Topological defects in superconductors and chiral magnets: Vortex and Quantum Solitons

Yusuke Kato
Department of Basic Science, The University of Tokyo, Japan

Topological defects such as domain walls, dislocations, disclinations, and vortices play crucial roles in low energy physics in order states in condensed matters. In this talk, I will discuss three topics related to defects in superconductors and chiral magnets; (1) driving forces on vortex in type II superconductors [1,2], (2) intrinsic hysteresis due to chiral solitons in classical monoaxial chiral magnets [3], and (3) quantum effect in chiral solitons in quantum spin chain [4,5].

(1) There has been a long-term controversial issue on the driving force on vortices in type II superconductors -Hydrodynamic force (Magnus force) or electromagnetic Lorentz force drives vortices-. We show a combination of the two forces is the only well-defined force on the vortex as a consequence of the path-independency of the London fluxoid [1,2].

(2) We refer to the monoaxial chiral magnets as magnets with the Dzyalonshinskii-Moriya interaction with strong monoaxial anisotropy [6,7]. In these magnets, large hysteresis has been experimentally observed in a magnetic loop between H_{small} and H_{large} [8], and the ratio of the two fields is found to be H_{small}/H_{large} close to 0.4 in most samples of $CrNb_3S_6$. We showed theoretically that H_{small}/H_{large} is $4/\pi^2$, which agrees quantitatively with experimental observations. The hysteresis is caused by the surface barrier for chiral solitons, and thus this phenomenon is analogous to the Bean-Livingston barrier in superconductors.

(3) Quantum spin chains of monoaxial chiral ferromagnet exhibit different magnetization processes for half-integer spin and integer spin, which is often referred to as the “spin parity effect”. i.e., different behaviors between even 2S and odd 2S. We show this spin parity effect in the chiral magnetic spin chain without relying on the Berry phase [4].

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