Spin-photon interfaces for quantum computing and quantum communication

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Non-classical states of light, such as single photons and entangled states, are essential for novel quantum technologies, including photonic quantum computing, quantum communications and key distribution, and the quantum internet. Large two-dimensional highly entangled 'cluster' states of photons are a class of so-called graph states which constitute a universal resource for quantum computing based on the 'one-way' model [1]. This model is equivalent to the circuit model, with the difference that all the entanglement is created upfront, and the computation proceeds with adaptive single-qubit measurements alone. Photons also carry information between nodes in a network and can be used for long-distance entanglement swapping via intermediate nodes known as quantum repeaters. Photonic graph states can be used for such quantum networks, as they can overcome the need for a quantum memory in typical quantum repeater schemes [2]. A crucial question is therefore how these states can be created efficiently. Most commonly graph states are created via optical elements and post-selection, an approach that is inherently probabilistic. To address this shortcoming, it was proposed to use quantum dots to generate one-dimensional photonic cluster states deterministically [3]. Our recent work focused on the deterministic generation of photonic graph states for quantum repeaters from optically active spin systems and revealed that very modest resources are required [4]. Recent progress [4-6] in the creation of such states from spin-photon interfaces based on spinful quantum emitters such as quantum dots and color centers will be presented.

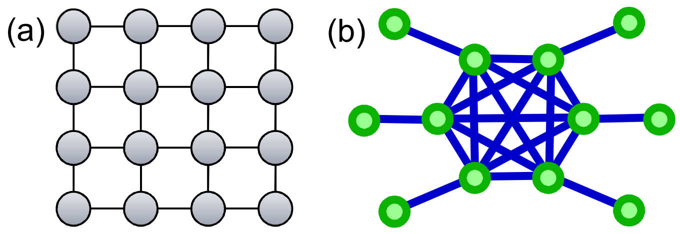

Figure 1:(a) a 2D cluster state (b) a repeater graph state. Circles denote qubits and lines represent entanglement.

References

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