New aspects of deconfined quantum criticality

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Abstract

Quantum phase transitions beyond the Landau-Ginzburg-Wilson paradigm based on order parameters are at the forefront of modern condensed matter physics. A specific example is the transition between an antiferromagnet (AFM) and a dimerized valence-bond solid (VBS) in 2 space dimension, where it has been argued that the critical behavior should be described by emergent fractionalized degrees of freedom (spinons) rather than the order parameters of the two phases [1]. Many studies have been carried out and much progresses has been made since the original idea was proposed. However, many new issues and controversies have also arisen, e.g., the possibility of a weakly first-order transitions rather than a continuous one and possible emergent higher symmetries at the transition. In this talk I will address such issues based on lattice models and quantum Monte Carlo simulations. We proposed and simulated [2] an effective model describing a first-order transition between the AFM and a two-fold degenerate plaquette VBS and found that the system develops a higher symmetry, O(4), from the O(3) and Z_2 symmetries of the order parameters. Such emergent symmetry had not been expected at a first-order transition but our results show that it appears at least up the largest accessible length scales ($\sim$ 100 lattice spacing). Such an unusual transition may be realizable in the 2D Shastry-Sutherland compound $SrCu_2(BO_3)_2$ and our model was used to interpret thermodynamic properties of this material in a recent experiment [3]. I will also discuss a perturbation of the deconfined critical point that leads to a new helical VBS phase [4], which had not been considered within existing theories of deconfined quantum criticality.

[1] Senthil, T., Vishwanath, A., Balents, L., Sachdev, S. and Fisher, M.P., Science, **303**, 1490 (2004)

[2] **Zhao, B.**, Weinberg, P. and Sandvik, A.W., Nat. Phys., **15**, 678 (2019)

[3] Guo, J., Sun, G., **Zhao, B.**, Wang, L., Hong, W., Sidorov, V.A., Ma, N., Wu, Q., Li, S., Meng, Z.Y. and Sandvik, A.W., Phys. Rev. Letters, **124**, 206602 (2020)

[4] **Zhao, B.**, Takahashi, J. and Sandvik, A.W., arXiv:2005.10184 (2020) (to appear in Phys. Rev. Lett.)