String Theory at MPP

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

Johanna Erdmenger

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Applications of Gauge/Gravity Duality


Strings 2014
PRINCETON
June 23-27
PRINCETON UNIVERSITY
IAS
Institute for Advanced Study

	Monday June 23	Tuesday June 24	Wednesday June 25	Thursday June 26	Friday June 27
8:00-9:00	Registration and Breakfast	Breakfast	Breakfast	Breakfast	Breakfast
Chair	*Brink*	*Louis*	*Kiritsis*	*Kimyeong Lee*	*Donagi*
9:00-9:30	Witten (9:15-9:30)	Polchinski	Erdmenger	Tachikawa	Nekrasov
9:30-10:00	Vafa				Neitzke
10:00-10:30	Sen	Papadodimas	Gauntlett	Kutasov	Sangmin Lee
10:30-11:00	Break	Break	Break	Break	Break
Chair	*Bianchi*	*Larsen*	*Eguchi*	*Ooguri*	*Wadia*
11:00-11:30	Simmons-Duffin	Van Raamsdonk	Marino	Tomasiello	Minahan
11:30-12:00	Rastelli	Bousso	Gaiotto	Cheng	Tseytlin
12:00-12:30	Bizon	Komargodski	Lunch	Anderson	Gromov
12:30-1:00	Lunch	Lunch		Lunch	Lunch
1:00-1:30					
1:30-2:00					
Chair	*Witten*	*Bachas*		*Berkovits*	*Schwarz*
2:00-2:30	Kovac	Freedman	Parallel	Stieberger	Vision Talks

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Stieberger | Unity of tree–level superstring amplitudes

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Stieberger — Unity of tree–level superstring amplitudes

Erdmenger — Applications of AdS/CFT to high energy and condensed matter physics

String Theory Research at MPP

Dieter Lüst, Ralph Blumenhagen: String Phenomenology, Non-geometric strings

PostDoc: Inaki Garcia-Etxebarria

PhD students:
Andre Betz, Michael Fuchs, Falk Hassler, Daniela Herschmann, Rui Sun Master students: Yuta Sekiguchi, Florian Wolf

Research:

- Double field theory, non-geometric string backgrounds
- string cosmology, BICEP2 triggered research on realization of large field inflation in string theory

String Theory Research at MPP

Honours: Otto-Hahn Medal 2013 for PhD thesis of Andreas Deser

Dieter Lüst with Gia Dvali, Stephan Stieberger: High Energy scattering of gravitons, classicalization and black holes

String theory and its effective physics

- **Members:** Thomas Grimm

  Postdocs: Tom Pugh
  Diego Regalado
  Ioannis Florakis (left to CERN in Sep. 2014)

  PhD students: Andreas Kapfer
  Jan Keitel
  Matthias Weissenbacher
  Federico Bonetti (left to New York University in Sep. 2014)

- **Main research topics:** (13 papers in 2014)
  - effective actions, string geometry, string phenomenology
  - topological string theory and instanton sums
  - loop computations and anomalies in gauge theory and string theory

AdS/CFT group Gauge/Gravity Duality

Johanna Erdmenger

Daniel Arean (GIF)
Eugenio Megias (EU Marie Curie)
Daniel Fernandez (Humboldt Foundation)

Stephan Steinfurt
Mario Araujo
Mario Flory
Charlotte Sleight
Ann-Kathrin Straub
Max Newrzella

Abhiram Kidambi

AdS/CFT correspondence:
Anti-de Sitter space / conformal field theory

(Maldacena 1997)

AdS/CFT correspondence:
Anti-de Sitter space / conformal field theory

(Maldacena 1997)

Gauge/Gravity Duality

AdS/CFT correspondence:
Anti-de Sitter space / conformal field theory

(Maldacena 1997)

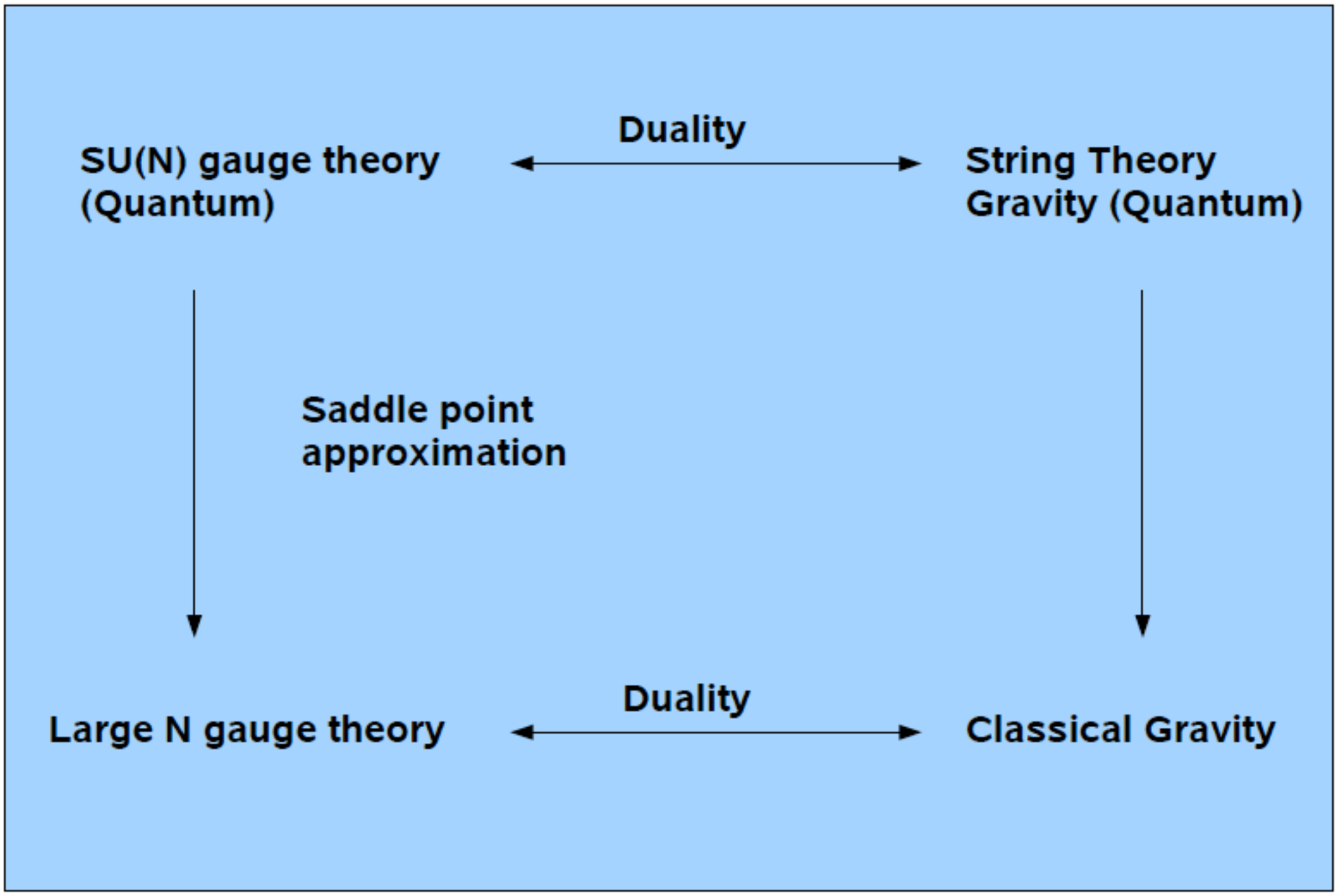
Gauge/Gravity Duality

Map:

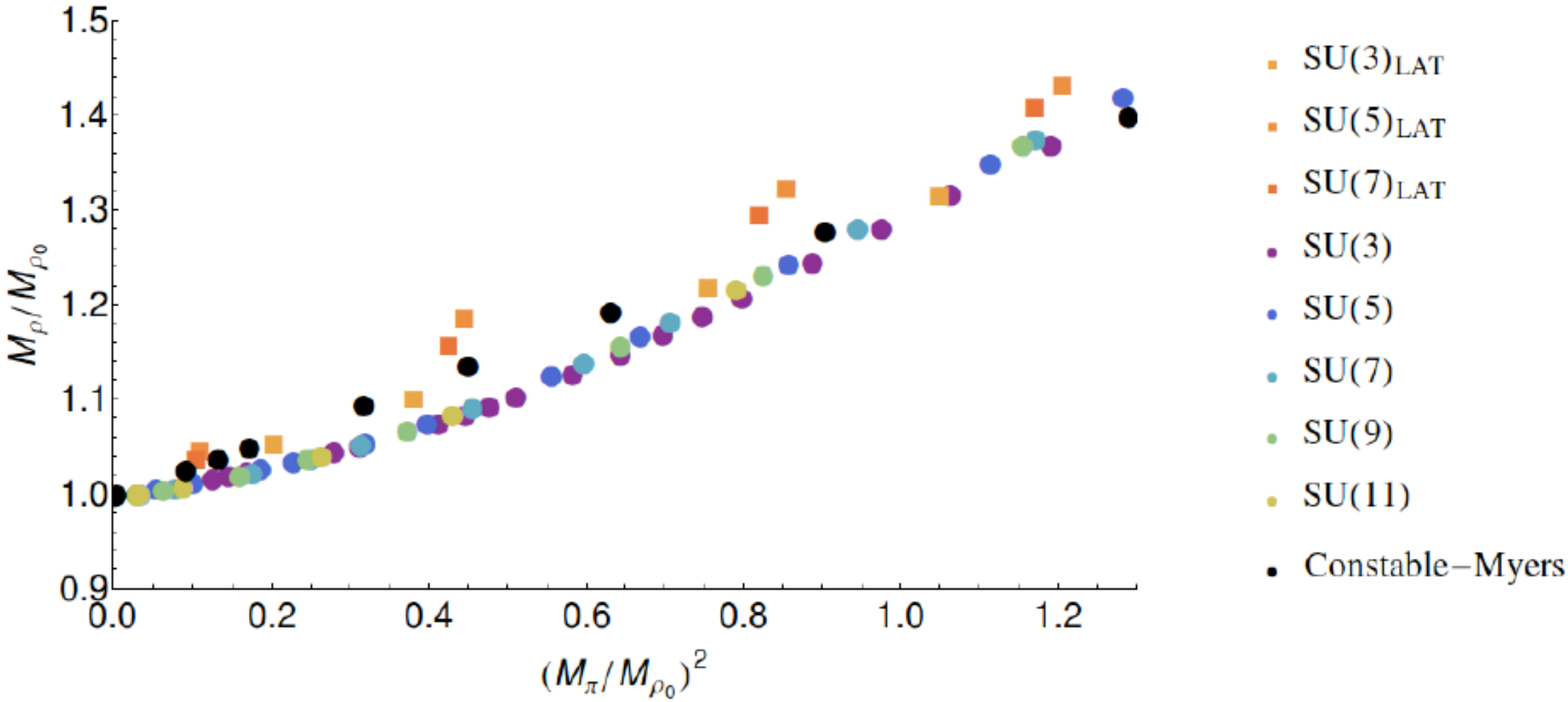
Strongly coupled gauge theory

Weakly coupled gravity theory

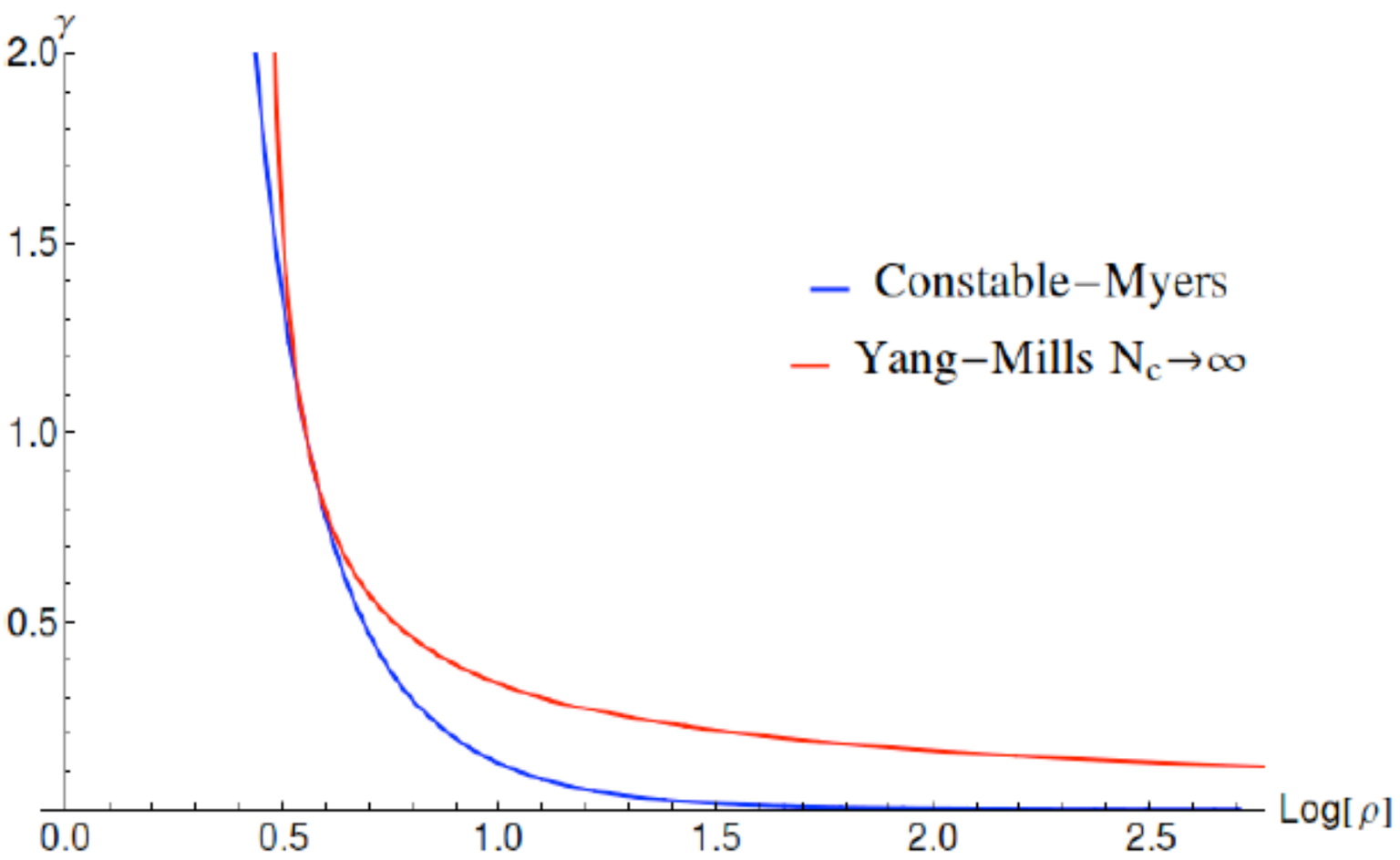
Gauge/Gravity Duality



QCD: rho mass vs. pi meson mass squared

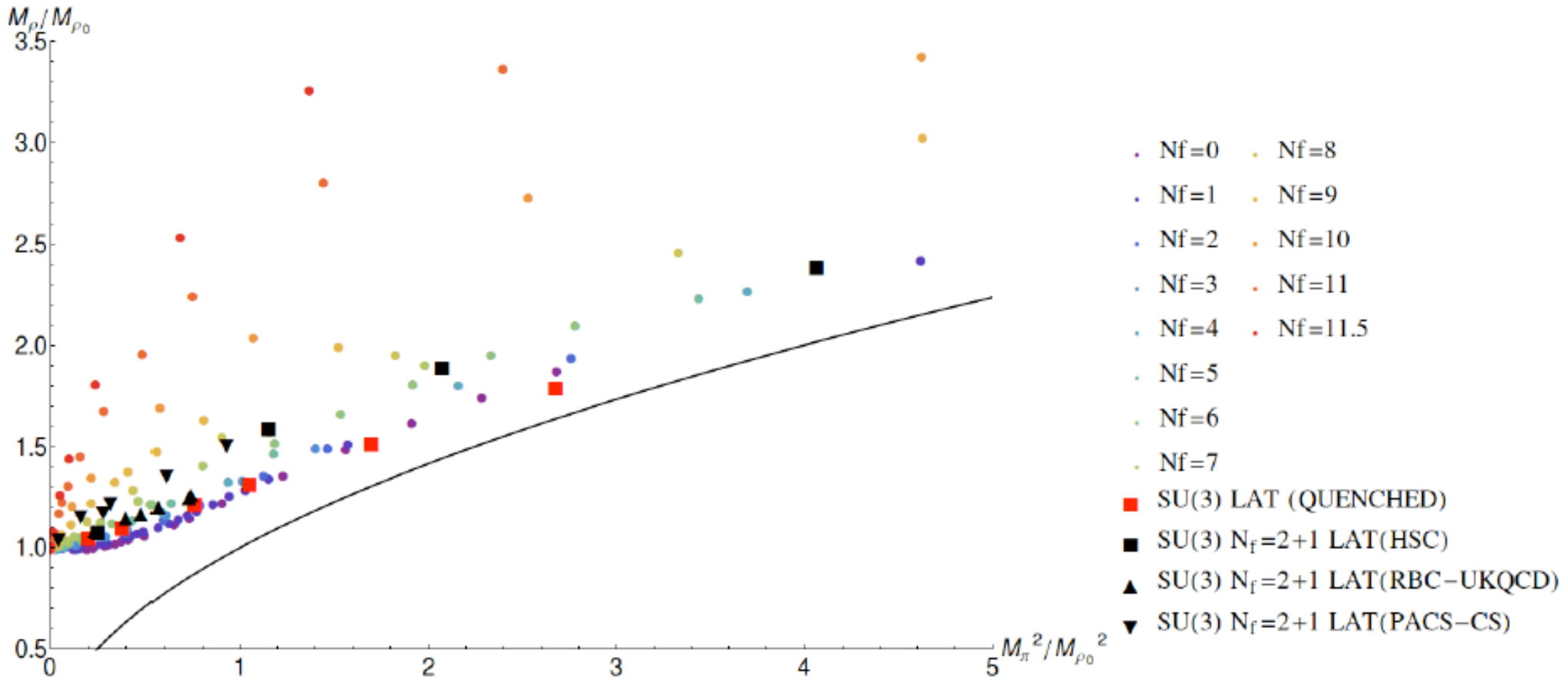


J.E., Evans, Scott 1412.3165



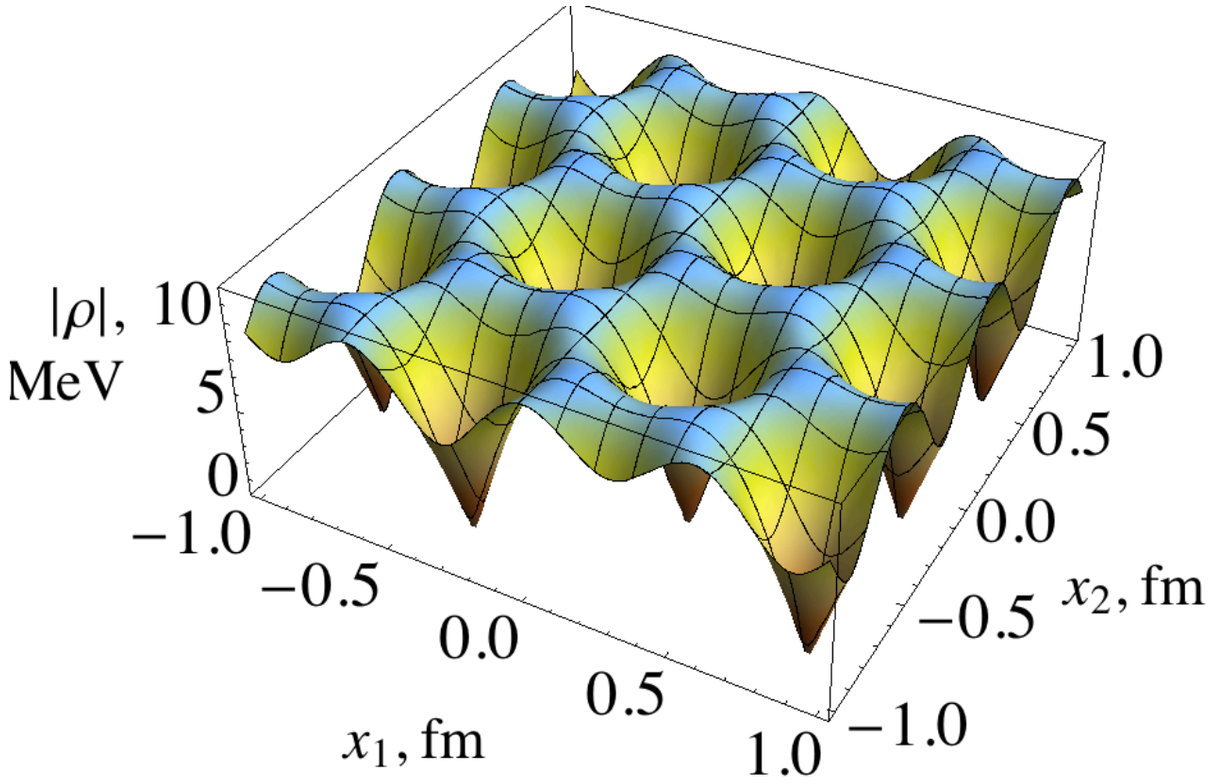
Anomalous dimension vs. RG scale

Varying the number of flavours

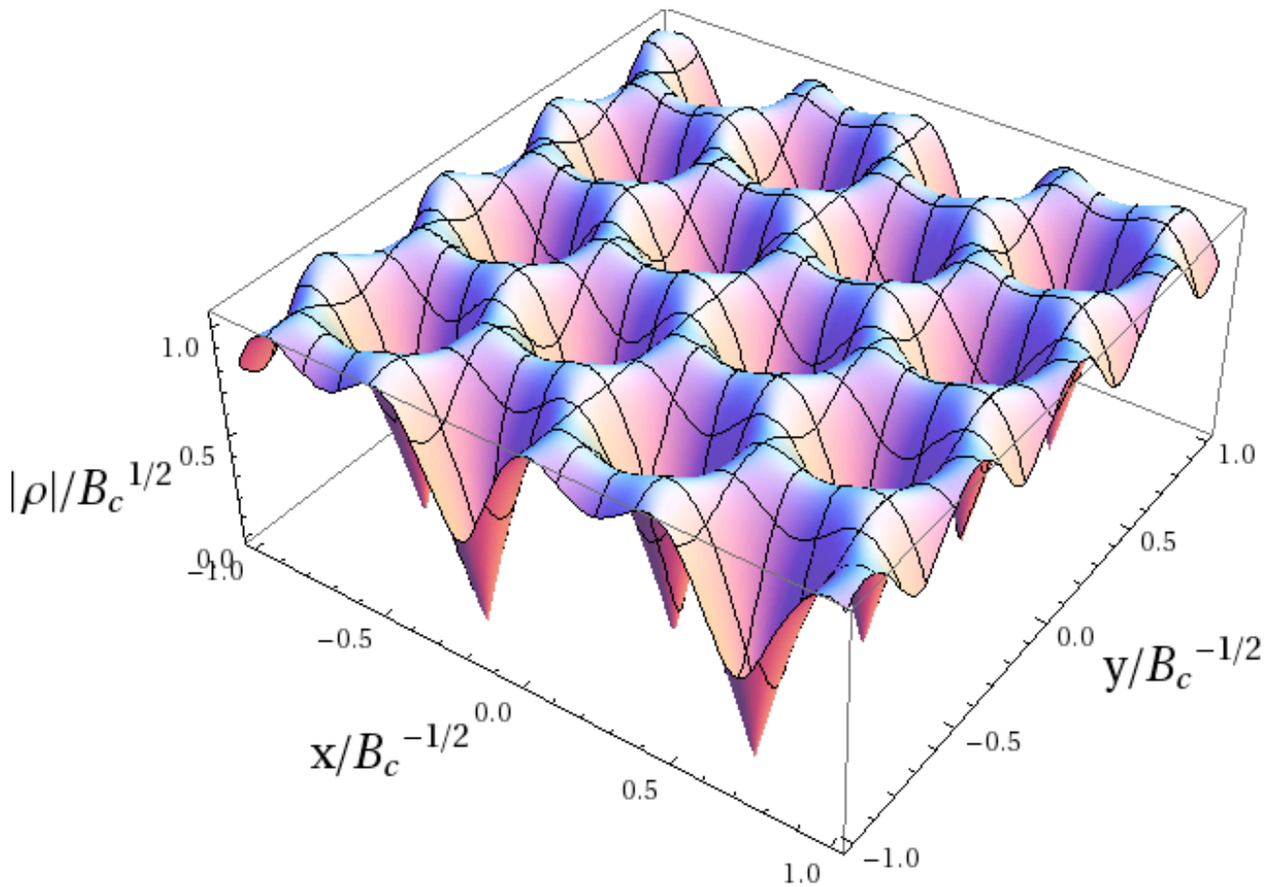


QCD in external magnetic field: Rho meson condensation

Condensate: Comparison to field theory calculation



Condensate Effective Field Theory (M. Chernodub)



Condensate Gauge/Gravity Duality

Bu, J.E., Shock, Strydom JHEP 2012

Bu, J.E., Shock, Strydom 1210.6669

Kondo model within gauge/gravity duality

J.E., Hoyos, O'Bannon, Wu JHEP 2013
J.E., Flory, Newrzella 1410.7811

- From condensed matter physics:
  electrons coupled to magnetic impurity

- Toy model for QCD:

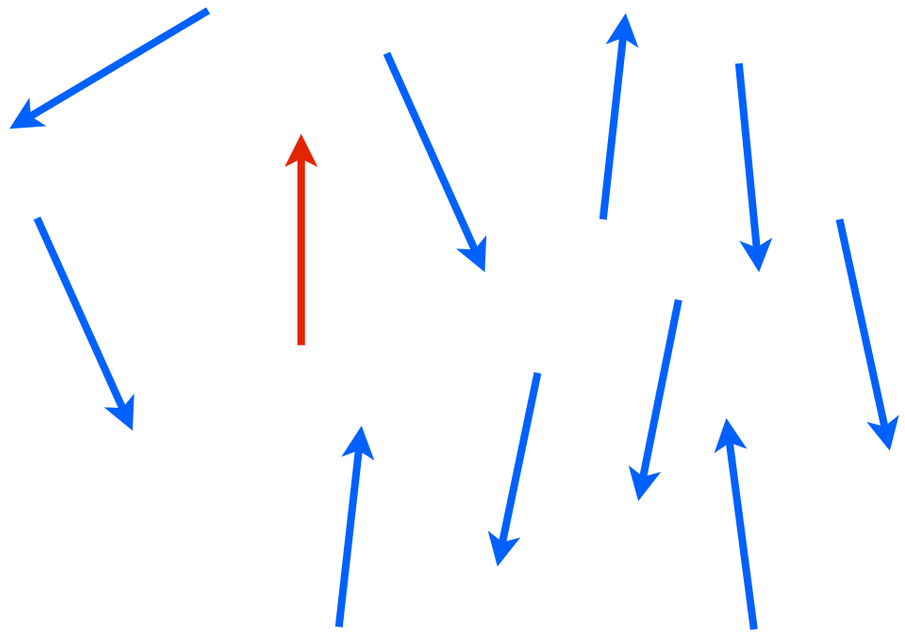
- Negative beta function

- Asymptotic freedom and confinement

- Dynamical scale generation

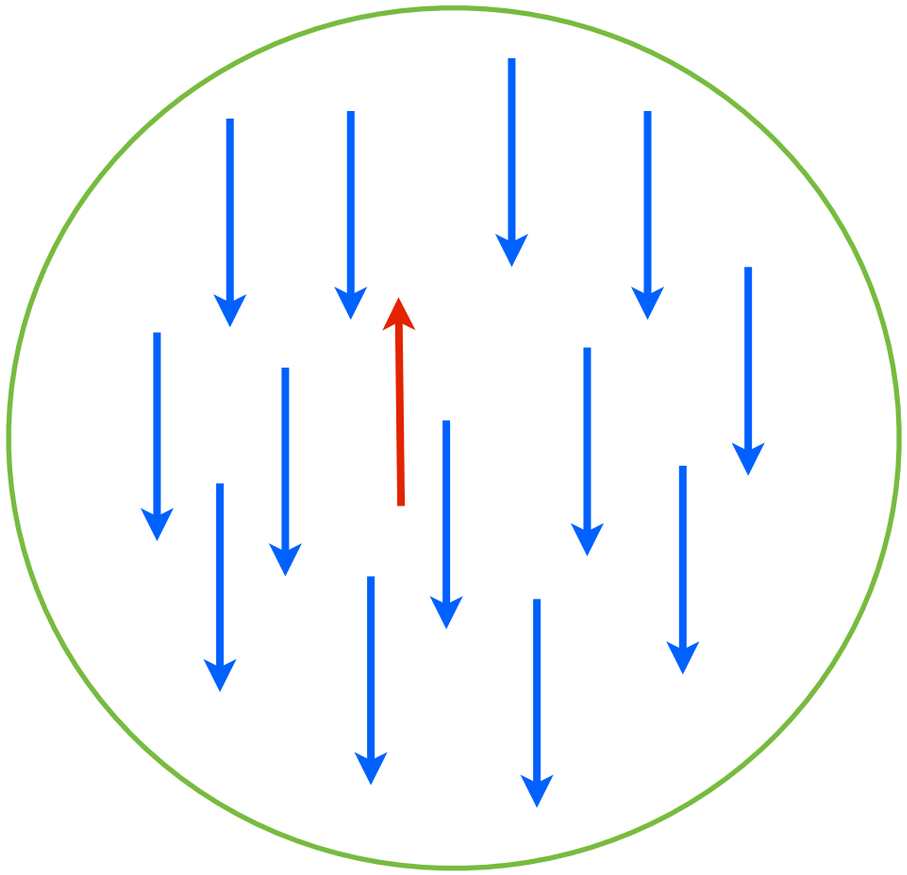
Physics of the Kondo effect

UV



Free electrons
+
impurity spin

IR



Impurity screened

Hamiltonian:

$$H = \frac{v_F}{2\pi}\psi_L^\dagger i\partial_x\psi_L + v_F\,\lambda_K\,\delta(x)\,\vec{S}\cdot\psi_L^\dagger\,\frac{1}{2}\vec{\tau}\,\psi_L$$

Hamiltonian:

$$H = \frac{v_F}{2\pi}\psi_L^\dagger i\partial_x\psi_L + v_F\,\lambda_K\,\delta(x)\,\vec{S}\cdot\psi_L^\dagger\frac{1}{2}\vec{\tau}\,\psi_L$$

Large N: Screening corresponds to condensation process

$S^a = \chi^\dagger T^a \chi$ Slave fermions

$\mathcal{O} = \psi_L^\dagger \chi$ Condensate

Gravity model

Action

$$S = S_{CS} + S_{AdS_2},$$

$$S_{CS} = -\frac{N}{4\pi}\int \mathrm{tr}\left(A\wedge dA + \frac{2}{3}A\wedge A\wedge A\right),$$

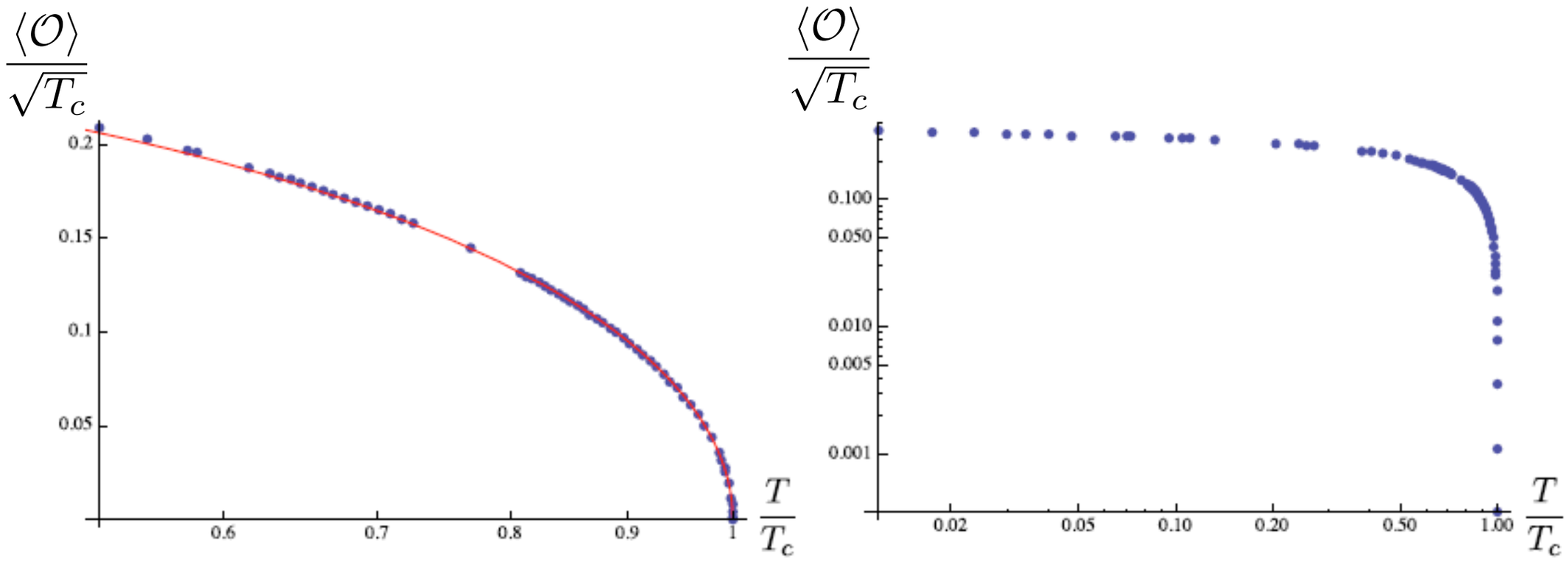
$$S_{AdS_2} = -N\int d^3x\,\delta(x)\sqrt{-g}\left[\frac{1}{4}\mathrm{tr}f^{mn}f_{mn} + g^{mn}\left(D_m\Phi\right)^\dagger D_n\Phi + V(\Phi^\dagger\Phi)\right]$$

BTZ black hole

$$ds^2 = g_{\mu\nu}dx^\mu dx^\nu = \frac{1}{z^2}\left(\frac{dz^2}{h(z)} - h(z)\,dt^2 + dx^2\right)$$

$$h(z) = 1 - z^2/z_H^2 \qquad\qquad T = 1/(2\pi z_H)$$

Condensate



Mean field transition

$\langle \mathcal{O} \rangle$ approaches constant for $T \to 0$

J.E., Hoyos, O'Bannon, Wu 2013

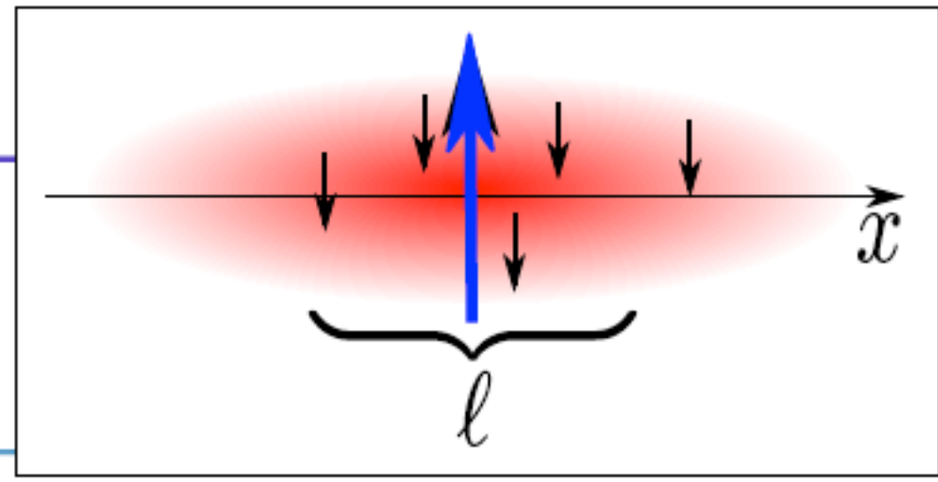
Entanglement entropy

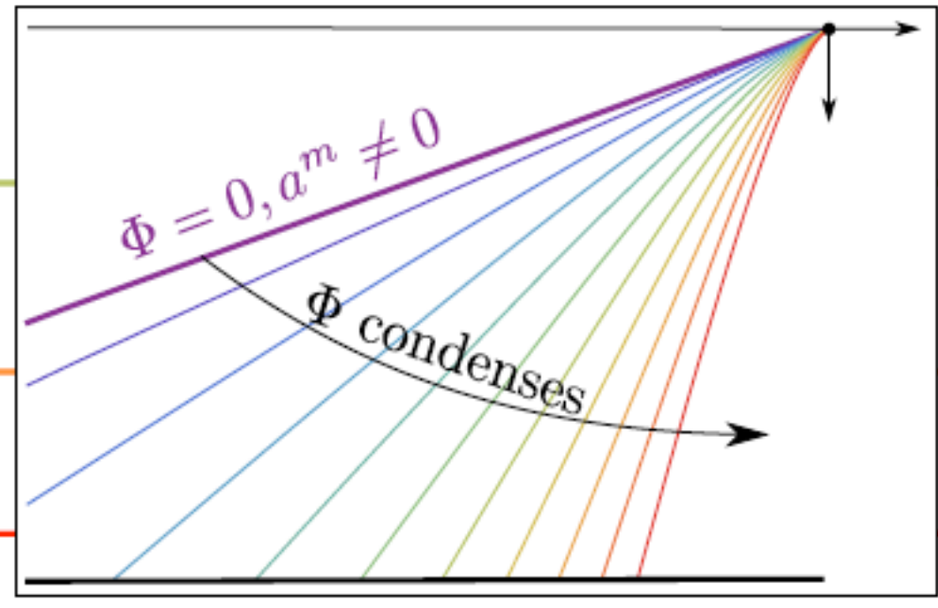
J.E., Flory, Hoyos, Newrzella, O'Bannon, Wu in progress

$S_{EE}(\ell) - S_{EE}(\ell)\big|_{\Phi\equiv 0}$

$\Phi = 0, a^m \neq 0$

0.00
−0.05
−0.10
−0.15
−0.20
−0.25
−0.30
0.5
1.0
1.5
2.0
2.5





sign of Kondo cloud?

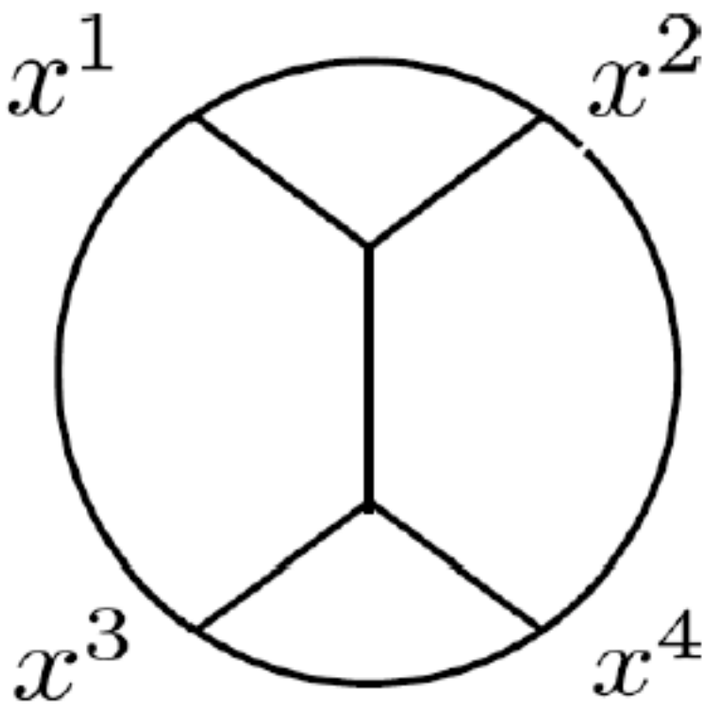
Φ condenses, Kondo cloud forms

Fundamental aspects of gauge/gravity duality:
Higher spin theories

Free O(N) vector model $\Leftrightarrow$ Higher spin gravity theory

$$\phi \nabla_{(\mu_1} \dots \nabla_{\mu_n)} \phi \qquad \Leftrightarrow \qquad A_{(\mu_1 \dots \mu_n)}$$

Klebanov, Polyakov 2002



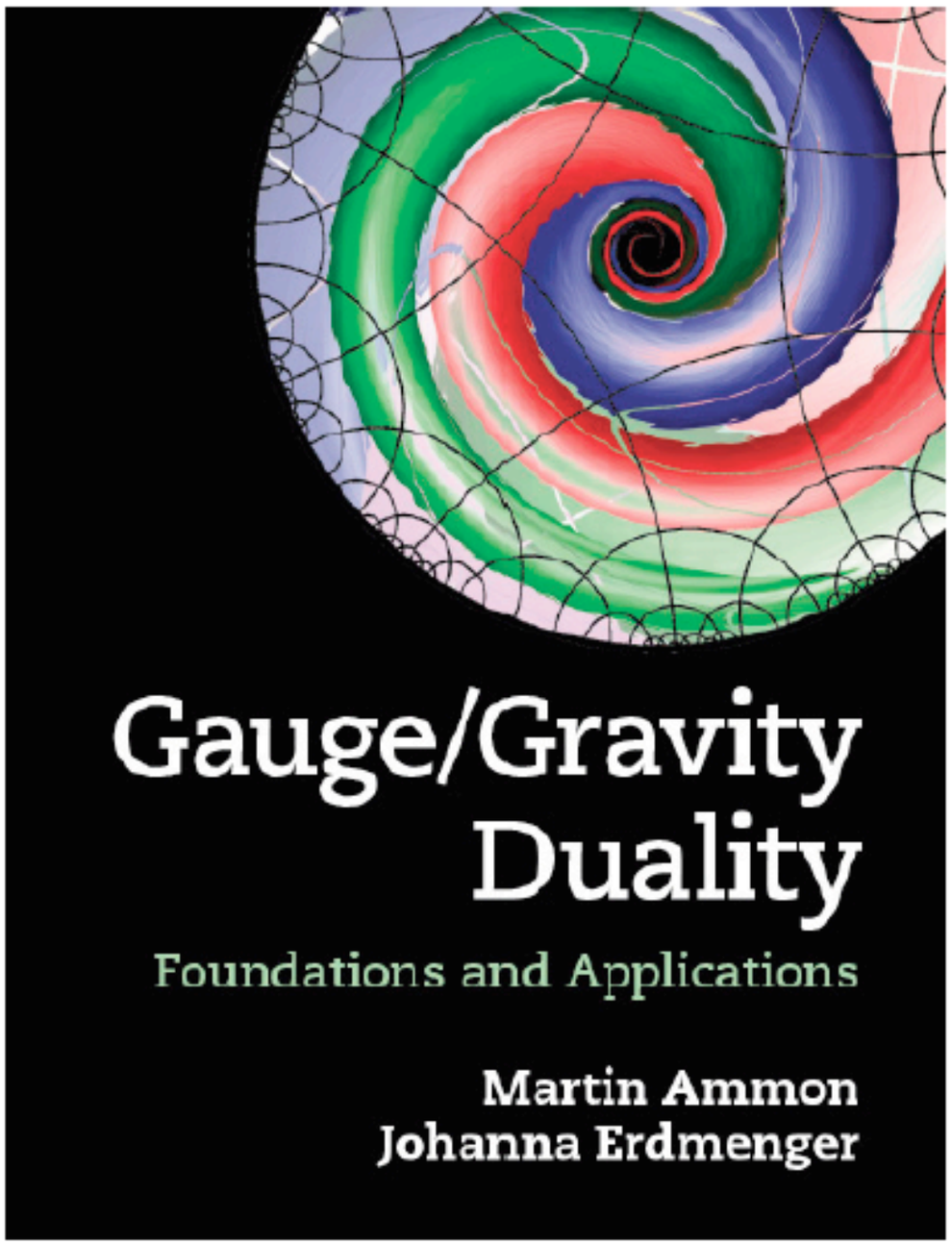
Calculation of four-point exchange diagrams

Bekaert, J.E., Ponomarev, Sleight 1412.0016

Gauge/Gravity Duality

- New relations between quantum field theory and gravity
- New relations between different areas of physics (e.g. particle and condensed matter physics)
- New tools for strongly coupled theories

If you would like to read more ...



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