

Abstract for the general public

The goal of this project is to provide a comprehensive experimental and theoretical description of the charge and spin properties of strain-free GaAs quantum dots (QDs), focused on the hole-spin properties.

A QD is a complex nano-sized object: it consists of about 100,000 individual atoms. QDs form the basis of excellent single-photon sources. The sources are fast: a photon can be created each nano-second. The sources are also pure (small probability of multi-photon emission) and coherent (high two-photon interference visibility). Furthermore, a QD can be equipped with a single electron. Exploiting the spin degree of freedom, a QD turns into a source of cluster states. As such, QDs will play an important role in quantum technology, specifically quantum communication and photonic quantum information processing.

In this project, we propose a joint experimental-theoretical effort, based on the complementary competence of the participating Swiss, German and Polish research groups (experimental semiconductor physics, materials science, atomistic theory, respectively). We will build on the existing fruitful collaboration, leading to a full understanding of the key physical properties of GaAs QDs. We will combine state-of-the art growth techniques and spectroscopic methods with advanced theoretical modeling based on simulations at the atomistic level. In this way, we will go beyond the effective-material descriptions and build the understanding of the system properties upon detailed microscopic knowledge. This whole process will support the emerging applications of this novel system in quantum technologies.

The proposed research aims at answering two key questions regarding the physical properties of strain-free GaAs QDs. The answers will determine their role in quantum technologies. The questions are: How are the key physical properties of the GaAs QDs determined by their shape, size, composition and environment? How can one design strain-free QDs for optimal quantum control?