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

Science and Engineering (Mathematical and Physical Sciences)

# Title of Project : Frustration-induced spin textures

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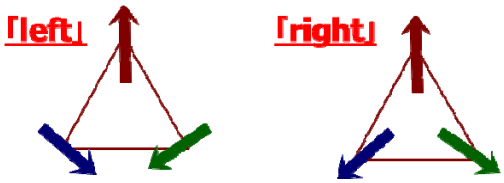
Research Area : Mathematical and Physical Sciences
Keyword : Magnetism, Frustration, Spin texture, $Z_2$ vortex, Skyrmion

## 【Purpose and Background of the Research】

In physical science, "frustration" means the situation where several optimizing conditions compete with each other and cannot be satisfied simultaneously. "Frustrated systems" then often find difficulty in settling down in obvious stable states and exhibit enhanced fluctuations, leading to novel orders, exotic thermodynamic states and gigantic responses, *etc.*

Our research project targets magnets. Microscopically, magnets consist of a huge number of atomic-scale micromagnets called "spins". Usually, two spins tend to align in the same direction (ferromagnet) or the opposite direction (antiferromagnet). Meanwhile, anti-ferromagnetic spins located on a triangle are not allowed to take mutually antiparallel directions. In such "frustrated magnets", spins often cant taking "curved" structures. A consequence of it is the emergence of the "right-circular" and "left-circular" states: see the figure. Such "right



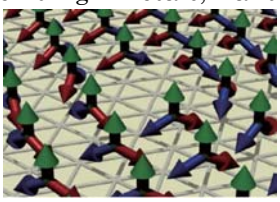

vs. left" degrees of freedom is called "chirality". In frustrated magnets, these two chiral states have exactly the same energy.

Curved spin structures induced by frustration has a lot of variety. In the present project, we take up two examples: "$Z_2$ vortex" and "skyrmion". Both are topologically stable nano-scale "spin textures", containing chiral degrees of freedom. $Z_2$ vortex, as demonstrated in the figure, was found theoretically more than 30 years ago by the project leader. Skyrmions attract much current interest, while such skyrmions are "antisymmetric" in that the right and the left are energetically inequivalent, while the skyrmion of our target is "symmetric", and is expected to show properties distinct from the standard skyrmions.

In this project, via the close collaboration between theorists and experimentalist, we wish to clarify novel phases and dynamics driven by frustration-induced spin textures in frustrated magnets, which contain rich internal degrees of freedom associated with the chirality.

## 【Research Methods】

Based on theoretical predictions by the project leader, we perform elastic and inelastic neutron scattering and resonant X-ray scattering experiments in zero and high fields. By comparing with the spin-dynamics simulations on localized sin models and with the bulk measurements, we establish the existence of the $Z_2$ vortex and the symmetric skyrmion for a series of triangular magnets. Preparing new candidate materials including metals, and performing transport measurements, we unravel the novel properties arising from frustration-induced spin textures.



## 【Expected Research Achievements and Scientific Significance】

Deepening of our fundamental understanding of topological aspects of statistical physics and condensed matter physics. Providing a possible clue toward future spintronics technologies.

## 【Publications Relevant to the Project】

・H. Kawamura, "Spin and Magnetism --- Essence of Modern Physics" Science-sya, 2016 (in Japanese).
・T. Okubo, S. Chung and H. Kawamura, Phys. Rev. Letters, **108**, 017206-(1-5) (2012).

【Term of Project】 FY2017-2021
【Budget Allocation】 165,300 Thousand Yen
【Homepage Address and Other Contact Information】
http:// thmat8.ess.sci.osaka-u.ac.jp/fstex/