Diffraction-Limited Visible-Light Imaging with VAMPIRES

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PI-type instrument, AVAILABLE FOR OPEN USE

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OVERVIEW

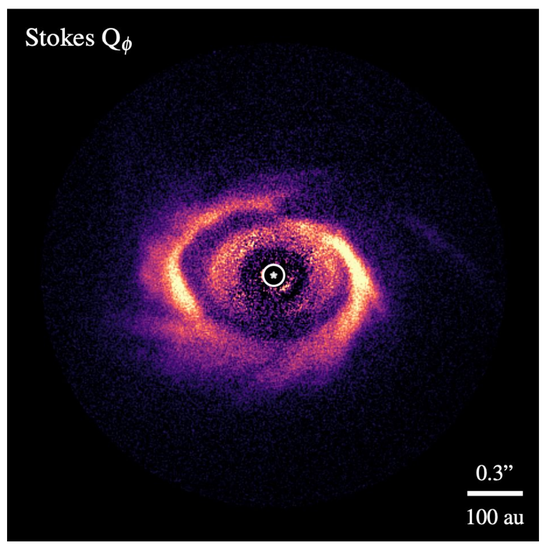
VAMPIRES is SCExAO's **visible light (600 nm - 800 nm) dual-beam imager**, optimized for high angular resolution and high contrast imaging. VAMPIRES includes polarimetric, multi-band, sparse aperture masking and coronagraphic capabilities.

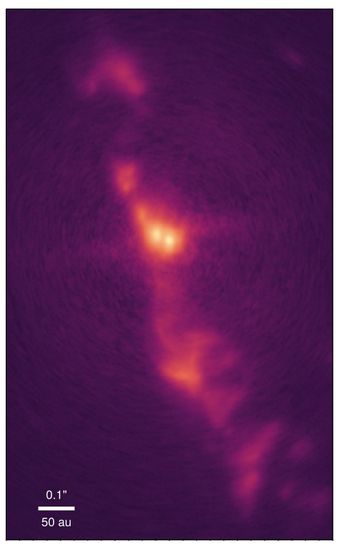
VAMPIRES benefits from the two-stage AO correction (AO188/AO3k + SCExAO), and operates at the diffraction limit, providing ~0.02" angular resolution.

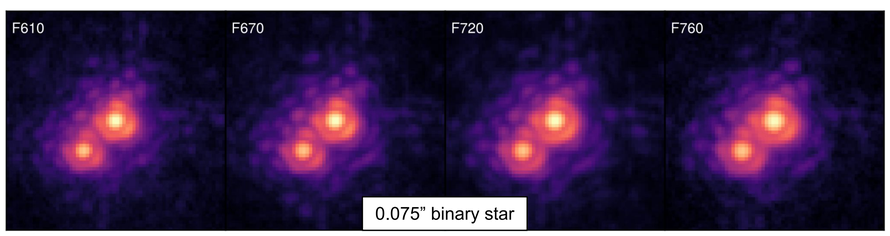
PI: Peter Tuthill, University of Sydney, Australia. Instrument team: University of Hawaii, University of Sydney and Subaru Telescope.

VAMPIRES operates simultaneously with near-IR SCExAO-fed instrumentation, including CHARIS.

SCIENCE GOALS AND CAPABILITIES







Instrument modes and capabilities:

- 3" x 3" FOV, 6 mas/px plate scale
- 5 Selectable 50 nm broadband filters plus multiband-imaging mode
- High angular resolution with AO188 + SCExAO wavefront control and correction
- Optimized for polarimetry; can use HWP alone or HWP + FLC for fast switching
- Coronagraphy (4 classic Lyot masks + dgVVC)
- Sparse aperture masking
- Narrowband spectral differential imaging (Halpha, SII)

Simple VAMPIRES results (left):

- Polarimetric scattered-light imaging of circumstellar disks (top left; HD 34700 disk polarized intensity at 750 nm)
- Halpha/SII narrowband imaging (top right; R Aqr emission nebula in Halpha)
- Halpha spectral differential imaging for accreting protoplanets (Uyama+2020)
- Sub-diffraction-limited imaging of mass-loss shells around giant stars using non-redundant aperture mask interferometry (Norris+2015)
- High-angular resolution imaging of stellar companions (bottom; 75 mas binary HD 204827 in multiband imaging mode)

RECENT HIGHLIGHTS

Major recent hardware upgrades :

- EMCCD sensors were replaced with ultra-low read noise CMOS detectors (photon number resolving) **improved dynamic range and speed**.
- New **multiband imaging mode** for simultaneous imaging through multiple broadband filters, compatible with polarization differential imaging and coronagraphy.

- New achromatic FLC (improved polarimetric efficiency at the shortest and longest wavelengths)
- Deployed double-grating vector vortex coronagraph (dgVVC; PI: D. Doelman) for improved contrast at small angular separations
- Deployed redundant apodizing pupil mask (RAP; PI: L. Leboullex) for increased resilience to wavefront errors
- Data processing pipeline available

FUTURE PLANS

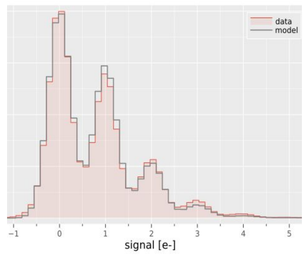
- Closed-loop pointing control of dgVVC (QACITS) + on-sky testing
- On-sky testing of RAP
- Development of coronagraphic low-order wavefront sensing loop
- Focal plane wavefront sensing development (fast and furious, LAPD, LDFC, petalometry)
- Halpha velocity mapping with narrowband dichroic image slicer

TECHNICAL OVERVIEW

Detectors

Two identical CMOS detectors, (*Hamamatsu ORCA-Quest*)

- 0.22 e- RMS read noise @ 40+ Hz
- 0.4 e- RMS read noise @ 500+ Hz
- 7.2 us to 1800 s DIT
- Hardware sync between both cameras and FLC



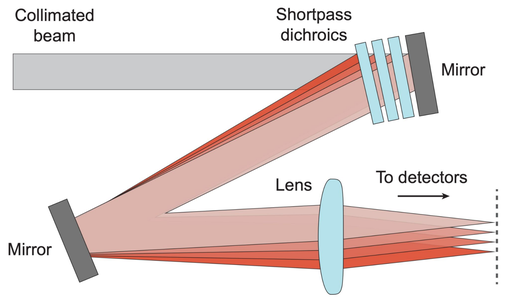
Control System

- Asynchronous python control code
- PyGame camera viewers
- Real time control with CACAO and MILK

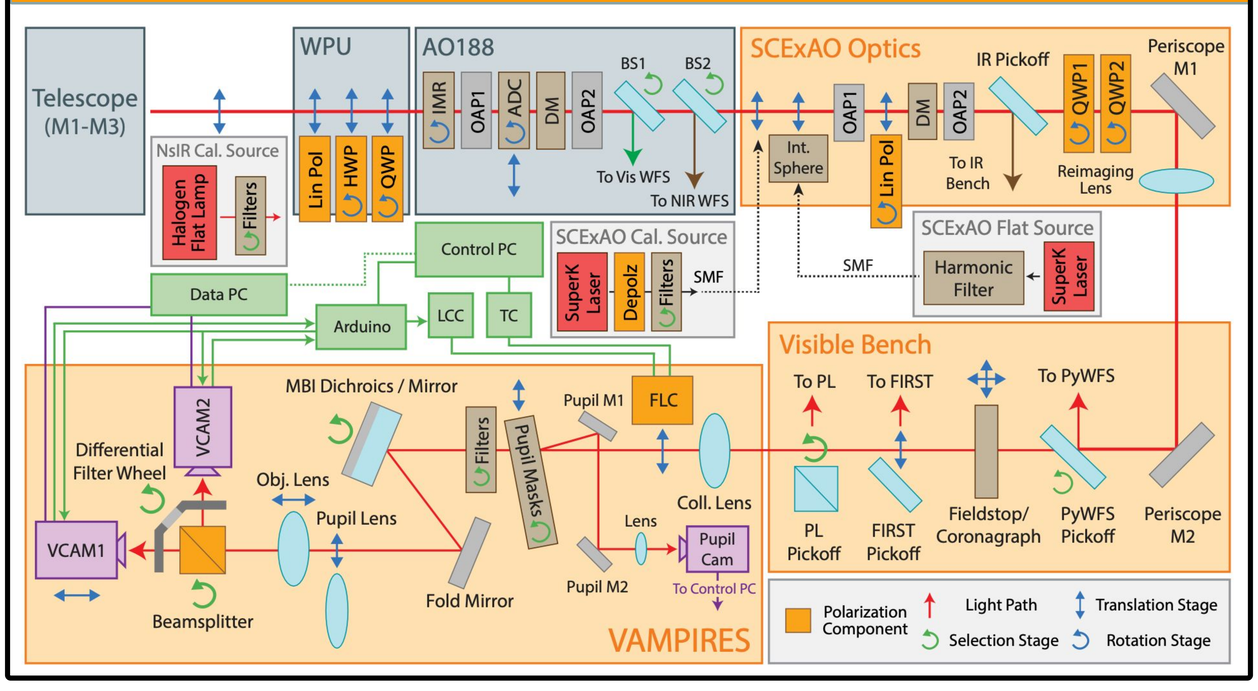
Precision timing: VAMPIRES science frames can be correlated with WFS telemetry and other high-speed cameras.

Multiband Imaging

- 4 fields imaged simultaneously
- Stack of low AOI dichroics



INSTRUMENT SCHEMATIC



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