

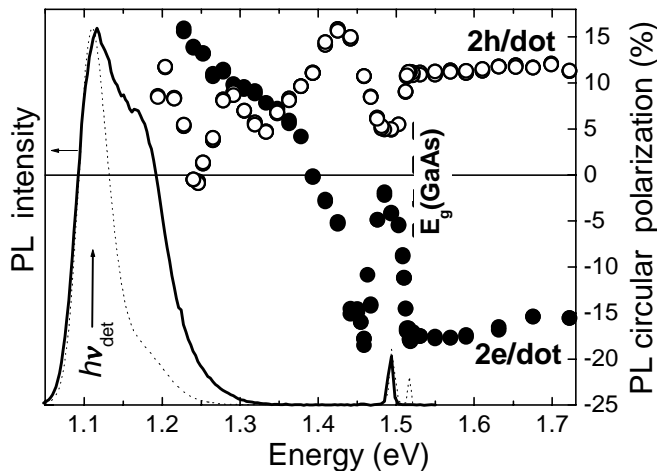
# Optical spin polarization in double-charged InAs self-assembled quantum dots

V.K. Kalevich<sup>1,2</sup>, K.V. Kavokin<sup>1</sup>, M. Ikezawa<sup>2</sup>, T. Okuno<sup>2</sup>, A.Yu. Shiryaev<sup>1</sup>, A.E. Zhukov<sup>1</sup>, V.M. Ustinov<sup>1</sup>, and Y. Masumoto<sup>2</sup>

<sup>1</sup>*Ioffe Physico-Technical Institute, St.-Petersburg 194021, Russia*

<sup>2</sup>*University of Tsukuba, Tsukuba 305-8571, Japan*

Carrier spin relaxation was supposed to be greatly suppressed in quantum dot (QD) structures due to quantum confinement [1]. However, an anisotropic exchange interaction of electrons and holes induced by the dot asymmetry can split the exciton radiative doublet and destroy spin polarization of QD excitons [2]. The anisotropic exchange interaction can be strongly suppressed in charged QDs containing odd number of carriers (including photo-created electron-hole pairs), since such QDs have half-integer spin and the anisotropic exchange does not split spin states due to the Kramers theorem [3]. Indeed, a long-living spin orientation has been observed in negatively charged InAs [4], InP [5], ZnSe [6] quantum dots containing 1 resident electron. As the Kramers theorem is not applicable to the complexes comprising even number of particles, the question of the spin conservation in QDs with even number of resident carriers remained so far open.



This work is an experimental study of optical spin orientation in  $\delta$ -doped InAs/GaAs QDs with 2 resident electrons or holes. Under optical excitation, capture of a photo-generated electron-hole pair into such a QD creates a negative or positive quatrion (double-charged exciton). The spin polarization was determined from the circular polarization of the QD photoluminescence (PL). We have found that the PL polarization is negative (with respect to the exciting light polarization) in negatively charged dots (close circles in Figure) [7] and positive in positively charged QDs (open circles in Figure) under excitation in the GaAs barrier. Negative polarization goes down to zero with the decrease of the excitation intensity while positive one is practically independent of the pump power. As photo-excited holes rapidly lose their spin polarization in the GaAs barrier [8] and are captured to QDs unpolarized, we attribute the PL polarization to optical orientation of electron spins. The observed strong dependence of the PL negative polarization on the pump intensity suggests that optical pumping of resident electrons plays a major role in the effect. A model involving energy- and spin relaxation within the spectrum of the quatrion states explains the negative sign of the polarization.

The finding of a considerable spin polarization in double-charged quantum dots is an evidence of a strong modification of the anisotropic electron-hole exchange in charged quatrions.

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