

QUANTUM INFORMATION SCIENCE AND TECHNOLOGY

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Quantum information is a field that embraces multiple different scientific and technological disciplines, which include mathematics, physics, electrical engineering, computer science and engineering, etc., and it has huge implications for practical applications, such as cryptographic communications, algorithmic and computational advances, and high-precision measurements and devices. As its title implies, unlike its “classical” counterpart, quantum information fundamentally relies on “quantum” characteristics of nature, for instance, the no-cloning theorem, quantum superposition, quantum entanglement, etc.

The most popular application in quantum information is quantum cryptography. In short, security of a typical quantum cryptographic protocol relies on the no-cloning principle of quantum mechanics; in layman’s terms, quantum information cannot be copied, and hence, a secret message between designated parties cannot be compromised. Developing such devices is one of the primary goals of my workplace, Korea Institute of Science and Technology. In the near future, these devices will be available at every site where high-security is a must, and we are aiming to install them as necessary parts of social infrastructure within a decade.

Because quantum nature of the universe is generally observable on a small scale, typically comparable to the nanoscale, quantum mechanics can also be used to enhance the performance of small devices that are traditionally made of electronics only. For example, one can replace an electric current in a circuit with a flow of light that is guided by fabricated nanoscale photonic structures to interact with quantum objects, like atoms or artificial atoms. If we were to replace electronic parts with photonic parts, there are huge advantages in size, power consumptions, precisions, etc. A numerous researchers in the field are working hard to make advancements in such technology, whose applications include chip-scale timepieces that are as accurate as an atomic clock, high-resolution low-noise imaging systems, and small electromagnetic sensors. Those devices are essential for many further applications, and we believe that such advancements in quantum devices will bring benefits to various aspects of humanity.

Finally, the implementation of a quantum computer can be an ultimate goal for quantum information science and technology. There are various physical systems, such as photons, ions, atoms, superconducting circuits, etc, to implement quantum computer. In KIST, we have been studying photonic system that can be utilized in quantum communication including quantum cryptography. The research will be further expanded to other physical systems and by hybridizing two or more different physical systems, we will explore the possibilities to realize quantum computation.