Topological Aspects of the Quantum Spin Nanotube

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The spin nanotube has attracted a lot of interest as an intersection between the strongly correlated electronics and the nanoscience. Among spin nanotubes we focus on the S=1/2 three-leg spin tube, because it has the largest quantum fluctuation and the strongest frustration. Our recent theoretical analyses on the system, using the numerical diagonalization and the density matrix renormalization group (DMRG) calculation indicated several interesting quatum phase transitions;

(i) a transition from the spin-gap to gapless phases with respect to the lattice distortion[1],
(ii) magnetic field induced chiral, dimer and Neel orders[2].

Since the spin gap is realized only when the unit cell is a nearly regular triangle, it is supposed to be originated to a topological aspect, namely the chiral symmetry. In order to clarify this aspect, We calculated the quantized Berry phase of the present spin tube. As a result, the quantized Berry phase is revealed to well characterize the quantum phase transition between the gapped and gapless phases[3]. We also propose a possible superconductivity in the carrier doped spin tube, based on the spin gap or the chirality mechanisms[2].

[1] T. Sakai et al., Phys. Rev. B 78 (2008) 184415.
[2] T. Sakai et al., J. Phys.: Condens. Matter 22 (2010) 403201.
[3] Y. Otsuka and T. Sakai, J. Phys.: Conf. Ser. 344 (2012) 012009.