SCExAO/MEC: High speed ultra-low noise spectro-imaging in near IR

Ben Mazin[f], Sarah Steiger[b], Alex Walter[c], Giovanni Strampelli[a], Olivier Guyon[d,e,f], Kyohoon Ahn[d], Vincent Deo[d], Tomoyuki Kudo[d,e], Julien Lozi[d], Sebastien Vievard[d,e]

[a] UCSB,, [b] Space Telescope Science Institute, [c] JPL, [d] Subaru Telescope, [e] Astrobiology Center, [f] University of Arizona

Contact: bmazin@ucsb.edu

AVAILABLE FOR OPEN USE

OVERVIEW

PI: Ben Mazin, UCSB

Over the last half decade we have constructed and operated the MKID Exoplanet Camera (MEC), a z through J band (800-1400 nm) Integral Field Spectrograph (IFS) located behind the Subaru Coronagraphic Extreme Adaptive Optics (SCExAO) at the Subaru Telescope on Maunakea. MEC uses Microwave Kinetic Inductance Detectors (MKIDs) as the enabling technology for high contrast imaging. MEC is the first permanently deployed near-infrared MKID instrument and is designed to operate both as an integral field spectrograph (IFS) and as a focal plane wavefront sensor in a multi-kHz feedback loop with SCExAO. The read noise free, fast time domain information attainable by MKIDs allows for the direct probing of fast speckle fluctuations that currently limit the performance of most high contrast imaging systems. MEC has been very successful, with ground-breaking papers in stochastic speckle discrimination (SSD) as well as several interesting discoveries.

Parameters	Values
Device Materials	PtSi on Saph., Nb g.p.
Device Format	140x146 pixels
Pixel Pitch	150 μm
Plate Scale	10.4 mas/pixel
Field of View	1.4" x 1.5"
Wavelength Band	800-1400 nm (z - J)
Spect. Res. ($\lambda/\Delta\lambda$)	5-7
Max Count Rate	5000 cts/pix/second
Pixel Dead Time	10 μs
Readout Frame Rate	>2 kHz
Operating Temp.	90 mK
4 K Stage Base Temp.	3.1 K
60 K Stage Base Temp.	57 K
90 mK Hold Time	>17 hours

Table 1: MEC Instrument Summary

MEC was operated for several observing nights last year, but weather and telescope closures, as well as the graduation of the two science graduates students at UCSB, impacted output.

FUTURE PLANS

Proposal Submitted to NSF ATI for MEC' Upgrade

- Increase pixel yield using MIT/LL MKIDs
- Increase QE by 2x
- Increase spectral resolution to R>30
- Improved remote operation
- CDI Algorithm development funding

Acknowledgements

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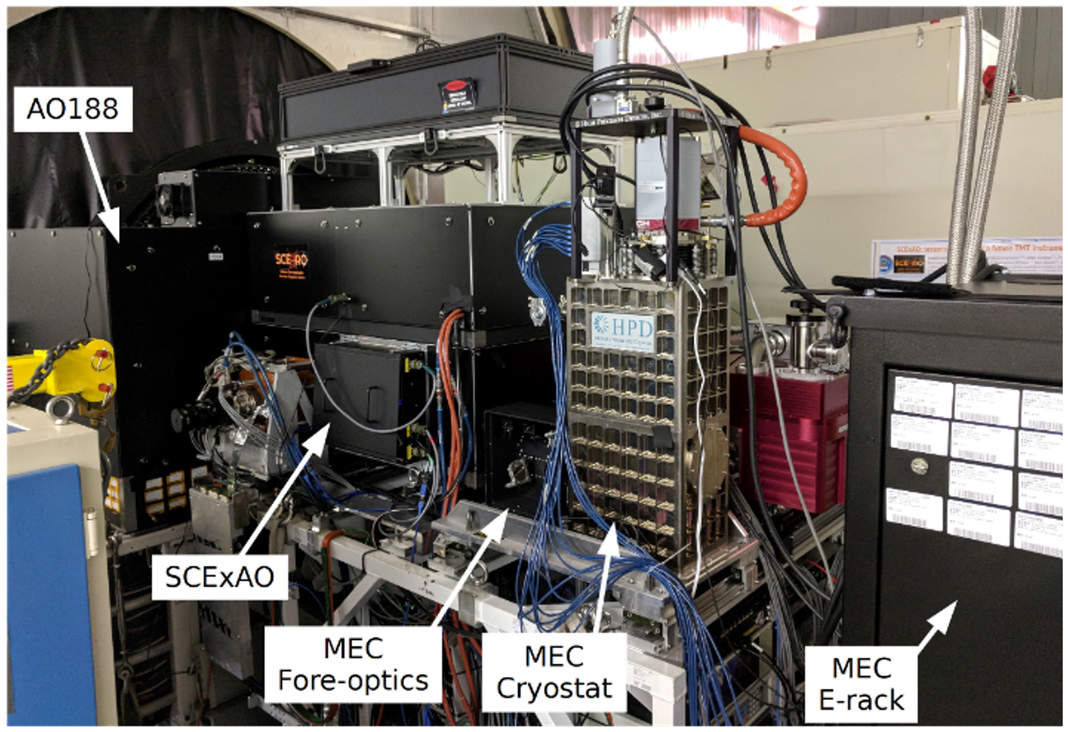
SCIENCE GOALS, CAPABILITIES AND HARDWARE

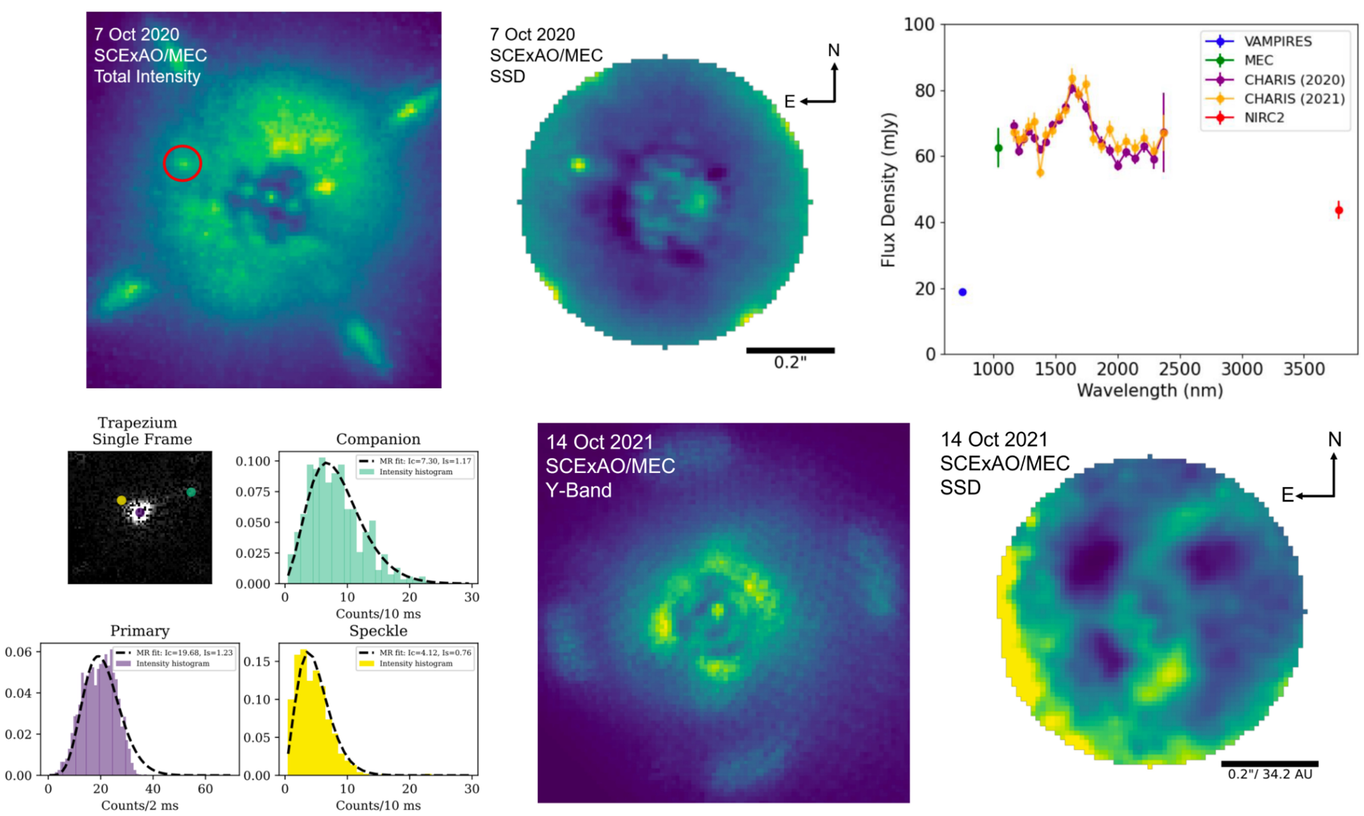
Science Instrument
Provide high contrast / angular resolution 800-1400 nm spectroimaging capabilities to observers

High Contrast Imaging R&D platform for ground and space
Support development activities in HCI with the unique photon counting and energy resolution of MKIDs. Provide path from lab testing to on-sky validation. Support collaborations. with HCI R&D groups.

TMT-PSI system-level prototyping
Validate technical solutions envisioned for TMT's exoplanet instrument, with a focus on its blue (<2um) arm, TMT-PSI BLUE.



RECENT SCIENCE HIGHLIGHTS



Some MEC science highlights. The upper left panels show an total intensity image of HIP 109437, whereas the upper center panel uses the same data set but with a time domain (stochastic speckle discrimination, SSD) analysis to help reject speckles, showing the companion clearly. The top right panel shows the spectra of HIP 5319 taken with multiple instruments. The MEC data point (shown in green) has similar SNR to other top instruments like CHARIS (purple and yellow) and NIRC2 (red). The bottom left panel shows arrival time statistics of photons from SCExAO as a function of field position. The bottom center panels shows a total intensity image of the disk around AB Auriga, while the bottom right shows the same data set with an SSD analysis, showing the ability of SSD to detect diffuse scattered light sources without the use of polarization.

ADDITIONAL INFORMATION

UCSB website: https://web.physics.ucsb.edu/~bmazin/
SCExAO website: https://www.naoj.org/Projects/SCEXAO/scexaoWEB/030openuse.web/042mec.web/indexm.html