AdS/CFT - a theoretical physicist lab

Vasco Gonçalves

Faculdade de Ciências do Porto

CF-UM-UP

HORIZON EUROPE

FCT - 2024.00230.CERN

fct Fundação para a Ciência e a Tecnologia

Marie Curie SE - HeI - High energy Intelligence

CEECIND/03356/2022

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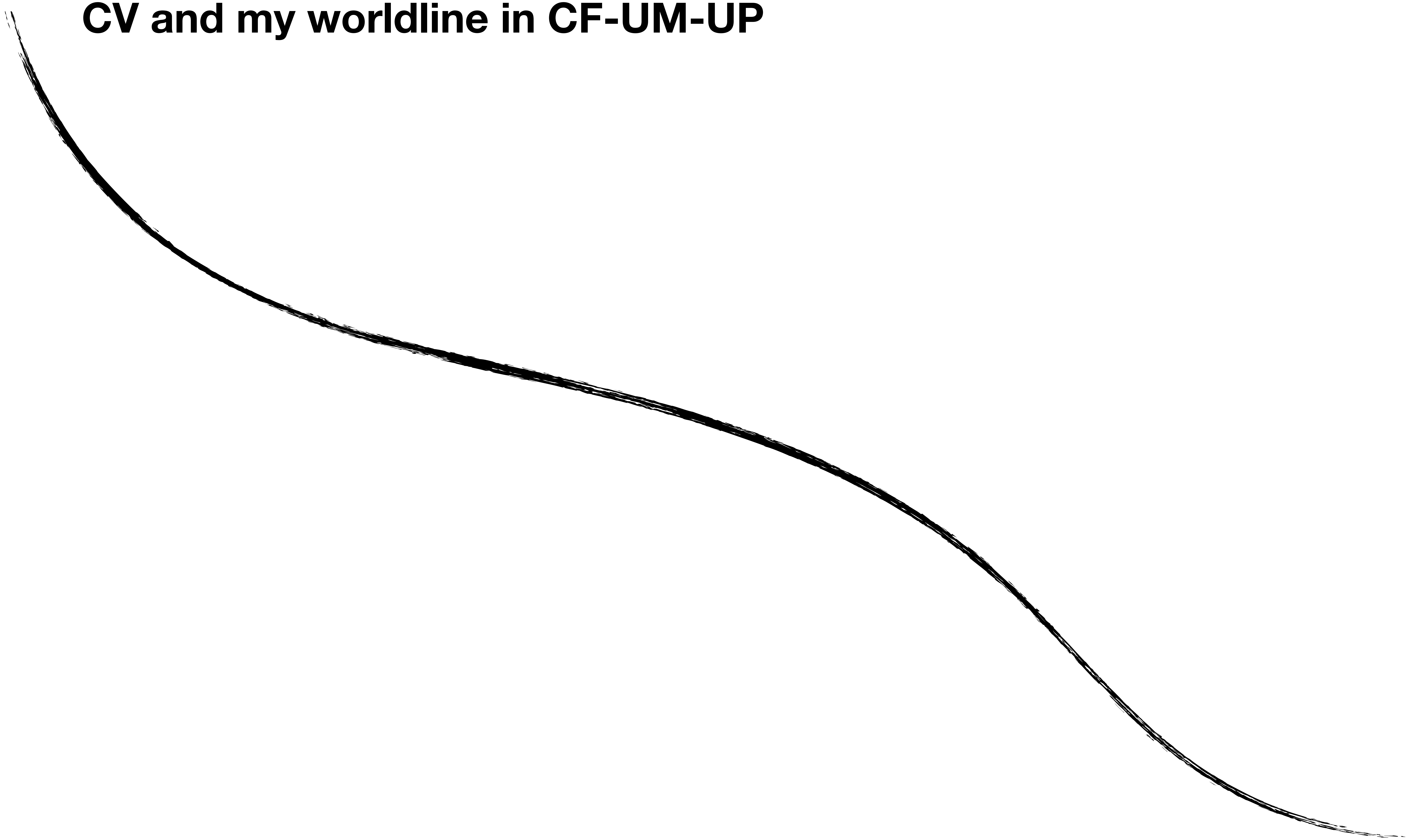
CV and my worldline in CF-UM-UP



CV and my worldline in CF-UM-UP

My research
and
thematic lines of CF-UM-UP

CV and my worldline in CF-UM-UP

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Example of a work w/ phd
student

CV and my worldline in CF-UM-UP

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Bachelor

Master

Phd

CV and my worldline in CF-UM-UP

Bachelor

Master → **Master thesis in graphene**

Phd

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→ **Extended scientific visits:**

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Extended scientific visits:

Perimeter Institute (6months)

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Cern, ICTP and some others

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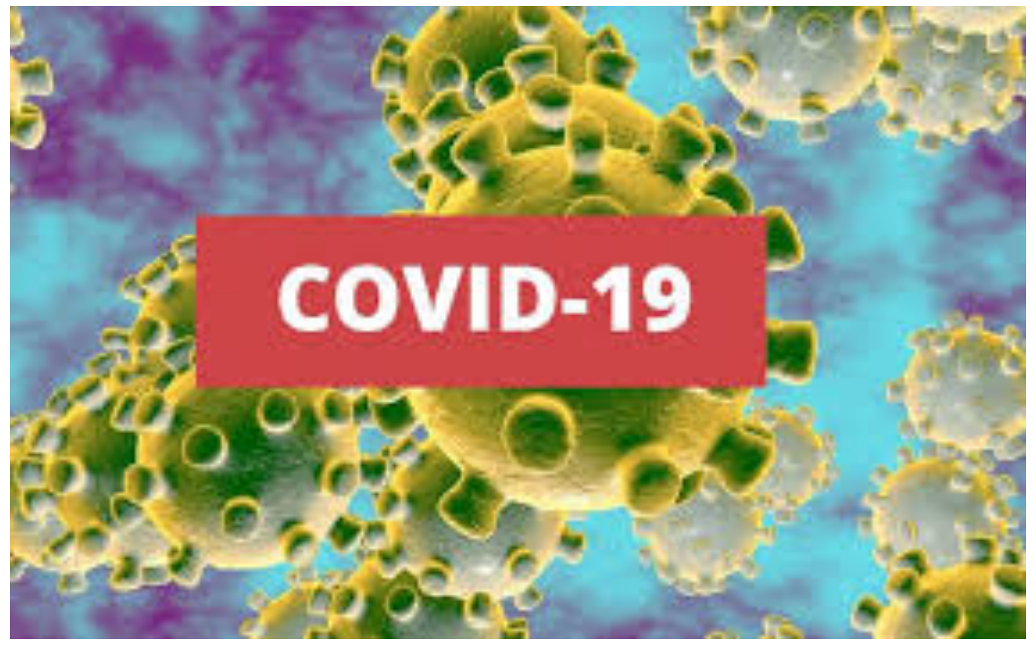

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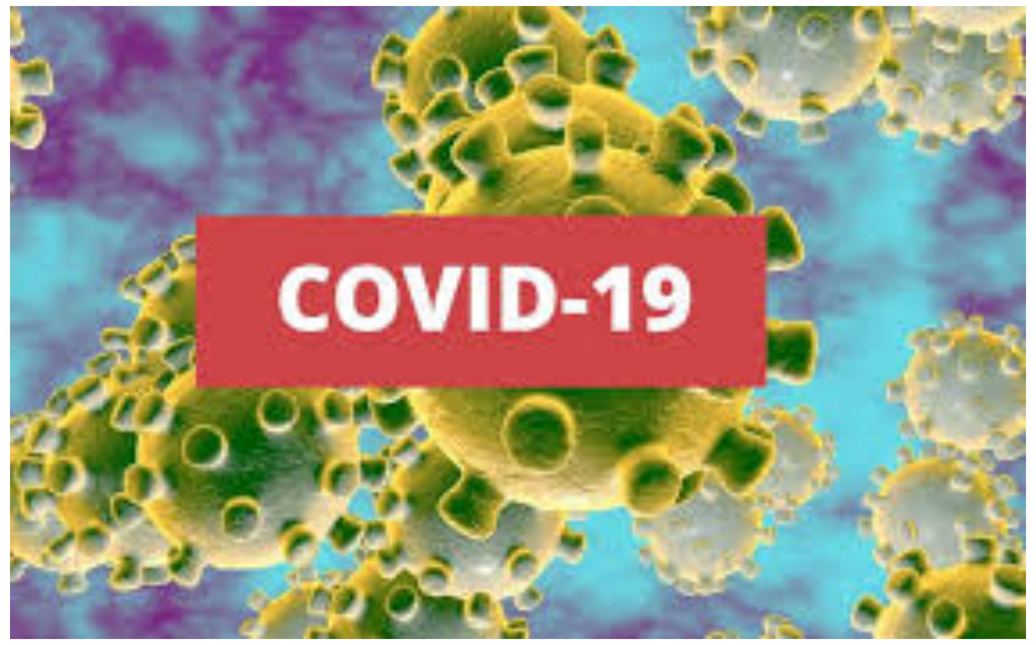

Fundação para a Ciência e a Tecnologia

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My research

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AdS - Anti de Sitter

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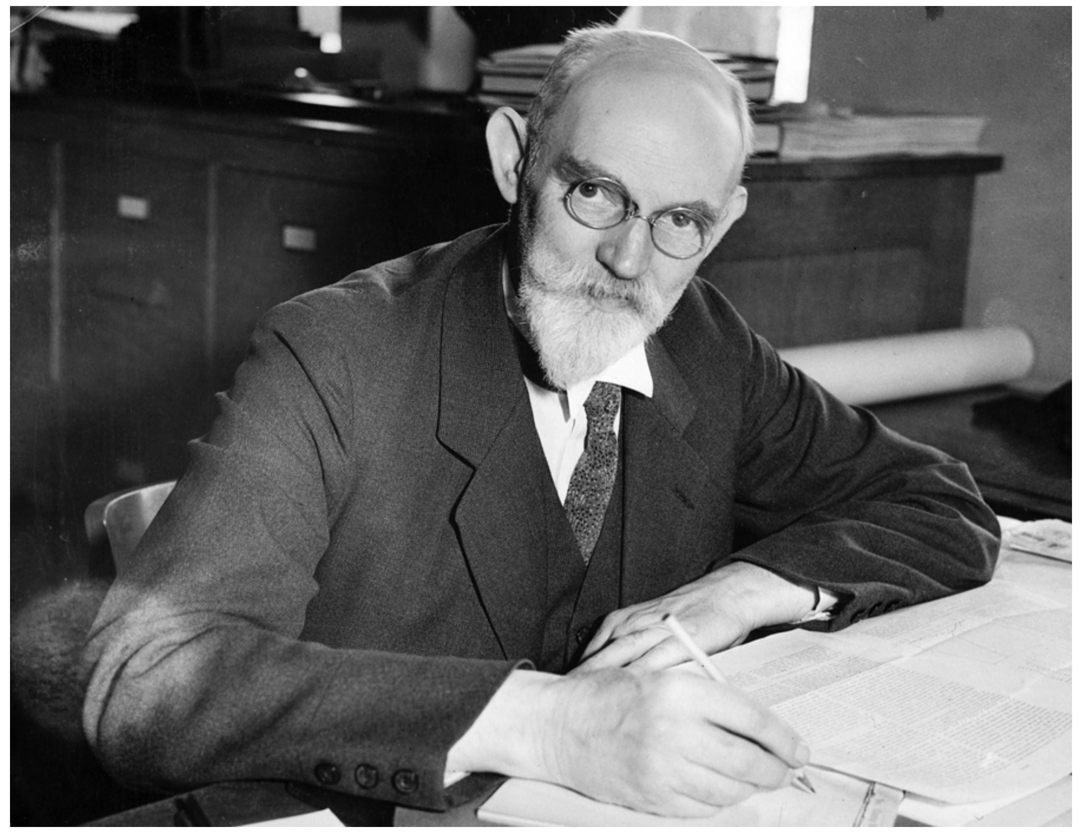

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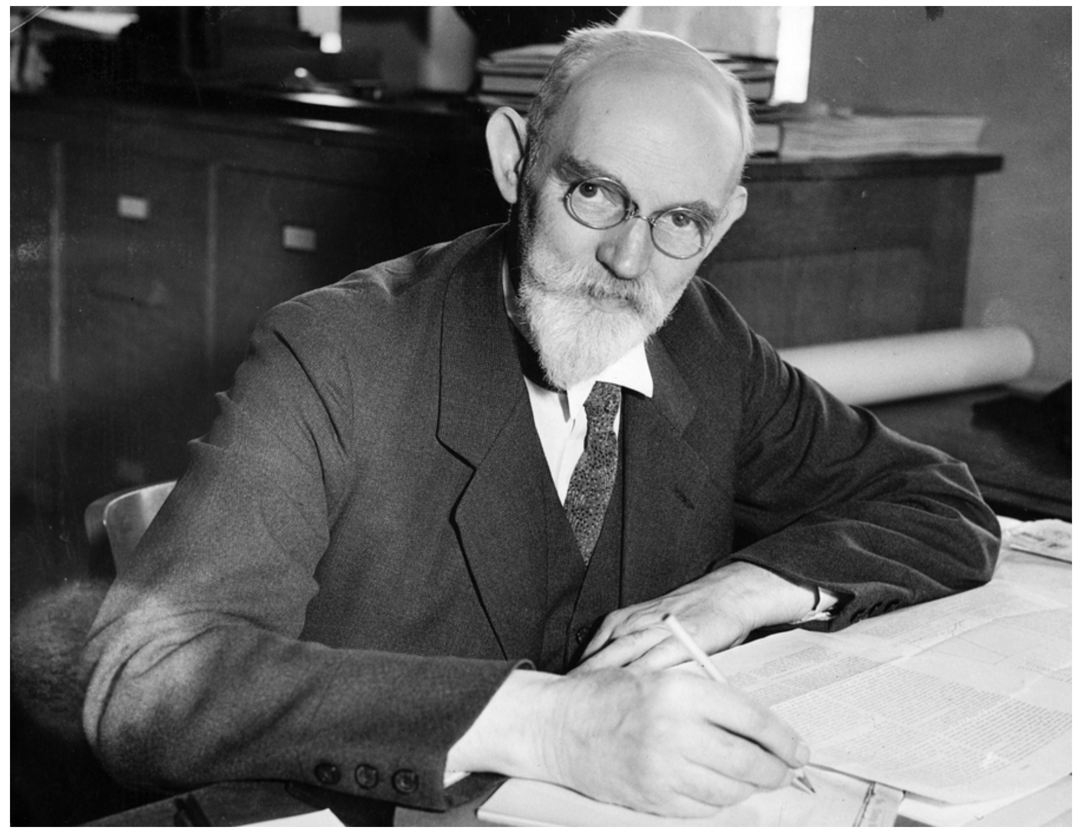
AdS - Anti de Sitter



de Sitter

$$-x_0^2 + \sum_{i=1}^{n} x_i^2 = R^2$$

Anti de Sitter

$$-x_0^2 + \sum_{i=1}^{n} x_i^2 = -R^2$$

Sphere

$$x_0^2 + \sum_{i=1}^{n} x_i^2 = R^2$$

My research

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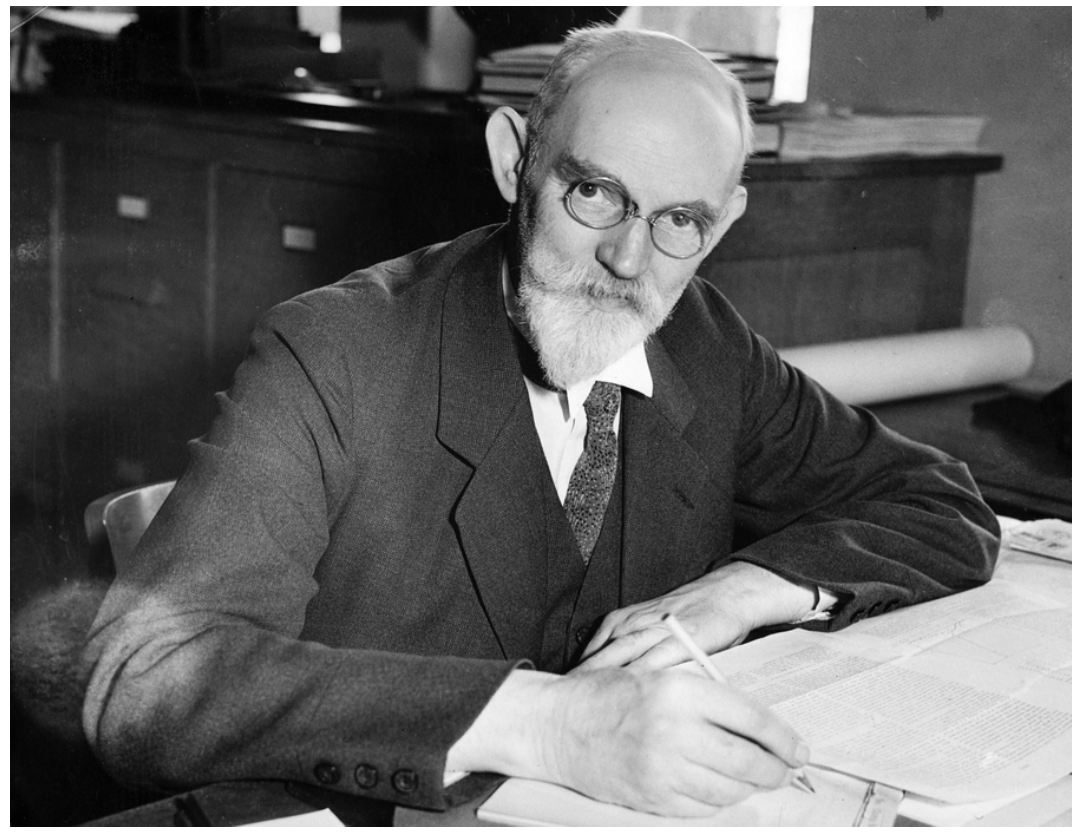

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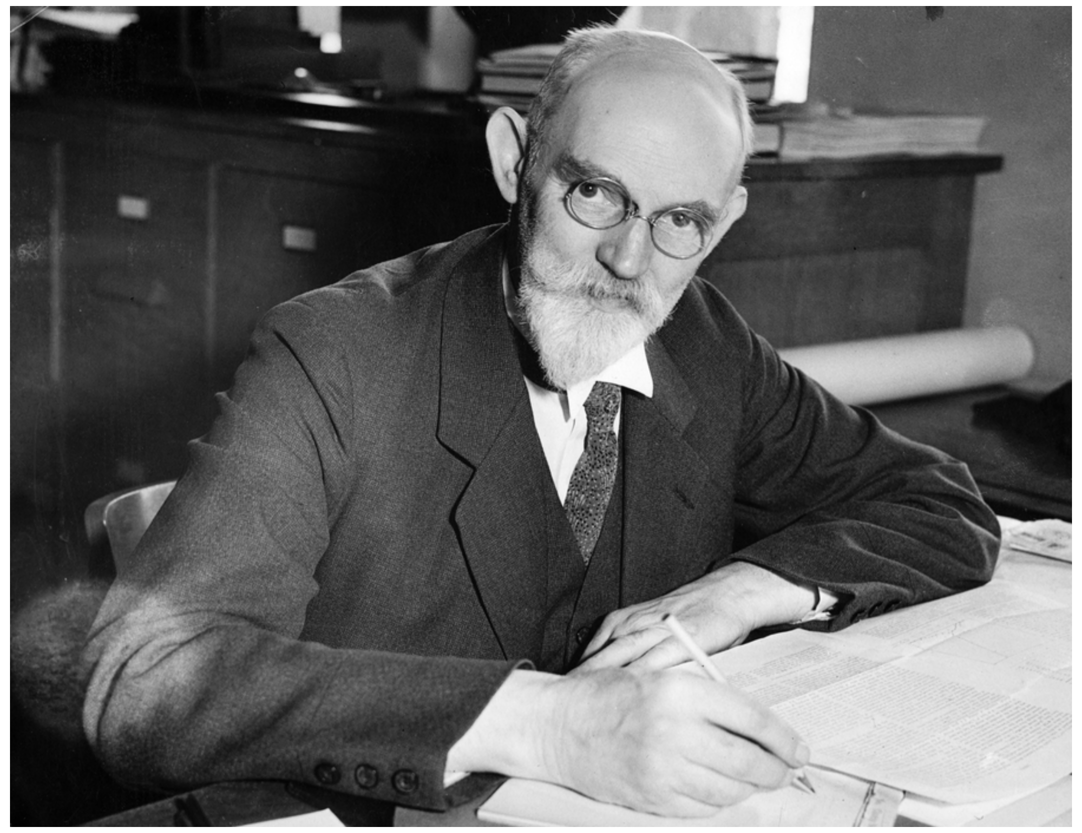
CFT - conformal field theory

My research

AdS - Anti de Sitter



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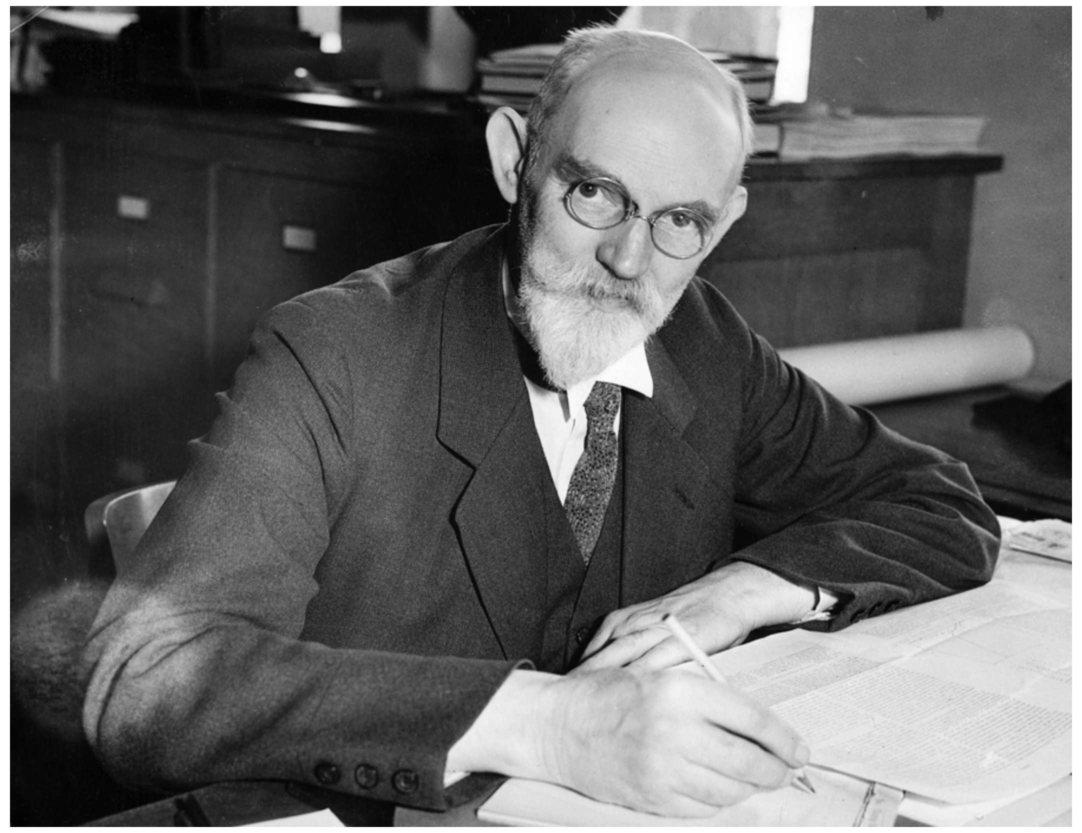
CFT - conformal field theory

Theory invariant under:

- Poincaré symmetry
- Scale invariance
- Special conformal transformations

My research

AdS - Anti de Sitter



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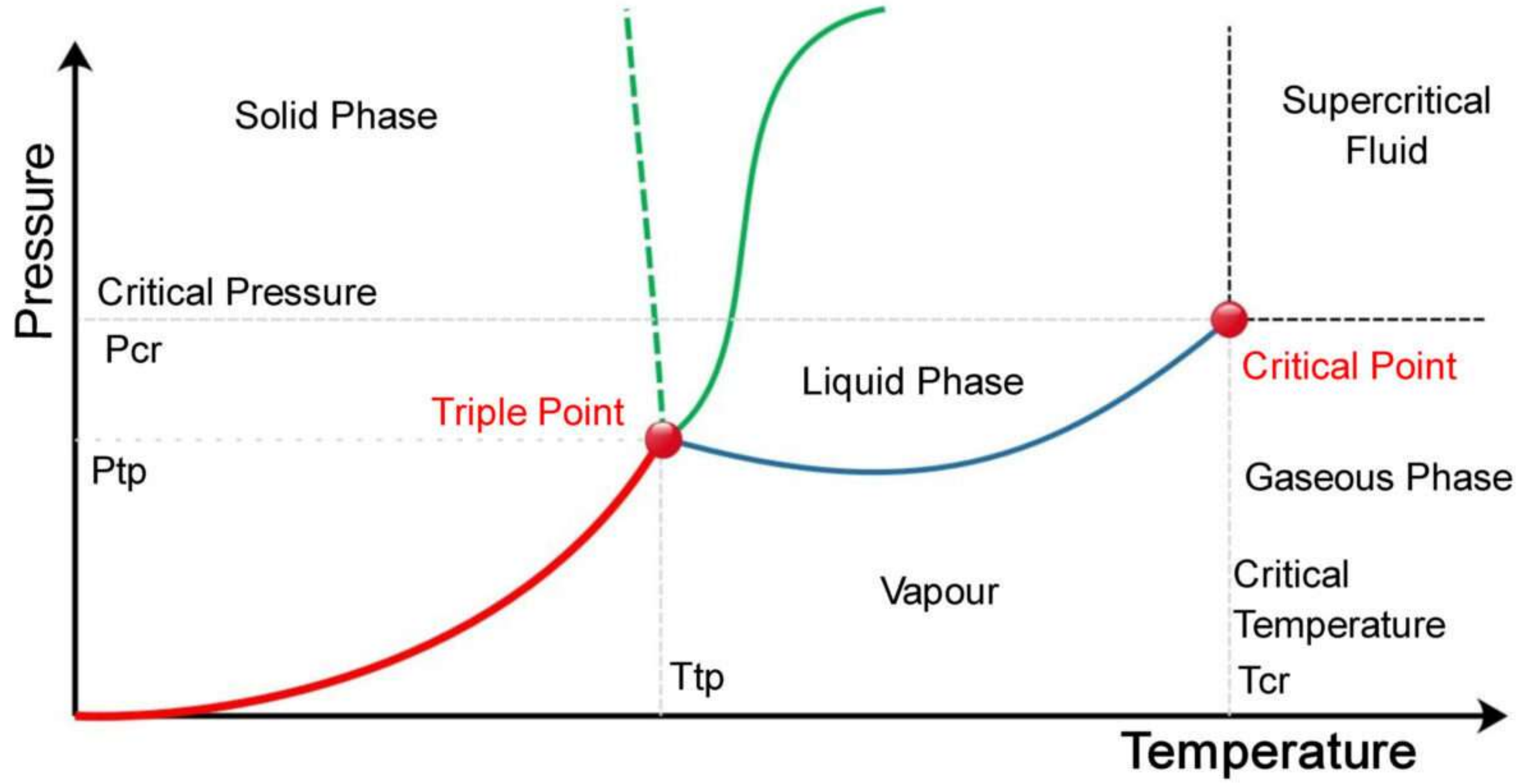

More uses of CFTs

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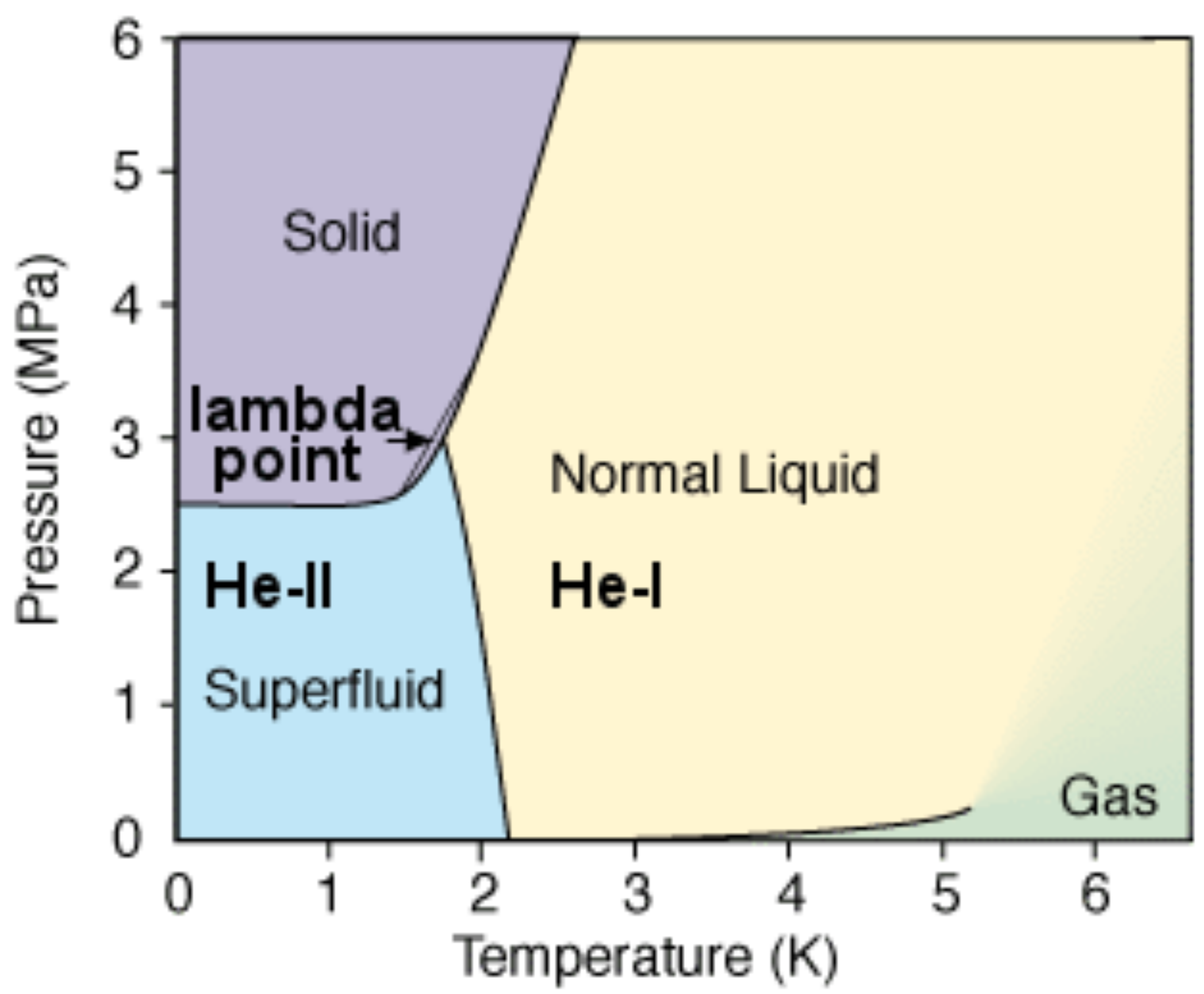
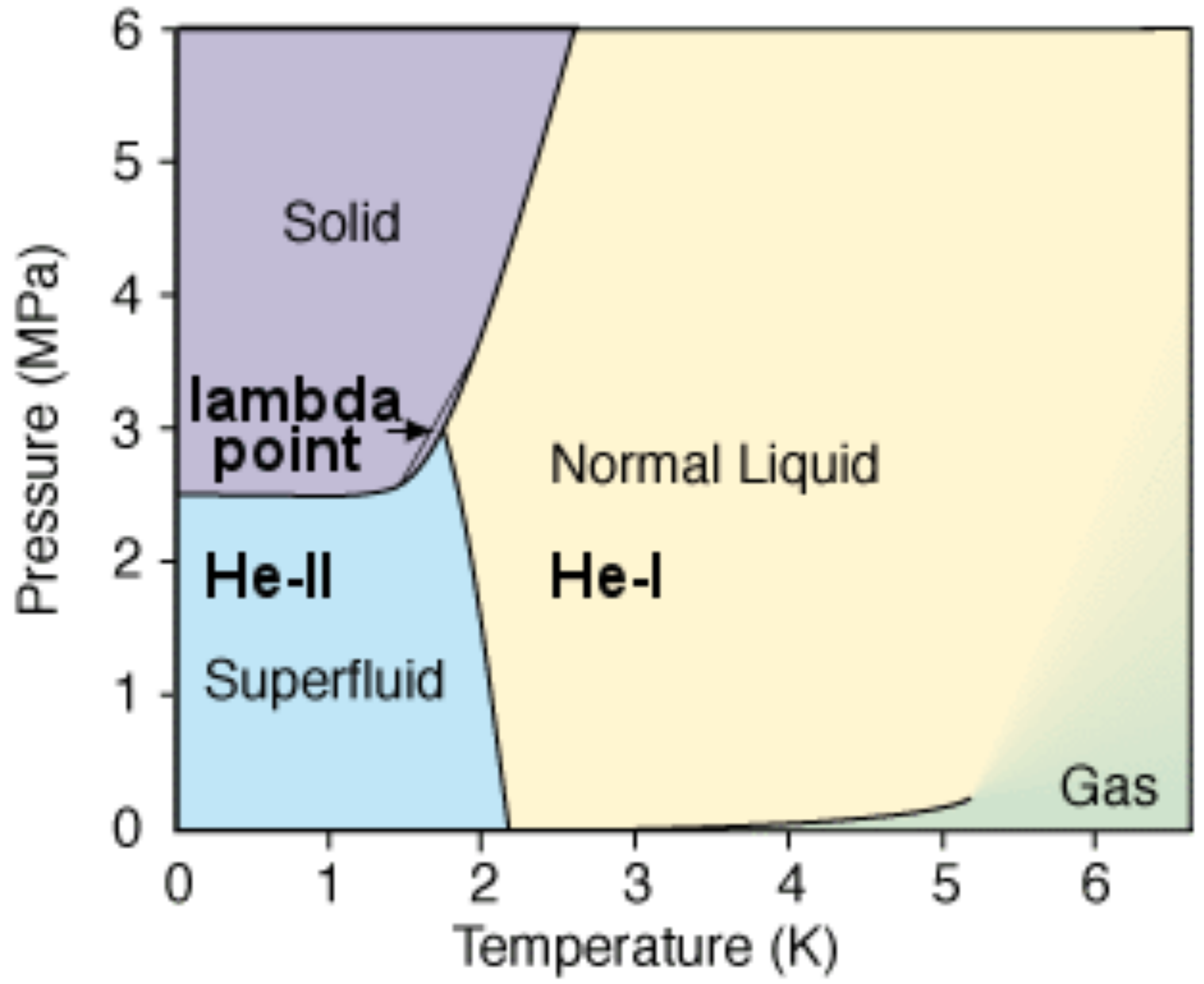
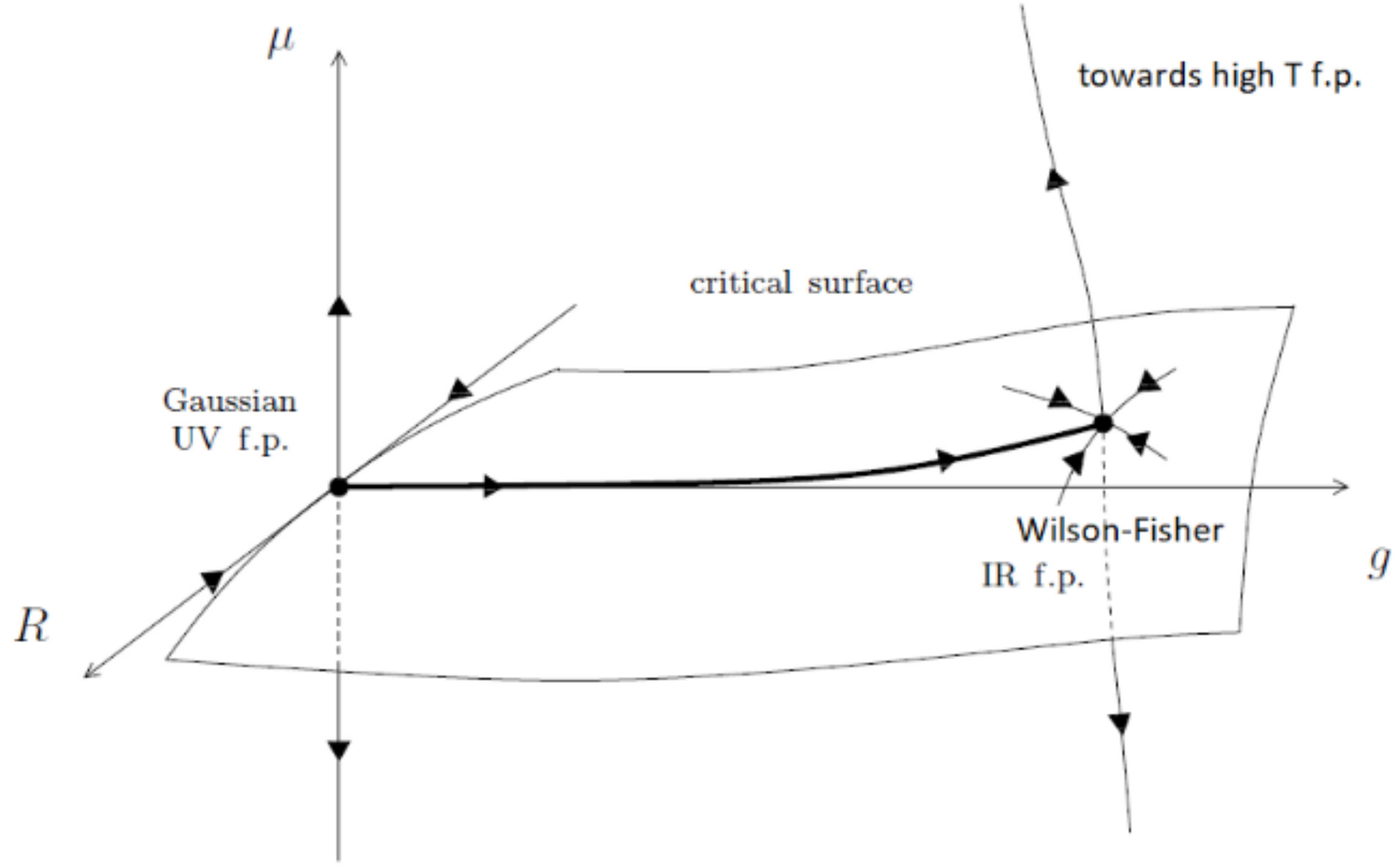


He-4 Phase Diagram

More uses of CFTs



He-4 Phase Diagram



Renormalization group flow

CFT - a guide

to

quantum gravity

CFT - a guide to quantum gravity

idea: Some CFTs are secretly theories of quantum gravity.
In other words

different sides of the same coin

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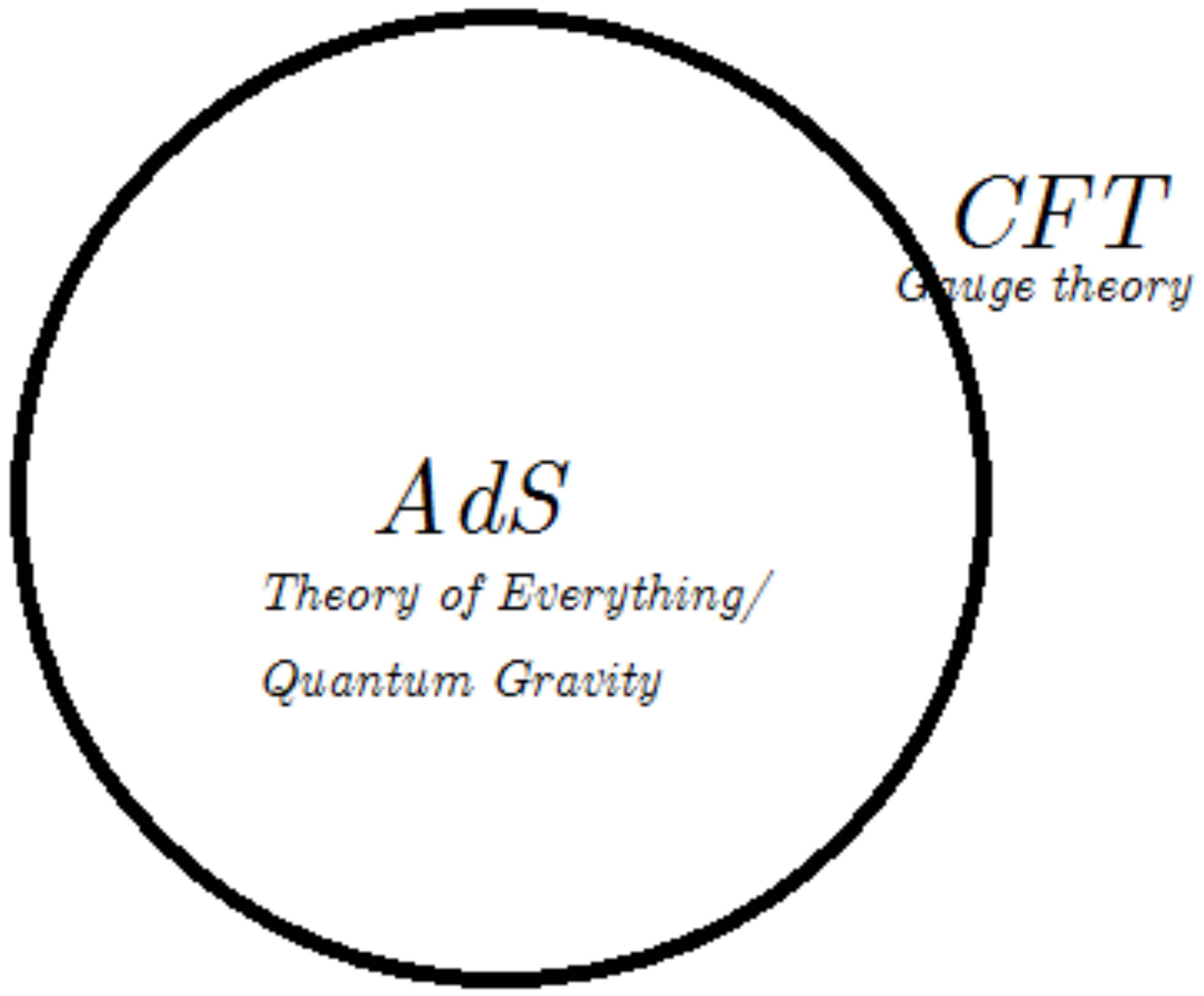
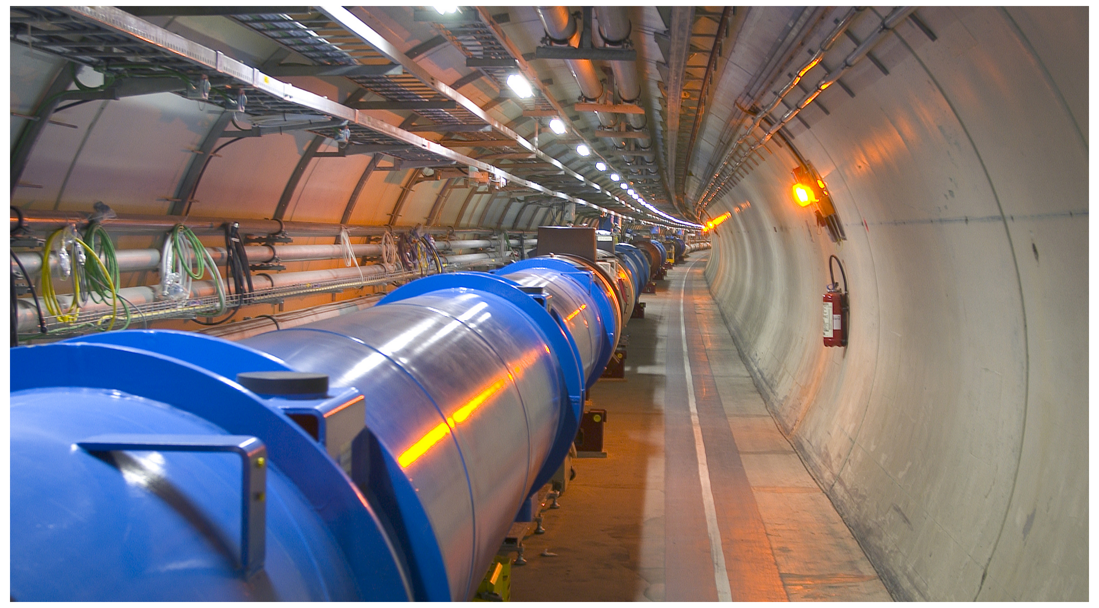


So

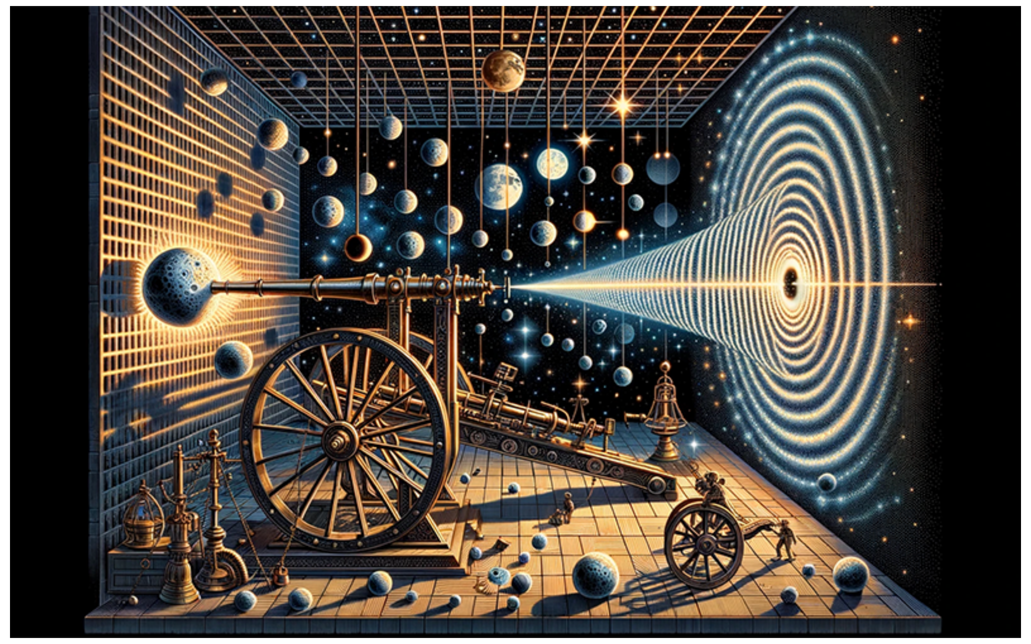
CFT explains

Critical points
in 2º order phase transitions

QFT/ RG flows



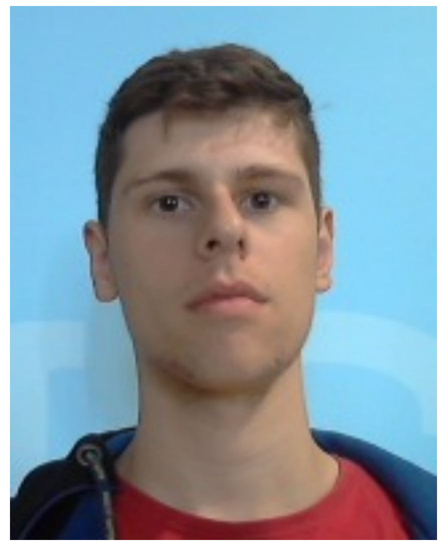
Quantum gravity



Fits perfectly within line 4

Three Phd students

Three Phd students



Bruno Fernandes

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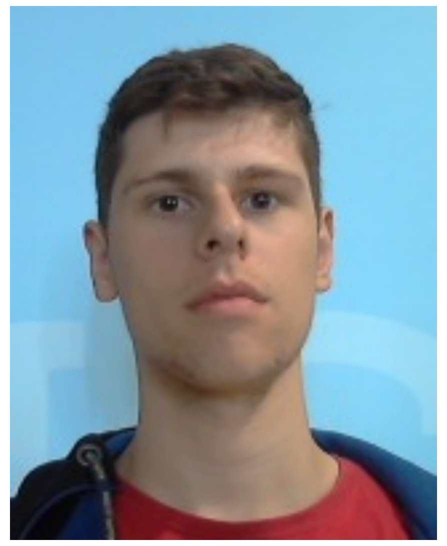

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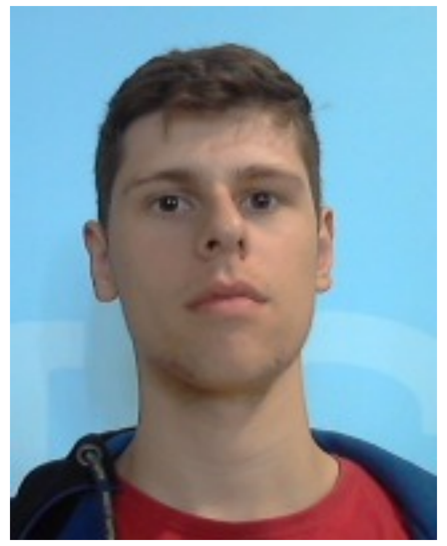

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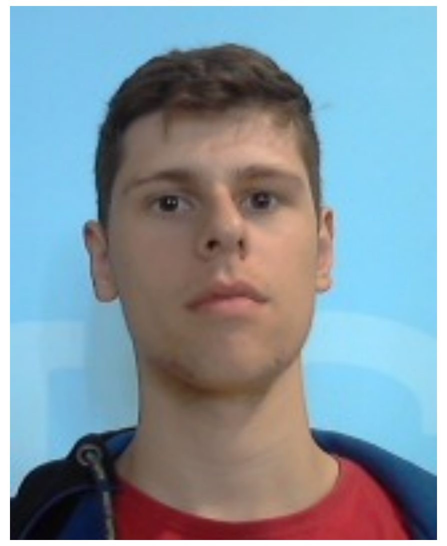

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Ricardo Rodrigues

Bootstrap (get the result using consistency conditions)

an infinity family of correlation functions in holographic theories.

How does this work in practice ?

How does this work in practice ?

Consistency conditions/ symmetry requirements
translated into a well defined
mathematical problem

How does this work in practice ?

example w/ spherical symmetry

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Toy model for mathematical problem:

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$\mathcal{M}$ and $\tilde{\mathcal{M}}$ rationals functions

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Consistency conditions/ symmetry requirements translated into a well defined mathematical problem

Toy model for mathematical problem:

$\mathcal{M}$ and $\tilde{\mathcal{M}}$ rationals functions

$$\mathcal{M}(s,t;\sigma,\tau) = \hat{R} \circ \tilde{\mathcal{M}}(s,t)$$

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$$\mathcal{M}(s,t;\sigma,\tau) = \hat{R} \circ \tilde{\mathcal{M}}(s,t)$$

$$\mathcal{M}(\beta s, \beta t; \sigma, \tau) \sim O(\beta) \quad \text{for } \beta \to \infty$$

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poles at $s, t = 2, \quad s + t = 6$

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$$\mathcal{M}(s,t;\sigma,\tau) = \hat{R} \circ \tilde{\mathcal{M}}(s,t)$$

$$\widehat{R} = \tau 1 + (1-\sigma-\tau)\widehat{V} + (\tau^2-\tau-\sigma\tau)\widehat{U} + (\sigma^2-\sigma-\sigma\tau)\widehat{UV} + \sigma\widehat{V^2} + \sigma\tau\widehat{U^2}$$

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$$\widehat{R} = \tau 1 + (1-\sigma-\tau)\widehat{V} + (\tau^2 - \tau - \sigma\tau)\widehat{U} + (\sigma^2 - \sigma - \sigma\tau)\widehat{UV} + \sigma\widehat{V^2} + \sigma\tau\widehat{U^2}$$

$$\widehat{U}^m V^n \circ \widetilde{\mathcal{M}}(s,t) \equiv \widetilde{\mathcal{M}}(s-2m, t-2n) \times \left(\frac{4-s}{2}\right)^2_m \left(\frac{4-t}{2}\right)^2_n \left(\frac{s+t-4}{2}\right)^2_{2-m-n}$$

How does this work in practice ?

example w/ spherical symmetry

Consistency conditions/ symmetry requirements translated into a well de… …d mathematical prob…

Toy model for mathemati…

$\mathcal{M}$ and $\tilde{\mathcal{M}}$ rationals funct…

$$\mathcal{M}(s,t;\sigma,\tau) = \hat{I}…$$

$$…)\widehat{V} + (\tau^2 - \tau - \sigma\tau)\widehat{U}$$

$$…\widehat{UV} + \sigma\widehat{V^2} + \sigma\tau\widehat{U^2}$$

$$\mathcal{M}(\beta s, \beta t;\sigma,\tau) \sim O(\beta)$$

$$… = \widetilde{\mathcal{M}}(s-2m, t-2n)$$

$$…\left(\frac{… - s}{2}\right)^2_m \left(\frac{4-t}{2}\right)^2_n \left(\frac{s+t-4}{2}\right)^2_{2-m-n}$$

poles at $s,t = 2, \quad s+t = 6$

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Consistency conditions/ symmetry requirements
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Solution

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$$\mathcal{M}(s,t;\sigma,\tau) = \hat{I}$$

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$$\widehat{U}V + \sigma\widehat{V^2} + \sigma\tau\widehat{U^2}$$

$$\mathcal{M}(\beta s, \beta t;\sigma,\tau) \sim O(\beta)$$

$$= \widetilde{\mathcal{M}}(s-2m, t-2n)$$

$$\left(\frac{\;-s}{2}\right)^2_m \left(\frac{4-t}{2}\right)^2_n \left(\frac{s+t-4}{2}\right)^2_{2-m-n}$$

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$$\tilde{\mathcal{M}} = \frac{C}{(s-2)(t-2)(s+t-6)}$$

$)\widehat{V} + (\tau^2 - \tau - \sigma\tau)\widehat{U}$

$\mathcal{M}(s,t;\sigma,\tau) = \hat{I}$

$\widehat{V} + \sigma\widehat{V^2} + \sigma\tau\widehat{U^2}$

$\mathcal{M}(\beta s, \beta t; \sigma, \tau) \sim O(\beta)$

$= \widetilde{\mathcal{M}}(s-2m, t-2n)$

$\left(\frac{-s}{2}\right)_m^2 \left(\frac{4-t}{2}\right)_n^2 \left(\frac{s+t-4}{2}\right)_{2-m-n}^2$

poles at $s,t = 2, \quad s+t=6$

Thank you