

Mirror dualities with four supercharges

Riccardo Comi

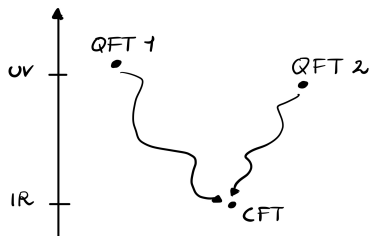
University of Milano-Bicocca

Based on: S. Benvenuti, RC, S. Pasquetti [2312.07667] and w.i.p

September 25, 2024

Infra-Red Dualities

We have an **IR Duality** whenever two different Ultra-Violet QFTs flow to the same Infra-Red fixed point.



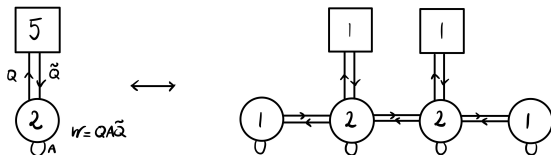
- First introduced in 4d SUSY theories. [Seiberg '94]
Many more SUSY examples in various dimensions have been found.
- Simple tests: **map of global symmetries** and **map of gauge invariant operators**.

$3d \mathcal{N} = 4$ mirror dualities

The moduli space of $3d \mathcal{N} = 4$ theories consist of two branches intersecting only at the origin:

- **Higgs branch:** parameterized by meson \rightarrow Classically exact
- **Coulomb branch:** parameterized by monopoles \rightarrow Quantum corrected

Mirror duality relates two $3d \mathcal{N} = 4$ theories by swapping their Higgs and Coulomb branch. [Intriligator-Seiberg '96] Example:



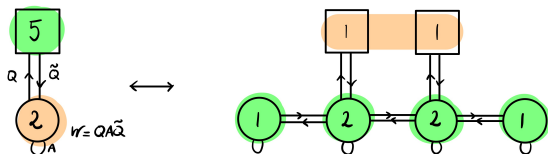
- In the mirror the $SU(5)$ enhances from the $U(1)^4$ topological symmetries.
- The mesons are mapped to a collection of monopoles and vice-versa.

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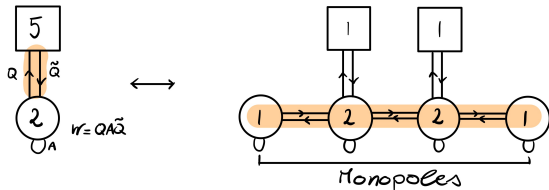
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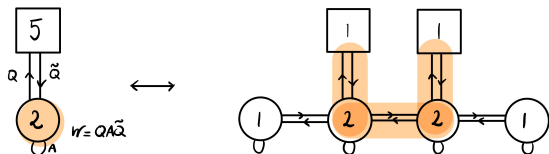
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$\mathcal{N} = 2$ mirror dualities

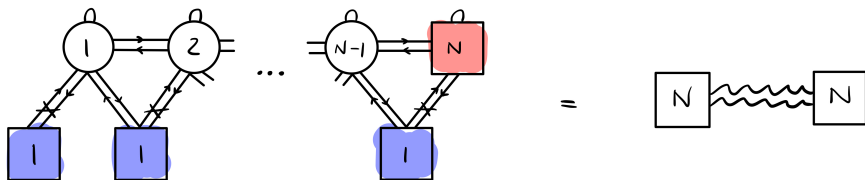
What about 3d $\mathcal{N} = 2$ theories?

We constructed a class of 3d $\mathcal{N} = 2$ theories enjoying a mirror-like duality. These can be constructed using a strongly coupled SCFT as building block...

[Benvenuti-RC-Pasquetti '23]

$FM[U(N)]$ theory: the improved hyper

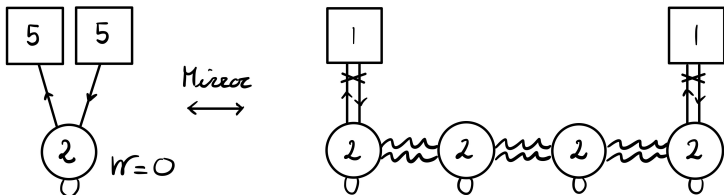
The $FM[U(N)]$ is a 3d $\mathcal{N} = 2$ SCFT at the IR fixed point of the UV Lagrangian:
[Pasquetti-Sacchi '19]



- **Global IR (enhanced) symmetry:** $U(N) \times U(N) \times U(1)^2$.
There is an extra $U(1)$ symmetry w.r.t. an hypermultiplet.
- **Self-dual under mirror duality** swapping emergent and manifest $U(N)$.
- The spectrum contains a **pair of bifundamentals** of $U(N) \times U(N)$.

Mirror dualities for 3d $\mathcal{N} = 2$ theories

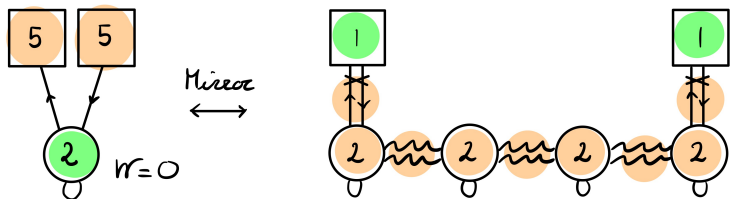
Example of a 3d $\mathcal{N} = 2$ mirror duality. [Benvenuti-RC-Pasquetti '23]



- **Proven in field theory** as a consequence of Seiberg-like duality.
- Complete map of the global symmetries.
The topological symmetries and the **extra $U(1)$'s of the improved hypers** enhance to $U(5) \times U(5)$.
- Complete map of gauge invariant operators.
Monopole operators map to mesons and vice-versa.

Mirror dualities for 3d $\mathcal{N} = 2$ theories

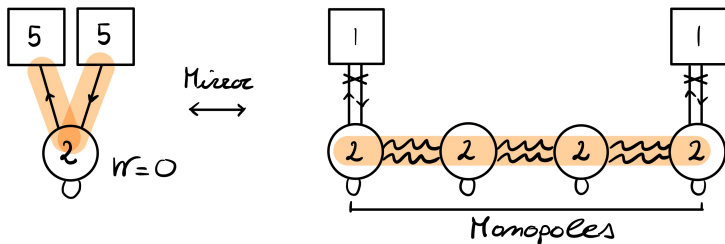
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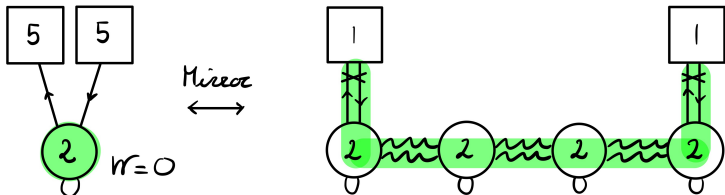
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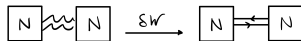
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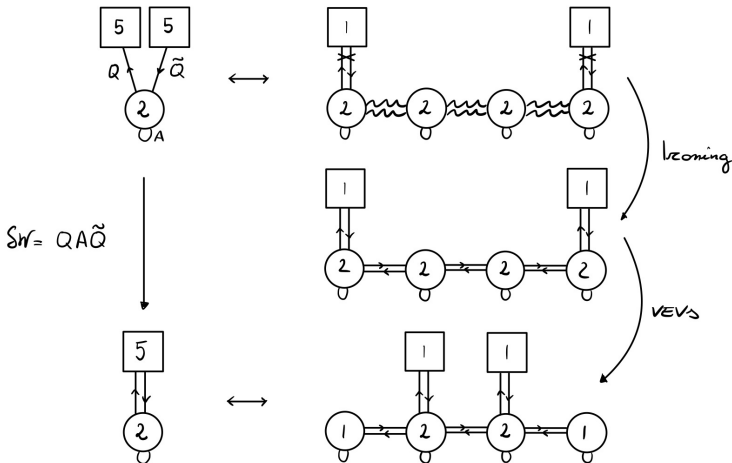
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Deforming to 3d $\mathcal{N} = 4$ mirror pair

The imp. hyper can be **ironed to a standard hyper**:



The $\mathcal{N} = 2$ duality can be deformed to the $\mathcal{N} = 4$.



Brane interpretation

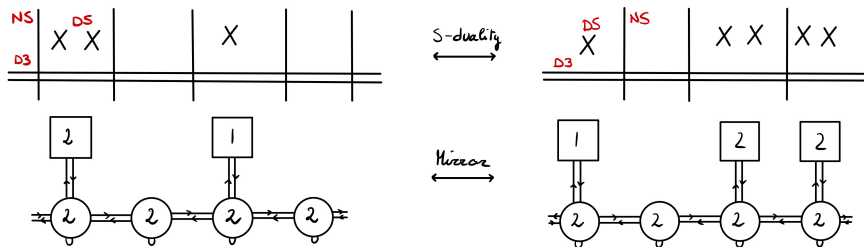
Mirror dualities for $3d \mathcal{N} = 4$ theories can be understood from the point of view of Type IIB brane setups.

The new class of $3d \mathcal{N} = 2$ mirror dualities fit inside the brane picture...

Brane setups with eight supercharges

$\mathcal{N} = 4$ theories can be **engineered in Type IIB** with NS5, D5, and D3 branes.

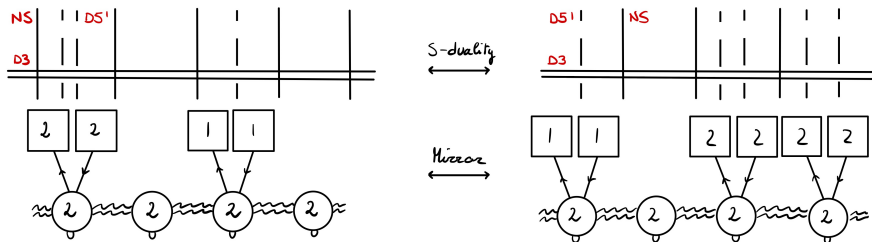
[Hanany-Witten '96]



- Read as:
 - Interval between two NS5: $U(N)$ gauge group
 - NS5 with D3 suspended on both sides: bifundamental hypermultiplet
 - D5: flavor for the corresponding node.
- Mirror duality is **induced by S-duality** swapping NS5 and D5.

Brane setups with four supercharges

Rotating a D5 brane breaks half SUSY and turn off the $\mathcal{N} = 4$ superpotential.
 Proposal: **improve the standard bifundamentals**.



- The mirror duality can be **proved in QFT**.
 → **the web is consistent!**
- The extra $U(1)$'s of the improved hypers map to extra flavor symmetries.
 → **complete map of global symmetries and operators!**

Conclusions

Some other things that we achieved:

- Generalized to theories with chiral matter and/or Chern-Simons level.
- Uplift to 4d $\mathcal{N} = 1$ theories with $USp(2N)$ gauge group.

Everything proved in QFT with an algorithmic technique.

Possible future extensions:

- More generic brane setups with different type of branes.
- Theories with different gauge groups.

Thank you!