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

Broad Section B

Title of Project : Rotational Symmetry Breaking in Strongly Correlated Quantum Matters

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Research Project Number : 18H05227 Researcher Number : 50199816
Keyword : Strongly Correlated Electrons, Quantum spin systems, Rotational Symmetry Breaking

【Purpose and Background of the Research】
Recently, nematic transition, in which electronic structure spontaneously break the underlying lattice symmetry has aroused great interest in strongly correlated systems, including cuprates, iron-pnictides, heavy fermion systems. The clarification of the origin of the nematic transition is very important because it is closely related to the long-standing central issues of condensed matter physics, such as pseudogap formation, unconventional superconductivity, hidden order and quantum criticality. Moreover, quantum spin liquid state in insulating systems, in which the long range magnetic order is destroyed by quantum fluctuations, has attracted much attention recently as a novel quantum phase. Ground states of these quantum spin liquid states, however, have been poorly explored so far. In particular, what kind of symmetry breaking occurs in these quantum spin liquid state is an unresolved issue. In this project, to clarify the rotational symmetry breaking in these novel quantum systems, we develop the ultrahigh sensitive torque magnetometry, which makes us possible to detect the magnetic anisotropy in unprecedented precision.

【Research Methods】
In a wide temperature range from 50 mK to 400 K, we develop the ultrahigh sensitive torque magnetometry, For the precise measurements of the in-plane magnetic torque, we use a system consisting of a two-dimensional vector magnet and a mechanical rotator (see Fig.1), which enables us to rotate the magnetic field **H** within the *ab* plane.

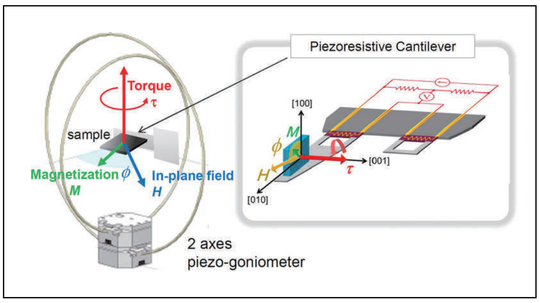

Figure 1

Computer controlling the vector field and mechanical rotator systems, we eliminate the misalignment and rotate **H** within the *ab* plane with the accuracy better than 0.1 degree.

【Expected Research Achievements and Scientific Significance】
It has been widely recognized that strongly correlated quantum many body systems exhibit various types of symmetry breakings. In this project, we clarify the rotational symmetry breaking in strongly correlated superconductors, including heavy fermion compounds, high-Tc cuprates and iron-pnictides, correlated electron systems with strong spin-orbit interactions, including irridates, and quantum spin liquids. These studies are expected to provide a key to understanding important aspects of long-standing unresolved issue in condensed matter physics.

【Publications Relevant to the Project】

- Y. Sato, *et al.* "Thermodynamic evidence for a nematic phase transition at the onset of the pseudogap in $YBa_2Cu_3O_y$" Nature Phys. 13, 1074–1078 (2017).
- S. Kasahara *et al.* "Electronic nematicity above the structural and superconducting transition in $BaFe_2(As_{1-x}P_x)_2$" Nature 486, 382-385 (2012).
- R.Okazaki *et al.* "Rotational Symmetry Breaking in the Hidden-Order Phase of URu_2Si_2" Science 331, 439-442 (2011).

【Term of Project】 FY2018-2022

【Budget Allocation】 198,250 Thousand Yen

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