Microwave Photonics and Quantum Applications

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The growing recent interest in quantum technologies can arguably be traced back to the Schor algorithm that offered the possibility of finding prime factors of large integers. This quantum algorithm revealed the possibility of breaking the code of encrypted communication with its profound ramifications for governments, financial institutions, and others. The Schor algorithm prompted the development of quantum computers and quantum communication, which in turn led to growing research in other areas where quantum phenomena can bring about advantages beyond what is possible with classical systems. Today, Quantum Technology is generally referred to the four areas: quantum computers, quantum sensors, quantum communication and quantum networks.

Quantum computers, where qubits perform the analogous tasks to bits used in digital computing, are under development in many international groups. While there are various approaches for realization of quantum computers, they all fall in categories of superconducting qubits, trapped ion qubits, neutral atom qubits, and photonic qubits. In the first instance, computing systems based on superconducting qubits operate with microwave pulses. In all other instances, photons are directly or indirectly (through interaction with ionized and neutral atoms) are responsible for generating the qubits. These computers are also expected to evolve to networked systems, so that, generally speaking, all quantum computer systems rely on techniques of microwave photonics for their operation.

In the case of quantum sensors, such as atomic clocks, atom based magnetometers, gyros and field sensors, the need for interaction of light with atomic systems further require techniques developed or utilized in microwave photonics. The same statement holds true for quantum communication and quantum networks, where reliance on transport of light in free space or optical fiber relies on many approaches developed for microwave photonics applications.

A major feature of all applications in quantum technology is the need for elimination of sources of loss and degradation of coherence that destroy the fundamentally quantum phenomena such as entanglement. In many cases, low noise systems required are similar to microwave photonics systems operating with low noise figure. This particular similarity represents the opportunity for both fields, quantum technology and microwave photonics, to enrich each other through further advances.

In this talk detailed description of the interplay between advances in microwave photonics and quantum technologies will be presented, with an emphasis on the opportunities it represents for scientific investigations, for technology and for industrial applications.