

$$\frac{1}{\sqrt{2}}|\text{cat}\rangle + \frac{1}{\sqrt{2}}|\text{dog}\rangle$$

Summary of Quantum Sensors sessions CPAD 2021

Conveners: Alex Sushkov, Andy Geraci

Speakers: Bradford Welliver, Jianjie Zhang, Benjamin Schmidt, Chloe Lohmeyer, Deniz Aybas, Derek Kimball, Tim Kovachy, Akash Dixit, William Terrano, Swati Singh, Nader Mirabolfathi, Andrew Sonnenschein, Yonatan Kahn, Kelly Backes

CPAD 2021

Virtual Event @ Stony Brook University, March 18-22, 2021

Quantum Sensors – BRN Priority Research Directions

Basic Research Needs for High Energy Physics
Detector Research & Development



Four Priority Research Directions:

Priority Research Direction (PRD)
PRD 12: Advance quantum devices to meet and surpass the Standard Quantum Limit
PRD 13: Enable the use of quantum ensembles and sensor networks for fundamental physics
PRD 14: Advance the state of the art in low-threshold quantum calorimeters
PRD 15: Advance enabling technologies for quantum sensing

Quantum Sensors – BRN Priority Research Directions

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Four Priority Research Directions:

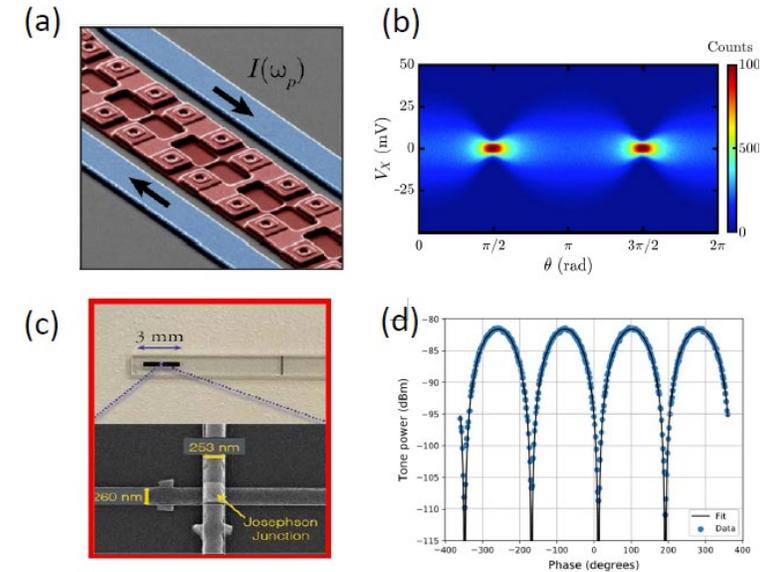
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Backaction-evading quantum upconverters operating below the Standard Quantum Limit (SQL) from 1 peV to 1 eV

Qubit-based quantum non-demolition (QND) photon counters from 5 to 30 GHz (20eV to 120eV)

Qubit-based pair-breaking photon counters above 30 GHz (120eV)

Opto-mechanical quantum sensors for DM experiments



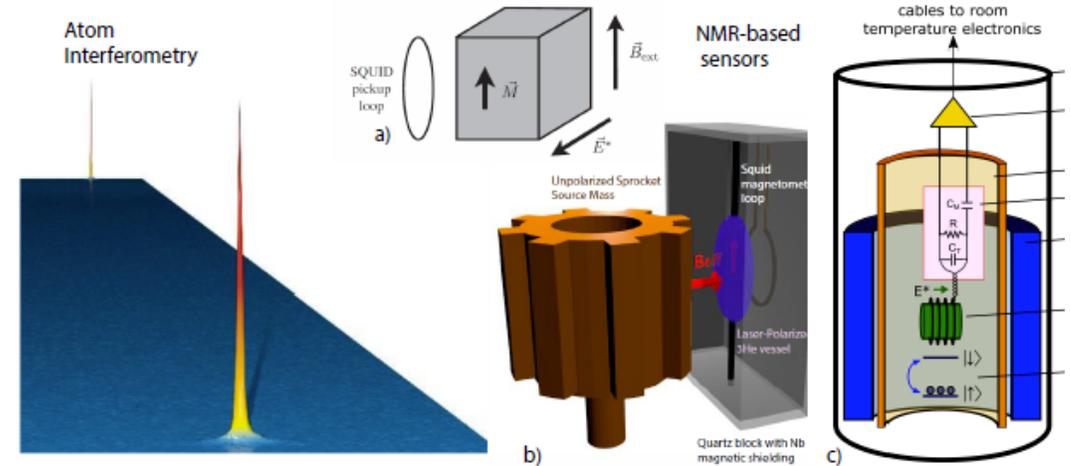
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Spin-based sensors for the QCD axion, axion-like particles, and wave-like dark matter

Atomic clocks and interferometers to search for gravitational waves, wave-like DM, and other new physics

Technology for EDM searches

Entanglement as a resource for quantum sensors such as clocks and magnetometers

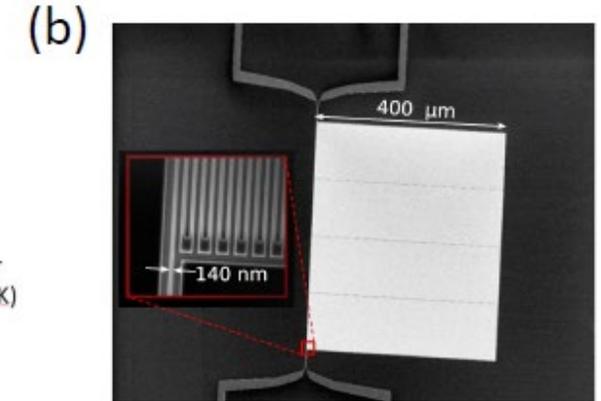
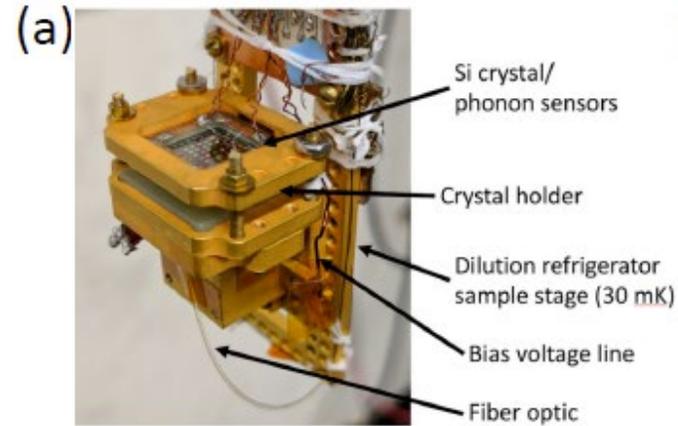
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Bolometer detectors: Transition-edge sensor (TES) or kinetic inductance detector (KID) devices

Superconducting nanowire single-photon detectors (SNSPDs)

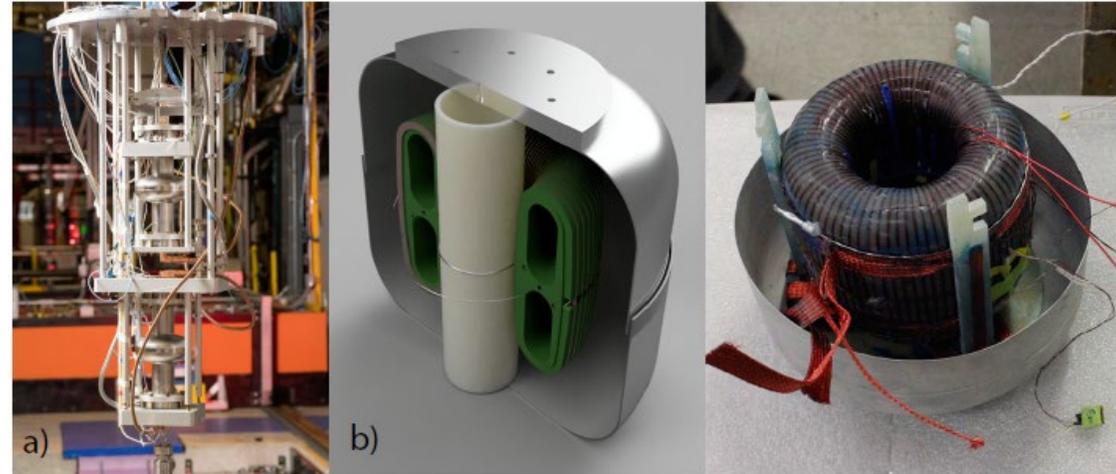
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High-Q electromagnetic resonators and supporting technologies

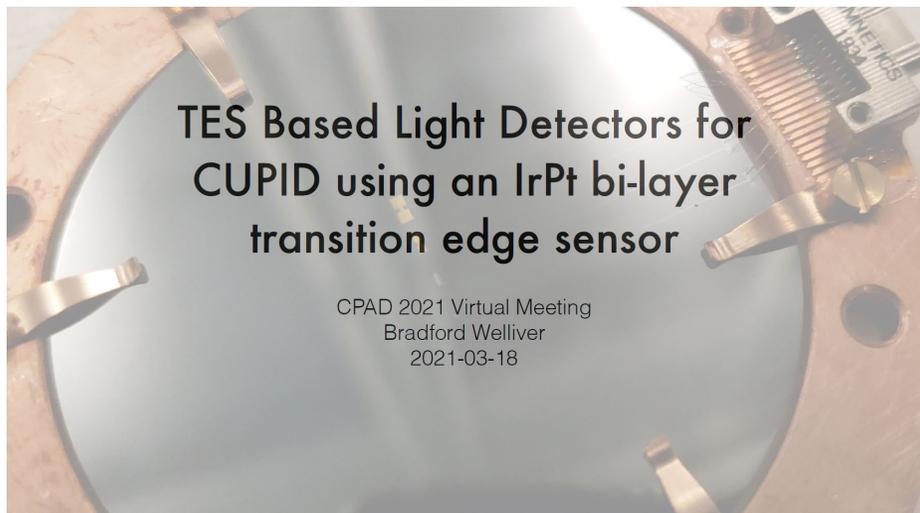
Optimized materials for quantum sensing

Atomic/Molecular/Optical and Nuclear-Spin based methods and enabling technologies

Optimized quantum sensing algorithms



CPAD 2021 Quantum sensors session 1



CPAD 2021



LOW-TC TES AS SENSORS FOR FUNDAMENTAL PHYSICS

JIANJIE ZHANG

Argonne National Laboratory

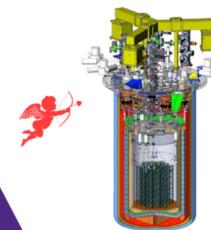
3/18/2021

Northwestern

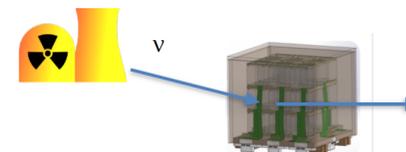
Design of low T_c TES chips as sensors for low background calorimeter arrays

CPAD 2021, March 18th

Authors: **Benjamin Schmidt**, Clarence Chang, Ran Chen, Enectali Figueroa-Feliciano, Marharyta Lisovenko, Valentina Novati, Runze Ren, Gensheng Wang, Vlad Yefremenko and Jianjie Zhang



RICOCHET





CPAD 2021 Quantum sensors session 2

ARIADNE: a laboratory search for the QCD axion with hyperpolarized ^3He spins

Chloe Lohmeyer
CPAD Workshop
Thursday March 18th, 2021

Searching for axion-like dark matter with ensembles of nuclear spins



Deniz Aybas, Janos Adam, Emmy Blumenthal, Alexander V. Gramolin, Dorian Johnson, Annalies Kleyheeg, Samer Afach, John W. Blanchard, Gary P. Centers, Antoine Garcon, Martin Engler, Nataniel L. Figueroa, Marina Gil Sendra, Arne Wickenbrock, Matthew Lawson, Tao Wang, Teng Wu, Haosu Luo, Hamdi Mani, Philip Mausekopf, Peter W. Graham, Surjeet Rajendran, Derek F. Jackson Kimball, Dmitry Budker, and Alexander O. Sushkov



CPAD Instrumentation Frontier Workshop 2021
3/18/21

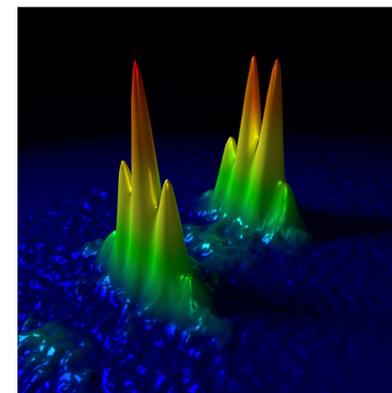



Global Network of Optical Magnetometers for Exotic Physics searches (GNOME)

Derek F. Jackson Kimball



Probing Fundamental Physics with Long-Baseline Atom Interferometry



Tim Kovachy

Department of Physics and Astronomy and Center for Fundamental Physics (CFP), Northwestern University

CPAD 2021



CPAD 2021 Quantum sensors session 3

Searching for dark matter with a superconducting qubit



Akash V. Dixit

Srivatsan Chakram, Kevin He, Ravi K. Naik, Ankur Agrawal, Aaron Chou, David I. Schuster

University of Chicago
avdixit@uchicago.edu

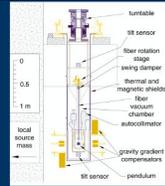
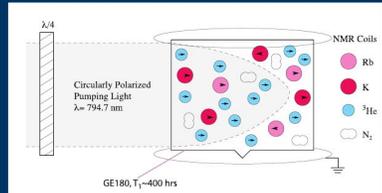
Searching for dark matter using mechanical systems

Swati Singh
University of Delaware,
Mar 19th 2021




<https://www.eecis.udel.edu/~swatis/>

Hugely coherent detectors for fundamental physics
Comagnetometers and Accelerometers

William Terrano, March 29 2021

Anisotropy of quantized electronic excitations in semiconductors for directional dark matter searches

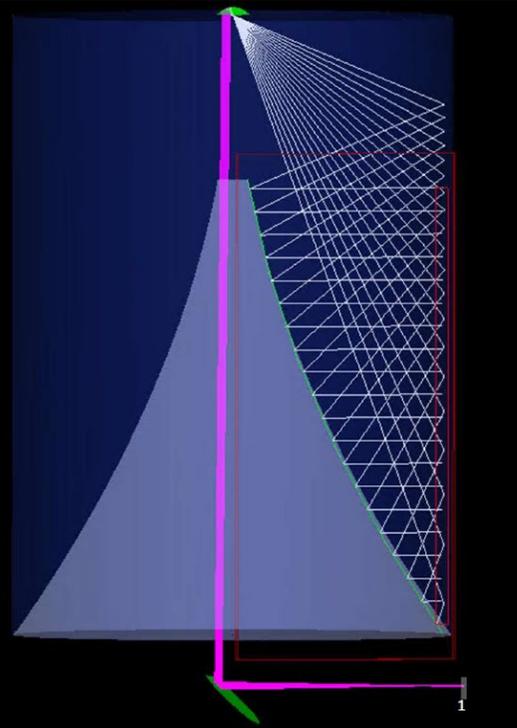
Nader Mirabolfathi
Mirabolfathi@physics.tamu.edu
CPAD March 2021

- Dark Matter searches at very low mass: NRDM.
- Nuclear recoil ionization threshold and possible directional effects.
- Crystal Defects and effects on expected DM NR spectrum.
- Low threshold Detector review.
- Conclusion and prospects.

CPAD 2021 Quantum sensors session 4

BREAD: Broadband Reflector Experiment for Axion Detection

Andrew Sonnenschein
Fermilab
CPAD Workshop
March 19, 2021



Data-driven dark matter-electron scattering rates from the dielectric function

Yoni Kahn
University of Illinois at Urbana-Champaign
CPAD Workshop, 3/19/21





CPAD 2021 Early career

Speeding up the Search for Axions with Quantum Squeezing



Kelly Backes

CPAD

March 22, 2021



JILA
CU Boulder and NIST



Wright
Laboratory