Quantum Computation and Communication, broadly speaking

Prof. Pranab Sen,

Tata Institute of Fundamental Research, Mumbai

Abstract:

This talk will introduce the concepts of quantum computation and communication. No prior exposure to these concepts shall be assumed. On the way we shall take a peek at the seminal contributions of Bennett, Brassard, Deustch and Shor, the 2022 Breakthrough Laureates in fundamental Physics. We shall also tip our hats to the contributions of Aspect, Clauser and Zeilinger, the 2022 Nobel Laureates in Physics. The fact that both the Breakthrough Laureates as well as the Nobel Laureates of 2022 have some connection to quantum computation and communication reminds us of the old saying "No one can resist an idea whose time has come!"

Aerial Quantum Key Distribution

Dr Anindita Banerjee,
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Abstract:

Quantum Entanglement a unique property of quantum mechanics is leveraged to establish quantum secure communication and it is also essential for working of quantum computers. It is critical to develop the technology to generate and distribute entanglement (entangled states) for both the purposes. The spatial distribution of quantum states comes under the branch of quantum communication (QC). The future quantum secure network and a quantum network will require reconfigurable nodes easily provided by free space quantum communication (QC). This can be achieved using three approaches (1) direct ground-to-ground free space QC, (2) satellite QC and (3) Drone based QC. First technique is distance limited. The second technique provides longer coverage, however, there are several challenges. We will discuss how Drone QKD can be used to address this challenge and the merits associated with it.

Cryogenic controller ICs for Quantum Computers

Prof. Mustafijur Rahman,

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Abstract:

Quantum computers have unparalleled potential in exponentially speeding up intractable computing problems including secure communication, meteorology, drug discovery and so on. Superposition combined with quantum phenomenon of entanglement enables quantum computer to perform vast complex computation in one shot and makes it fast enough to outpace even today's state-of-the-art supercomputers. However, a fault tolerant quantum computer requires a million or more qubits and it is not trivial to scale up today's technology to this extent. This talk will give an overview of recent trends in quantum computing hardware including popular solid-state qubits and a cryogenic controller chip necessary to control multiple qubits paving the way for realizing a scalable quantum computer. This talk will briefly introduce qubit read/write circuits and highlight the challenges in the design of the state-of-the-art quantum computing hardware and cryogenic controller IC.

Quantum Networks

Prof. Aditi Sen De,

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Abstract:

The quantum theory of nature, formalized in the first few decades of the 20th century, contains elements that are fundamentally different from those required in the classical description of nature. Based on the laws of quantum mechanics, in recent years, several discoveries have been reported that can revolutionize the way we think about modern technologies. I will talk about such inventions in the field of communication and some of our recent results in building communication networks.

Topological Superconductivity and its implication for quantum computers

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The discovery of Dirac and Weyl semimetals (WSM) has brought forth the condensed matter realization of Dirac/Weyl fermions, which were previously theorized as low energy excitations in high energy particle physics. In the recent past we have witnessed some exceptional developments in chalcogenide and pnictide materials that have been identified with such properties. The age-old industrial thermoelectric materials based on selenides and tellurides have been turned into topological insulators and Weyl semi-metals. Superconductivity derived from such exotic systems promises to usher-in new understanding of correlated electronic systems. In this talk we shall review electromagnetic properties of some of the topological superconductors and identify the characteristics required for its implementation as a "qubit". A brief discussion on current trends in realizing quantum computers by using properties of topological superconductors will be included.

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The prospects and challenges of quantum computing with spin qubits

Prof. S. Mahapatra,

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Abstract:

The spin states of electrons represent a promising two-level-system for realization of a scalable quantum computing architecture. As the naturally abundant isotope of Silicon (28Si) has zero nuclear-spin, (enriched) Si serves as an ideal solid-state environment to host electron spin qubits, ensuring long coherence and relaxation times. Moreover, the physical implementation of the spin quantum computing architecture relies on the mature CMOS process technology, enabling large scale integration of dense arrays of spin qubits. In the past couple of years, tremendous advances have been made in this field, with demonstration of high-fidelity control, manipulation, measurement and of spin qubits, as well as methods to enable qubit coupling over long-distances. In this talk, starting from the fundamental concepts of spin quantum computing, I will present a brief overview of the prospects and challenges towards development of a scalable architecture.