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Report on
"Relativistic spintronic effects in semiconductor structures",
by Lukáš Nádvorník

This thesis reports the observation, and investigation of long-lived (~20 ns, ~10 μm spin transport) electron spin coherence at an undoped GaAs/AlGaAs heterojunction, where the electrons are photo-generated, rather than the result of intentional doping. Photo-generated electron-hole pairs are separated by an electric field due to surface charges, and the electrons are blocked at the GaAs/AlGaAs potential barrier forming a long-lived electron gas.

For me this is a significant new observation, since most n-doped QW structures, where long-lived electron-spin coherences have been reported for 2 decades, also contain GaAs/AlGaAs heterojunctions as part of the overall structure. As a result of this work, I suspect a number of previous works need to be reinterpreted. The study is highly methodical, comparing multiple samples to isolate the cause of the observed electron-spin coherence, and multiple measurement techniques to build a coherent and robust interpretation.

The thesis also reports an investigation of spin transport of photo-carriers in a Hall bar device. Measurements to map the spatial variation of the spin-Hall voltage generated by a laser are made. Proof-of-concept experiments to use the Hall bar device as a polarimeter are presented. The small device has a high spatial resolution, and may have potential for imaging applications, either as an array/camera type device, or possibly as a point-like detector.

Overall, the thesis clearly demonstrates the candidates' strong ability to conduct creative scientific research. He has displayed mastery of a range of optical and electrical measurement techniques, and of device fabrication. He understands the theory, and displays a high level of skill for making experimental arguments.

Questions to the candidate

1. In sec. 2.3, a setup for measuring the THz response of a material is described. A ZnTe crystal is used to generate and detect the THz signal. Why do you use ZnTe? What determines the time-duration and frequency of the THz pulse, and what range can you achieve? What determines the thickness of the crystal used, and do you use the same thickness for generation and detection? Is phase-matching important?

2. In sec. 4.2, a moderately n-doped GaAs/AlGaAs heterostructure is used. Is this similar to the wafer presented in fig. 3.1(c)? If so, is the spin transport occurring in the photo-generated electron gas trapped at the GaAs/AlGaAs heterojunction, or in the 2deg?

3. In sec. 4.1, the electron lifetime of the photo-generated electron gas is given as ~600 ns. Is the electron gas generated by a single pulse, or does it build up in time? How long does it take to generate the electron spin coherence?

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