**High Resolution Photonic MKID Spectrograph**

M. Daal¹, Renan Moreira², J. Bailey¹, and B. A. Mazin¹

¹ University of California, Santa Barbara, ² Ultra-low Loss Technologies

### SPECIFICATIONS

- Make a single mode fiber (SMF) fed spectrometer, R~5,000, suitable for use at any large telescope where the light is channelized by a photonic circuit chip and then detected by a separate chip with an energy-resolving superconducting detector (MKID) array.
  - Wavelength Range: 400 ~ 800 nm
  - Collimated, narrow, and high throughput
  - Spectrometer components on a few cm² chip
  - Small size avoids thermal and vibration deflections
  - Use intrinsic energy resolution to sort the orders in each output channel of the photonic circuit.
  - Target: 3 x 5 orders sorted
  - Single photon sensitivity, lack of read noise and integration time enable time resolved spectroscopy and high sensitivity to faint objects

**WHY PHOTONICS?**

Photronics: Devices that make use of optical waveguides or other structures or materials that can manipulate properties of light such as phase and direction.

**Further reading**

- Use adaptive optics of telescopes to format light into single mode fiber (or MMF + Lantern)
- Photonic circuits put conventional spectrograph collimator, disburser and camera optics on a few cm² chip
- Small size avoids thermal and vibration deflections
- Use intrinsic energy resolution to sort the orders in each output channel of the photonic circuit.
- Target: 3 x 5 orders sorted
- Single photon sensitivity, lack of read noise and integration time enable time resolved spectroscopy and high sensitivity to faint objects

**WHY MKIDS?**

- The MKID is necessary to:
  - Exploit multiplexibility to obtain thousands of orders
  - Use intrinsic energy resolution to sort the orders in each output channel of the photonic circuit.
  - Target: 3 ~ 5 orders sorted
  - Single photon sensitivity, lack of read noise and integration time enable time resolved spectroscopy and high sensitivity to faint objects
  - Miniaturization afforded by ability to position detectors only at output channel locations

### MKIDs

- Can be operated in on Calorimetric or Bolometric modes
- Photons change surface impedance of superconductor, \( L_k \)
- Each photon creates phase pulse in calorimetric mode
- Possible to couple inductor to photons exiting output waveguides or output waveguide evanescent waves

\[
f_0 \propto \frac{1}{(L_0 + L_k)C}
\]

**WHY MKIDS?**

- The MKID is necessary to:
  - Exploit multiplexibility to obtain thousands of channels
  - Use intrinsic energy resolution to sort the orders in each output channel of the photonic circuit.
  - Target: 3 ~ 5 orders sorted
  - Single photon sensitivity, lack of read noise and integration time enable time resolved spectroscopy and high sensitivity to faint objects
  - Miniaturization afforded by ability to position detectors only at output channel locations

### RESEARCH TASKS

- Measure optical properties of photonic circuitry test at < 1 K
- Photonic circuit design incorporating above
- Photonic circuit to MKID chip butt coupling design and test at < 1 K
- Demonstration of spectrum from known source

**REFERENCES**


---

18th International Workshop on Low Temperature Detectors, Poster #378

July 21st – 26th 2019, Milano