Quantum Information Processing with Quantum Metasurfaces

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In this talk, we propose quantum metasurfaces for implementing various quantum information tasks. A quantum metasurface is a device whose optical response is controlled by the quantum state of a two-level control atom. We demonstrate that the transformation defining a quantum metasurface is analogous to a classical Fredkin universal gate, suggesting its use for information processing. In particular, we show that it is possible to implement quantum teleportation between control atoms of two distant quantum metasurfaces, mediated by coherent light states. This leads to a high-fidelity, high-probability teleportation scheme. We also demonstrate that this scheme is robust against various error sources. Subsequently, we study entanglement swapping and quantum repeaters, which achieve high performance through the use of coherent states. Furthermore, we show that it is also possible to implement quantum state transfer. We also focus on the problem of estimating the quantum states of propagating light and show that an array of quantum metasurfaces allows us to estimate the Wigner function at any point in phase space. Other pseudo-distribution functions can also be obtained.

We will also briefly discuss recent results on quantum state estimation for distributed quantum computing, quantum computer synchronization, and applications of quantum information tools to the determination of post-Newtonian parameters in general relativity.