Tohoku University Research Program "Frontier Research in Duo" (FRiD)

Quantum Sensing: From Materials to Universe

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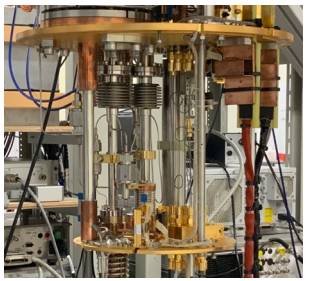
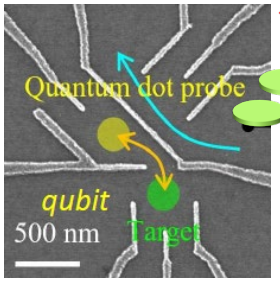
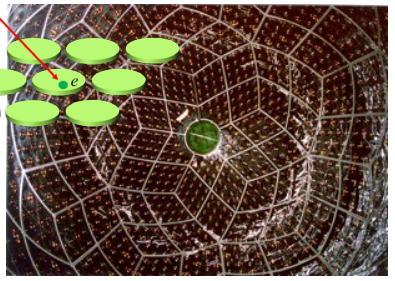
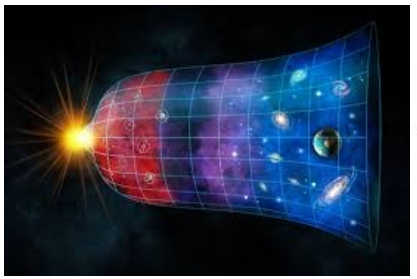
Project Summary

Quantum science and technology promise revolutionary advances in many aspects of technology and human life in future. One major interest and focus in this area has been quantum computing, which is based on quantum bits (qubits). However, developing a practical quantum computer operating on a large number of qubits remains very challenging. One reason is that qubits can be very sensitive to perturbations in the environment. On the other hand, such sensitivity to environment can also be harnessed to turn qubits (even just a small number of them) into powerful "quantum sensors". Such quantum sensing could offer a more near-term-available quantum technology (compared to quantum computing) with many useful applications. In this project, we will study quantum sensors --- particularly those based on quantum dots (a platform for qubits), and explore their applications in both materials research (e.g., sensitive measurements of electric and magnetic properties of novel materials) as well as high energy physics and cosmology (e.g., radiation detection, neutrino research, searching for dark matter and other fundamental particles important to understand the universe). The project will bring together researchers from diverse disciplines – ranging from materials science, spintronics to high energy physics – from Tohoku university as well as our overseas partner institution (Purdue University in USA), to develop key scientific capabilities and collaborations to pursue world-leading quantum sensing research. This project will pave the way for using quantum sensors as enabling new tools that could pioneer major new scientific paradigms and methodologies, promising breakthrough discoveries and applications in the next 10-15 years.









Key words: quantum materials and devices; quantum dots; qubits and quantum sensors; radiation detectors; neutrino research; dark matter search

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Topic for FY2020

- We developed fabrication setup for the two-dimensional quantum materials and devices.
- We started measurement of two-dimensional quantum materials and devices.
- We improved the operation of the quantum dot (QD) sensors and considered the application to high-energy radiation detection.
- We started integrating topological and superconducting quantum materials into dark matter detectors at RCNS to use this setup to detect the solid state properties of these materials; as well as exploring attempt dark matter detection
- Continued collaboration with Purdue on NV center quantum sensing of magnetic materials