【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Mathematical and physical sciences)

Title of Project : Study of Quantum Magnetic Phases by High Magnetic Field Neutron Scattering and XMCD

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Research Area : Physics, Magnetism
Keyword : X-ray・Neutron, High Magnetic Field, Quantum Phase Transition

【Purpose and Background of the Research】

A variety of states are induced in matter by the application of high magnetic field and/or low temperature. We call each state of a matter as phase. The translation between these phases is called as phase transition. It is an important subject of condensed matter physics to find out novel phases in extreme conditions and to examine the origin of such phases. In phase transition, fluctuation plays an essential role. There are two types of fluctuations, thermal fluctuation and quantum fluctuation. The phase transition driven by the quantum fluctuation is called quantum phase transition and unexpected strange phases appear.

It is important to suppress the thermal fluctuation to examine the quantum phase transitions. The application of high magnetic field at low temperature is the best way to exclude the thermal effect and to pick up the intrinsic quantum effect. Another important point in our research is to use the microscopic probes such as neutron and X-ray to examine the quantum phase transitions. The combination of X-ray and neutron with the high magnetic field is very difficult task and so the example has been quite limited. Recently, we have established the world record of high magnetic field X-ray and neutron experiments and these successes are the basis of the present project.

【Research Methods】

We are aiming at generating 50 T, which is 1 million times as intense than geomagnetic field. To realize this, we use the pulsed magnetic field method. In pulsed magnet, more than 10 kA current flows by the capacitor bank discharge. The unique point of our system is to use the mini coil as shown in the photograph. The coil is very small and so the installation is easy. It increases dramatically the opportunities of high magnetic field experiment in X-ray and neutron facilities. In fact, our method is employed in abroad such as France and United States.

The key points of measurement are uses of X-ray and neutron. In X-ray, we can evaluate the magnetization in element selective manner for the difference of absorption edges in different elements. If we use this method, we can pick up the magnetic contribution of specific element in microscopic manner.

Another probe is the neutron, which is the atomic size small magnet. For this property, we can determine directly the arrangement of magnetic moments in matter with the atomic resolution. The powerfulness of the combination of high magnetic field with the X-ray and neutron will uncover the exotic properties of various quantum phases.

【Expected Research Achievements and Scientific Significance】

Our project would contribute to the understanding of quantum phase transition and quantum phases. Such understanding will be the basis of developing new functional materials such as multiferroics, quantum magnets, magnets with ubiquitous elements and so on.

【Publications Relevant to the Project】

(1)H. Nojiri *et al.* Neutron Laue Diffraction Study on the Magnetic Phase Diagram of Multiferroic $MnWO_4$ under Pulsed High Magnetic Fields, Phys. Rev. Lett. **106** (2011) 237202.

(2)T. Nakamura, Y. Narumi *et al.*, Soft X-ray Magnetic Circular Dichroism of a CoFe/MnIr Exchange Bias Film under Pulsed High Magnetic Field, Applied Physics Express **4** (2011) 066602.

Fig. 1 Minicoil with 3 cm diameter

【Term of Project】

FY2011-2015

【Budget Allocation】

163, 000 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.hfpm.imr.tohoku.ac.jp/