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Topological Origin of Gap Nodes of Superconductors

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Node structures of anisotropic superconductors are focued in a periodic system from its intrinsic topological order of the ground state[1]. There is a clear correspondence between the superconductivity and the three dimensional Quantum Hall effect [2] which enables us to clarify origins of superconducting gap nodes. By this analogy, the superconducting node is considered as a critical point of a quantum phase transition between two (2-dimensional) states with different toopological orders. Topological origin of the point nodes and the line nodes are demonstrated geometirically in relation to the time reversal symmetry breaking.

Before discussing the node structures, we will review recent developments in topological aspects of superconductivity. [3,4]

Motivated by the geometric character of spin Hall conductance, the topological invariants of generic superconductivity are discussed based on the Bogoliuvov-de Gennes (BdG) equation on lattices. In the parameter space of the BdG hamiltonian, an analogue of the Dirac monopole exists and the charge of the monople gives a topological number of the superconductivity.

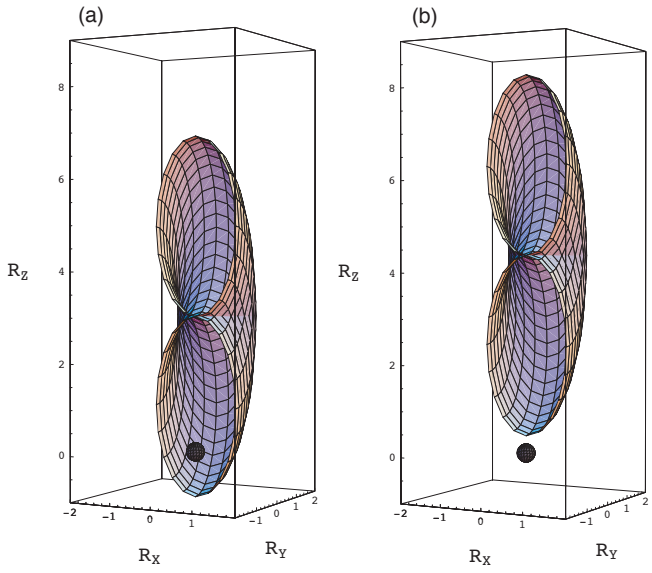

Figure 1: Examples of closed surfaces $R_1(T^2_{xy})$ which are cut by the $R_Y - R_Z$-plane. The monopole is at the origin. $t = d_z = 1$, $\mu = -5$: (a)$k_z = 0$, (b)$k_z = -2\pi/5$.(From Ref. [4])

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[4] Y. Hatsugai M. Kohmoto and S. Ryu, preprint, cond-mat/0308332