Functional Matter
Designer Materials and Quantum Technologies
Ein fakultätsübergreifendes Kooperationszentrum

Invitation

Quantum Optics with Semiconductor Nanostructures

Jeroen ELZERMAN
ETH Zürich

Semiconductors are host to various quanta that can be very robust against relaxation and decoherence. In particular, semiconductor nanostructures known as quantum dots can controllably confine single electron and hole spins. These trapped single spins are coupled via various mechanisms to the solid-state matrix they are embedded in, giving rise to subtle interactions, for instance with the nuclear spin bath. I will focus on self-assembled InGaAs quantum dots embedded in a GaAs crystal. These nanostructures, with a diameter of around 20 nm and a height of a few nm, are optically active. This has enabled optical spin-state initialization, ultra-fast manipulation and read-out, identifying these quantum dots as ideal model systems for solid-state quantum optics. In contrast to single dots, coupled self-assembled quantum dots have only been studied relatively recently. These coupled structures can be grown by embedding two layers of self-assembled quantum dots, typically separated by 2-20 nm, in a single heterostructure. Such coupled quantum dots can be used to explore interactions between two individual quantum systems.
I will present our recent experiments [1] that demonstrate conditional quantum dynamics, whereby the quantum state of one system controls the evolution of the state of another quantum system. In our case, the probability that one quantum dot makes a transition to an optically excited state is controlled by the presence or absence of an optical excitation in the neighbouring dot. Interaction between the two dots is mediated by the tunnel coupling between optically excited states and can be optically gated by applying a laser field of the right frequency. This interaction mechanism could form the basis of an optically effected controlled-phase gate between two solid-state qubits.

[1] L. Robledo, J.M. Elzerman, G. Jundt, M. Atatüre, A. Högele, S. Fält, A. Imamoglu, Science **320**, 772 (2008)

Friday 29th May 2009
14h00

im Hörsaal des
Atominstitutes der Österreichischen Universitäten.

J. Schmiedmayer