凝縮系物理学ゼミナール

Condensed Matter Seminar

Location: Room 413, School of Science Bldg. 5 (理学 5 号館 413 号室)

Date: 13:30-15:00, Wednesday, 21 November 2012

"Index theorem for topological insulator heterostructure systems"

Speaker: Mr. **Ken Shiozaki** (Condensed Matter Theory Group)

Abstract:

Three dimensional topological insulator heterostructure systems show the various novel phenomena such as gapless modes localized at defects which lead to the axion responses when perturbations breaking time-reversal symmetry (*e.g.* magnetic fields) are introduced. The origin of these phenomena is the nontrivial topology in both momentum and real spaces. The interface structure with finite energy gap between the ground and the first excited states can be deformed smoothly into the Hamiltonian that varies slowly in real space without closing the energy gap. Then, dealing with the spatial coordinates **r** as the adiabatic parameter, one can introduce the semiclassical Hamiltonian $H(\mathbf{k},\mathbf{r})$, which describes topological properties of the heterostructure system. On the other hand, in some cases, it also happens that semiclassical Hamiltonian approaches fail to describe correctly low energy properties.

In this study [1], we present full quantum treatment for three dimensional topological insulator heterostructure systems not based on the semiclassical Hamiltonian. We prove the index theorem for Dirac fermion heterostructure systems such as the s-wave superconductor junction system attached with a magnetic insulator on the surface of a three-dimensional topological insulator. We find that the total number of the Majorana zero energy bound states is governed not only by the phase difference but also by the non-topological massive modes localized at the junction interface. The result implies that the topological protection for Majorana zero modes in class D heterostructure junctions may be broken down under a particular but realistic condition. We also discuss gapless modes in line defects and the associated electromagnetic responses in topological insulator-magnetic insulator heterostructure systems.

Reference:

[1] Ken Shiozaki, Takahiro Fukui, and Satoshi Fujimoto, Phys. Rev. B **86**, 125405 (2012).