# アンドープ GaAs 量子井戸における長寿命スピンダイナミクスの起源
# Origin of long-lived spin dynamics in undoped GaAs quantum wells

NTT 物性基礎研 [1], 東北大工 [2] ○眞田 治樹 [1], 国橋 要司 [1], 田中 祐輔 [1], 後藤 秀樹 [1],
小野満 恒二 [1], 好田 誠 [2], 新田 淳作 [2], 寒川 哲臣 [1]
NTT-BRL[1], Tohoku Univ. [2], °Haruki Sanada[1], Yoji Kunihashi[1], Yusuke Tanaka[1], Hideki Gotoh[1],
Koji Onomitsu[1], Makoto Kohda[2], Junsaku Nitta[2], and Tetsuomi Sogawa[1]
E-mail: sanada.haruki@lab.ntt.co.jp

Finding a way to preserve spins in non-magnetic semiconductors is essential for future spin-based electronics. The spins of excitons have been widely explored because the polarization-dependent selection rule of inter-band optical transition provides rich information about their spins [1]. However, the time scale on which we can measure the exciton spins is limited by the radiative lifetime, which is often less than 1 ns. In this report, we discuss the origin of the unexpectedly long decay time (>10 ns) of a Kerr rotation (KR) signal observed in an undoped GaAs quantum well (QW).

We grew an undoped 20-nm-thick GaAs/AlGaAs (001) QW by MBE, and carried out time and spatially resolved photoluminescence (PL) and KR measurements at 8 K. The main PL and PL excitation (PLE) peaks assigned to the bright exciton had the linewidths narrower than 0.7 meV, indicating that the crystal quality is high enough for us to discuss the exciton behavior. Figure 1 shows that a component of the KR signal survived for 16 ns in a small area (~ ϕ6 μm) of circularly polarized pump laser focused on the sample. This decay time is one order of magnitude longer than the radiation lifetime measured with a streak camera. The decay time decreased as we increased the temperature or broadened the pump spot size. We also observed the spin precession frequency in an external magnetic field shifted when we changed the direction of the pump circular polarization. This suggests that non-equilibrium electron spins polarize host nuclear spins, and the electron spins experience an additional effective magnetic field created by the polarized nuclei. This fact supports the presence of electron spins involving the long-lasting KR signal.

A probable origin of the observed long KR decay is the existence of spin-polarized dark excitons. A dark exciton, which is formed with an electron ($S = \pm 1/2$) and a hole ($J = \pm 3/2$), has a total angular momentum of $\pm 2$, and thus it cannot be directly excited or emit photons by inter-band transition [2]. We consider that the dark excitons are formed via hole-spin flip process, and KR can be used to probe their spin states; the probe light polarization is affected by the unbalanced occupation of different electron and hole spins when the dark excitons reside in the QW. Additional data (not shown here) also gave us the opportunity to discuss spin diffusion and spin-orbit interaction for the dark excitons, which have not previously been closely investigated. The ability to access the dark exciton spins might offer the possibility of memorizing quantum information in solid state systems.

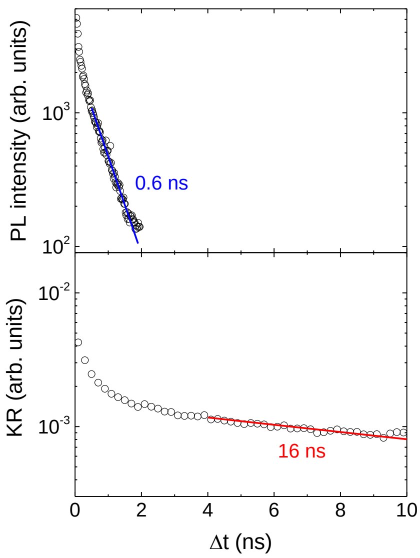


Fig. 1 Time evolution of PL and KR measured at around the wavelength of the bright exciton peak.

This work was supported by JSPS KAKENHI Grant Numbers JP15H05699 and JP16H03821.

[1] A. Vinattieri *et al.*, APL **63**, 3164 (1993), T. Amand *et al.*, PRL **78**, 1355 (1997).
[2] D.W. Snoke *et al.*, PRB **55**, 13789 (1997).