A Microwave Kinetic Inductance Detector for the DAG Telescope (DAG-MKID)

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Tolga Güver[1,2], Ben Mazin[3], Kieran O'Brien[4], Burak Kay[5], Sinan Aliş[1,2], F. Korhan Yelkenci[1,2], Cahit Yeşilyaprak[6,7], Sinan K. Yerli[8], Ayşe Erol[5], Onur Keskin[9]

[1]Department of Astronomy and Space Sciences, Faculty of Science, Istanbul University [2]Istanbul University Observatory Research and Application Center
[3]Department of Physics, University of California at Santa Barbara [4]Department of Physics, University of Oxford
[5]Department of Physics, Faculty of Science, Istanbul University [6]Atatürk University, Science Faculty, Department of Astronomy and Astrophysics
[7]Atatürk University, Astrophysics Research and Application Center (ATASAM) [8]Orta Doğu Teknik Üniversitesi (METU), Physics Department
[9]Işık University, Department of Mechanical Engineering

Eastern Anatolia Observatory (DAG)

We present the details of a proposed microwave kinetic inductance detector (MKID) for the Eastern Anatolia Observatory (DAG). The observatory will have a modern 4m size telescope that is currently under construction. Current plan to obtain the first light with the telescope is late 2019.

DAG has a Ritchey-Chretien configuration with two Nasymth foci (no Cassegrain focus) and a 4-m primary mirror. The focal length will be 56m resulting in a f-ratio of 1.8 and an unvignetted field of view of 30 arcmin. The mirrors will be coated with Aluminum resulting in a high reflectivity in the 350 – 3000 nm. There will be active optics as well as GLAO (corrected field of view 5') in one of the Nasymth foci (see posters AS16-9910-113 and AS16-9909-316 for details).

Figure 1: Illustration of DAG telescope and its operation facility. The Observatory site (3155 meters above sea level) will be the 3rd **highest observatory** for a 4 meters class telescope. The site known to have more than 250 clear nights.

DAG Focal Plane Instrumentation (FPI) project has recently been accepted by the Turkish Government and started in May 2016. Within this project a new laboratory will be established in Istanbul University which will serve as a test, calibration and maintenance unit as well as a data archive facility.

MKIDs

MKIDs are a type of superconducting detectors that work on the principle that incident photons can change the surface impedance of a superconductor because of the kinetic inductance effect. This change can be accurately measured using a superconducting inductor in a resonator (see e.g.).

MKIDs allow for the detection of individual photons with very high time resolution (μs) and low energy resolution (R = $\lambda/\Delta\lambda$ = 10-25 @ 1.1 - 0.4 μm).

MKIDs do not suffer from readout and dark noise, and do not need any optical elements (apart from a collimator) and therefore provide a better response than many of the currently used IFUs.

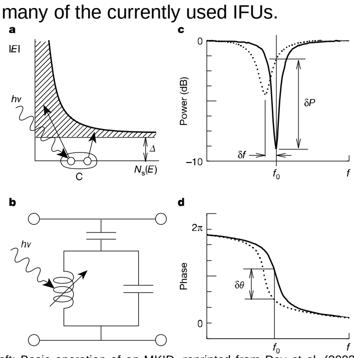

Figure 2 : Left: Basic operation of an MKID, reprinted from Day et al. (2003). (a) Photons with energy hv are absorbed in a superconducting film, producing a number of excitations, called quasi-particles. (b) To sensitively measure these quasi-particles, the film is placed in a high frequency planar resonant circuit. In the right panels, the amplitude (c) and phase (d) response of a microwave excitation signal sent through the resonator as a function of frequency are shown. The change in the surface impedance of the film following a photon absorption event pushes the resonance to lower frequency and changes its amplitude. If the detector (resonator) is excited with a constant on-resonance microwave signal, the energy of the absorbed photon can be determined by measuring the degree of phase and amplitude shift. Right: Example of frequency domain multiplexing (FDM) of MKIDs showing many resonators being read out through a single transmission line.

DAG-MKID will be made using PtSi which has a better yield and quantum efficiency. DAG-MKID array will consist of 183x183 pixels. It will have a FoV of ≤1' and a pixel scale of ≤0.5''. The array will be sensitive to photons in the 400 – 1350 nm wavelength range and effective spectral resolution of λ/Δλ = 10-25, and a time resolution of ~ 1 μs.

Unique Features of DAG-MKID

In the era of currently planned or ongoing multi-wavelength surveys (PanSTARRS, SDSS, GAIA, LSST, WFIRST, e-ROSITA, Euclid, FERMI, etc.) DAG Science team is planning to position the observatory as a reliable and effective follow-up mission in addition to regular observing campaigns. For this purpose the telescope will be observing in queue mode and will have a flexible observing programme.

If successfully installed DAG-MKID will play a key role in such a telescope because of its key capabilities:

- **No read-out or dark noise enabling the observations of dim objects effectively.**
- **Ability to observe with very high time resolution.**
- **Ability to create spectral energy distributions (400 - 1350 nm) of all the detected sources in the field of view simultaneously without using any optical elements.**

Possible Science Cases

With these capabilities DAG-MKID will be effective mostly in the following science cases:

- **Search for electromagnetic counter-parts of gravitational wave signatures.**
- **Follow-up of Gamma-Ray bursts and supernovae.**
- **Monitoring observations of X-ray binaries, CVs, AGNs and other time variable objects.**
- **Observations of Nearby Pulsars.**
- **Transit observations of exoplanets.**
- **Determining photometric redshifts of galaxies.**
- **Detection of galaxy clusters up to z~1.**

REFERENCES

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