Poster-2-1

Breaking new ground in quantum detection with SNSPDs: the search for light-mass dark matter and high-critical-temperature superconductors

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Initially developed for deep-space communication and quantum information science, SNSPDs possess specific characteristics that make them particularly suited for detecting light dark matter (DM). Although these detectors have already shown promising results [1], they require further development before being used in the final designs for a DM experiment. In first part of my talk, I will discuss the remaining technological challenges, design, and characterization of the devices.
The operation of SNSPDs based on conventional superconductors, which have a low critical temperature (Tc), requires costly and bulky cryocoolers. This motivated exploration of other superconducting materials with higher Tc that would enable single-photon detection at elevated temperatures, yet this task has proven exceedingly difficult. Here I show that with proper processing, high-Tc superconductors can meet this challenge [2][3]. We fabricated superconducting nano- and microwires out of thin flakes of BSCCO, thin MgB2 films and LSCO-LCO bilayer films and demonstrated their single-photon response up to 25, 20 and 8 K, respectively. High-Tc based SNSPDs exhibited single-photon sensitivity at the technologically important 1.55 um telecommunications wavelength. This demonstration expands the family of superconducting materials for SNSPD technique, opens the prospects of raising the temperature ceiling, and raises important questions about the underlying mechanisms of single-photon detection by unconventional superconductors.

[1] Y. Hochberg, I. Charaev, S. W. Nam, V. Verma, M. Colangelo, and K. K. Berggren, Detecting Sub-GeV Dark Matter with Superconducting Nanowires, Phys Rev Lett, vol. 123, no. 15, 2019, doi: 10.1103/PhysRevLett.123.151802.
[2] I. Charaev et al., Single-photon detection using high-temperature superconductors, Nat Nanotechnol, vol. 18, no. 4, 2023, doi: 10.1038/s41565-023-01325-2.
[3] I. Charaev et al., Single-photon detection using large-scale high-temperature MgB2 sensors at 20 K, Aug. 2023, Available: https://arxiv.org/abs/2308.15228v1, accepted for publication in Nature Communications, March, 2024.