

# 凝縮系物理学ゼミナール

## Condensed Matter Theory Seminar

Date: 13:30-15:00, Wednesday, 15 January 2024

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Title: Nonlinear magnetoelectric effect under magnetic octupole order

Speaker: Mr. Jun Oike

### Abstract:

Extensive investigation has recently been conducted into a new class of antiferromagnetic order known as magnetic octupole order [1-3]. However, the high rank of octupoles makes it difficult to detect and manipulate them by using conventional methods such as the anomalous Hall effect.

In this study, we propose the nonlinear magnetoelectric effect (NMEE), a second-order response to an electric field that induces a spontaneous magnetization, as a finite response under magnetic octupole order [4]. First, we classify the magnetic point groups to identify antiferromagnets with such order, and derive the NMEE tensor using quantum kinetic theory. Then, we confirm the effectiveness of the NMEE through model calculations for two specific examples: a d-wave altermagnet and a pyrochlore lattice with all-in/all-out magnetic order. In particular, the intrinsic NMEE exhibits a large response in a magnetic Weyl semimetal phase of the pyrochlore lattice. This enhanced response is explained by the fact that the response tensor involves the quantum metric, which is enhanced near Weyl points. Furthermore, our results show that the NMEE has a sizable value that can be detected by the magneto-optical Kerr effect.

### References:

- [1] S. Bhowal and N. A. Spaldin, *Phys. Rev. X* **14**, 011019 (2024).
- [2] M.-T. Suzuki et al., *Phys. Rev. B* **95**, 094406 (2017).
- [3] T.-H. Arima, *J. Phys. Soc. Jpn.* **82**, 013705 (2013).
- [4] J. Oike, K. Shinada, and R. Peters, *Phys. Rev. B* **110**, 184407 (2024).