Solid-state ensemble of highly entangled photon sources at rubidium atomic transitions

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Polarization-entangled photon pairs play a key role in scalable quantum communication applications. They enable secure quantum key distribution [1], robust qubit transfer via teleportation [2] and can be used to distribute entanglement between separated computation nodes, rendering even a “quantum internet” possible [3].

However, deterministic sources of highly entangled photon pairs challenge the community for already more than two decades. Semiconductor quantum dots are among the leading candidates for this task, offering pure single photon pair emission with high internal quantum efficiency, outperforming probabilistic sources based on spontaneous parametric down-conversion.

Despite various investigated structures and material systems [4,5,6,7], most quantum dot species still suffer from drawbacks such as extremely low yield, low degree of entanglement and poor wavelength control, blocking the way for scalable applications.

Here, we show that with an emerging family of GaAs/AlGaAs quantum dots grown by droplet etching and nanohole infilling, it is possible to obtain a large solid-state emitter ensemble of highly entangled photons pairs on a wafer - without any post-growth tuning [8]. Under pulsed resonant two-photon excitation, all measured quantum dots emit single pairs of entangled photons with ultra-high purity, high degree of entanglement and ultra-narrow wavelength distribution at rubidium transitions. Therefore, this material system is an attractive candidate for the realization of a solid-state quantum repeater - among many other key enabling quantum photonic elements.

[1] A. K. Ekert, Phys. Rev. Lett. **67**, 661 (1991)
[2] C.H. Bennett *et al.*, Phys. Rev. Lett. **70**, 1895 (1993)
[3] H. J. Kimble, Nature **453**, 1023-1030 (2008)
[4] G. Juska *et al.*, Nat. Photonics **7**, 527 (2013)
[5] M. Müller *et al.*, Nat. Photonics **8**, 224-228 (2014)
[6] M. A. Versteegh *et al.*, Nat. Commun. **5**, 6298 (2014)
[7] T. Kuroda *et al.*, Phys. Rev. B **88**, 031306 (2013)
[8] R. Keil *et al.*, Nat. Commun. **8**, 15501 (2017)

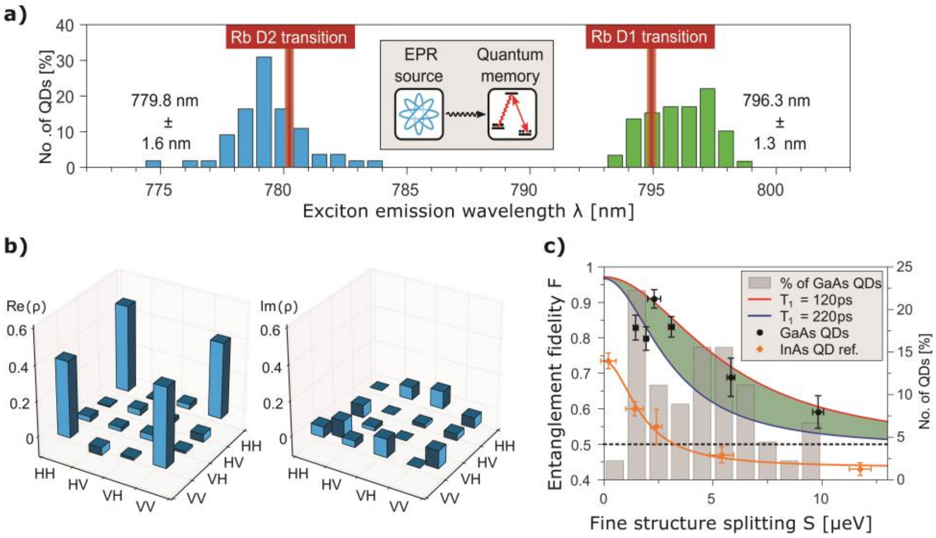

Fig. 1: **a** Exciton emission wavelength distribution for two different samples tailored for coupling to the D1 and D2 atomic transitions of Rubidium. **b** Real and imaginary part of the two-photon density matrix **c** Entanglement fidelity of GaAs/AlGaAs QDs as a function of fine structure splitting S