

# 凝縮系物理学ゼミナール

## Condensed Matter Seminar

Date: 13:30-15:00, Wednesday, 11 January 2023

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Title: Nonlinear optical responses in noncentrosymmetric  
superconductors

Speaker: Hiroto Tanaka (Condensed Matter Theory Group)

### Abstract:

Various optical measurements have been used to reveal the complex ordered states of quantum materials. Especially, nonlinear responses yield rich information such as symmetry and geometric properties of quantum phases. On the other hand, it has been widely known that superconductors show remarkable electromagnetic properties such as the zero resistivity and the Meissner effect. Thus, the unique nonlinear responses of superconductors, which stem from the Cooper pairs' quantum condensation, have been attracting attention.

We focus on second-order optical responses, which appear in materials breaking space-inversion symmetry. A theory of the second-order nonlinear response in superconductors was recently formulated, and a specific BdG Hamiltonian with a sublattice degree of freedom was investigated numerically [1]. On the other hand, it has been unclear how the superconductivity influences the nonlinear optical properties. It is desirable to perform a comprehensive analysis of the superconducting nonlinear optical responses based on a canonical model.

To this end, we investigate the second-order nonlinear responses in superconductors with single-band model Hamiltonians[2]. In the light of antisymmetric spin-orbit coupling, we present a systematic study of the superconducting nonlinear optical responses. However, the superconductivity-induced nonlinear optical responses disappear under some conditions on pair potential. We show that the coexistence of intraband and interband pairing is necessary for the superconducting second-order optical responses. Our study identifies a basic ingredient in superconducting nonlinear optics and may cover a broad range of noncentrosymmetric superconductors such as heavy-fermion and two-dimensional superconductors [3].

### Reference:

[1] H. Watanabe et al., Phys. Rev. B 105, 024308 (2022).

[2] H. Tanaka et al., arXiv :2205.14445.

[3] Non-Centrosymmetric Superconductors: Introduction and Overview, edited by E. Bauer and M. Sigrest, Lecture Notes in Physics Vol. 847 (Springer, Berlin, 2012); Y. Saito et al., Nat. Phys. 12, 144 (2016).