Title: A tensor-network approach to fixed-point models of topological phases

Speakers: Andreas Bauer

Collection: Tensor Networks: from Simulations to Holography III

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Abstract: "I will introduce a tensor-network based language for classifying topological phases via fixed-point models. The "models" will be tensor networks formalizing a discrete Euclidean path integral living in a topological space-time, and can be obtained from Hamiltonian models by Trotterizing the imaginary time evolution. Topological fixed-point models are invariant under topology-preserving space-time deformations. Space-time manifolds and homeomorphisms can be combinatorially represented by graph-like "networks", which together with "moves" form a "liquid". The networks can be interpreted as tensor networks, and the moves as equations which determine the fixed-point models. Different combinatorial representations of the same space-times yield new kinds of fixed-point models. Given the limited time, I will stick to very simple examples in 1+1 dimensions for this talk."

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A unified diagrammatic approach to topological fixed point models

Andreas Bauer

17.11.2020

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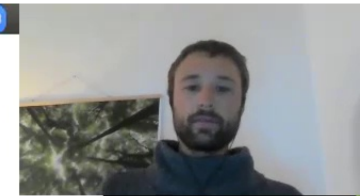

Approach

Penrose notation

combinatorics: topological spacetime

tensors: fixed-point models

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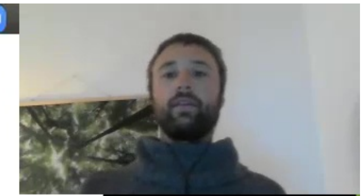
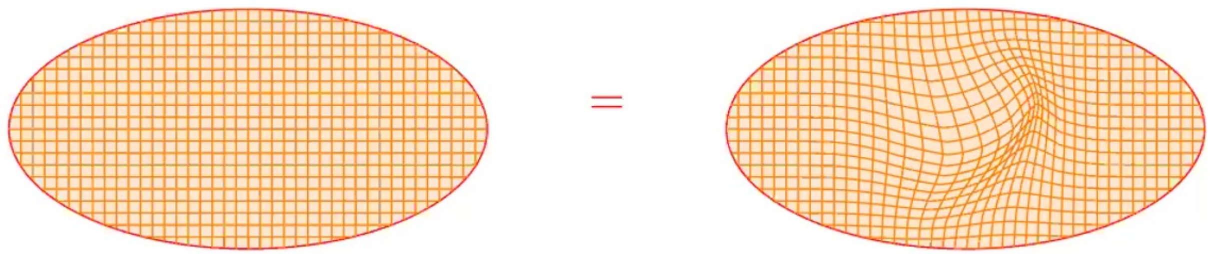


Topological deformability

Invariance of Euclidean path integral under homeomorphisms



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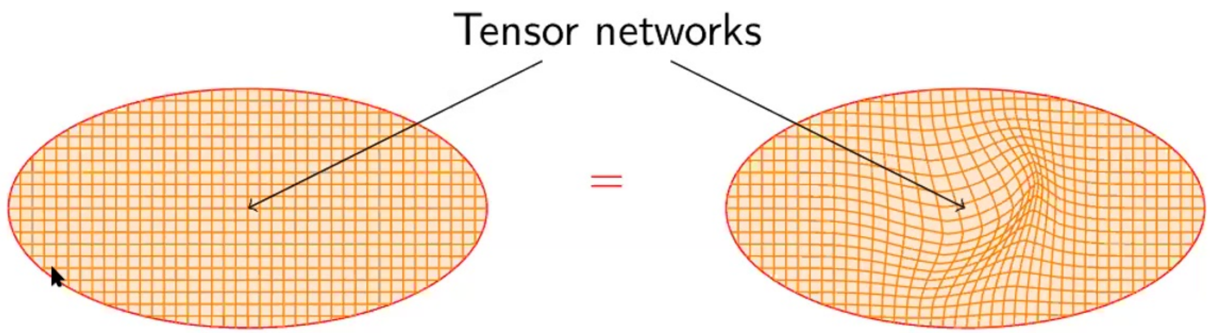

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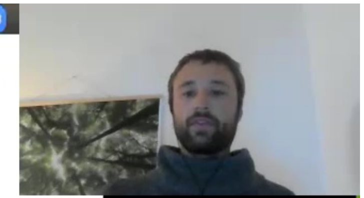

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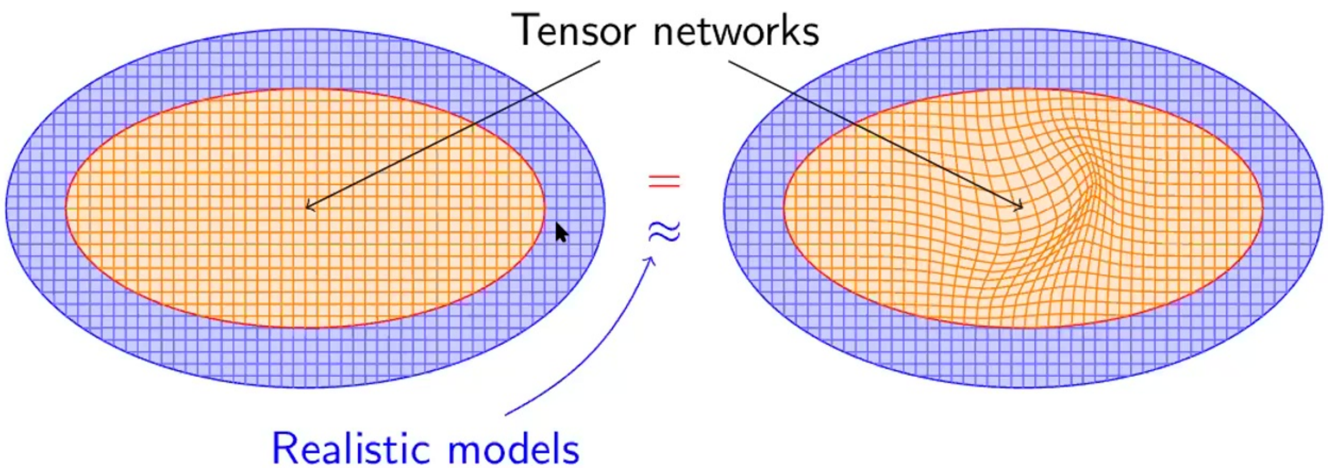

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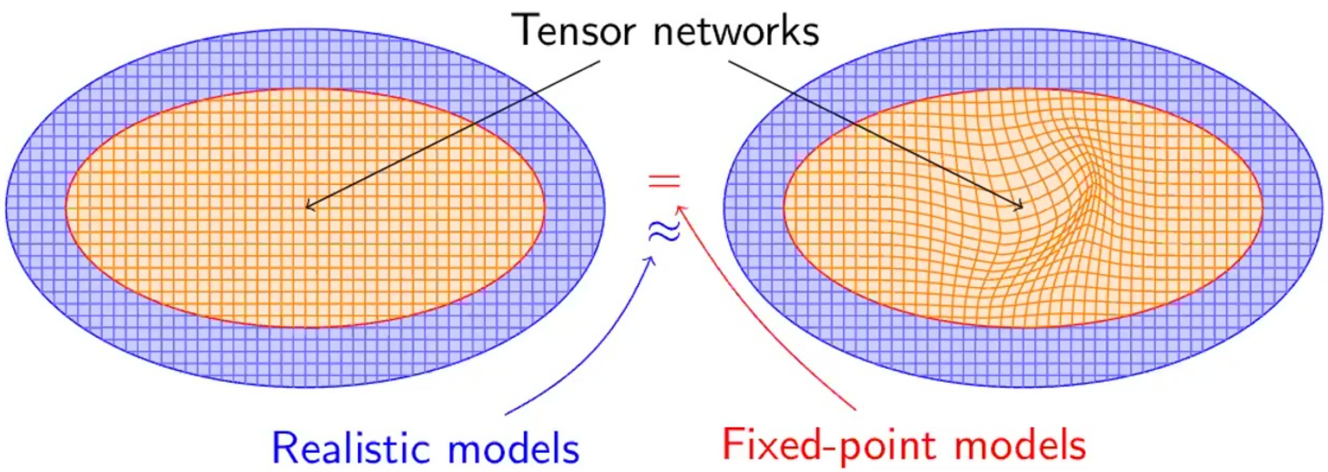

✓ Conventional topological order

✓ Symmetry breaking order

✗ Fracton order

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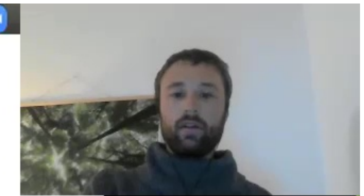
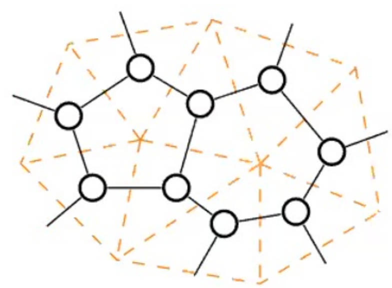


Example: $1+1$D triangulations

Represent 2-manifold by triangulation:



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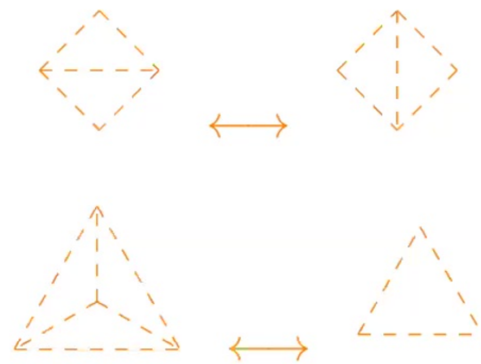
Example: $1+1$D triangulations

Represent homeomorphisms by Pachner moves:



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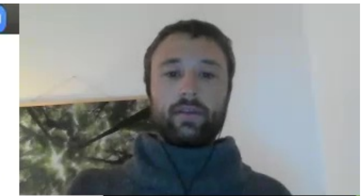

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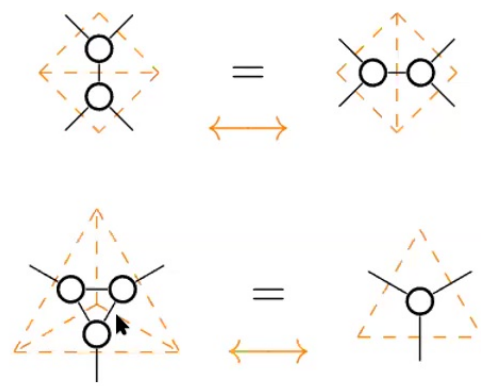

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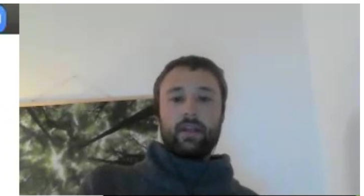

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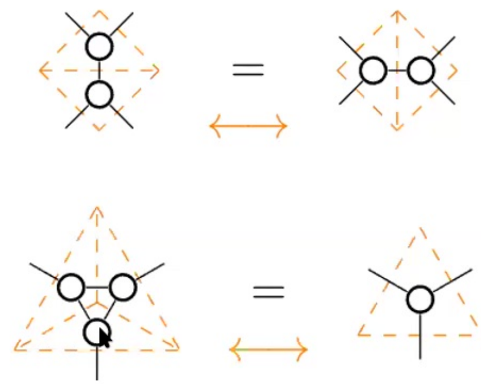

- combinatorial structure = “liquid”
- 3-index tensor fulfiling the equations = “model of liquid”

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Example: $1+1$D triangulations

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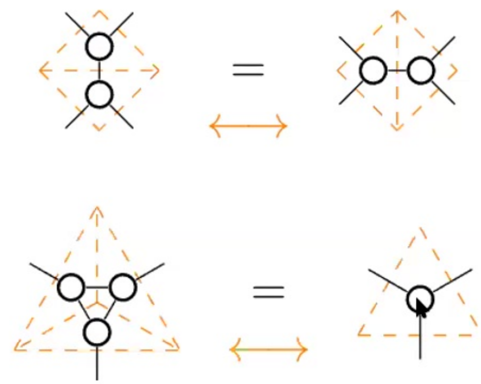

- combinatorial structure = "liquid"
- 3-index tensor fulfiling the equations = "model of liquid"
- equations can be interpreted in different "tensor types"

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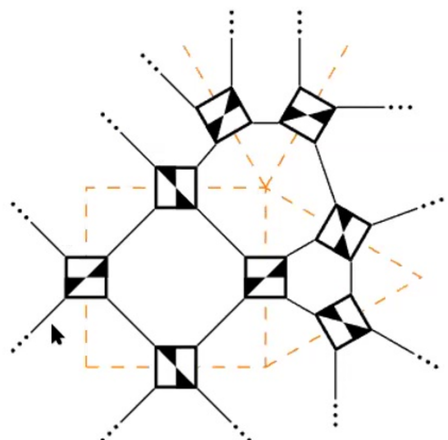
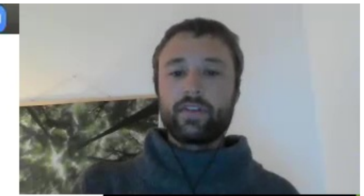
1 + 1D edge liquid

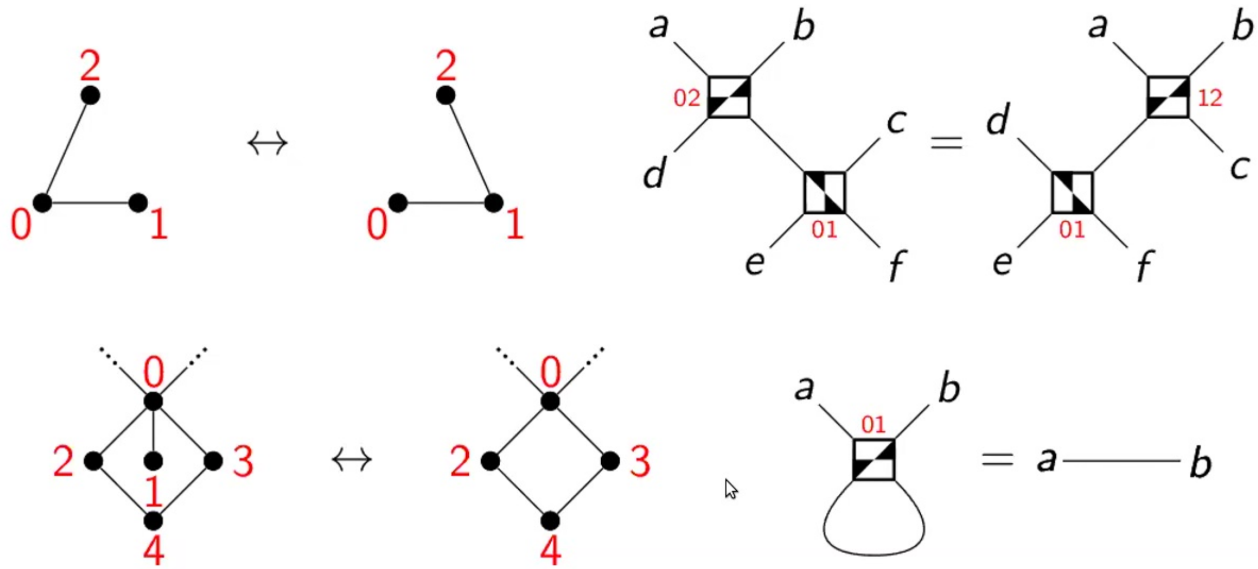
- There are other ways to represent 2-manifolds
- Toy example: One tensor at every edge





1 + 1D edge liquid

Moves:



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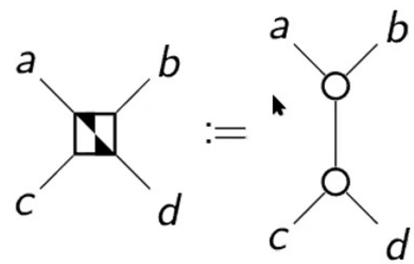
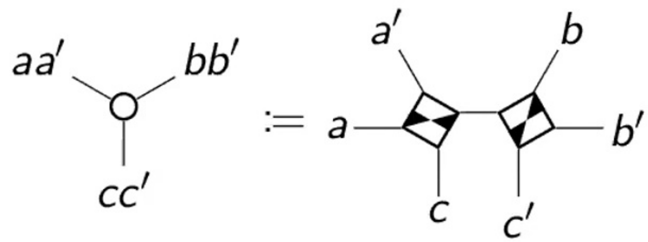
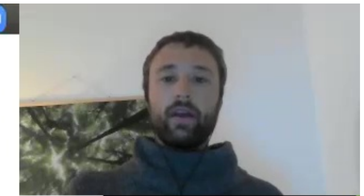
Equivalence between the two liquids

- Mapping edge-liquid → triangle-liquid:



- Mapping triangle-liquid → edge-liquid:





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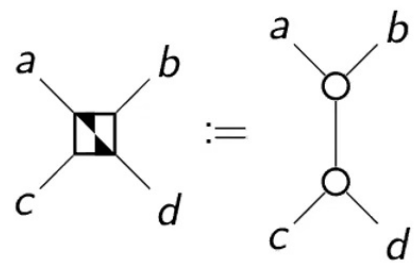
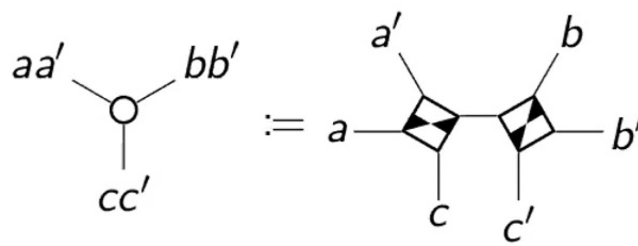


- Mapping triangle-liquid $\rightarrow$ edge-liquid:



- Models for liquids describe the same phases

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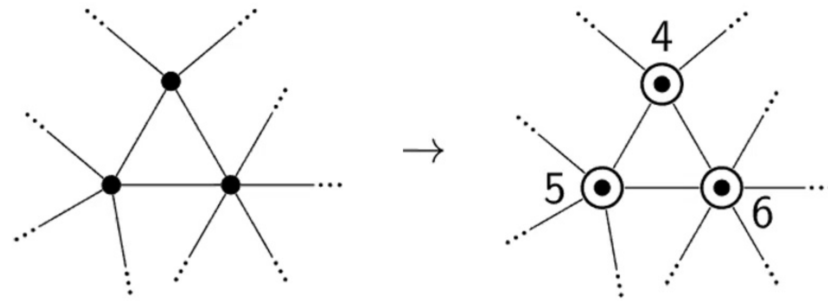
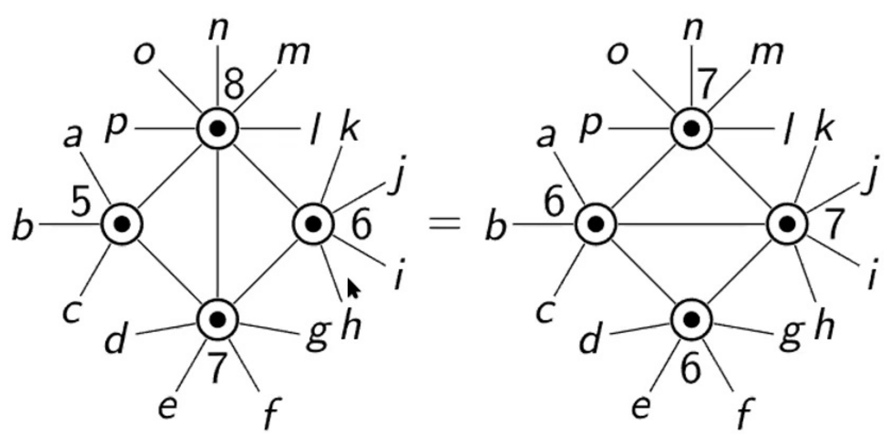
Vertex liquid

- Represent every vertex by a tensor



- 5-valent, 6-valent, . . . vertices represented by different tensors.
- Moves:



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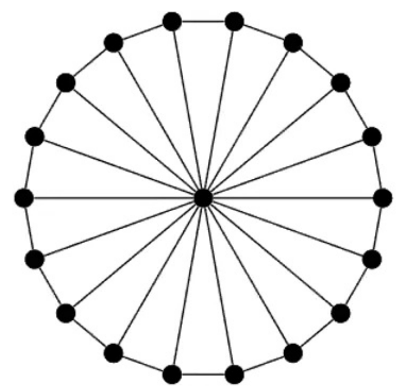
Vertex liquid

- No obvious equivalence to triangle liquid



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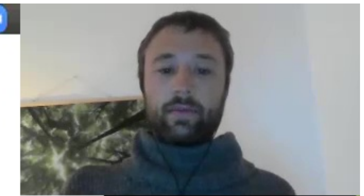

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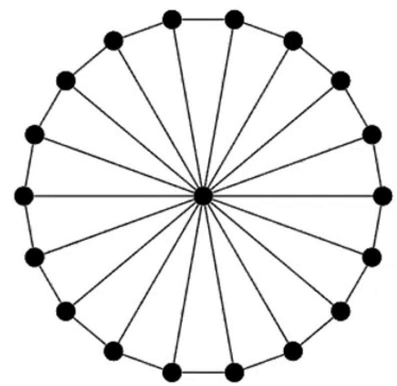

- ⇒ Could potentially contain models for more general phases
- Apparently not the case in 1+1D
- No standard boundary construction
- No standard commuting-projector construction
- Chiral phases in 2+1D?

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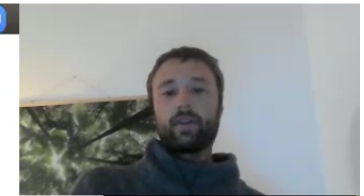

Other liquids

- Fixed-point models in any dimension, for boundaries/anyons/domain walls/defects, with/without orientation/spin structure/...
- E.g., tensors as tetrahedra of 3D triangulation $\rightarrow$ string-net models
- E.g., tensors at edges and faces of 3D cell complex $\rightarrow$ Kitaev quantum doubles for weak Hopf algebras
- More general liquids with possibly more general phases (chiral phases?)
- Conformal fixed-point models?