

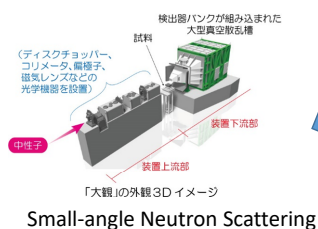
# Observation of Magnetic Skyrmions under External Field using Quantum Beams

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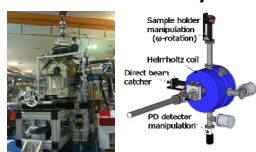
Magnetic skyrmion, a nanometer scale spiral magnetic structure, is expected to be utilized as a new information medium in the next generation spintronics technology. We have conducted research to observe magnetic skyrmion under applied external field by utilizing multi-probe of quantum beams, *i.e.* neutron and synchrotron x-ray. At the small-angle neutron scattering beamline “TAIKAN” in J-PARC MLF facility, we demonstrated a new approach for skyrmion phase control based on a mechanical stress and succeeded in observing creation and annihilation of a skyrmion crystal in chiral magnet MnSi by applied uniaxial pressure of several tens MPa [1]. In the synchrotron facility of Photon Factory (PF), we have developed a novel experimental technique of the transmission-type resonant soft x-ray small-angle scattering and observed a skyrmion crystal in chiral magnetic FeGe [2]. Since this measurement method enables to detect magnetic scattering even from a micro-meter scale sample, we succeeded in observing electric field control of the magnetic skyrmion in an insulating chiral magnet  $\text{Cu}_2\text{OSeO}_3$  [3]. In the future, we aim at measuring characteristics of skyrmion-based device sample during device operation, *i.e.* “*operando measurement*” with utilizing features of quantum beams such as pulse neutron and coherent soft x-ray.

## J-PARC MLF “TAIKAN”



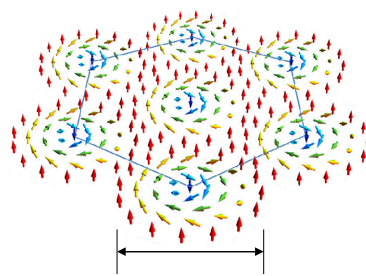
Small-angle Neutron Scattering

## Photon Factory



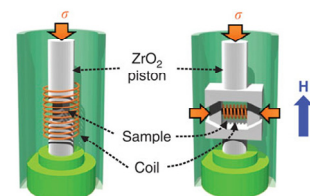
Small-angle x-ray scattering

## Magnetic Skyrmion



Few tens ~ few hundreds nm

## Uniaxial pressure



External Control

## Electric Field

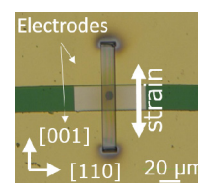


Fig: Observation of magnetic skyrmion under external fields by multi-probe of neutron and soft X-ray. (cited from Ref. 1 and modified to fit this abstract.)

## Bibliography

- [1] Y. Nii, T. Nakajima, Y. Yamasaki *et al.*, Nature Communications 6, 8539 (2015).
- [2] Y. Yamasaki, *et al.*, Physical Review B 92, 220421(R) (2015).
- [3] Y. Okamura, Y. Yamasaki *et al.*, Physical Review B 95, 184411 (2017).