Edge states in two dimensional spin and bosonic systems

Takafumi Suzuki
Graduate school for Engineering, University of Hyogo, Himeji, Hyogo 671-2280, Japan

Topological insulators (TIs) [1] have been of great interest in condensed matter physics. One of the most important point is that TIs are characterized by non-local quantities such as topological quantities of the bulk or gapless surface states [2,3]. The TI phases and the surface states are quite stable for any time-reversal symmetric perturbations. On the other hand, the Haldane-gap state in quantum spin systems is another class of the topological state [4], because, similarly to TIs, this gapped state has no local order and is characterized by the non-local (string) order parameter or free spins at the edges. In recent theoretical progress, characteristics of the Haldane-gap state have been captured from the aspect of symmetry and entanglement spectrum [5, 6]. In this study, motivated by the recent development of theories for topological phases and surface states, we study properties of edge states in two-dimensional quantum spin systems and bosonic lattice systems with confinement potential by applying the quantum Monte Carlo method. Focusing on the experimental realization, we particularly focus on the three points; (1) which systems can have gapless edge states, (2) the stability against perturbations, and (3) the difference between the edge modes of TIs and spin systems.

[1] See, for example, M. Z. Hasan and C. L. Kane, RMP82, 3045 (2010); X.-L. Qi and S. C. Zhang, arXiv:1008.2026.
[2] A. P. Schnyder, S. Ryu, A. Furusaki, and A. W. W. Ludwig, PRB 78, 195125 (2008).
[3] A. Kitaev, AIP Conf. Proc. 1134, 22 (2009).
[4] F.D.M. Haldane, Phys. Lett. 93A, 464 (1983); PRL50, 1153 (1983).
[5] F. Pollmann, E. Berg, A. M. Turner, and M. Oshikawa, arXiv:0909.4059; F. Pollmann, A. M. Turner, E. Berg, and M. Oshikawa, PRB81, 064439 (2010).
[6] Z.-C. Gu and X.-G. Wen, PRB80, 155131 (2009); X. Chen, Z.-C. Gu, and X.-G. Wen, PRB83, 035107 (2011).