QFT and UQM - Overview

Andreas Karch (University of Washington, Seattle)

Overview Talk at UQM Kick-off Meeting, Sep 13 2019
What is UQM?
What is UQM?

Ashvin
Big Question - Big Answers
What’s up with dualities in 2+1 dimensions?
Abelian Duality Web (Tong, AK, Seiberg, Senthil, Wang, Witten) (2016)

Base pair
(Wilson Fisher scalar + flux = free fermion)

Another base pair
(scalar = fermion + flux)

Particle-Vortex duality

Self-duality of 2 flavor QED
(deconfined quantum criticality)

Fermionic Particle-Vortex
(half filled Landau level)

many new Abelian dualities....
Outline

• Patterns
• Defects
• Beyond
Baryons, monopoles and dualities in Chern-Simons-matter theories

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Bose/Fermi duality for SU(N) with fundamental matter obeying “flavor bound”
Dualities Galore

Chern-Simons-matter dualities
with $SO$ and $USp$ gauge groups

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Duality and bosonization of $(2+1)d$ Majorana fermions

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Bose/Fermi duality for $SO(N)$ and $Sp(N)$ with fundamental matter obeying “flavor bound”
Dualities Galore

A Symmetry Breaking Scenario for QCD$_3$

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Bose/Fermi duality for SU(N), SO(N) and Sp(N) with fundamental matter beyond “flavor bound”. Multiple transitions and quantum phase.
Duality Galore

A master bosonization duality

Three-dimensional dualities with bosons and fermions

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Bose + Fermi/ Bose + Fermi duality for SU(N), SO(N) and Sp(N) with fundamental matter obeying flavor bound.
Duality Galore

Generalization of QCD$_3$ Symmetry-Breaking and Flavored Quiver Dualities

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Bose + Fermi/ Bose + Fermi duality for SU(N), SO(N) and Sp(N) with fundamental matter beyond flavor bound.
The Master Duality

One duality to rule them all,
One duality to find them
One duality to bring them all,
and in the darkness bind them
The Master Duality

One duality to rule them all,
One duality to find them,
One duality to bring them all,
and in the darkness bind them?

Not so fast!
More dualities galore

• Fermi/Fermi dualities with a single rank-2 tensor
  - adjoint
    (Gomis, Komargodski, Seiberg)
  - symmetric and anti-symmetric
    (Choi, Delmastro, Gomis, Komargodski)

• Bose/Bose dualities with a single rank-2 tensor
  (Aitken, Baumgartner, AK)

• Even more interesting Fermi/Fermi dualities
  (Choi, ...
More dualities galore

- **Fermi/Fermi dualities with a single rank-2 tensor**
  - adjoint (Choi, Delmastro, Gomis, Komargodski)
  - symmetric and anti-symmetric (Choi, Delmastro, Gomis, Komargodski)

- **Bose/Bose dualities with a single rank-2 tensor**
  - (Aitken, Baumgartner, AK)

- Even more interesting Fermi/Fermi dualities
  - (Choi, ...)
Some Order in the Chaos:

New dualities from old:

• **Gauge Global Symmetries:**

  F flavors, SU(F) Global Symmetry, Gauge: Quiver

(Jensen, AK; Aitken, Baumgartner, AK)

• **Orbifolding:** Mod out by discrete symmetry
Some Order in the Chaos:

New dualities from old:

- Gauge Global Symmetries:
- Orbifolding: Mod out by discrete symmetry

Claim: adjoint rank-2 tensor theory from Master by Orbifolding 2-node quiver

(Aitken, Choi, AK)
Some Order in the Chaos:

Still: far from clear that Master is all we need

Holy Grail: 3d Pouliot duality

(If you ever thought 4d N=1 SUSY Seiberg duality had a pattern to it, try to explain “SO with spinors”)
2+1 Dualities and Defects

- Duality with boundaries
  3d bulk / 2d surface

- Duality on boundaries/interfaces
  4d bulk / 3d surface
Duality on Defects

3d Chern-Simons matter theories can arise on interfaces and domain walls of 4d gauge theories.

(Gaiotto, Komargodski, Seiberg)

• Universal language to understand these recently developed: “Anomalies in the Space of Coupling Constants”
  
  (Cordova, Freed, Lam, Seiberg)

• Relation to duality via “holography”

  (Aitken, Baumgartner, AK)
Duality with Defects

• Beautiful Story when supersymmetry is added:
  
  (Dimofte, Gaiotto, Paquette)

• Without Supersymmetry we barely scratched the surface:
  
  (Gaiotto; Aitken, Robinson, AK)

Is any of this relevant to “real” physics?
Beyond....

What about 3+1 dimensions?

What about 1+1 dimensions?

Fractons?