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

Science and Engineering (Mathematical and Physical Sciences)

Title of Project : Understanding of the Superconducting Mechanism and Search for a Novel Superconducting State in Uranium Heavy-Fermion Compounds

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Research Project Number : 15H05745 Researcher Number : 90243196
Research Area : Material Science
Keyword : Ferromagnetic Superconductors, Strongly Correlated Electron System, Heavy-Fermion

【Purpose and Background of the Research】

The discovery of "ferromagnetic (FM) superconductors" had a great impact to the research community studying "unconventional" superconductivity. Since superconductivity was reported in FM UGe_2 under pressure in 2000, similar superconductors have been discovered in uranium compounds, particularly URhGe and UCoGe show superconductivity at ambient pressure, which are suitable for studying the SC properties. The characteristic features of these FM superconductors are that the anisotropy of the SC upper critical fields (H_{c2}) is extremely large, and that superconductivity is enhanced by external fields (H) or reappears after the suppression with increasing H, as shown in Fig. 1. These features have never been observed in any other superconductors before. We have considered that such peculiar behaviors are linked to the SC mechanism of these superconductors.

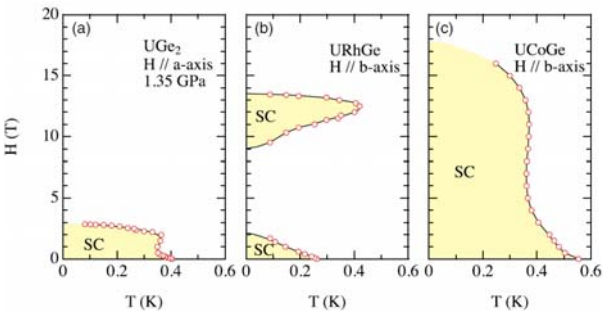

Figure 1 SC upper critical field in three FM superconductors (cited from D. Aoki and J. Flouquet, J. Phys. Soc. Jpn. **83**, 061011 (2014)).

【Research Methods】

We have performed nuclear magnetic resonance (NMR) measurements to clarify the relationship between the FM fluctuations and superconductivity, since NMR is one of the best measurements to investigate the field dependence of low-energy FM fluctuations down to low temperatures. From the NMR measurements on high-quality, single-crystal samples, we have sought common features, which are related to the SC mechanism. In addition, there are a few Uranium superconductors, which possess a SC multi-phase. We try to understand the SC properties of these superconductors, and try to find similar phenomena in the FM superconductors.

【Expected Research Achievements and Scientific Significance】

The goal of the project is to clarify the SC properties and pairing mechanism of the FM superconductors from experimental and theoretical point of view. Particularly, we pursue to understand the properties of "spin-triplet SC state", expected to be realized in the FM superconductors.

【Publications Relevant to the Project】

- "Coexistence of superconductivity and ferromagnetism in URhGe", D. Aoki, A. Huxley, E. Ressouche, D. Braithwaite, J. Flouquet, J.-P. Brison, E. Lhotel and C. Paulsen, *Nature* **413**, 613-616, (2001).
- "Superconductivity Induced by Longitudinal Ferromagnetic Fluctuations in UCoGe", T. Hattori, Y. Ihara, Y. Nakai, K. Ishida, Y. Tada, S. Fujimoto, N. Kawakami, E. Osaki, K. Deguchi, N. K. Sato, and I. Satoh, *Phys. Rev. Lett.*, **108**, 066403-1-5, (2012).
- "Reentrant Superconductivity Driven by Quantum Tricritical Fluctuations in URhGe: Evidence from ^{59}Co NMR in $URh_{0.9}Co_{0.1}Ge$ " Y. Tokunaga, D. Aoki, H. Mayaffre, S. Krämer, M.-H. Julien, C. Berthier, M. Horvatić, H. Sakai, S. Kambe, and S. Araki, *Phys. Rev. Lett.* **114**, 216401 1-5, (2015)

【Term of Project】 FY2015 - 2019
【Budget Allocation】 153,800 Thousand Yen
【Homepage Address and Other Contact Information】

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