Title: Session 1 - Valentina Prilepina

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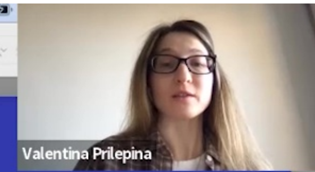
Abstract: Virtual

Mapping the Theoretical Landscape through the Conformal Bootstrap

Valentina Prilepina

October 24, 2022
Perimeter Institute

Why Study Conformal Field Theories (CFTs)?



CFTs describe universal physics of scale invariant critical points:

- continuous phase transitions in condensed matter and statistical physics systems
- fixed points of RG flows

Provide a handle on

- Universal structure of the landscape of QFTs
- Quantum gravity via the AdS/CFT correspondence and holography

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Provide a handle on

- Universal structure of the landscape of QFTs
- Quantum gravity via the AdS/CFT correspondence and holography
- String theory
- Black holes

Conformal bootstrap program seeks to systematically apply

- conformal symmetry
- crossing symmetry
- unitarity/reflection positivity

to map out and solve the space of allowed CFTs

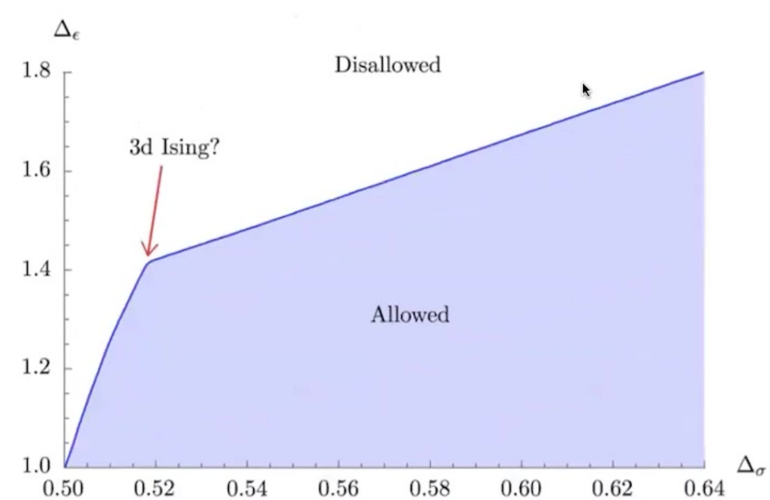

Figure: Upper bound on Δ_ϵ as a function of Δ_σ in 3d CFTs [El Showk

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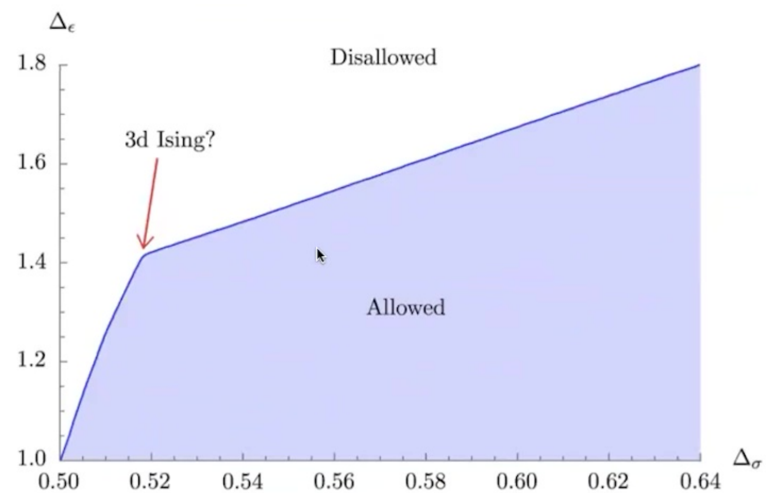

Figure: Upper bound on Δ_ϵ as a function of Δ_σ in 3d CFTs [El-Showk, Paulos, Poland, Rychkov, Simmons-Duffin, Vichi, '12; '14]

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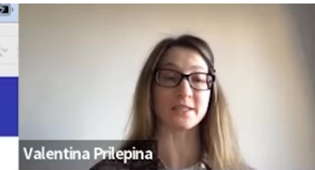

- Owing to bootstrap: tremendous progress on the numerical and analytic fronts! e.g. Ferrara et al. (1971, 1973), Dobrev et al. (1976, 1977), Polyakov (1974), Dolan & Osborn (2001, 2004, 2011), Poland et al. (2012), Simmons-Duffin (2014), El-Showk et al. (2014), Kos et al. (2014, 2015, 2016), Costa & Hansen (2015), Rejon-Barrera & Robbins (2016), Echeverri et al. (2016), Costa et al. (2016), Fortin & Skiba (2016, 2019), Karateev et al. (2017), Poland & Simmons-Duffin (2019)
- Dream: to classify and solve the entire landscape of CFTs and predict their observables

CFTs are signposts in the landscape of QFTs!

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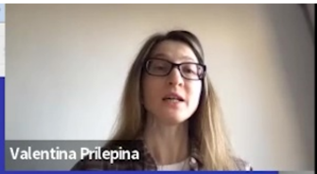
The Higher-Point Conformal Bootstrap



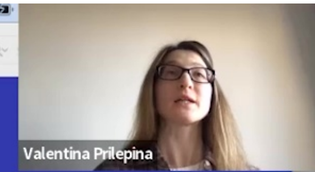
So far, most results extracted by considering 4-point functions!

(for a review, see e.g. Poland, Rychkov and Vichi (2019))

$\Rightarrow$ Explicit expressions or recursion relations for conformal blocks appearing in 4-point functions of scalars in arbitrary d

$\Rightarrow$ Rich variety of techniques for handling 4-point blocks in arbitrary Lorentz representations

Goal of this Work

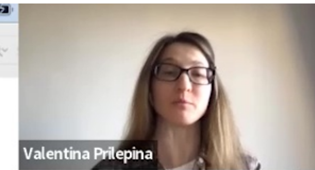


We seek to

- Identify a simple and practical approach to computing 5-point and higher-point blocks
- Improve and extend our understanding of 5-point and higher-point blocks by deriving simple recursion relations

For example,

- Consider scalar 5-point function $\langle \phi_{\Delta_1} \phi_{\Delta_2} \Phi_{\Delta_3} \phi_{\Delta_4} \phi_{\Delta_5} \rangle$
- Compute the conformal block for arbitrary symmetric traceless tensor exchange in (12) and (45) OPEs



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Our results

- May be seen as a natural generalization of recursion relations for 4-point blocks obtained by Dolan & Osborn (2011)

The Weight-Shifting Operator Formalism

This formalism (due to Karateev et al. (2017)) introduces a

- Large class of conformally-covariant differential operators

⇒ These operators may be used to relate correlation functions of operators in different representations of the conformal group

⇒ Method enables determination of seed conformal blocks as well as more general blocks

⇒ Allows for efficient derivation of recursion relations

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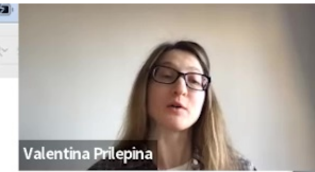


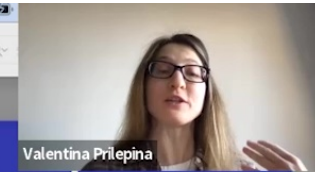
Our overall strategy involves

⇒ Acting with specific combinations of weight-shifting operators on a given conformal block

⇒ Then applying the two- and three- point crossing relations as needed

Goal: to re-express the original block in terms of

- linear combinations of lower-spin blocks with shifted external and, potentially, exchanged dimensions



Four-Point Conformal Bootstrap via the Embedding Space OPE Formalism

Interested in

- Using the embedding formalism of Fortin & Skiba (2019)
  - to develop a general and efficient approach to the four-point conformal bootstrap

- Formalism uses a special uplift from position space to the embedding space

$\Rightarrow$ Advantage of the formalism: Approach treats fermions and bosons on an equal footing!

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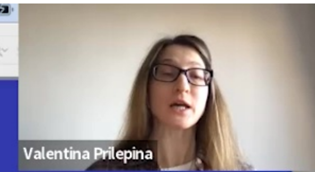
⇒ Advantage of the formalism: Approach treats fermions and bosons on an equal footing!

From the perspective of the Dynkin indices, everything looks the same!

- Uplift makes universal treatment of all quasi-primary operators in arbitrary irreps of the Lorentz group possible.



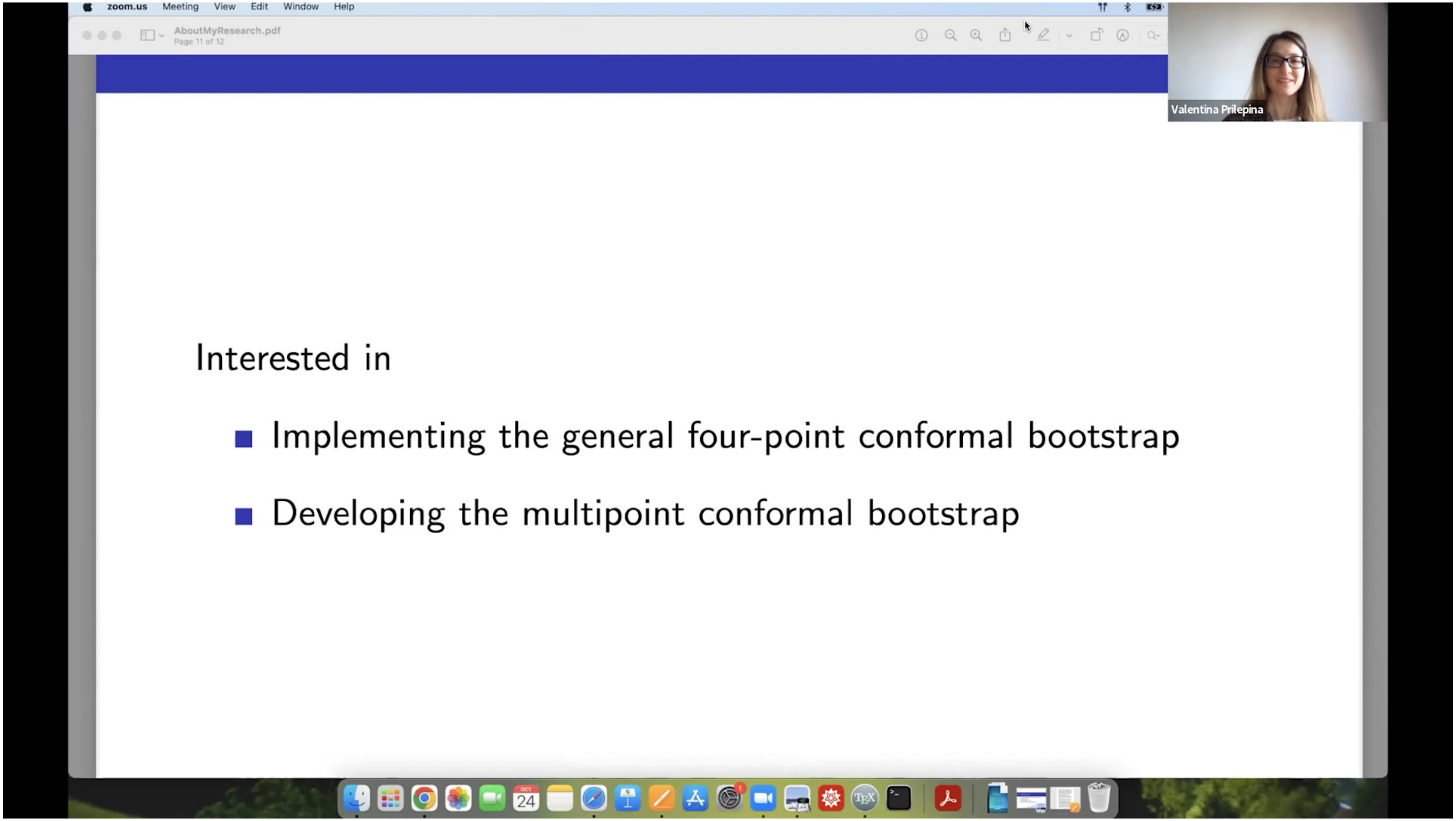
Goal of the Analysis

Goal:

- To implement conformal bootstrap program for $\langle TTTT \rangle$ and $\langle JJJJ \rangle$

Involves constructing a general efficient algorithm that outputs

- Conformal blocks for all nontrivial irreps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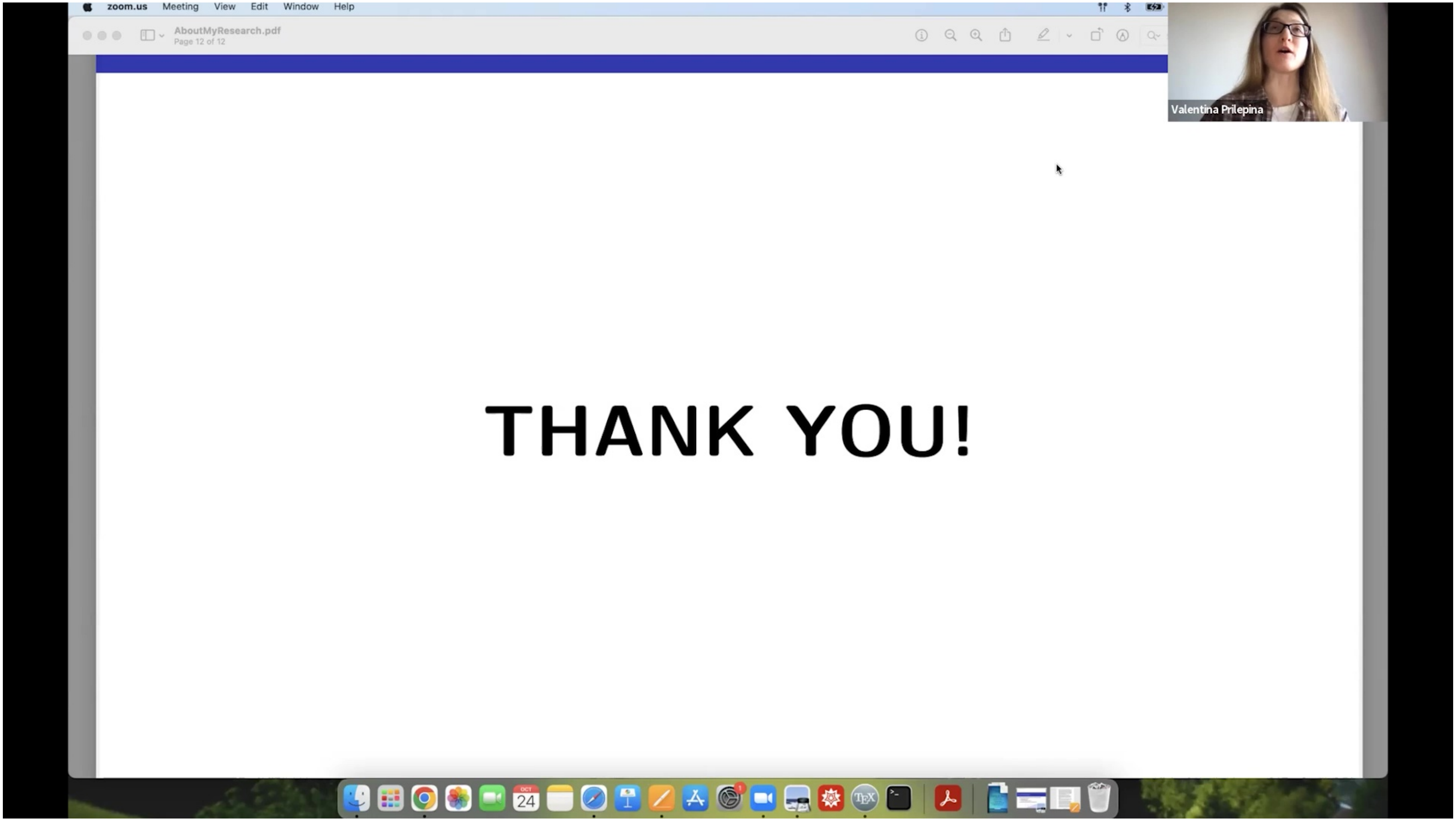
Valentina Prilepina
Interested in
Implementing the general four-point conformal bootstrap
Developing the multipoint conformal bootstrap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THANK YOU!