

## **QUANTEX: QUANTum vortEX imaging using nanodiamonds**

Measuring and mapping magnetic fields can be crucial in many applications. For example, tiny magnetic fields that arise from the human heart and brain can help in the early identification and treatment of neurological diseases, or in detecting flaws in safety-critical materials such as airplane engines and high-pressure oil and gas pipelines. The magnetic fields to be measured are very small in magnitude (typically in the microtesla range) and thus require a highly sensitive and spatially resolved magnetometer. One of the attractive tools for magnetic field sensing is the negatively charged nitrogen-vacancy (NV) color center in diamond. The NV center has emerged as a prominent quantum sensor in recent years thanks to its high sensitivity, operation at ambient temperature, and biocompatibility. Moreover, NV nanodiamonds (NDs) enable sensing with very high spatial resolution at the nanoscale.

This project aims to develop a novel and versatile NV-ND magnetometer that utilizes the cross-relaxation feature of an ensemble of NV centers, also called the zero-field feature (ZFR). In contrast to conventional diamond NV magnetometry, the magnetic field is measured without applying microwaves but by scanning the magnetic field near zero and measuring the positional shift of the ZFR feature. The biggest advantage of this technique is the elimination of microwaves applied to samples, which might pose additional challenges in some systems, such as high-T<sub>c</sub> superconductors, biological samples, and other conductive materials. Our preliminary results show that it is possible to observe the ZFR feature at low temperatures. Moreover, we have discovered previously unknown features in the zero-field spectrum.

I will use this NV-ND magnetometer to experimentally investigate and characterize the zero-field feature and its additional unknown features at low temperatures ( $< 10$  K). Additionally, as a proof of concept, I will study the feasibility of using this near-zero-field feature to detect magnetic fields generated by vortices in type-II superconductors.

To complete this project, I will use the expertise of our NV research group at Jagiellonian University. Finally, we anticipate these observations will provide further insight into the physical nature of the ZFR and the preferable NV spin depolarization channels at low temperatures. The ZFR technique might pave the way for a nanodiamond-based, microwave-free, all-optical, wide-field magnetometry.