Quantum Information Science (QIS)

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There is a worldwide research effort exploring the potential of quantum mechanics for applications. The field began with Feynman's proposal in 1981 to build a computer that takes advantage of quantum mechanics and has grown enormously since Peter Shor's 1994 quantum factoring algorithm. The idea of utilizing quantum mechanics to process information has since grown from computation and communication to encompass diverse topics such as sensing and simulations in biology and chemistry. Leaving aside the extensive experimental efforts to build controllable large-scale quantum devices, theory research in quantum information science (QIS) investigates several themes:

- **Quantum algorithms and complexity**
    - If a perfectly functioning quantum computer were built, which problems could it solve faster than conventional computers, and which problems do not admit any speedup?
    - What is the fundamental limitation in the computational power of our universe governed by quantum mechanics?
- **Quantum information theory**
    - How can we store, transfer, or manipulate quantum information in the presence of noise?
    - How can we efficiently communicate and compute in the presence of errors?
    - What are the basic properties of quantum entanglement and information?
- **Measurement and control**
    - How can we efficiently manipulate and characterize quantum devices?
    - Apart from computations and communications, what other applications can benefit from quantum hardwares?

    - What are the ways to improve applications such as ultra-sensitive sensors or precise clocks?
- **Applications and connections**:
    - How can ideas from QIS contribute to other research areas as diverse as convex optimizations, black holes, and exotic quantum phases of matter?
    - Is there a unified framework to efficiently describe quantum entanglement and information in complex systems?

Research at NMU-NITheCS in QIS will also focus on new quantum algorithms, efficient simulations of quantum systems, methods to characterize and control existing or near-term quantum hardware, connections to many-body physics, applications in high-energy physics, and many other topics.