THE PICTURE-C MKID Camera

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PICTURE-C

The Planetary Imaging Concept Testbed Using a Recoverable Experiment-Coronagraph (PICTURE-C) Project is a balloon-borne observatory that aims to do high-contrast direct imaging of debris disks and exoplanets at visible wavelengths.

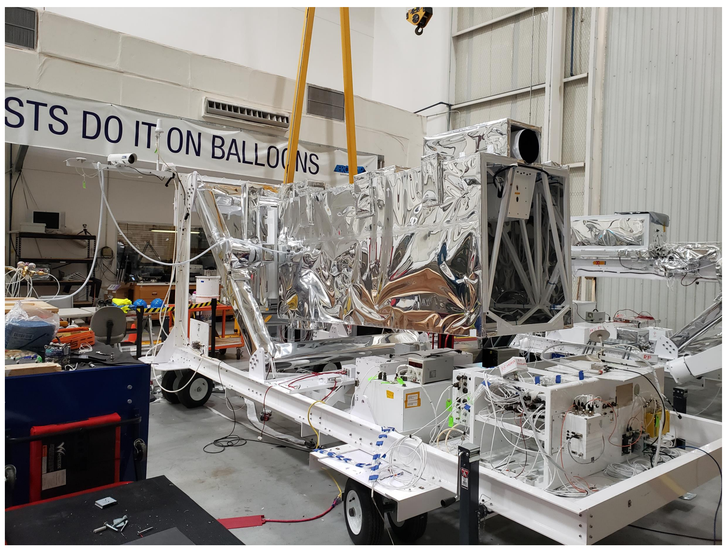


Figure 1 – The Wallops ArcSecond Pointer (WASP) gondola. The telescope is covered in mylar (center) and the PICTURE-C MKID camera will be mounted at the back of it (left).

Visible light observations of debris disks and exoplanets will complement IR observations taken from ground-based telescopes.

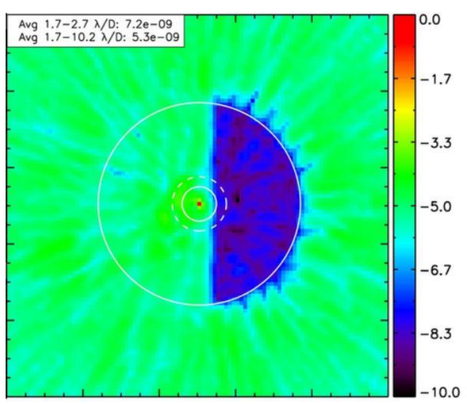


Figure 2 – Projected contrast ratio from PICTURE-C observations. Reproduced from Mendillo et al.[2]

1. **Operates from λ=540-660 nm**
2. **Goal of 10^{-7} contrast ratio from 1.7-10 λ /D**
3. **Experiment targets stars at d=3-10 pc from earth. Inner working angle (IWA) corresponds to 1 AU separation at 3 pc**
4. **Visible observations are more sensitive to reflected starlight.**
   IR observations more sensitive to thermal emission.

MKIDs

Microwave Kinetic Inductance Detectors (MKIDs) are single-photon counting detectors with intrinsic energy resolution and the ability to measure photon arrival times with microsecond accuracy. They are superconducting microresonators that operate at 100 mK (for the current PtSi devices).

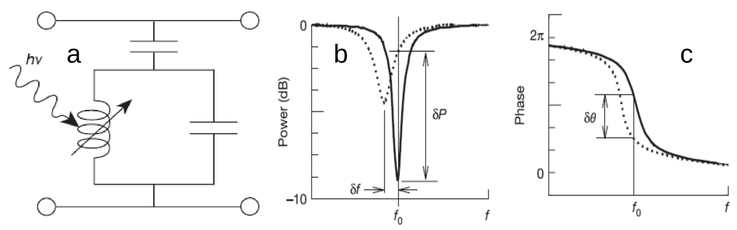


Figure 3 – MKID design and operation schematic. (a) Model of an MKID as a lumped-element circuit with a photon hitting the photosensitive inductor. The change in inductance shifts the MKID's resonant frequency. This causes the microwave probe tone exciting the resonator to shift in amplitude (b) and phase (c). Reproduced from Day et al.[1]

Using frequency domain multiplexing, thousands of MKIDs can be read out using a single microwave feedline. This enables fabrication of arrays with up to 20,000 pixels.

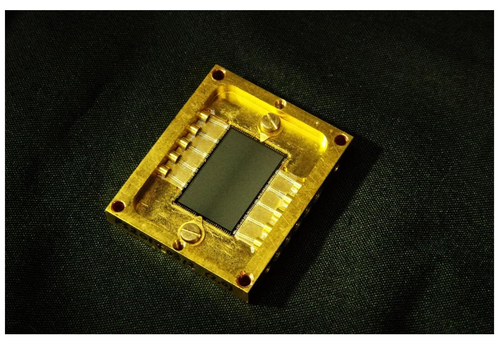
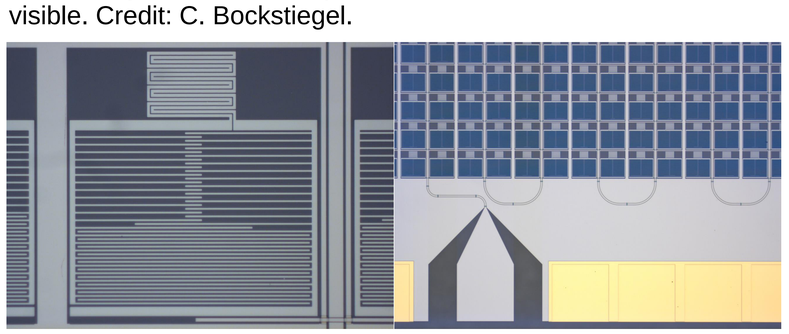


Figure 4 - 10,000-pixel DARKNESS MKID array. Identical to PICTURE-C MKID camera arrays. Credit: C. Bockstiegel.

Figure 5 – (Left) A single MKID pixel. (Right) Zoomed out view of the MKID array with numerous pixels and the microwave feedline visible. Credit: C. Bockstiegel.



PICTURE-C MKID Camera

The PICTURE-C MKID Camera has been built at UCSB to interface with the telescope on the WASP gondola (fig. 1). It is a successor to the Dark-speckle Near-IR Energy-resolved Superconducting Spectrophotometer (DARKNESS) and the MKID Exoplanet camera (MEC). Both operate from 0.8-1.4 microns on ground-based telescopes.

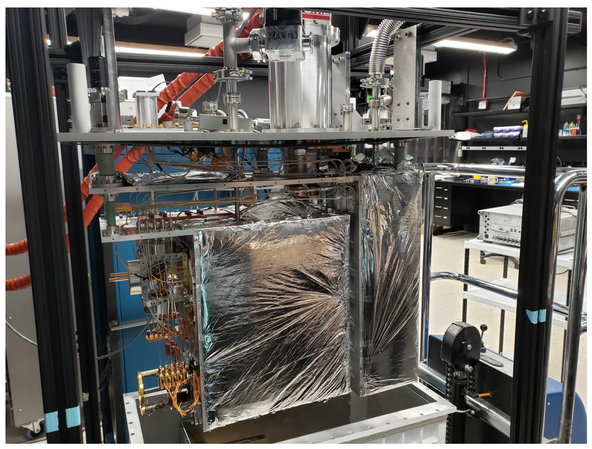


Figure 6 – PICTURE-C MKID Camera cryostat in its lab configuration. Cryogen tanks at center and right. Cryogenic wiring is seen to the left. Device mounting "cold stage" at the bottom left.

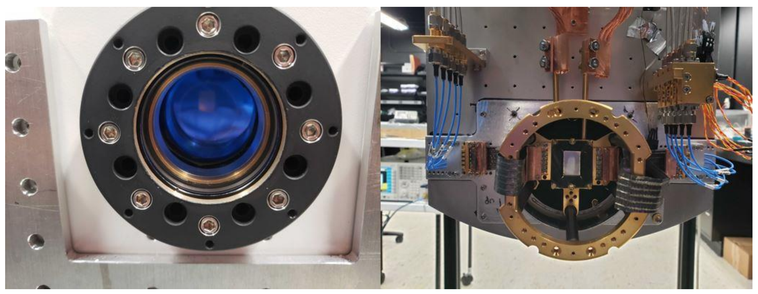


Figure 7 – (Left) View of the MKID device through 300 K window and optical filters at 77 K and 4 K. (Right) MKID device mounting stage. Superconducting flexible coax "FLAX" cables connect the device to conventional coax cables (blue) at 4 K. Cryogenic amplifiers are shown on the top right.

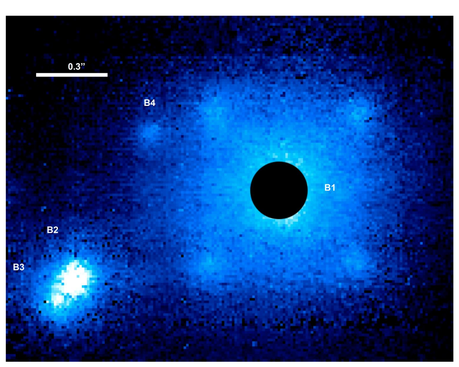


Figure 8 – A typical MKID observation. Trapezium Cluster, from MEC at Subaru in December 2019. Primary star is blocked by a coronagraph. Reproduced from Walter et al.[3]

References

1. Day et al. *Nature* **425,** 817–821 (2003)
2. Mendillo et al. Proc. SPIE 11117, https://doi.org/10.1117/12.2529710
3. Walter et al. *PASP,* (2020). Accessed on arXiv:2010.12620