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

Broad Section B

Title of Project： Pioneering of neutron spin polarization material science

FUJITA Masaki
(Tohoku University, Institute for Materials Research, Professor)

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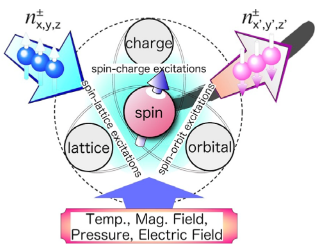
【Purpose and Background of the Research】

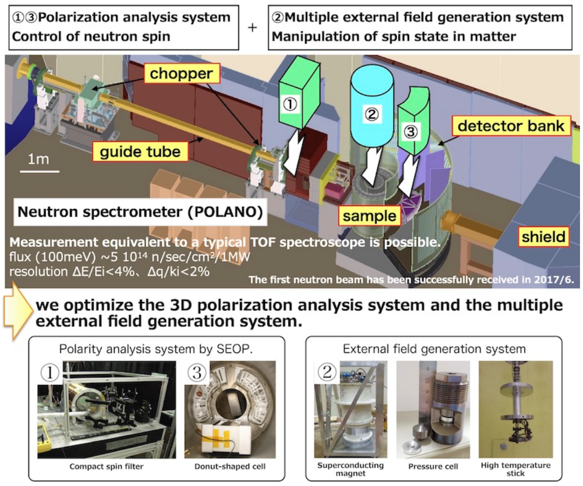
Spin-based materials and their physical properties have been receiving increasing attention. In spintronics science, spin current, which is the flow of spin angular momentum, is extensively studied to convert into light, heat, and electricity, and to comprehensively control them by magnetization. To elucidate the spin current and conversion mechanism, the observation of spin motion in the non-equilibrium stable state is indispensable. In addition, for transition metal compounds such as cuprate oxides, "multi-dynamics", which combines spins with charge, orbital, and lattice degrees of freedom, is attracting attention for understanding novel physical properties. Neutron scattering is a powerful method for observing spin motion in the energy/momentum space. By using a spin-polarized neutron beam, spin information in materials can be obtained favorably and selectively. However, with the conventional methods, the observable energy/momentum region is limited., and how to detect a complex spin state at high energy region remains a challenging issue.

【Research Methods】

In this research, we aim to realize a new experimental method "resonance spin decomposition method" that can clarify the nature of high-energy composite spin dynamics and extract the exotic spin state. For this purpose, (1) we install a high-energy neutron polarization device based on the spin-exchange optical pumping (SEOP) method into a spectrometer at J-PARC, and (2) contract multiple external field generation systems (temperature, magnetic field, pressure, electric field) that can coexist with the SEOP system. The feature of this method is to determine the essential dynamics that respond to the emergence of physical properties. By utilizing the time-of-flight method at J-PARC, information of spin dynamics in a wide energy/momentum space can be obtained simultaneously. We will demonstrate the effectiveness of this method by selecting high-temperature superconductors and spin current/thermoelectric conversion materials as the first research subjects. We will elucidate how complex spin dynamics are involved in the emergence of physical properties through these researches.



Conceptual diagram of research content. Detailed spin information is extracted from the multi-degree-of-freedom composite excitation of electrons using polarized neutrons. By applying an external field to the sample, a change in the spin state is induced to obtain more detailed information.



The high-energy neutron spectrometer POLANO installed at J-PARC, the SEOP polarization analysis system and the multiple external field generation system introduced in this study.

【Expected Research Achievements and Scientific Significance】

The polarized neutron scattering method is a strategic element that opens up the next generation of neutron science. Therefore, neutron research facilities around the world are focusing on their sophistication. Under such circumstances, the realization of the "resonant spin decomposition method" using high-energy neutrons will be a highly competitive tool for Japanese neutron science. In addition, by demonstrating the effectiveness of this method with various materials, we open the way to "neutron spin polarization material science" to explore the relationship between the electronic state and physical properties.

【Publications Relevant to the Project】

- K. Sato and M. Fujita *et al.*, J. Phys. Soc. Jpn. **89**, 114703 (2020).
- K. Ishii and M. Fujita *et al.*, Phys. Rev. Mat. **5**, 024803 (2021).
- Y. Nambu and M. Fujita *et al.*, Phys. Rev. Lett. **125**, 027201 (2020).
- T. Yokoo and M. Fujita *et al.*, AIP Conf. Proc. **1969**, 050001 (2018).

【Homepage Address and Other Contact Information】

http://qblab.imr.tohoku.ac.jp