Seminar

Floquet engineering in strongly correlated electron systems

Kazuaki Takasan
(Kyoto University)

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721, Science Complex B

Realization of novel quantum states by periodic driving is called “Floquet engineering” and has recently attracted much attention in experimental as well as theoretical studies[1].These studies are mainly in the field of cold atomic systems[2]. We want to apply this concept “Floquet engineering” to solid state systems, especially to strongly correlated electron systems. In this seminar, I give two new theoretical propositions that enable us to engineer the quantum states of matter.

(i) Laser-induced topological superconductivity in cuprate thin films [3].

We propose a possible way to realize topological superconductivity with application of laser light to superconducting cuprate thin films. Applying Floquet theory to a model of d-wave superconductors with Rashba spin-orbit coupling, we derive the effective model and discuss its topological nature. Interplay of the Rashba spin-orbit coupling and the laser light effect induces the synthetic magnetic fields, thus making the system gapped. Then the system acquires the topologically non-trivial nature which is characterized by Chern number. The effective magnetic fields do not create the vortices in superconductors, and thus the proposed scheme provides a promising way to dynamically realize a topological superconductor in cuprates. We also discuss an experimental way to detect the signature.

(ii) Laser-irradiated Kondo insulators : Engineering Kondo effect and topological properties [4].

We theoretically investigate the nature of laser-irradiated Kondo insulators. Using Floquet theory and slave boson approach, we study two simple variants of a periodic Anderson model (PAM). One is a locally hybridizing model (LPAM) and the other is a non-locally hybridizing model (NPAM). NPAM is known as a minimal model of topological Kondo insulators. Our results shows that the Kondo effect is enhanced by laser light in the case of LPAM, but it is suppressed in the case of NPAM. Namely the behavior of Kondo effect under laser light is qualitatively opposite between LPAM and NPAM. It implies that the optical response of Kondo insulators is an effective probe of the structure of hybridization. Furthermore, we discuss the topological properties of NPAM under laser light. Applying linearly polarized laser light, trivial-topological phase transition occurs. In the case of circularly polarized laser light, time-reversal symmetry is broken. Corresponding this breaking, topological phase transitions to Chern insulators and Weyl semimetals are realized. We discuss experimental setups for detecting the engineered Kondo effect and topological properties.

[1] M. Bukov et al. Adv. Phys. 64, 139-226 (2015)
[2] A. Eckardt arXiv:1606.08041
[3] K. Takasan, A. Daido, N. Kawakami and Y. Yanase, in preparation
[4] K. Takasan, M. Nakagawa and N. Kawakami, in preparation

Contact: Sumio Ishihara, Department of Physics
TEL.: (Ext) 6436
e-mail: ishihara@cmpt.phys.tohoku.ac.jp