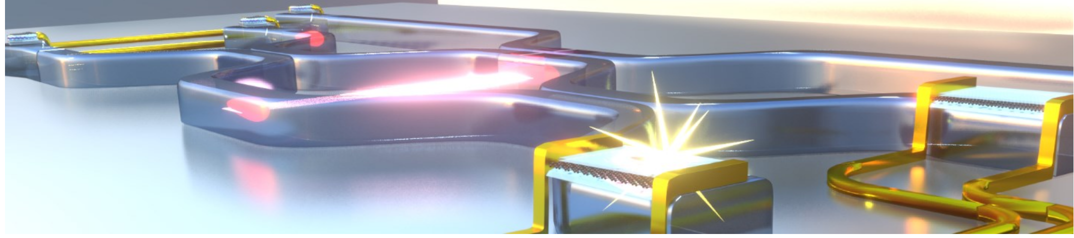

Master's Thesis: Quantum Photonics with 2D materials

Prof. Kai Mueller's group, Walter Schottky Institut & MCQST

(project leader: Dr Matteo Barbone)

2D materials are at the forefront of an ever growing research interest for applications in quantum information science and technology. Due to unique properties such as ultimate photon extraction efficiencies, nuclear spin-free isotopes, integration with silicon technology and potential for scalability, 2D materials have all the tools to overcome the critical limitations set by conventional material systems, and become the building blocks for future solid-state quantum technological applications[1].

However, current quantum light emitters based on 2D materials have random emission energy. This prevents photon indistinguishability[2], a non-negotiable requirement for advanced quantum information. Moreover, the current fabrication processes are incompatible with silicon photonics and on-chip integration. To unleash the full potential of 2D materials in our field, we are currently working towards realizing a novel material platform based on fully deterministic 2D Quantum Dots. In the first part of the project you will make nm-sized 2D Quantum Dots top-down, using a combination of near-resolution limited electron beam lithography and Reactive Ion Etching on 2D materials-heterostructures. Such quantum dots will be both positioning-wise and energy-wise deterministic, scalable and will overcome the critical functional limitations of the current solid-state quantum emitters in 2D materials. You will study the optical properties of such quantum emitters at cryogenic temperatures and with magnetic fields. Further, you may have the option of integrating such quantum emitters and their arrays with diode structures and waveguides, realizing and studying spin-qubits, with an eye towards qubit registers made of arrays of coupled but independently controlled quantum-dots. No other current solid-state system can do so.

You should: enjoy science and be curious! Curiosity and genuine interest for what you do make you overcome most obstacles and fill most gaps, although a decent background on solid-state physics and optics is strongly encouraged. You should also be motivated to getting involved in a cutting-edge problem, as this project is challenging (not gonna lie!) but potentially ground-breaking. Since you will work in close collaboration with a small team, you should also enjoy working with others, don't expect to always have the last word, have a knack for a good laugh and shouldn't take yourself too seriously, it will help you overcoming the usual frustrations of research 😊. Hands-on experience in optics, electronics, programming or cleanroom fabrication also wouldn't hurt, but is entirely secondary to your personal motivation and commitment to this fascinating project.

You will get: experience on state-of-the-art (or beyond) nanofabrication, electro- and magneto-optical spectroscopy, and cryogenics in excellent laboratories; a sound understanding of the physics of 2D materials and solid-state quantum optical systems; and if everything goes well a nice (or even amazing) paper in a top journal. Maybe most importantly, you will have fun along the way.

For enquiries feel free to write to Matteo: Matteo.Barbone@wsi.tum.de

[1] Igor Aharonovich, Dirk Englund, and Milos Toth, Nat. Photon. **10** (10), 631 (2016)
[2] C. Palacios-Berraquero, et al., Nat. Commun. **8**, 15093 (2017)