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PHOTONICS LECTURE

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LECTURE HALL A1

Time-bin entangled photons from semiconductor quantum dots

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For long-distance quantum communication, a source of entangled photon pairs is essential for the implementation and usage of quantum information protocols such as quantum teleportation and quantum key distribution. However, photons that are sent through optical fibers suffer from decoherence due to polarization mode dispersion, which results in a gradual loss of entanglement when polarization-entangled photon pairs are used. In contrast, time-bin entangled photons pairs are more robust in optical fibers. Generating these photon pairs requires precise temporal control of a photon pair source. Several proposals exist on how time-bin entangled photon pairs can be created from quantum dots or by parametric down conversion. For deterministic generation of the entangled state, semiconductor quantum dots are our system of choice, as they provide on-demand generation of photon pairs with a high yield. Additionally, the presence of optically dark exciton states in quantum dots make the deterministic preparation of time-bin entangled states possible [1,2].

In this talk, I give an overview of the different approaches to realization of time-bin entanglement and how it can be understood theoretically. For this, the density matrix of the photonic state is retrieved from calculations of the temporal dynamics of the quantum dot. Additionally, I discuss options to optically excite the dark exciton states using strong magnetic fields in combination with chirped laser pulses. Comparing the findings to recent experimental results, it shows that determinisic time-bin entanglement from quantum dots is now within experimental reach.

References

[1] C. Simon and J.-P. Poizat, Phys. Rev. Lett. 94, 030502 (2005)

[2] M. Neumann, F. Kappe, Thomas K. Bracht et al., Phys. Rev. B 104, 075428 (2021)