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Fluorine donors in ZnSe: A raising multifunctional qubit for photonics mediated quantum information technology

The classic II/VI semiconductors (ZnSe, MgSe, CdSe) and their alloys are an emerging material system to implement building blocks for solid-state quantum information devices. In these materials, nuclear spins can be depleted and extended coherence times of the same order than that in silicon are expected. However, in contrast to silicon, the II/VI materials provide a direct bandgap and high electronic oscillator strength, which allows for the design of high-brightness quantum optical devices. Doping of ZnSe with fluorine donors (F:ZnSe) grants direct optical access to individual atom-like transitions (e.g. the bound-exciton transition D^0X) of the donors: Upon radiative recombination of a D^0X, an unpaired electron spin qubit remains resident at the fluorine nucleus and forms the key ingredient of our optically controllable quantum devices. In this keynote lecture, we will address the application of isolated single fluorine donors in ZnSe nanostructures as efficient single photon sources (SPS). The latter specifically allows for optically interfacing the electron spin of the neutral fluorine donor through the D^0X transitions in a magnetic field. This provides an elegant way of conversion of quantum states between spins and single photons. Recent key results emphasize the versatility of the fluorine qubit for setting-up a small all-optically controlled quantum network bridging macroscopic distance. This includes the post-selection of polarization-entangled photon pairs emitted from two independent ZnSe:F SPS separated by a distance of about 5 cm and the development of an all-optically readout procedure of the spin-state of the fluorine qubit via spin-dependent optical pumping.

Biography

Alexander Pawlis is an expert in Material Science, Nanotechnology and epitaxy of II/VI and III/V semiconductors. After his PhD in 2004, he started a close collaboration with the group of Professor Yamamoto at Stanford University. They jointly pioneered the first optical controlled single photon sources and spin qubits based on fluorine atoms in ZnSe. After habilitation in 2012, he founded a Junior Research Group at the University of Paderborn, Germany on material science and quantum optics with II/VI materials. Since 2015, he is Group Leader and Member of staff in PGI 9 of Forschungszentrum Jülich.

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