Nanoscale defects as probes of time reversal symmetry breaking

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Nanoscale defects such as Nitrogen Vacancy (NV) centers can serve as sensitive and non-invasive probes of electromagnetic fields and fluctuations from materials, which in turn can be used to characterize these systems. In this talk, which is based on our recent work[1], we will specifically discuss how NV centers can directly probe time-reversal symmetry breaking (TRSB) phenomena in low-dimensional conductors and magnetic insulators. We argue that the relaxation rate of NV centers can vary dramatically depending on whether its magnetic dipole points towards or away from the TRSB material. This effect arises from the difference in the fluctuation spectrum of left and right-polarized magnetic fields emanating from such materials. It is perhaps most dramatic in the quantum Hall setting where the NV center may experience no additional contribution to its relaxation due to the presence of the material when initialized in a particular spin state but a large decay rate when initialized in the opposite spin state. More generally, we show in our work[1], that the NV center relaxation rate is sensitive to the imaginary part of the wave-vector dependent Hall conductivity of a TRSB material. We argue that this can be used to determine the Hall viscosity, which can potentially distinguish candidate fractional quantum Hall states and pairing angular momentum in TRSB chiral superconductors. We also consider Wigner crystals realized in systems with large Berry curvature and discuss how the latter may be extracted from NV center relaxometry.

References

[1] De, Suman Jyoti and Pereg-Barnea, T. and Agarwal, Kartiek, **arXiv:2406.14648 (2024)**.