Presentation Design and Organization

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Sources:
- The Non-Designer's Design Handbook
- Hugh Crumley's course at Duke
- Experience

Disclaimer

Subjectivity and opinions ahead!

You’ll develop your own personal style over time.

Talks are somewhat like papers...

- Introduction/Motivation /Idea/Question
- Model/Methods
- Results
- Conclusions/Future Directions

A simple fermionic model of deconfined phases and phase transitions

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(Dated: July 15, 2016)

Using Quantum Monte Carlo simulations, we study a series of models of fermions coupled to quantum Ising spins on a square lattice with N flavors of fermions per site for $N = 1, 2$ and 3. The models have an extensive number of conserved quantities but are not integrable, and have rather rich phase diagrams consisting of several exotic phases and phase transitions that lie beyond Landau-Ginzburg paradigm. In particular, one of the prominent phase for $N > 1$ corresponds to $2N$ gapless Dirac fermions coupled to an emergent $\mathbb{Z}_2$ gauge field in its deconfined phase. However, unlike a conventional $\mathbb{Z}_2$ gauge theory, we do not impose the 'Gauss's Law' by hand and instead, it emerges due to spontaneous symmetry breaking. Correspondingly, unlike a conventional $\mathbb{Z}_2$ gauge theory in two spatial dimensions, our models have a finite temperature phase transition associated with the melting of the order parameter that dynamically imposes the Gauss's law constraint at zero temperature. By tuning a parameter, the deconfined phase undergoes a transition into a short range entangled phase, which corresponds to Néel/Superconductor for $N = 2$ and a Valence Bond Solid for $N = 3$. Furthermore, for $N = 3$, the Valence Bond Solid further undergoes a transition to a Néel phase consistent with the deconfined quantum critical phenomenon studied earlier in the context of quantum magnets.

PACS numbers: 71.10.-w,71.10.Hf,75.40.Cx,75.40.Mg

CONTENTS

I. INTRODUCTION

Ground states of strongly interacting electronic systems can longer true for gapless phases such as Fermi liquids [11–13], or gapped topological phases such as a fractional quantum Hall liquid, and such phases are thus said to possess 'long-range entanglement' [7, 8, 14].

Experience as well as heuristic arguments suggest that Hamiltonians whose ground states posess long range entanglement are relatively difficult to simulate on a classical computer. For example, even a phase as ubiquitous and as well understood as a Fermi liquid is rather hard to simulate numerically because fermions at finite density with repulsive interactions tend to have an intricate sign structure in their wavefunctions leading to the infamous Monte Carlo fermion sign problem [15–17]. Similarly, fractional quantum Hall phases again possess a non-trivial sign structure to their wavefunctions [18], and therefore so far are amenable only via techniques such as Exact Diagonalization [19, 20] and Density Matrix RG [21], which are restricted to only small two-dimensional systems due to exponential scaling of numerical cost with system size. However, there do exist long-range entangled phases that do not suffer from Monte Carlo sign problem. Two prominent examples are: (1) Interacting Dirac fermions with an even number of flavors [22] (2) A gapped $\mathbb{Z}_2$ topological ordered system such as a Toric code Hamiltonian [14] in a magnetic field [23]. The absence of sign problem for the former is related to the positive fermion determinant, while in the latter case, the Hamiltonian has non-positive off-diagonal elements in a local basis, allowing one to

But they're also not like papers!

$$(1+h_4)^{-1} \quad (1+h_4h_3)^{-1} \quad (1+h_4h_3h_2)^{-1} \quad (1+h_4h_3h_2h_1)^{-1} \quad 1$$

$$(1+h'_1)^{-1}$$

$$(1+h_4)^{-1} \quad (1+h_4h_3)^{-1} \quad (1+h'_1h_4h_3h_2)^{-1} \quad (1+h'_1)^{-1}$$

$$(1+h'_2)^{-1}$$

$$(1+h_4)^{-1} \quad (1+h'_2h'_1h_4h_3)^{-1} \quad (1+h'_2h'_1)^{-1} \quad (1+h'_1)^{-1}$$

$$(1+h'_3)^{-1}$$

$$(1+h'_3h'_2h'_1h_4)^{-1} \quad (1+h'_3h'_2h'_1)^{-1} \quad (1+h'_2h'_1)^{-1} \quad (1+h'_1)^{-1}$$

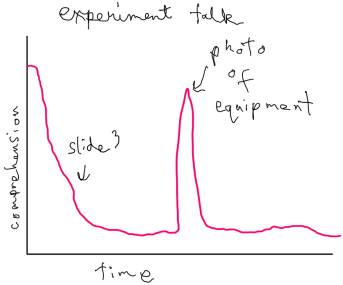
- Can control when things appear.
- Prioritize understanding over compactness/rigor.

Presentation software

- Popularity is subfield-dependent
- Keynote, Powerpoint
- Beamer (templates: overleaf.com)
- Google Slides, LibreOffice, OpenOffice

(Beamer)

When physics talks are outside your subfield...



What not to do...

Low Energy Electron Microscopy (LEEM)

- Electrons are initially accelerated to high energy (20keV) in order to steer and focus the electron beem accurately, traveling through a series of lenses which focus them as a single beam on the sample
- The objective lens focuses the electrons onto the sample and also decelerates them to *low* energies of only a few electron volts in order to achieve surface sensitivity.
- The backscattered electrons are then accelerated again by the objective lens so that they can be steered further by magnetic lenses, directed into the imaging column, and focused to form the final image.
- Differences in crystal orientation, surface structure, and the presence of adsorbed materials will cause a difference in the intensity of the beam.

But I did have an equipment picture!

Photos of LEEM Instrument

Top View **Side View**

- Sample temperatures determined from filament current–using a calibration curve correlating optical pyrometer readings with dosing currents.

My theory presentation the following year...

Coherent and Incoherent Terms

In a randomly distributed assortment of scatterers it can be shown that the terms where $\alpha \neq \beta$ give a negligible contribution to the sum. However, for a large collection of scatterers in some sort of regular distribution the contributions of the terms mixing $\mathbf{f}_\alpha$ and $\mathbf{f}_\beta$, where $\mathbf{r}_\alpha$ and $\mathbf{r}_\beta$ are sufficiently close, become important. Thus the equation becomes:

$$\mathbf{f} \cdot \mathbf{f}^* = \sum_{\alpha=1}^{N} |\mathbf{f}_\alpha|^2 + \sum_{\alpha\beta=\mathrm{nn}} \mathbf{f}_\alpha \cdot \mathbf{f}_\beta^* \tag{11}$$

where “nn" means the near neighbors. The first sum in this equation will yield the same intensities as those for a single sphere multiplied by N, and will be referred to as the incoherent term, whereas the second sum will be referred to as the coherent term, as it contains the structural information of the particular system and creates its distinctive scattering pattern.

Equations: Keep it simple

Don't write your talk out on the slide.
Focus on key words, equations–say the rest.

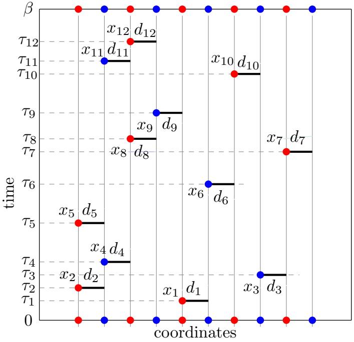
Example:

$$\mathbf{f} \cdot \mathbf{f}^* = \sum_{\alpha,\beta} \mathbf{f}_\alpha \cdot \mathbf{f}^*_\beta$$
$$\approx \sum_{\alpha=1}^{N} |\mathbf{f}_\alpha|^2 + \sum_{\alpha\beta=nn} \mathbf{f}_\alpha \cdot \mathbf{f}^*_\beta$$

- Nearest neighbor approximation for physical distribution of scatterers.

Equations: Aid with diagrams

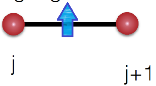
$$Z = \int [d\tau] \sum_{k,\left[\langle x,\hat{d}\rangle\right]} \mathrm{Tr}\Big(\hat{H}_{x_k,\hat{d}_k}(\tau_k)\ldots\hat{H}_{x_2,\hat{d}_2}(\tau_2)\hat{H}_{x_1,\hat{d}_1}(\tau_1)\Big),$$



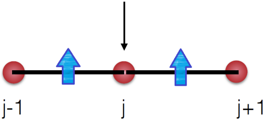
Equations: Integrate with diagrams

- Hamiltonian:
$$\hat{H} = \sum_j \left[-t \left(\hat{c}_j^\dagger \hat{c}_{j+1} + \hat{c}_{j+1}^\dagger \hat{c}_j \right) \hat{\sigma}_j^z - h \hat{\sigma}_j^x \right],$$

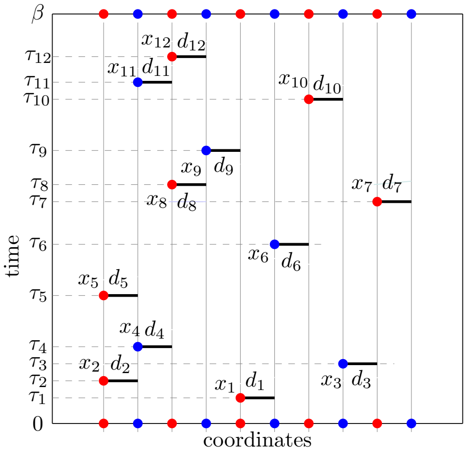
gauge fields



- $\left[\hat{Q}_j, \hat{H} \right] = 0$, where $\hat{Q}_j = \hat{\sigma}_{j-1}^x \hat{\sigma}_j^x (-1)^{\hat{c}_j^\dagger \hat{c}_j}$.

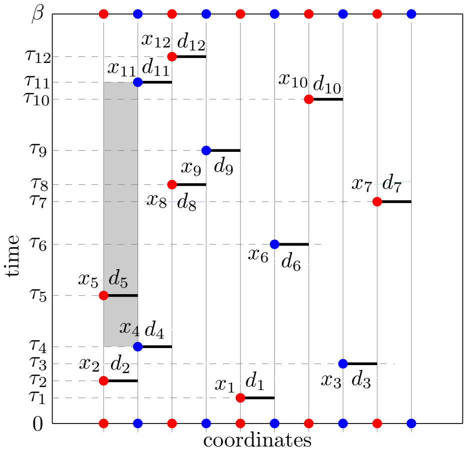


Use diagrams instead of equations when possible!



Each image corresponds to a mathematical expression.

Use diagrams instead of equations when possible!



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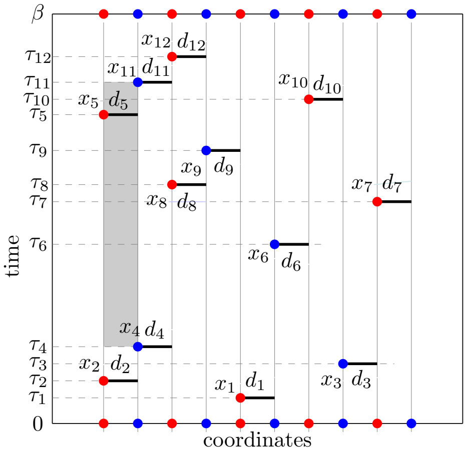

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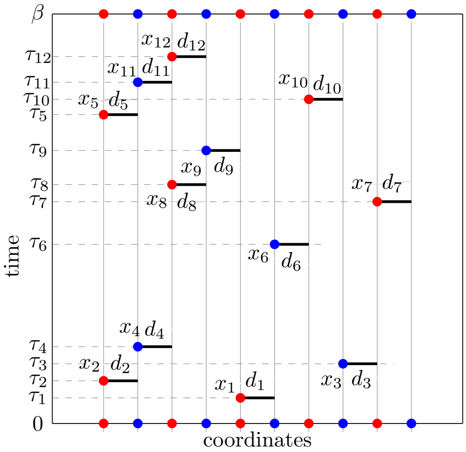

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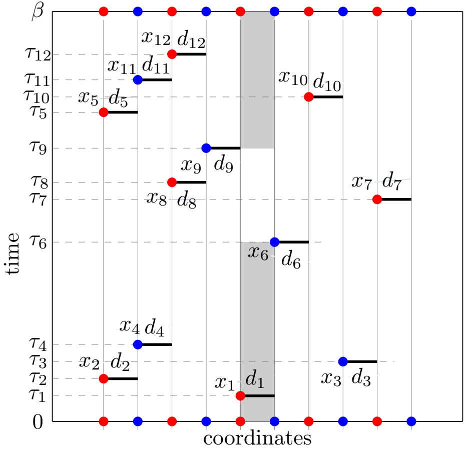

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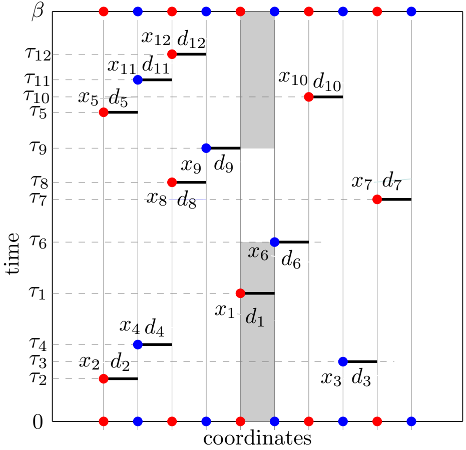

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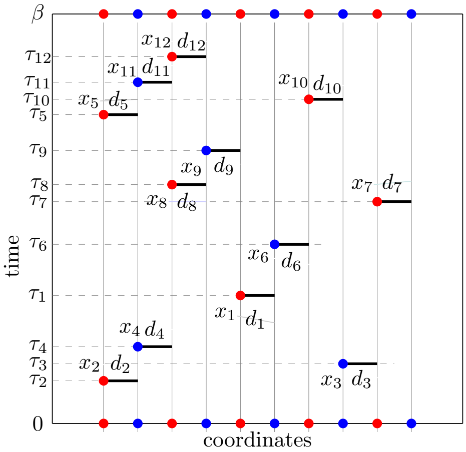
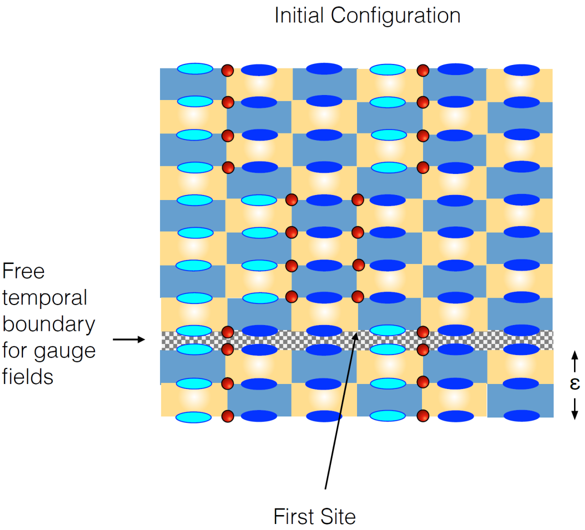
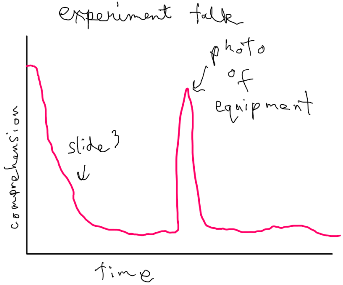


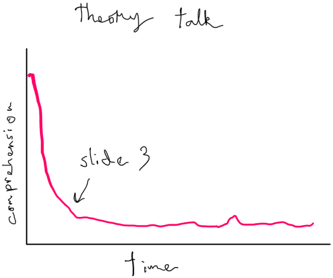
Each image corresponds to a mathematical expression.

You can combine diagrams into animations



How else to deal with this issue? Analogies.





Science communicators and their analogies...

We have many richer analogies at our disposal though.

- Connect to a more well-known physics concept, when possible!

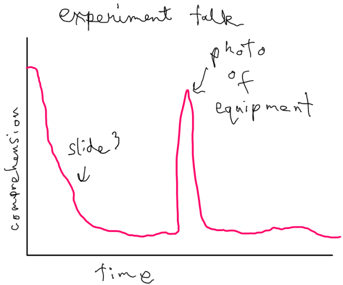
Example:

$$\hat{Q}_j \left|\psi\right\rangle_{\text{GLS}} = \hat{\sigma}^x_{j-1}\hat{\sigma}^x_j(-1)^{\hat{c}^\dagger_j \hat{c}_j} \left|\psi\right\rangle_{\text{GLS}} = q_j \left|\psi\right\rangle_{\text{GLS}}.$$

- QED analogy:

$$\left[\hat{\sigma}^x_{j-1}\hat{\sigma}^x_j(\equiv \vec{\nabla}\cdot\vec{E}) - q_j(-1)^{\hat{c}^\dagger_j \hat{c}_j}(\equiv \rho)\right] \left|\psi\right\rangle_{\text{GLS}} = 0.$$

One other thing



"Never underestimate the enjoyment [and added understanding] people get from hearing things they already know."
–Tom Mehen

Lots of possibilities, lots of room for improvement

- My presentations get better over time, I get rid of excess as I go.
- Time is also a factor–some of these things can be very time consuming.
- Put down what you need, and what you have time for.

It's an incremental, iterative process

You'll develop your own style over time.

(photo credit: visualize.com)