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Z_2 gauge theory for valence bond solids on the kagome lattice

KYUSUNG HWANG, YEJIN HUH, YONG BAEK KIM, Department of Physics and Centre for Quantum Materials, University of Toronto, Toronto, Ontario M5S 1A7, Canada — We present an effective Z_2 gauge theory that captures various competing phases in spin-1/2 kagome lattice antiferromagnets: the topological Z_2 spin liquid (SL) phase, and the 12-site and 36- site valence bond solid (VBS) phases. Our effective theory is a generalization of the recent Z_2 gauge theory proposed for SL phases by Wan and Tchernyshyov. In particular, we investigate possible VBS phases that arise from vison condensations in the SL. In addition to the 12-site and 36-site VBS phases, there exists 6-site VBS that is closely related to the symmetry-breaking valence bond modulation patterns observed in the recent density matrix renormalization group simulations. We find that our results have remarkable consistency with a previous study using a different Z_2 gauge theory. Motivated by the lattice geometry in the recently reported vanadium oxyfluoride kagome antiferromagnet, our gauge theory is extended to incorporate lowered symmetry by inequivalent up- and down-triangles. We investigate effects of this anisotropy on the 12-site, 36-site, and 6-site VBS phases. Particularly, interesting dimer melting effects are found in the 36-site VBS. We discuss the implications of our findings and also compare the results with a different type of Z_2 gauge theory used in previous studies.

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