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

Science and Engineering (Mathematical and Physical Sciences)

Title of Project : DC Electric Field and Current: Novel Control Parameters for Strongly Correlated Electron Systems

Yoshiteru Maeno
(Kyoto University, Graduate School of Science, Professor)

Research Project Number : 17H06136 Researcher Number : 80181600
Research Area : Mathematical and physical sciences
Keyword : Strongly correlated system

【Purpose and Background of the Research】

As control parameters of the Mott insulating state characteristic of strongly correlated electron systems, element substitution and pressure have been widely used; novel phenomena such as high-temperature superconductivity, colossal magnetoresistance and spin-triplet superconductivity have been found.

The purpose of this research is to establish the effectiveness of the DC electric field and current as novel control parameters of strongly correlated electron systems. We study new phenomena emerging in the non-equilibrium steady state mainly under the DC current, and deepen the understanding of these phenomena as well as of their physical mechanism.

【Research Methods】

As the main target material, we choose the 4d-electron ruthenium oxide Ca_2RuO_4 and aim to clarify the mechanism of its insulator/metal transition induced by DC electric field, as well as unusual magnetism induced by DC current that we recently discovered. Furthermore, we will clarify the details of the current-induced phenomena in the related system $Ca_3Ru_2O_7$.

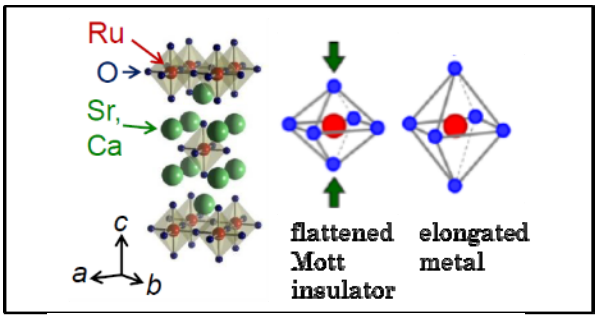

Figure 1 Crystal structure of Ca_2RuO_4

In addition, among 3d and 5d electron oxides, we select Mott insulators with relatively small energy gap and clarify the effect of DC electric field and current. In this project, we also establish experimental techniques of photoemission spectroscopy under electric current, and reveal the variations of electronic states under the non-equilibrium steady conditions. We also extend international collaborations to develop theoretical models, to examine phonon instabilities and to study local dynamics by scanning probes.

【Expected Research Achievements and Scientific Significance】

The ability to change the conductivity and magnetism remarkably by just switching on and off the DC current is a breakthrough phenomenon utilizing the nature of many-body effects in strongly correlated electron systems. This approach opens up a possibility to induce electronic states never accessible with conventional control parameters: in addition to unusual magnetism, other phenomena such as unconventional superconductivity may emerge. Thus, the outcome of this project may well provide a strong impact in the basic knowledge of modern condensed matter physics and also a suggestive direction for future device application.

【Publications Relevant to the Project】

・ "Electric-field-induced metal maintained by current of the Mott insulator Ca_2RuO_4",
F. Nakamura, M. Sakaki, Y. Yamanaka, S. Tamaru, T. Suzuki, Y. Maeno,
Sci. Rep. **3**, 2536 (1-6) (2013).
・ "Current-induced strong diamagnetism in the Mott insulator Ca_2RuO_4",
C. Sow, S. Yonezawa, S. Kitamura, T. Oka, K. Kuroki, F. Nakamura, Y. Maeno,
arXiv: 1610.02222 (2016).

【Term of Project】 FY2017-2021

【Budget Allocation】 159,000 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.ss.scphys.kyoto-u.ac.jp/kibanS_h29-33/index.html