Towards entanglement transfer from a single photon pair to a single electron-photon pair using spin-resolved light hole excitation

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Quantum entanglement is a phenomenon characteristic of quantum physics, and appears in quantum states of the same kind and the different kinds as well, for example a photon and a spin. Especially the latter can be generated via quantum state transfer and was indeed demonstrated for photon-spin pairs via photon emission from a quantum dot (QD) [1,2]. The state transfer from a photon pair to a photo-spin pair is a more straightforward approach, but still technically challenging. So far we have used a gate-defined GaAs QD to study the entaglement transfer from a polarization entangled photon pair to a pair of a photon and a photo-electron spin in the dot. We previously demonstrated coincident detection of a photon and a photo-electron in the dot from a polarization entangled photon pair [3]. The next step is to readout the photo-electron spin in the dot. Therefore we have developed an electrical spin readout technique to demonstrate angular momentum transfer from a photon to an electron spin in the dot [4]. In this experiment, however, we have used electron-heavy hole (HH) exciton to generate the photo-electron, and it is known that the HH exciton cannot provide the coherent state transfer from photon to photo-electron spin in the dot [5]. On the other hand, the spin-resolved light hole (LH) excitation is appropriate for the quantum state transfer from a linearly polarized photon to an electron spin [4]. In this work we show the experiment of the LH excitation to generate a photo-electron spin with preserving angular momentum.

We applied an in-plane magnetic field of 7 T to the GaAs QD at 25 mK and irradiated a single polarization photon to the QD to generate a single photo-electron (Fig. 1). The photon trapping by the dot is detected using a nearby charge sensor. We first observe resonant excitation of the Zeeman split LH states, in the energy spectrum of single photo-electron trapping efficiency. Then, we adjust the photon energy such that only one of the spin-split LHs is resonantly excited, and irradiate a polarized photon with the polarization of either parallel or perpendicular to the magnetic field onto the double dot having just a spin-polarized electron in one dot. We use Pauli spin blockade in the double QD to read out the photo-generated spin for each event of trapping a single photo-electron [4]. We observe that the blockade probability of the single photo-electron spin significantly depends on the incident photon polarization, indicating that a photon polarization is coherently transfferred to an electron spin with preserving angular momentum [6].

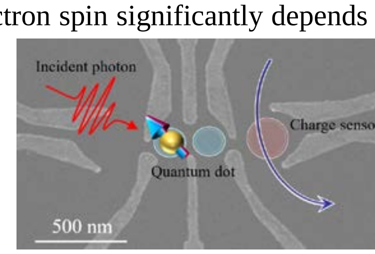

Fig. 1: A SEM photo of the device. Linearly polarized photons are only irradiated onto the QD in the center through an aperture in a metal mask.

References

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