

Topological Phases and Interaction Effects

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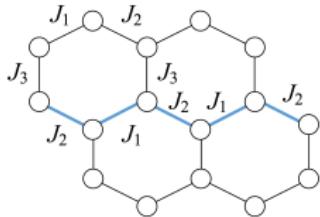
Introduction

- 2D Kitaev honeycomb model (A. Kitaev, 2006)

→ A_x, A_y, A_z \mathbb{Z}_2 gapped spin

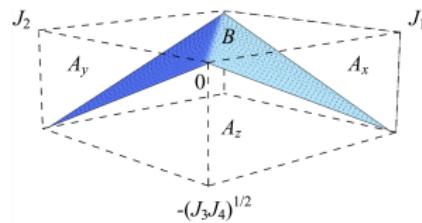
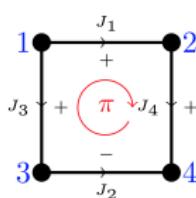
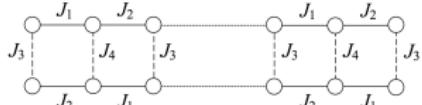
liquid phase: toric code, $\nu = 0$;

→ B gapless spin liquid phase:
anyonic excitations, $\nu = \pm 1$.



(real statue from Université de Montréal, Canada)

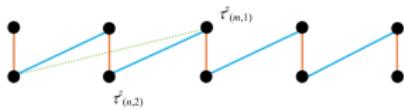
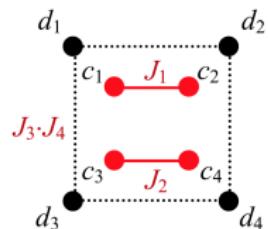
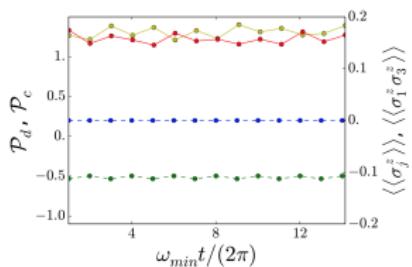
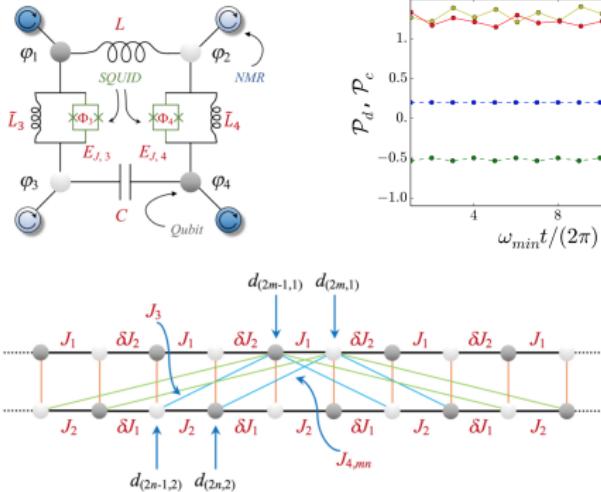
- Generalization to two-leg ladders (K. Le Hur, A. Soret, F. Yang*, PRB 2017)



*Authors by alphabetical order for this paper
[M1 project of Fan]

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- Experimental realization: *cold atoms* (L.-M. Duan *et al*, 2003), *quantum materials* $\alpha\text{-RuCl}_3$ (J.G. Rau *et al*, 2016) and ***quantum circuits*** (F. Yang, L. Henriet, A. Soret, K. Le Hur, PRB 2018).

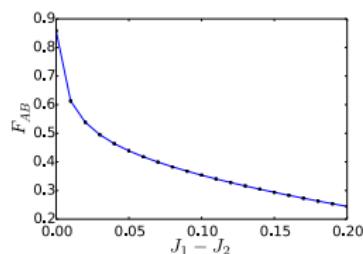
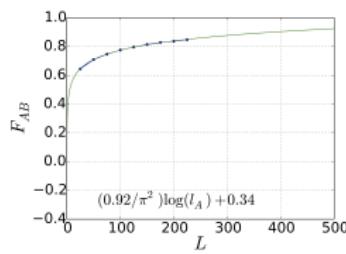
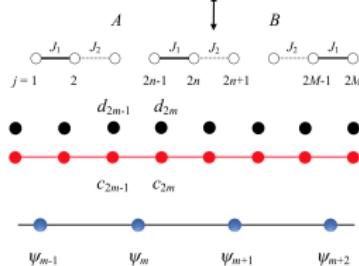


Quantum information encoded in valence bond fluctuations

(In collaboration with K. Plekhanov from Basel, draft in preparation)

$$\mathcal{F}_{AB} = \left| \sum_{i \in A} \sum_{j \in B} \langle Q_i Q_j \rangle_c \right|, \quad Q_j = \sigma_{j,1}^a \sigma_{j,2}^a = -ic_{j,1}c_{j,2}, \quad a = x, y, z.$$

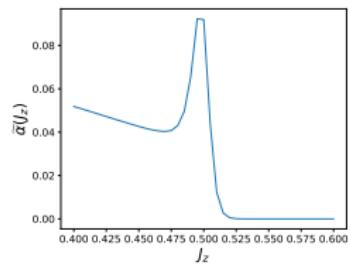
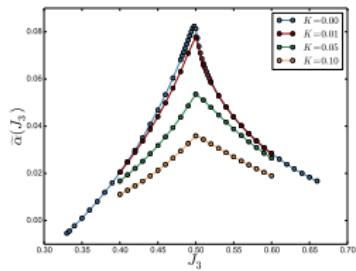
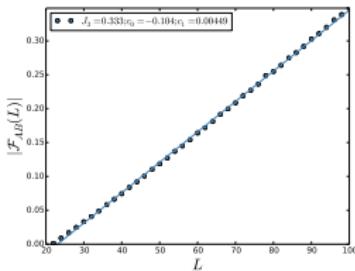
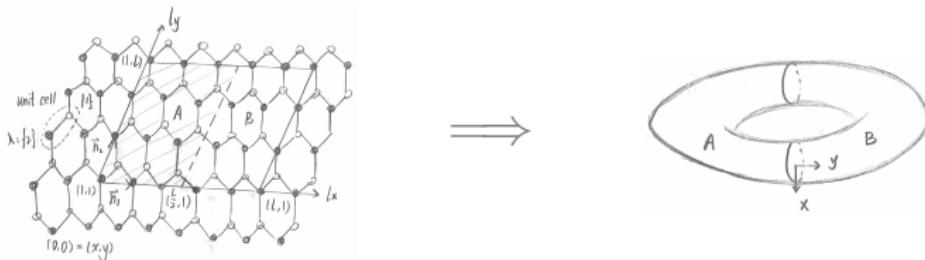
- In one dimension, $\mathcal{F}_{AB} \propto \mathcal{S}_A = (\textcolor{red}{c}/6) \log l_A + \mathcal{O}(1)$, $\textcolor{red}{c} = 1/2$.



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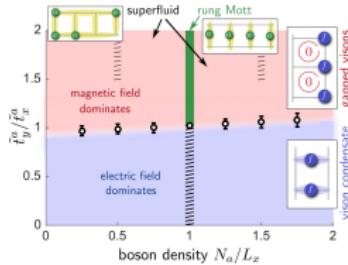
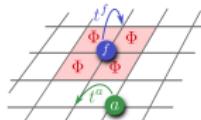
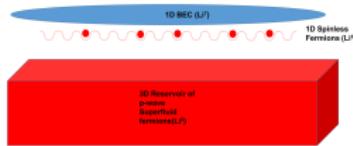
- In two dimensions, $\mathcal{F}_{AB} \sim S_F = \tilde{\alpha}L + \mathcal{O}(1)$.

$$\mathcal{H} = \sum_{\langle jk \rangle} iJ_a c_j c_k u_{\langle jk \rangle_a} + \sum_{\langle \langle jk \rangle \rangle} i\kappa c_j c_k [-u_{\langle ji \rangle_a} u_{\langle ik \rangle_b}] \quad u_{\langle jk \rangle_a} \equiv +1$$



Prospects

- Proximity effect in 1D Bose-Fermi mixtures (on-going)
→ topological p -wave SC and chirality
(In collaboration with V. Perrin, I. Garate and A. Petrescu from Sherbrooke)
- Hybrid ladder system in ultracold atoms (starting soon)
→ from $U(1)$ flux-attachment to \mathbb{Z}_2 lattice gauge theories
(In collaboration with A. Petrescu and F. Grusdt, M. Aidelsburger from Munich)



Thanks for your attention.

Questions ?