Coherent Precession of an Individual 5/2 Spin

M. Goryca

Institute of Experimental Physics, Faculty of Physics, University of Warsaw, ul. Pasteura 5, 02-093 Warszawa, Poland

Up to now, coherent behavior of an individual spin in a solid have been demonstrated in several two- and three-level systems utilizing i.e. single electron in quantum dot (QD) [1-3] or a nitrogen-vacancy center in diamond [4-5]. Such systems are interesting not only from the scientific point of view, but also from the point of view of future information processing devices and quantum computing. However, more complex multi-level large-spin systems have not been accessible experimentally so far. They have been considered only theoretically, showing i.e. possibility of using them as a multi-qubit systems [6]. This talk summarizes the recent progress in a direct observation of coherent dynamics of an individual Mn$^{2+}$ impurity embedded in a CdTe QD [7], having both electronic and nuclear spin equal to 5/2.

In order to probe the spin state of the single Mn$^{2+}$ impurity we performed a time-resolved measurement of the absorption of a QD containing such an ion. The QD was resonantly excited with two circularly polarized picosecond laser pulses. The energy of the photons was tuned to the transition energy of an exciton-Mn complex with arbitrary chosen spin state of the magnetic ion. The absorption was detected by using the excitation transfer to a neighboring QD and observation of the emission from this dot, similarly to the technique presented previously [8-9]. The delay between the two pulses was precisely controlled so that the second pulse could probe the evolution of the investigated system after the perturbation introduced by the first pulse.

The system under investigation was placed in a magnetic field applied in the Voigt configuration, parallel to the surface of the sample. Under such conditions the spin of the magnetic impurity starts to precess after the pump pulse, which drives it out of the relaxed state. Thus the probability of the absorption of the second pulse (of the same energy as the first one) depends on the delay between the pulses. By measuring this absorption we are able to observe in detail the occupation evolution of different spin states of the system. We also determine the spin dephasing time limited mainly by the crystal field originating from the strain of the QD material. Experimental data are well reproduced with a theoretical model.

[6]. A. Gün et al., Quantum Information Processing 12, 205 (2013).