Snowmass 2021
Quantum Information Science
(TF10)

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QIS for HEP ….

- Topical group explores aspects of QIS relevant for HEP
- Algorithms to quantum simulate QFTs
- Novel approaches to fundamental physics using quantum systems and sensors
- Connections between entanglement, quantum information and holography
- Computational and theoretical components.

Quantum Sensing

- New ways to probe fundamental physics with quantum systems: searches for dark matter, BSM interactions and gravitational waves

Many of these begin with a theory paper:

Axions Dark photons B-L GW

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Atom interferometry

Searches with SRF cavities

Molecular systems

Q-limited accelerometers

NV-centers

LC Circuits

Spin precession

Optical systems

Precision atomic physics

...

Simulations of QFT

- Quantum simulation: real time dynamics and finite density. No sign problem.
- New QFT representations suitable for quantum computation e.g. Hamiltonian LGT, quantum links, tensor networks
- Analog vs digital. Quantum simulation expts. Algorithms suited for specific architectures.

New mappings of Hamiltonians to Qubits

Error correction

Algorithms for time evolution

Identifying HEPy toy problems

Gauge invariance

Initial state preparation

Protocols for reading out observables

co-design

Tensor Networks

- New classical algorithms eg tensor renormalization group TRG, HOTRG, ATRG ..
- Non-abelian gauge symmetries, fermions, susy
- Discrete holography. QFTs on tessellations of hyperbolic space, relation to eg MERA, quantum error correction ...

Dual representations

Transfer matrix

Character expansion

Entanglement and holography

- Emergence of spacetime and gravity in and beyond the classical limit
- Storage and evolution of quantum information in gravitational systems (e.g. black hole information)
- Implications for cosmology
- Essence of the holographic map.

Computational Directions

- Quantum computing may, some day, open new directions for data analysis. e.g. LHC, jet physics.
- New classical algorithms inspired by quantum.
- Optimization and image acquisition in astrophysics datasets.
- Quantum machine learning.
- Could play a role in future event generators (related to simulation, showering, etc).

Are we missing something ?

- This is ground up process. The community should determine what are important topics.
- Please tell us, in LOI form or otherwise, what you find exciting.

Overlaps with other topical groups

- String theory group, TF01.
- Lattice theory group, TF05 (simulation).
- Astroparticle theory, TF09 (sensors).
- Cosmic frontier (sensors).
- Quantum computation group (Computational Frontier). [Please note kickoff meeting August 10-11]

Cross listing LOIs and white papers to multiple topical groups and/or frontiers is welcome when relevant.

How will this work ?

- As conveners want to encourage people to send in **LOI** (letters of interest/intent)
  - Max 2 pages. Many modes: Expression of interest or excitement in some topic. Mini white paper. Prelude to (later) submission of white paper… any of the above. **(soft) deadline Aug 31**
- A zoom meeting in early winter.
- **White papers**. Longer. Will be submitted to arXiv. Deadline July 2021.

Summary Document

- A summary document White papers and LOIs will be used as input to writing of 10-15 page document for each topical group.
- Conveners (plus some subset of white paper authors) will be responsible for this.
- When: by end of summer 2021.

Communication

- Email. we will use the TF10 listserv. sign up to it if you want to receive more info.
- The TF10 wiki will be updated.
- Slack. We are not seasoned Slack users but will probably learn quickly.
- We will set up a google doc for people to enter LOI intensions (following comments in the meeting).

Questions ..?