION MODE**:
  - R~70-90: J, H, and K Bands
  - 55-60% instrument throughput
  - ~15% from atmosphere to detector
- **POLARIZATION DIFFERENTIAL IMAGING MODE**:
  - Compatible with both low-res and hi-res modes
  - A Wollaston prism is added in front of the entrance
  - 2.07”x1.0” FOV for each polarization.





FUTURE PLANS

Most upgrades in the next few years will happen upstream of CHARIS, on the extreme-AO correction. AO188 is being upgraded to AO3k, which will deliver much more stable images, and allow wavefront sensing on redder targets. With AO3k, SCExAO will be able to focus on creating very high contrast regions to detect fainter companions.

The main upgrade envisioned for CHARIS is the upgrade of the detector, a HAWAII 2RG, to a 2kx2k HgCdTe avalanche photodiode detector. This detector would be the successor of Leonardo’s 1kx1k Ike Pono, tested in collaboration with University of Hawaii’s Institute for Astronomy.

With this type of detectors, we would reduce the readout noise to sub-electron levels, and allow us to run at higher frame rates.

Acknowledgements

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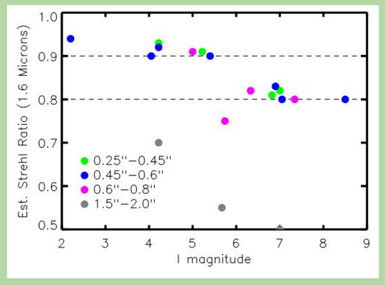
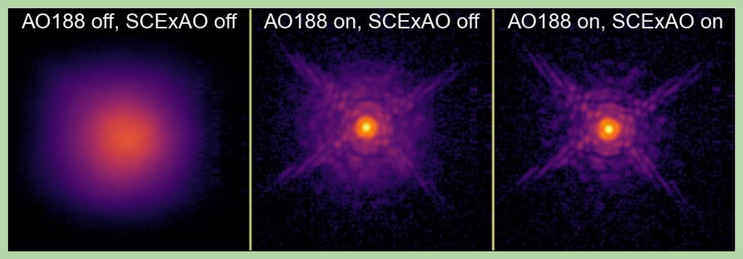
SCIENCE GOALS AND CAPABILITIES

Major Science Objective
→Spectral characterization of Exoplanets, Disks, Brown dwarfs
→spectro-polarization study of disks

Extreme-AO correction from SCExAO

- Visible PyWFS (800-900 nm)
- 1200 controlled modes
- 1-3.5 kHz loop speed
- ExAO R-mag limit: 9-10
- Some correction down to R-mag ~14
- Strehl ratios > 90% with good seeing
- **Results are highly dependant on seeing!**



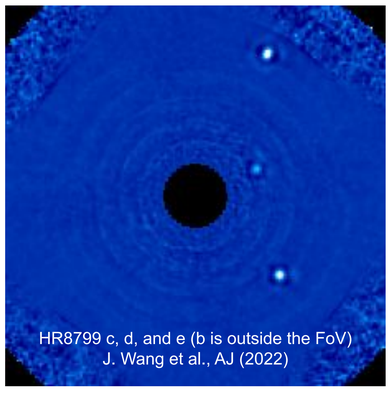


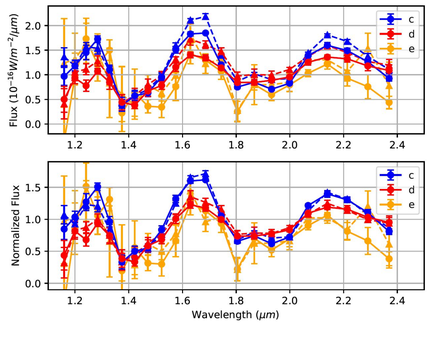
Basic Parameters

Field of view	2.07"x2.07"	
	2.07"x1.0"	Spectro-polarimetric mode (Wollaston prism in)
Plate Scale	16.2 mas/lenslet	
Recommended Satellite Spot Contrast	$1x10^{-1}$ - $1x10^{-3}$	Tunable
Satellite Spot Location	15.9 lambda/D (~0.63" at 1550 nm)	Scales linearly with lambda
Detector	Hawaii 2RG	
Wavelength coverage	1154 nm to 2387 nmm	SCExAO feeds CHARIS with wavelengths longer than 950nm
CHARIS throughput	Low resolution mode: 65-70%	~15% from atmosphere to detector
	High resolution mode: 55-60%	
Spectral resolution	Low resolution mode: R~19	J, H and K bands combined
	High resolution mode: R~70-90	J, H or K band
Coronagraph modes	Lyot, vAPP, PIAACMC, Vortex	
Angular Differential Imaging	YES	SCExAO operates in fixed pupil mode
Speckle control	YES (static WF map)	Speckle control performed using SCExAO internal science camera
Tip-Tilt control	YES	Tip-Tilt control performed using SCExAO Low Order Wavefront Sensor
Spectro-polarimetric imaging	YES	A Wollaston prism, combined with a field stop. See Spectro-Polarimetric Imaging section
Dithering	±2"	It is now possible to offset the field-of-view with respect to the guide star

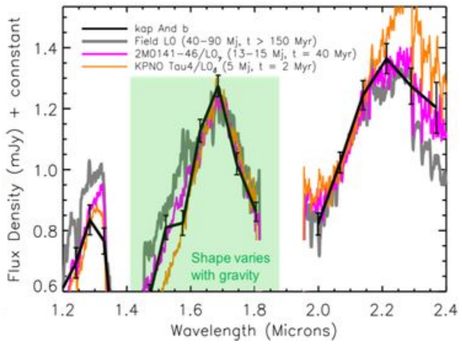
RECENT SCIENCE HIGHLIGHTS

Exoplanets & brown dwarfs



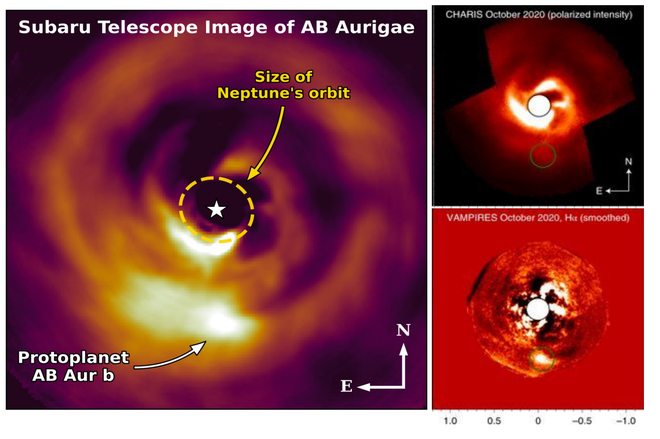


CHARIS characterized several known exoplanets and brown dwarfs, and even discovered a few low-mass companions. spectral informations allow us to constrain temperature, chemistry and gravity of exoplanets.



Disk science

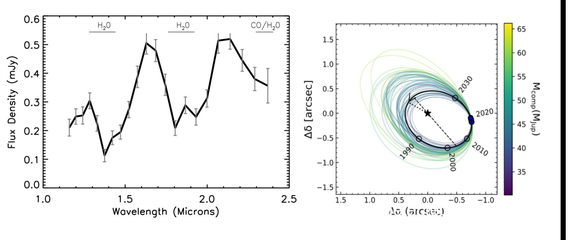
CHARIS can be used in classical ADI/SDI mode to study protoplanetary and debris disks, but also with the PDI mode.

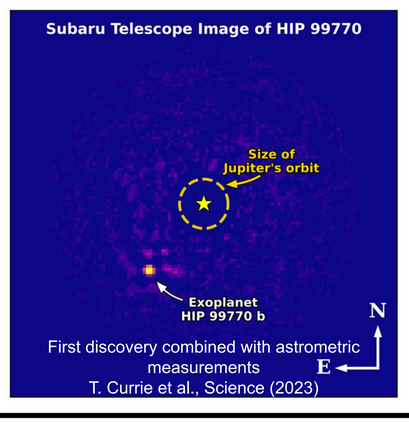


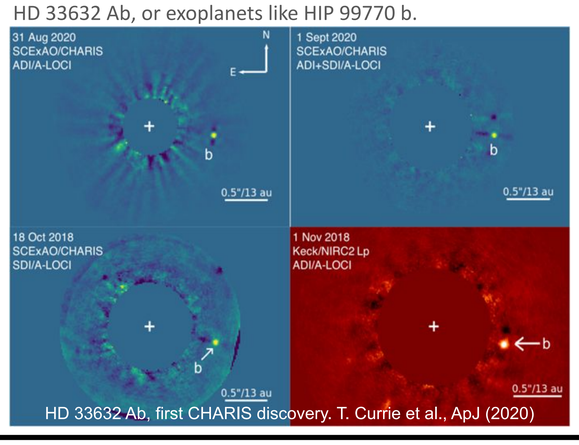
Combining direct imaging with astrometry and/or RV detections

Indirect detection methods like astrometry and RV can be used to narrow down the targets of interest for CHARIS, and allow for more frequent detections. CHARIS demonstrated this method, finding low-mass brown dwarf companions like HD 33632 Ab, or exoplanets like HIP 99770 b.

Spectrum and orbit of HD 33632 Ab, thanks to direct imaging and astrometry data







Solar system

Some extended objects can be imaged by CHARIS, although the AO is not optimized for this.