# Transfer from Structured Light Polarization to Persistent Spin Helix State in GaAs/AlGaAs Two-Dimensional Electron Gas

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In III-V compound semiconductors such as GaAs/AlGaAs two-dimensional electron gases, there are two types of spin-orbit interactions (SOIs), called Rashba SOI and Dresselhaus SOI, which provide electron spins with effective magnetic fields corresponding to their momentum. When the amplitudes of the effective magnetic fields through these SOIs are equal, the precession motion of the electron spins becomes coherent, and the spatial structure of the electron spins becomes robust. This state is called the persistent spin helix (PSH) state [1,2], where the coherently rotated spins form spatial spin structures. Recently, structured light has been utilized to realize various patterns of spins and structures in solid states [3]. Here we combine the structured light polarization and spatial spin structure in semiconductor two-dimensional electron gas and enable the spatial structure of electron spins with an arbitrary period.

The sample was a (001)-oriented 20 nm GaAs/AlGaAs quantum well structure, where the Rashba and Dresselhaus SOIs are close to the PSH condition. The dynamics of the perpendicular spin component $S_z$ at $T = 15$ K were detected using spatiotemporal Kerr rotation (STRKR) microscopy with pulsed pump and probe lasers. The pulsed pump laser holds a spatial structure of light polarization by a spatial light modulator (SLM) and is focused onto the sample surface with a spot diameter of around 100 μm.

Figure 1 shows the circular polarization component of the reflected image from the sample captured by a CMOS camera. This means that the spatial structure of the polarization was generated by the SLM. By using this as a pump light, direct generations of the spatial structure of electron spins were successfully achieved due to the optical selection rule specific to III-V compound semiconductors, i.e. the direction of the excited electron spins is determined in response to the helicity of the light.

By controlling the SLM, it was also possible to transfer the structured light polarization to the wave-like spatial structures of electron spins with periods as small as 5 μm. Measurements of the time evolution of these different periods showed that the spatial structure of electron spins with a period $\lambda \sim 8$ μm was the most robust. These results were consistent with the theory that under the PSH state, the electron spins have coherent precession, and therefore the spatial structure of the electron spins equal to their precession motion length becomes robust.

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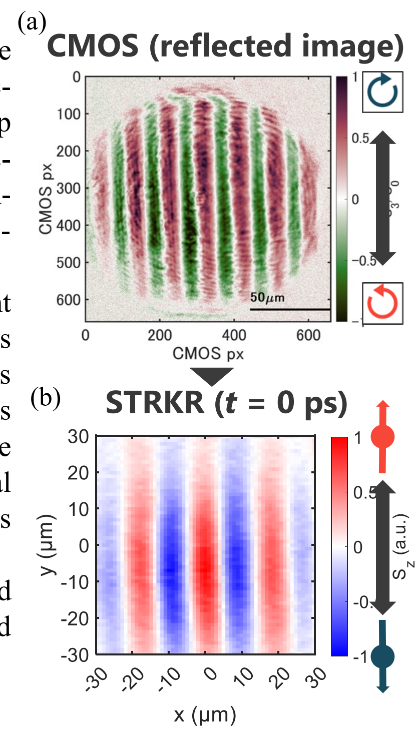


Fig.1. (a) Spatial structure of the polarization of the pump light.
(b) Spatial structure of the perpendicular spin component.

References

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