【Grant-in-Aid for Scientific Research (S)】

Physics of strongly-correlated topological spin-triplet superconductivity with uranium atom

Principal Investigator	Tohoku University, Institute for Materials Research, Professor AOKI Dai Researcher Number:30359541
Project Information	Project Number : 22H04933 Project Period (FY) : 2022-2026 Keywords : strongly correlated topological superconductivity, microfabrication, spin-triplet superconductivity, uranium compounds

Purpose and Background of the Research

●Outline of the Research

We focus on unconventional superconductivity based on the strongly correlated f-electron systems. Special attention is given to novel heavy fermion superconductor UTe2 and ferromagnetic superconductors, and understanding spin-triplet superconducting states and topological superconductivity through experiments under extreme conditions and microscopic theory.

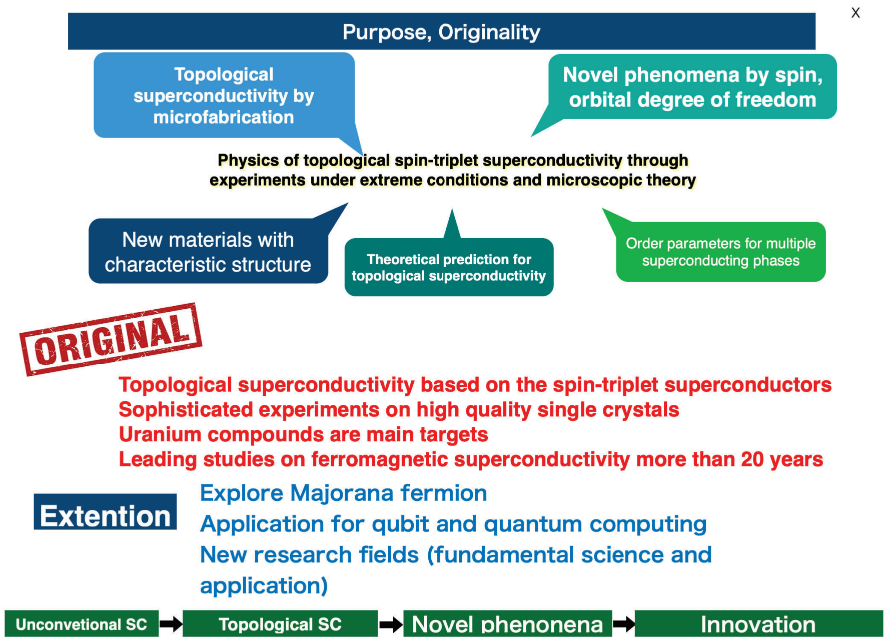

Figure 1. Outline of the research

●Backgound

Ferromagnetism and superconductivity had been thought to be competitive phenomena, but our studies reveal coexistence of both phenomena with a spin-triplet state, in which superconductivity survives under extremely high magnetic field. Surprisingly, superconductivity is even induced by magnetic field. Recent theories propose that spin-triplet superconductivity is a good playground for topological superconductivity. This might be connected to a hunt for Majorana fermion and application to quamtum computing.

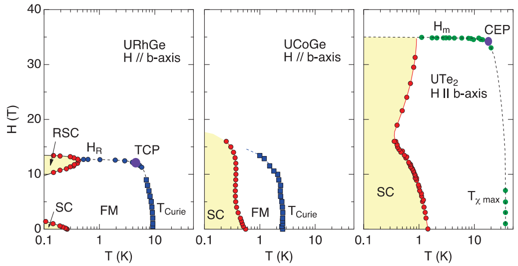

Figure 2. Field-induced superconductivity in ferromagnetic superconductors and UTe_2

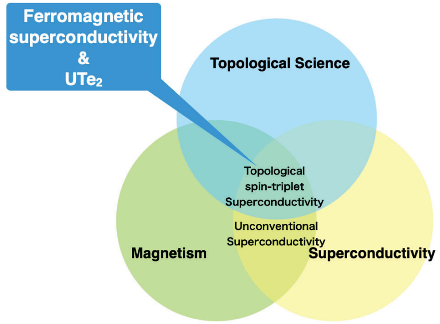

Figure 3. relation between magnetism, superconductivity, and topological science

Expected Research Achievements

●Our targets and methodology

Our targets and research contents are following: 1) Microscopic elucidation on superconducting and magnetic phases through experiments under extreme conditions (low temperature, high field, high pressure), 2) determination of order parameters for multiple superconducting phases, 3) edge states and novel phenomena due to topological superconductivity, 4) highest quality single crystals and new materials, 5) Fermiology. In order to detect the edge state in transport measurements, we perform the microfabrication in a focus ion beam. Using this technology, we expect novel phenomena, such as non-reciprocal transport phenomena, diode effect on topological superconductivity, half-integer quantum vortex and so on. For the development of new materials, we focus on characteristic crystal structures, such as zig-zag, ladder, combining various crystal growth technique mainly on uranium compounds. Uranium compounds with 5f electrons are “gold mines” to explore unusual novel phenomena, such as unconventional superconductivity, “hidden order”, from a viewpoint of fundamental science. Our research project may shed lights on a new aspect for actinide research.

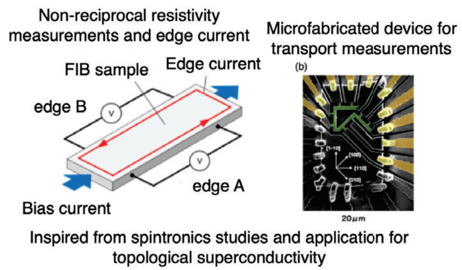

Figure 4. FIB sample and detection for edge current

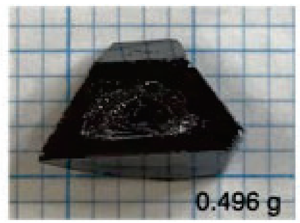

Figure 5. High quality large single crystals of spin-triplet superconductor UTe_2

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