YRM 2020: Quantum Meet

Quantum Science and Technology
EECS Perspective
Indian Inst. of Science

July 24, 2020

Presenter: Shayan Srinivasa Garani

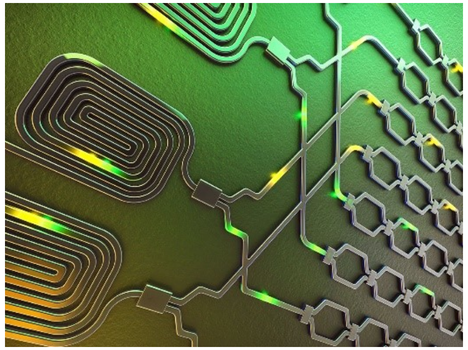
Agenda

- Quantum Science and Technology
  - Overview
  - Active Research Pursued at IISc
  - Faculty from EECS
  - Recruitment Focus

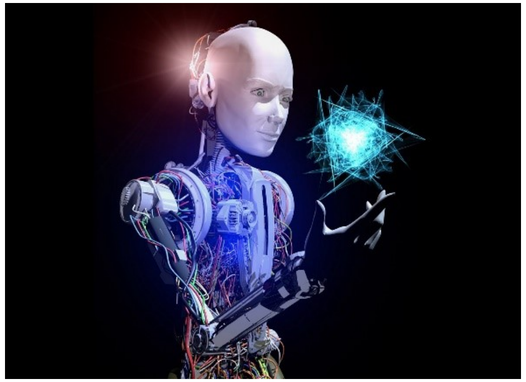
Quantum Science and Technology Applications

Quantum computers

Quantum communications



Quantum integrated photonics



Quantum AI-bio systems

Quantum Finance

Courtesy: Google Images

A Multidisciplinary Research

- Quantum technologies
- Quantum circuits and systems
- Quantum integrated systems
- Quantum physical laws and experiments
- Quantum information processing
- Quantum devices
- Quantum computing algorithms

Active Areas of Research

- Quantum Materials and Devices
- Quantum Information Processing
- Interfacing Circuits for Quantum Devices

⋮

2D Quantum Materials

The Journal of Physical Chemistry Letters

pubs.acs.org/JPCL Letter

Machine-Intelligence-Driven High-Throughput Prediction of 2D Charge Density Wave Phases

Arnab Kabiraj and Santanu Mahapatra*

Cite This: *J. Phys. Chem. Lett.* 2020, 11, 6291–6298 Read Online

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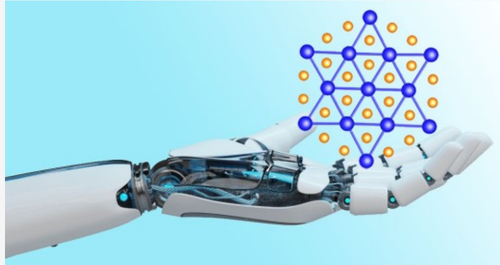
ABSTRACT: Charge density wave (CDW) materials are an important subclass of two-dimensional materials exhibiting significant resistivity switching with the application of external energy. However, the scarcity of such materials impedes their practical applications in nanoelectronics. Here we combine a first-principles-based structure-searching technique and unsupervised machine learning to develop a fully automated high-throughput computational framework, which identifies CDW phases from a unit cell with inherited Kohn anomaly. The proposed methodology not only rediscovers the known CDW phases but also predicts a host of easily exfoliable CDW materials (30 materials and 114 phases) along with associated electronic structures. Among many promising candidates, we pay special attention to $ZrTiSe_4$ and conduct a comprehensive analysis to gain insight into the Fermi surface nesting, which causes significant semiconducting gap opening in its CDW phase. Our findings could provide useful guidelines for experimentalists.



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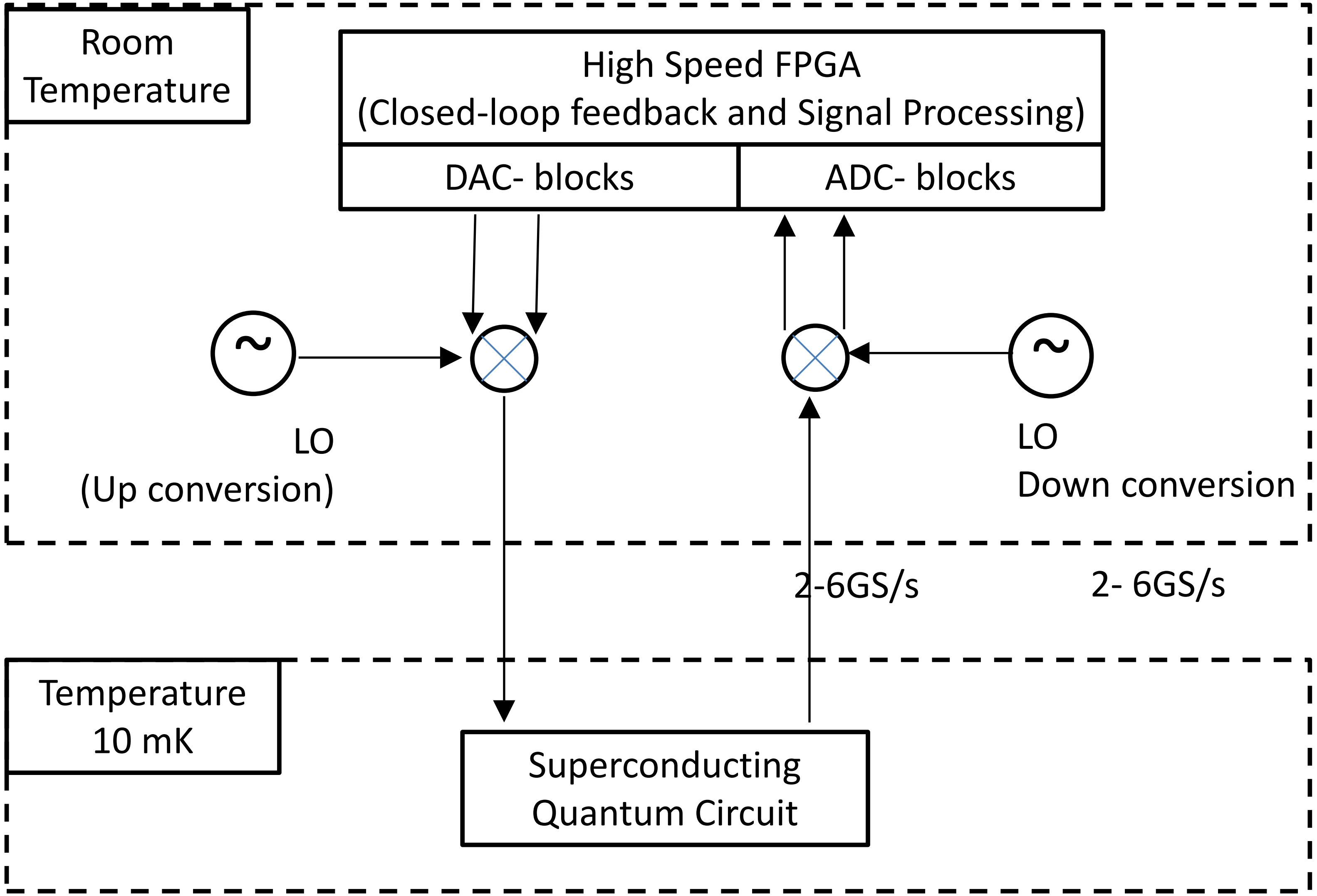
Tuneable quantum spin Hall states in confined 1*T*′ transition metal dichalcogenides

Biswapriyo Das[1*], Diptiman Sen[2] & Santanu Mahapatra[1]

Investigation of quantum spin Hall states in 1*T*′ phase of the monolayer transition metal dichalcogenides has recently attracted the attention for its potential in nanoelectronic applications. While most of the theoretical findings in this regard deal with infinitely periodic crystal structures, here we employ density functional theory calculations and $k.\,p$ Hamiltonian based continuum model to unveil the bandgap opening in the edge-state spectrum of finite width molybdenum disulphide, molybdenum diselenide, tungsten disulphide and tungsten diselenide. We show that the application of a perpendicular electric field simultaneously modulates the band gaps of bulk and edge-states. We further observe that tungsten diselenide undergoes a semi-metallic intermediate state during the phase transition from topological to normal insulator. The tuneable edge conductance, as obtained from the Landauer-Büttiker formalism, exhibits a monotonous increasing trend with applied electric field for deca-nanometer molybdenum disulphide, whereas the trend is opposite for other cases.

- Quantum transport modeling
- 2D Quantum Materials: 2D Magnets, CDW, Topological Insulator

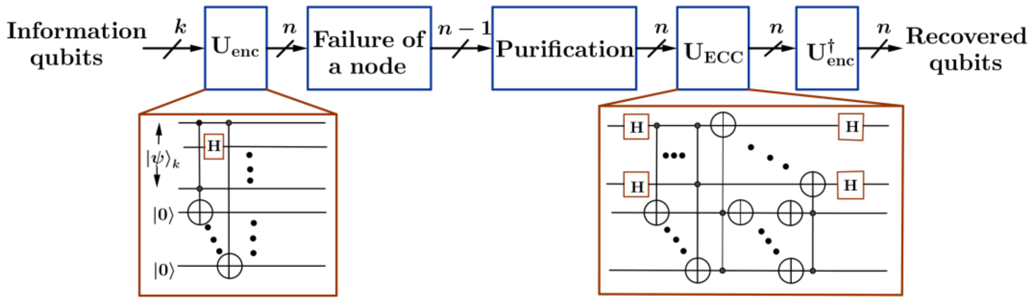
Control and Measurement Hardware

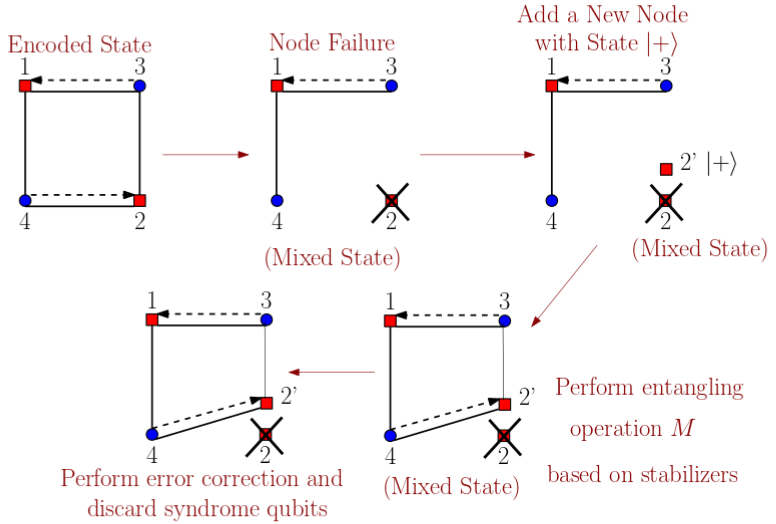


Chetan S. Thakur and team in collaboration with Physics researchers

Quantum Information Processing

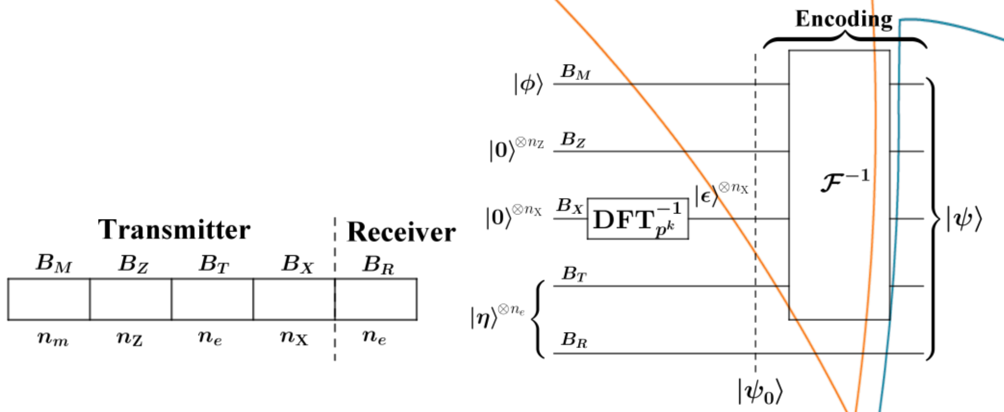
Recovery of quantum distributed storage from a node failure using modified graph state codes





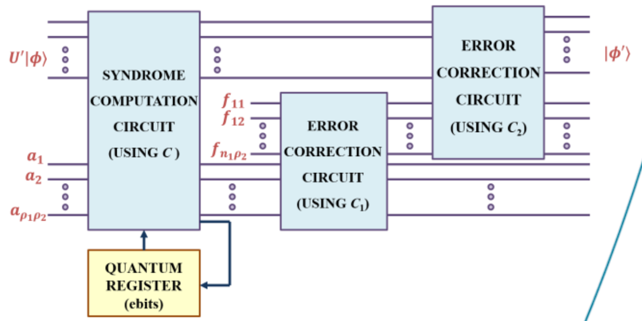
- A. Raina, P. J. Nadkarni, and S. S. Garani, Quantum Info. Proc., **19 (70),** Feb. 2020.
- P. J. Nadkarni, A. Raina, S. S. Garani, “Modified graph state codes for single node recovery in quantum distributed storage” (Accepted in Physical Review A)

Entanglement-assisted Reed Solomon codes



- P. J. Nadkarni and S. S. Garani, IEEE Information Theory and Applications Workshop 2019, San Diego, Feb. 2019.

Entanglement-assisted Tensor Product codes



- P. J. Nadkarni and S. S. Garani, IEEE Information Theory Workshop 2017, Kaohsiung, Nov. 2017.

EECS Faculty Working in Closely Related Areas

- https://iisc.ac.in/initiative-on-quantum-technologies/
- Other related groups (from EECS)
  - – Faculty in theoretical computer science related research cluster
  - – Faculty in microelectronics research cluster
  - – Faculty in photonics research related cluster

Hiring Focus Areas

- We welcome and seek bright and highly motivated individuals in all quantum areas from theory to experiments that can work within EECS and research clusters.

- CSA department has a strong algorithms and complexity group ~ 7 faculty members
  - No presence in quantum computing, except in post-quantum crypto.
  - CSA seeks faculty members in the broad area of quantum computation.

- Hands-on experimentalists and those that can build practical quantum systems (research clusters within EECS).
  - Integrated circuit design: Ultra low temperature electronics
  - Nanoelectronics as well as Spintronics based quantum devices
  - Science of quantum materials, device development and applications