Generation of heralded entanglement between distant quantum dot hole spins

<u>Aymeric Delteil</u>,[1] Sun Zhe,[1] Wei-bo Gao,[1,2] Emre Togan,[1] Stefan Faelt,[1] Ataç Imamoğlu[1]

[1] *Institute of Quantum Electronics, ETH Zurich, 8093 Zurich, Switzerland*
[2] *Division of Physics and Applied Physics, Nanyang Technological University, Singapore 637371*
Adresse email de l'orateur : delteila@phys.ethz.ch

Entanglement plays a central role in fundamental tests of quantum mechanics as well as in the burgeoning field of quantum information processing. Particularly in the context of quantum networks and communication, a major challenge is the efficient generation of entanglement between distant stationary (spin) qubits. Here, we report the realization of heralded quantum entanglement between two semiconductor quantum dot spins separated by more than five meters. Our results extend the previous demonstrations of distant spin entanglement in single trapped ions or neutral atoms, in atom ensembles and nitrogen vacancy centers to the domain of artificial atoms in semiconductor nanostructures that allow for on-chip integration of electronic and photonic elements. Moreover the efficient spin-photon interface provided by self-assembled quantum dots[1] allows us to reach an unprecedented rate of 2300 entangled spin pairs per second, which represents an improvement of four orders of magnitude as compared to prior experiments[2].

The entanglement generation scheme relies on single photon interference of Raman scattered light from both dots[3]. A single photon detection projects the system into a maximally entangled state. We developed a delayed two-photon interference scheme that allows for efficient verification of quantum correlations. Our results lay the groundwork for the realization of quantum repeaters and quantum networks on a chip.

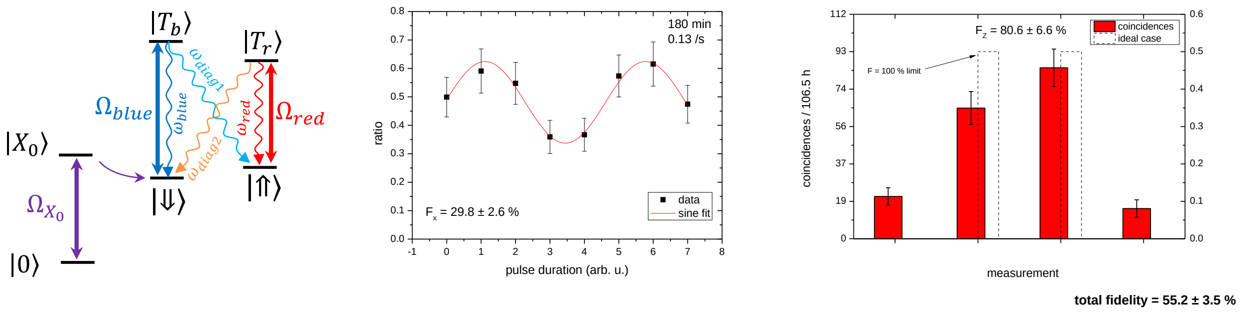

Figure 1 : (a) Energy level of the quantum dots. The two optically generated hole ground states serves as the stationary qubit to be entangled; (b) Quantum correlations of the generated entangled state, determined by the normalized two-fold coincidences between the scattered photons during the entanglement generation pulse and a non-local measurement pulse. (c) Classical correlations, measured by three-fold coincidences between photons detected during the entanglement pulse and two measurement pulses, performing measurement of the four combinations of the spin eigenstates.

[1] W.-B. Gao *et al.*, Nature **491**, 426 (2012)
[2] L. Slodička *et al.*, Phys. Rev. Lett. **110**, 083603 (2013)
[3] C. Cabrillo *et al*. Phys. Rev. A **59**, 1025 (1999)