IF1: Quantum Sensors

CSS Parallel Session
7/18/22

Agenda

- Introduction
- Overview of Coordinated white papers
  - Interferometers, clocks, and traps
  - Spin Dependent Processes
  - Superconducting Sensors
  - Quantum Calorimeters
  - Community Discussion
- Break
- Introduction to Topical Group Report
- Discussion / report editing

IF01 Convenors

- Tom Cecil
  - Argonne National Laboratory
  - SPT, CMB S4
- Kent Irwin
  - Stanford University/SLAC
  - Axions / DM Radio, CMB-S4, legacy in SuperCDMS, x-ray spectroscopy, submm imaging
- Reina Maruyama
  - Yale University
  - Axions, double beta decay, WIMPs (HAYSTAC, CUORE, COSINE-100)
- Matt Pyle
  - UC Berkeley
  - 100meV-10GeV Dark Matter Direct Detection: (SPICE, HERALD, SuperCDMS)
- Silvia Zorzetti (FNAL)

Quantum Sensors and Snowmass Science

- Ultralight wavelike dark matter (generalized axions, hidden photons, scalars)
- Scattering / absorption of dark matter particles
- Electric dipole moment measurements (electron, nuclear, neutron)
- Gravitational waves
- Dark energy
- Violations of fundamental symmetries
- New forces and particles

Quantum Sensors in Context

Quantum sensors instrumentation has close connection with:

- IF2: Instrumentation Frontier, photon detectors
- IF7: Electronics/ASICs subgroup
- CF1: Cosmic Frontier, Dark Matter particle-like
- CF2: Cosmic Frontier, Dark Matter wave-like
- AF5: Accelerator for PBC and Rare Processes

Important to make sure that interfaces are well defined, and nothing is “dropped in the cracks.”

This is an emerging technology area and there are many connections to other frontiers.

IF01 Community White Papers

- Received 74 LOIs tagged with IF01
- Grouped LOIs into 4 groups - planned coordinated white paper for each
  - Superconducting Sensors
  - Quantum Calorimeters
  - AMO: Spins, NMR, and Defects
  - Interferometers, Clocks, and Traps
- Currently have 2 submitted coordinated white papers:
  - https://arxiv.org/abs/2203.09488: Quantum Sensors for High Precision Measurements of Spin Dependent Interactions
  - https://arxiv.org/abs/2203.07250: Snowmass 2021: Quantum Sensors for HEP Science - Interferometers, Mechanics, Clocks, and Traps
- 11 other white papers cross-listed under IF01

IF01 cross-listed white papers

- G. Wang, C. L. Chang, M. Lisovenko, V. Novosad, V. G. Yefremenko, J. Zhang. ”Light Dark Matter Detection with Hydrogen-rich Crystals and Low-Tc TES Detectors”, arXiv:2201.04219 [physics.ins-det] (pdf). (also under CF01)
- Reza Ebadi, Mason C. Marshall, David F. Phillips, Tao Zhou, Michael Titze, et al. ”Directional Detection of Dark Matter Using Solid-State Quantum Sensing“, arXiv:2203.06037 [physics.ins-det] (pdf). (also under CF01)
- S. Brooks, K. Brown, F. Méot, A. Nomerotski, S. Peggs, M. Palmer, et al. ”Ion Coulomb Crystals in Storage Rings for Quantum Information Science”, arXiv:2203.06809 [physics.acc-ph] (pdf). (also under TF10, AF01, CompF06)
- Alaina Attanasio, Sunil A. Bhave, Carlos Blanco, Daniel Carney, Marcel Demarteau, et al. (Windchime Collaboration). ”The Windchime Project”, arXiv:2203.07242 [hep-ex] (pdf). (also under CF01, TF08)
- Daniel Carney, Nirmal Raj, Yang Bai, Joshua Berger, Carlos Blanco, Joseph Bramante, et al. ”Ultraheavy particle dark matter”, arXiv:2203.06508 [hep-ph] (pdf). (also under CF01, TF08)
- Joel Ullom, Daniel Schmidt, Simon Bandler, Thomas Stevenson, Mark Croce, et al. ”Measuring the electron neutrino mass using the electron capture decay of 163Ho”, arXiv:2203.07572 [nucl-ex] (pdf). (also under NF05)

IF01 cross-listed white papers (cont.)

- M.F. Albakry, I. Alkhatib, D.W.P. Amaral, T. Aralis, T. Aramaki, I.J. Arnquist, I. Ataee Langroudy, et al. ”A Strategy for Low-Mass Dark Matter Searches with Cryogenic Detectors in the SuperCDMS SNOLAB Facility“, arXiv:2203.08463 [physics.ins-det] (pdf). (also under NF03, CF01, UF03)
- A. Armatol, C. Augier, F. T. Avignone III, O. Azzolini, M. Balata, K. Ballen, A. S. Barabash, et al. ”Toward CUPID-1T”, arXiv:2203.08386 [nucl-ex] (pdf). (also under NF05, RF04, UF03)
- Asher Berlin, Sergey Belomestnykh, Diego Blas, Daniil Frolov, Anthony J. Brady, Caterina Braggio, et al. ”Searches for New Particles, Dark Matter, and Gravitational Waves with SRF Cavities”, arXiv:2203.12714 [hep-ph] (pdf). (also under CF0, TF0, CompF06)
- D. Antypas, A. Banerjee, C. Bartram, M. Baryakhtar, J. Betz, et al. ”New Horizons: Scalar and Vector Ultralight Dark Matter”, arXiv:2203.14915 [hep-ex] (pdf). (also under RF03, CF02, TF09)
- J. Jaeckel, G. Rybka, L. Winslow, for the Axion Prospects Collaboration. “Axion Dark Matter”, arXiv:2203.14923 [hep-ex] (pdf). (also under RF03, CF02, TF09, AF07)

Community White papers

- Common Themes
  - Dark matter
  - Quantum Calorimeters
  - SRF cavities
- ‘New’ concepts
  - Quantum science in storage rings
  - Arrays of suspended pendulum
  - Others?

Final thoughts

- Overall goal of the topical group report is to represent what quantum sensors are doing, and can do, for HEP science
- We need the community's input to make this happen
  - Please review the draft report: LINK
  - Leave comments here: LINK
- Many thanks to everyone who has contributed so far!