# Deterministic and Reconfigurable Graph State Generation with a Solid-State Quantum Emitter

**H. Huet**[1], P. Ramesh[1,2], S. Wein[3], P. Hilaire[3], N. Coste[1,4], N. Somaschi[3], M. Morassi[1], A. Lemaitre[1], I. Sagnes[1], M.F. Doty2, O. Krebs[1], L. Lanco[1,5], D. A. Fioretto[1,3] and P. Senellart[1]

[1]Université Paris-Saclay, CNRS, C2N, Palaiseau, France
[2]University of Delaware, Newark, USA
[3]Quandela SAS, Palaiseau, France
[4]School of Mathematical and Physical Sciences, Sydney, Australia
[5]Université Paris Cité, CNRS, C2N, Palaiseau, France

helio.huet@universite-paris-saclay.fr

In this work, we demonstrate the deterministic and reconfigurable generation of spin-photon entangled graph states using a semiconductor InGaAs quantum dot, embedded in a micropillar cavity (Fig. 1a). Our protocol, based on the Lindner and Rudolph scheme [1], leverages the spin precession and synchronized optical pulses (Fig. 1b,c) to vary the entanglement topology at will via fully controlled unitary gate U(θ,φ). This allows us to generate caterpillar graph state (Fig. 2), the most general type of graph state that can be produced by a single quantum emitter. We then disentangle the spin from the photonic chain and reconstruct the photons polarization state via quantum state tomography, achieving fidelities up 80%. The deterministic and reconfigurable generation of graph states demonstrated here represents a crucial step towards scalable entanglement resources and practical, fault-tolerant measurement-based quantum computation.

## References

[1]. N. H. Lindner and T. Rudolph, Physical Review Letters, vol. 103, p. 113602, 2009.
[2]. A. Greilich, S. E. Economou, S. Spatzek, et al. Nature Physics, vol. 5, pp. 262–266, 2009.

## Figures

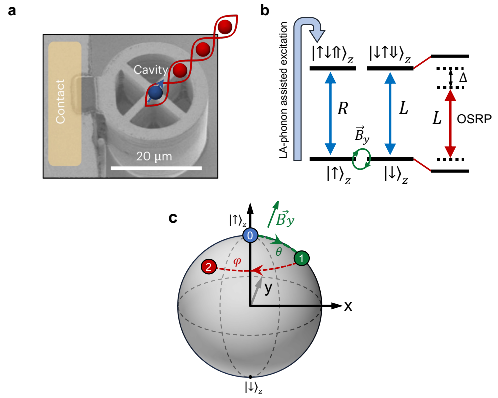


**Figure 1: a.** Scanning electron micrograph of an electrically-contacted QD-micropillar cavity device and schematic representation of entanglement between QD spin and emitted photons. **b.** Optical selection rules of a negatively charged QD under small (< 100 mT) transverse magnetic field and optical spin rotation pulse [2] (OSRP) enabling the spin rotation about the y (angle θ) and z-axis (angle φ), respectively. **c.** Representation of complete spin control in the Bloch sphere.

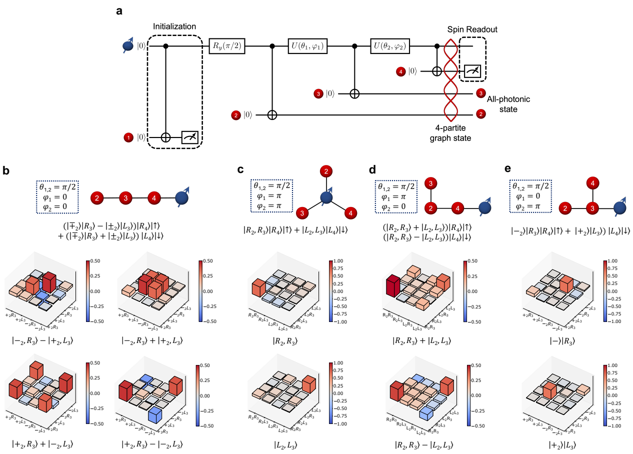


**Figure 2: a.** Optical excitation sequence and corresponding quantum circuit diagram used to generate arbitrary 4-partite graph state. The Larmor precession of the spin acts as a Ry(θ) gate, while the OSRP serves as a Rz(φ) gate, together forming an unitary gate U(θ,φ). **b-e**, Graph representation, unitary gate parameters ($θ_{1,2}$ and $φ_{1,2}$), and corresponding real part of the two-photon density matrix, conditioned on photons #1 and #4 being measured in R/R (top) or R/L (bottom) for various entanglement topology.