【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Chemistry)

Title of Project : Toward a New Class Magnetism by Chemically-controlled Chirality

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Research Area : Material Sciences
Keyword : Chiral Magnetism, Spintronics, Spin Phase order, Multiferroics

【Purpose and Background of the Research】

Chirality is commonly found in nature from particle physics to molecular chemistry. It is characterized by a reflection asymmetry that we are most familiar with in terms of our left hand being the mirror opposite of our right hand. When this kind of handedness appears in the structure of atoms or molecules in a solid, it affects the way that the magnetic moments of unpaired electrons organize themselves through the Dzyaloshinskii-Moriya (DM) interactions. In a symmetric structure, these interactions cancel out, but in a chiral lattice they do not. The DM interactions stabilize a screwlike helical arrangement of the magnetic moments. The result is a helical magnetic arrangement with a winding period of several tens or hundreds of nanometers, which is much longer than the lattice constant. Therefore, even though the chiral properties depend on the symmetry of the lattice, they can be understood and manipulated at the mesoscopic level, independently of the structural details.

From 2006 and 2010, two Grant-in-Aid for Scientific Researches (A) "Crystal and magnetic Chirality" and "Establish of Design of Chiral Magnets" were proceed and 1) got an evidence of the crystal chirality influences spin structure through DM interactions, and 2) found of material design of chiral magnets, and 3) discovered an order of spin phases in macro-scopic scale.

From these backgrounds, our research objectives can be listed below.

1. Establish material design and method to prepare new chiral magnets.
2. Quantification between structural chirality and magnetic chirality
3. Find out new specific properties coming from macro-scale spin phase order.
4. Establish way to new spintronics devices.

【Research Methods】

Object of this scientific project is widely spread from physics to material, theoretical, experimental physicists and chemists are organized. New properties coming from macro-scale ordered spin phase are focused on and predicted from theory and experimentally, and reveal the mechanism for material design.

【Expected Research Achievements and Scientific Significance】

The macro-scopic phase orders are key issue of new properties and giant effects. For instance, macro-scopic phase order of charge shows superconductivity, macro-scopic phase order of photons corresponds to laser. The world first's founding of macro-scale spin order in chiral magnets will be expected many unknown effects.

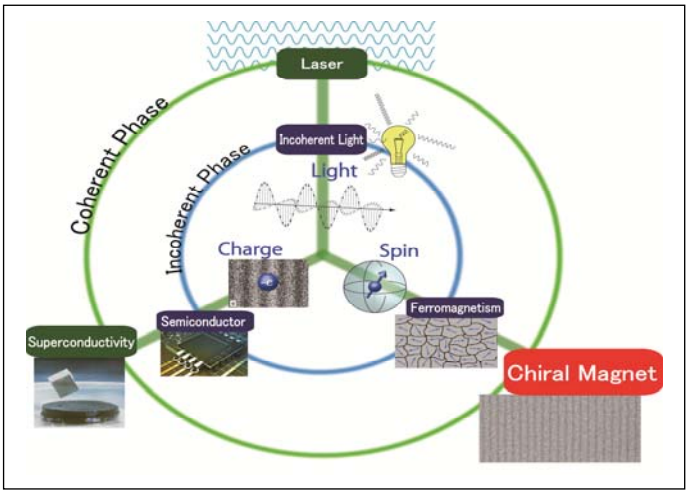

Figure 1 Phase and coherences of light, charge and spin.

【Publications Relevant to the Project】

- Chiral Magnetic Soliton Lattice on a Chiral Helimagnet, Y. Togawa, et. al., Phys. Rev. Lett., 108, 107202 (2012)
- Giant nonlinear magnetic response in a molecule-based magnet, M. Mito et. al., Phys. Rev. B, 79 12406 (2009)
- K. Inoue and J. Kishine, Chapter 4: "Magnetism and Chirality" Multifunctional Molecular Materials, Pan Stanford Publishing Group, 2012

【Term of Project】 FY2013-2017
【Budget Allocation】 185,100 Thousand Yen
【Homepage Address and Other Contact Information】
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