Graduate Program in Spintronics Seminar

Control of Spin Relaxation in Disordered Quantum Wells and Nanowires

1:00-2:00 pm

Thursday, October 3 2019

Room 102, Education and Research Building [B01]
School of Engineering,
Aobayama East Campus, Tohoku University

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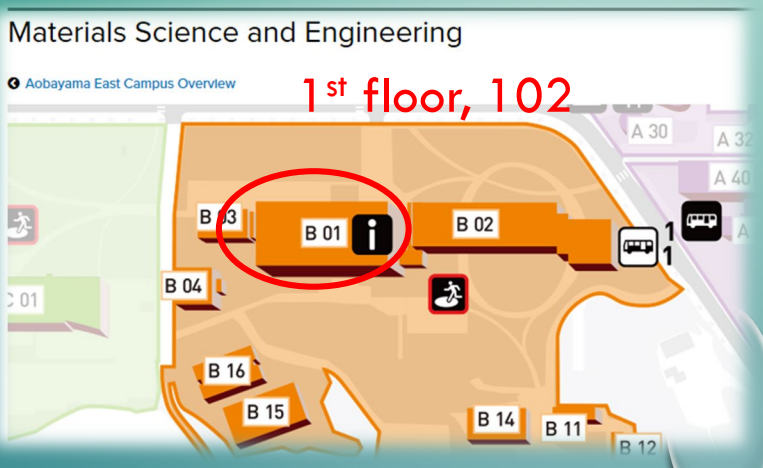

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Control of Spin Relaxation in Disordered Quantum Wells and Nanowires

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In this lecture, we address the topic of Dyakonov-Perel spin relaxation for two important types of semiconductor nanostructures: disordered 2D quantum wells and nanowires. Theoretically, we investigate possibilities to control the spin relaxation process by adjusting spin-orbit coupling (SOC) parameters, crystal orientation, or geometrical confinement. We pay close attention to the experimental signatures of the spin relaxation, with the focus on the optical orientation and weak (anti)localization measurement.

As a generalization of earlier findings,[1,2] we identify general conditions for the realization of spin-preserving symmetries for 2D electron gases with Rashba and Dresselhaus SOC.[3] It is shown that a persistent spin helix can be realized if and only if at least two growth-direction Miller indices agree in modulus. We determine the appropriate requirements on the axial symmetric Rashba and Dresselhaus contributions and discuss the impact of cubic Dresselhaus terms which usually break this symmetry. A general closed-form expression for the weak (anti)localization is provided to support a subsequent experimental investigation. Aside from this, we demonstrate that also in [001]-oriented 2D hole gases spin-conserving symmetries can be found if, in addition, uniaxial shear strain is present.[4]

Semiconductor nanowires can have very distinct spin relaxation properties due to their mesoscopic nature and the huge degree of freedom in device preparation. Most prominent is the boundary-induced motional narrowing effect which strongly alters the spin lifetime as well as the structure of the long-lived spin texture. We developed theoretical models to describe the spin relaxation mechanism and the weak (anti)localization correction in different types of nanowires.[5-8] These models are fitted to experimental data and transport parameters extracted. We demonstrate that the experimental results for the spin lifetime can differ dramatically between optical and transport measurements.[8]

References:

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3. M. Kammermeier, *et al.*, Phys. Rev. Lett. **117**, 236801 (2016).
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8. M. Kammermeier, *et al.*, Phys. Rev B **98**, 035407 (2018).