Light-induced topological superconductivity in cuprates and transition metal dichalcogenides

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Topological state of matter is a new and important paradigm in the modern condensed matter physics. In particular, topological superconductors (TSCs), which host a superconducting gap protected by non-trivial topology of the wavefunction, have attracted great interests because they provide a platform to realize Majorana fermions that can be used for quantum computation [1]. However, experimental realization of TSCs has been still a challenging task. While a few indications have been obtained in artificial systems by state-of-the-art experiments [2], the realization in natural superconducting materials are still limited. On the other hand, it was proposed to control of topological states of matter by applying the laser light [3] and the possible experimental signatures supporting this scenario has been reported [4]. Laser light drives the electrons in solids far from equilibrium and topologically non-trivial states are realized transiently. This provides a new approach to control the states of matter in ultrafast time scale.

Stimulated by these developments, we have theoretically investigated how to realize TSCs by laser light. In this talk, we would like to explain two of our proposals about light-induced topological superconductivity [5, 6].

One is for high-T_c cuprate superconductors [5]. Based on the Floquet theoretical approach, we have found that a thin film of cuprate superconductors on a substrate can be a TSC with application of circularly polarized laser light. Interplay of the Rashba spin-orbit coupling (SOC) and the laser light induces an effective Zeeman fields which make the Dirac nodes in the *d*-wave superconducting gap fully-gapped and then realize a TSC. The other is about transition-metal dichalcogenides (TMDs) [6]. We have studied a simple effective model of bilayer MoS_2 with circularly polarized laser light and found that this system also can be a TSC. This is very different from the above case because the symmetry of the superconducting gap is a simple *s*-wave and this material does not have strong SOC. The interlayer coupling plays an important role and induces the effective Zeeman field which is a similar one appearing in the cuprate case. The both of the effective Zeeman fields are different from a usual magnetic field because they do not create vortices, which strongly break the superconductivity, and thus our schemes are very feasible to realize TSCs. The signatures of these light-induced phases can be detected by time-resolved optical measurements. In the talk, we would like to explain the experimental setup and the possible approach to observe the signature of TSCs in detail. This talk is based on the collaboration with N. Kawakami, Y. Yanase, A. Daido, H. Chono.

References:

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