Gravity & Condensed Matter

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Holographic Chern-Simons Defects

~~Gravity & Condensed Matter~~

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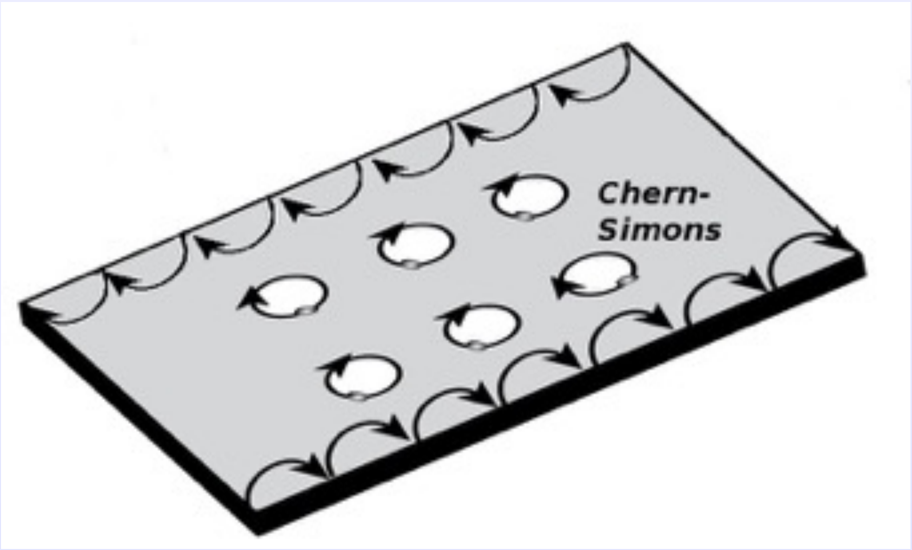
arXiv.org > hep-th > arXiv:1601.00525

Why (YM)-CS Holography with/without Defects?

$$S_A = -\frac{1}{4g_{3\mathrm{d}}^2}\int d^3x\,\mathrm{Tr}(F^{\mu\nu}F_{\mu\nu}) + \frac{k}{4\pi}\int Tr\,(A\wedge F)$$

Confinement/ Topological

FQHE / Edge States



Level-Rank Duality

$$SU(N)_k \leftrightarrow U(k)_{-N,-N}$$

Aharony 1512.00161

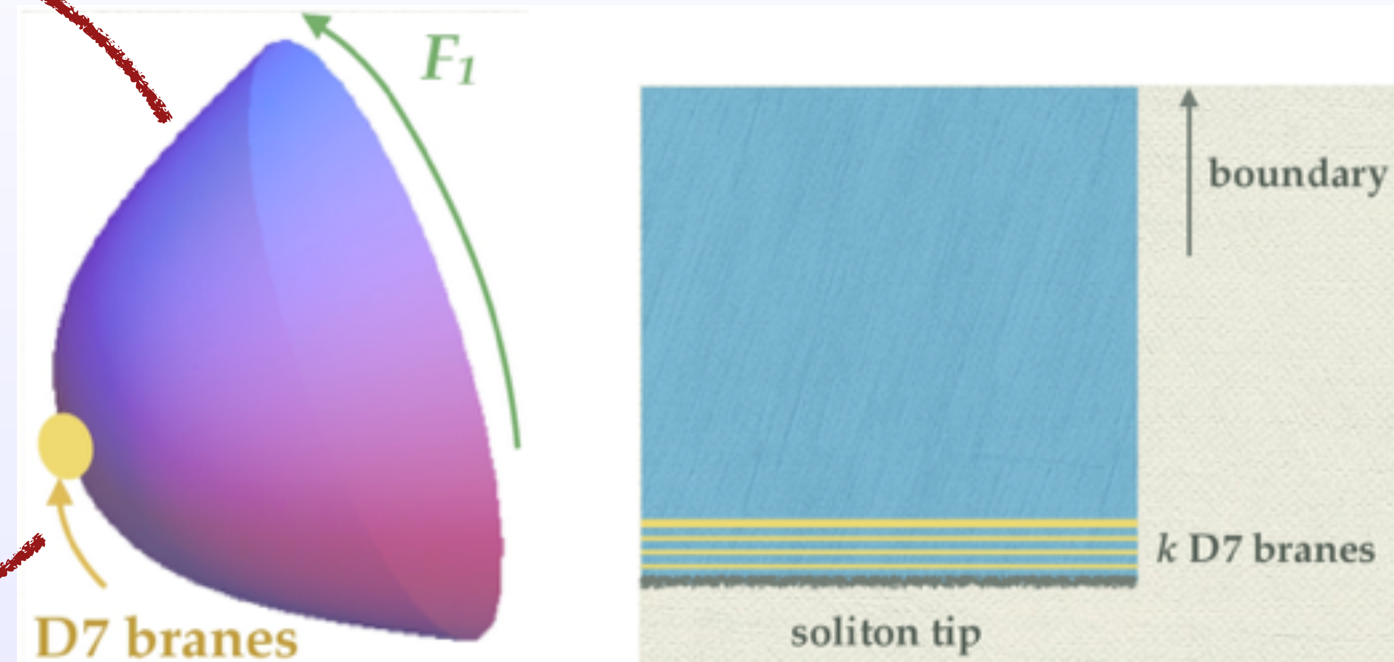
$$\begin{aligned}
\sigma_{xy} &= \nu\frac{e^2}{h} \\
\nu &= \frac{1}{2k+1} \qquad U(1)_{2k+1} \\
\nu &= \frac{1}{2} \qquad SU(2)_2
\end{aligned}$$

Defect D7 Branes

$$-\frac{1}{4g_{3d}^2}\int d^3x Tr_{SU(N)}F^2$$

$$\frac{k}{4\pi}\int d^3x Tr_{SU(N)}A\wedge F$$

$g_{3\mathrm{d}}^2 = g_s M_{\mathrm{KK}}$



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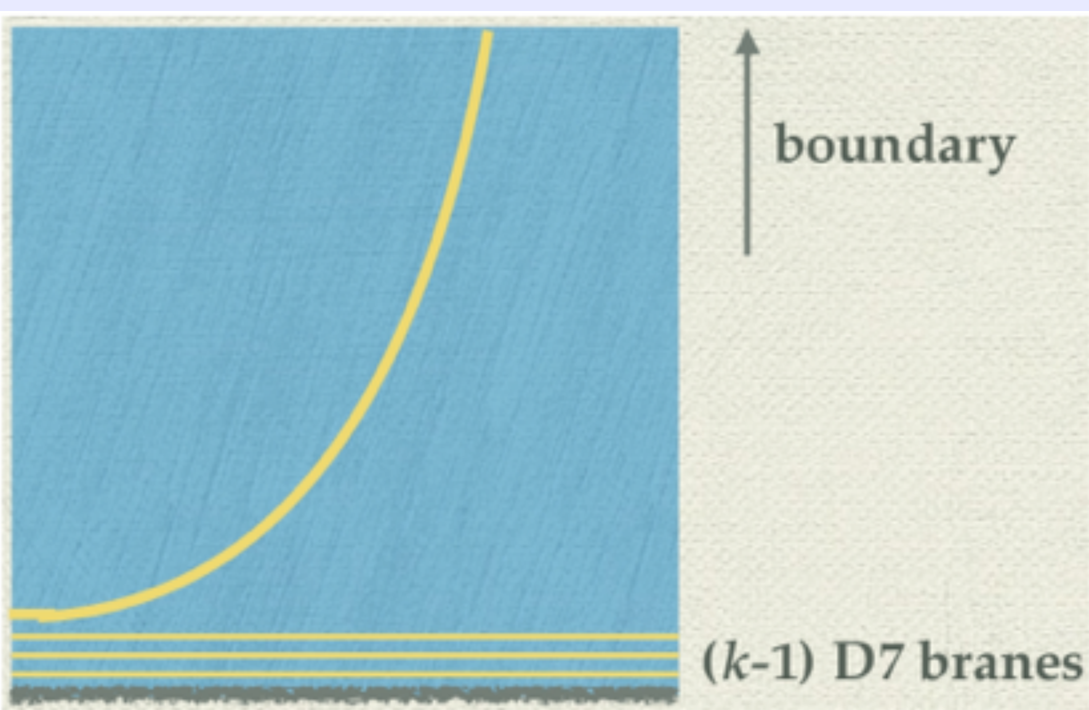

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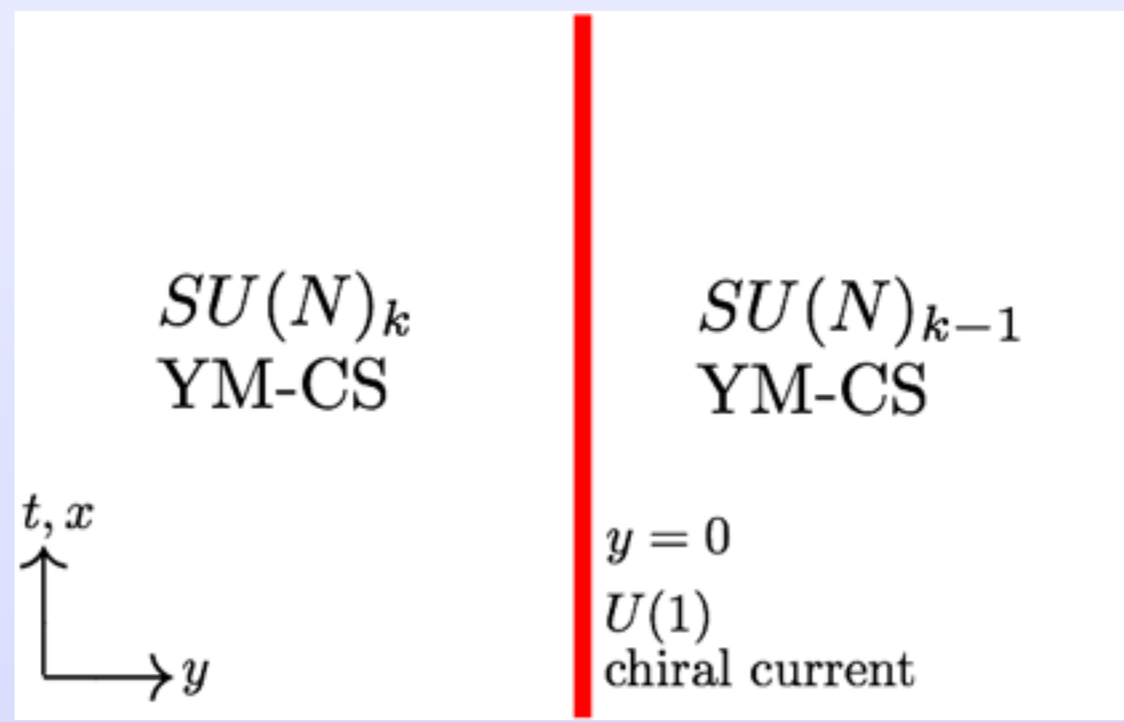
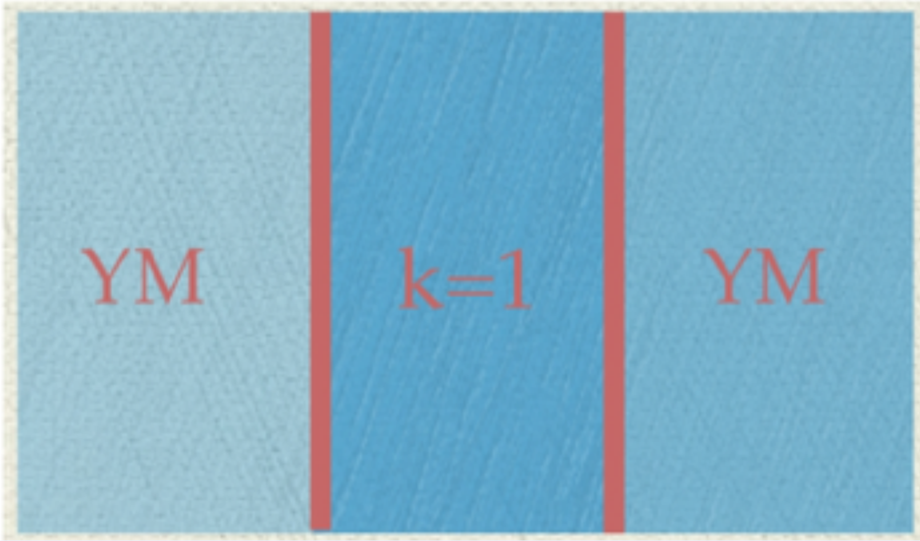
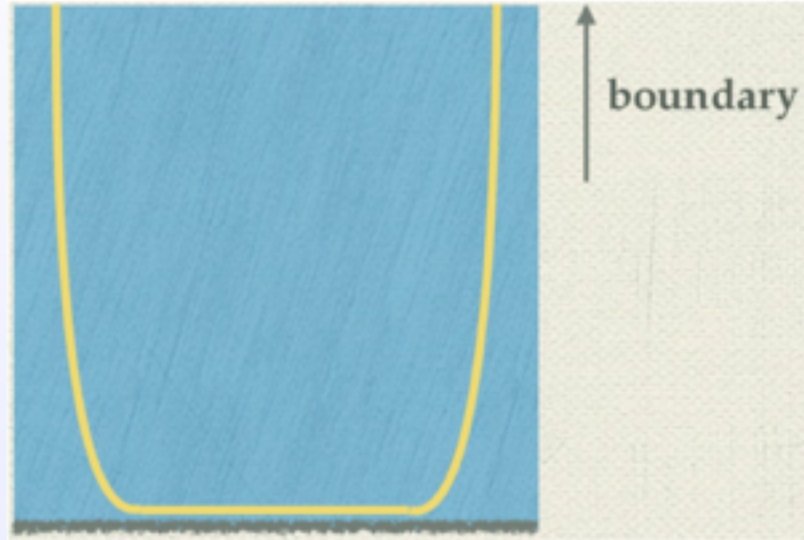
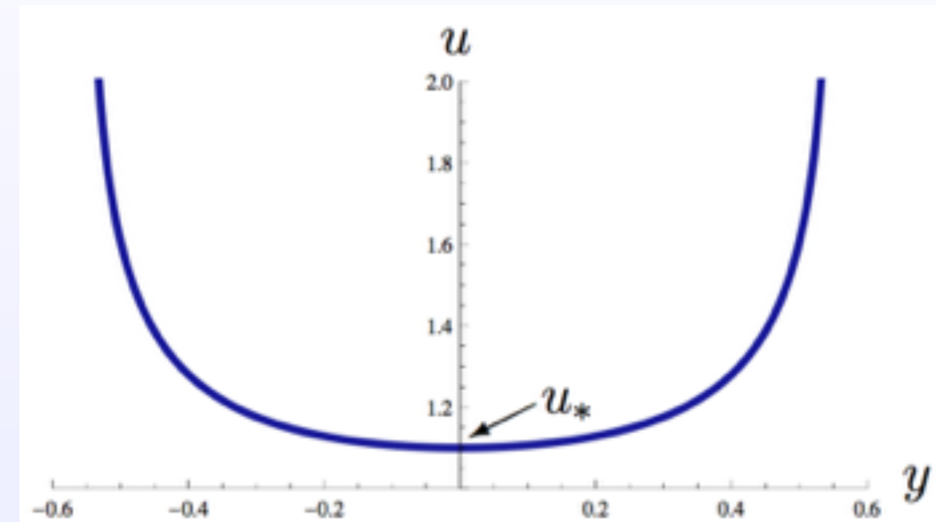


$$S_\psi = \int_{y=0} d^2x\, \psi_-^\dagger(i\partial_+ + A_+)\psi_-$$

Holography of Defect D7 Branes







$$S^{\mathrm{D7}}_{\mathrm{DBI}} = -T_{3\mathrm{d}} \int dx^0 dx^1 du \sqrt{-\mathcal{G}}$$

$$S^{\mathrm{D7}}_{\mathrm{CS}} = \frac{1}{8\pi^2} \int F_5 \wedge a \wedge da$$

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$$\begin{aligned} \mathcal{A}_+ &\rightarrow \mathcal{A}_+ + \partial_+ \Lambda \\ \delta_\lambda S_{\mathrm{total}} &= \frac{N}{4\pi} \int_{z\rightarrow+\infty} d^2x\, \Lambda \partial_- \mathcal{A}_+ \end{aligned}$$

operator	Δ	source	vev
$J_- \sim \psi_-^\dagger \psi_-$	1	a_+	a_-
$\mathcal{O}_y \sim \psi_-^\dagger F_{+y} \psi_-$	3	y	y
$\mathcal{O}_+ \sim \psi_-^\dagger F_{+y}^2 \psi_-$	5	a_-	a_+

Harvey+Royston 0804.2854

Level-Rank Duality with Defects

$$SU(N)_k \leftrightarrow U(k)_{-N,-N}$$

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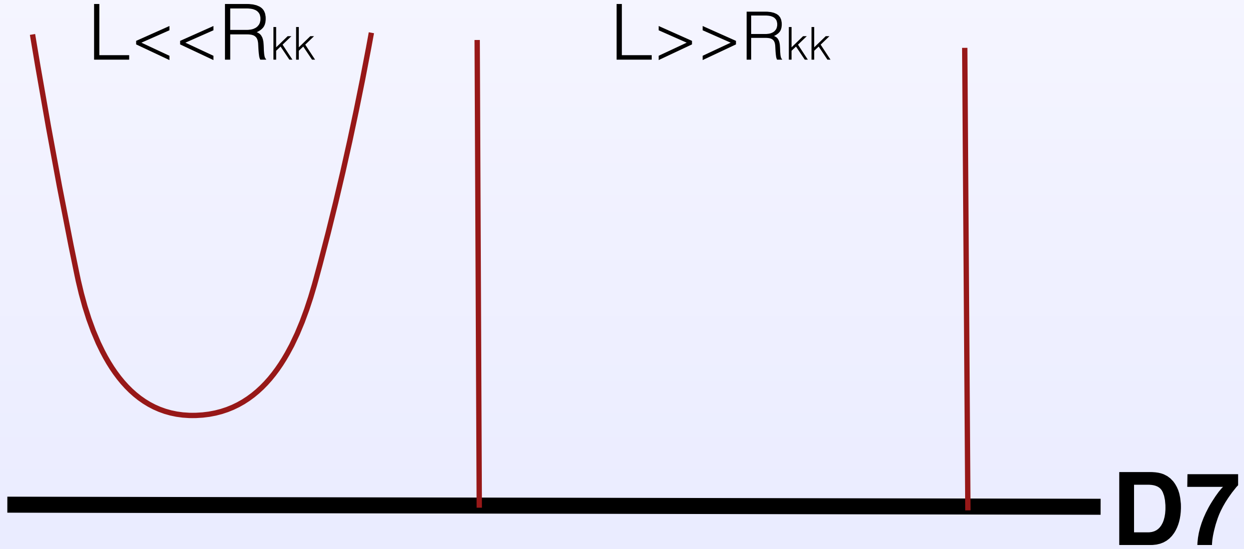
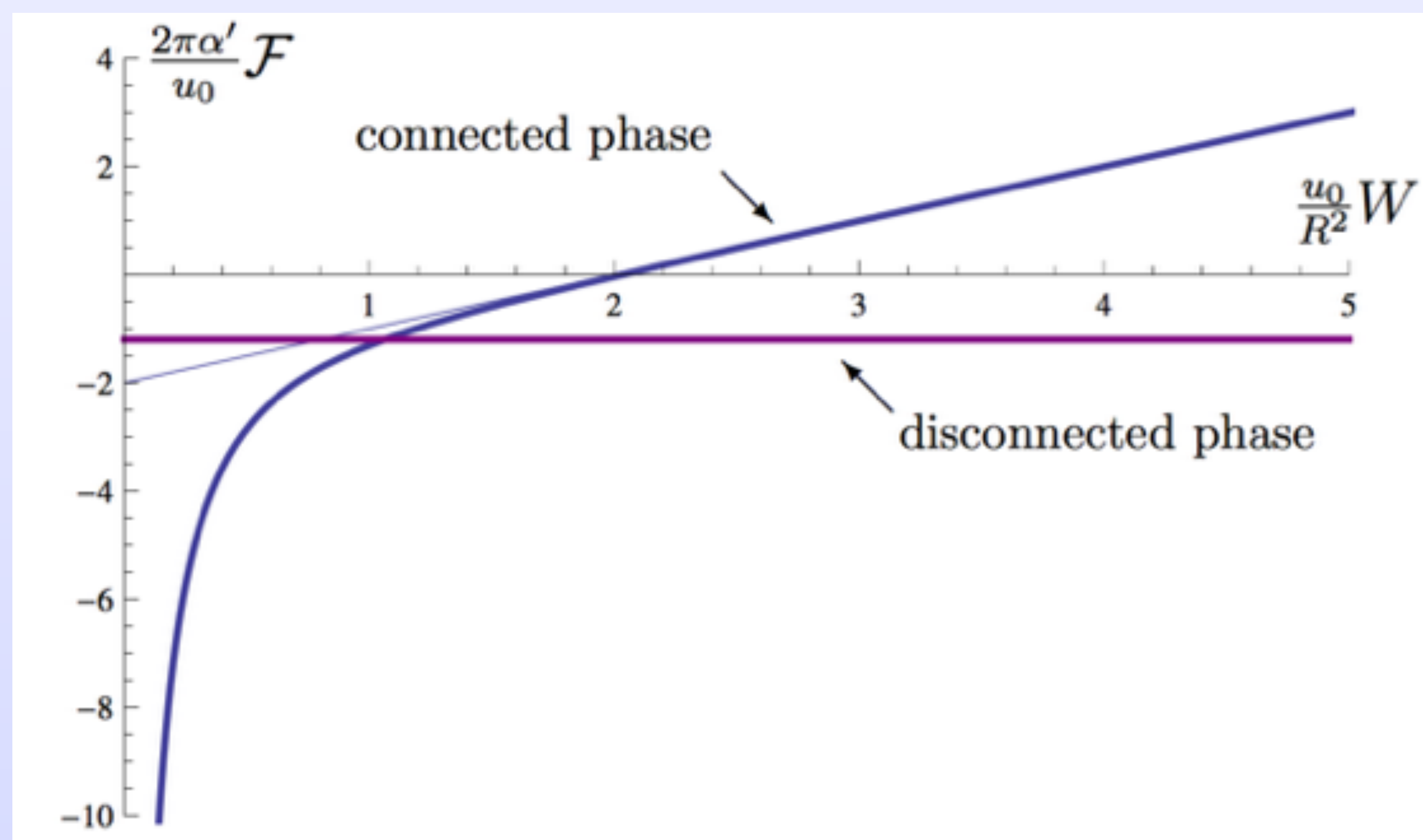
Correlations and Phase Transitions I



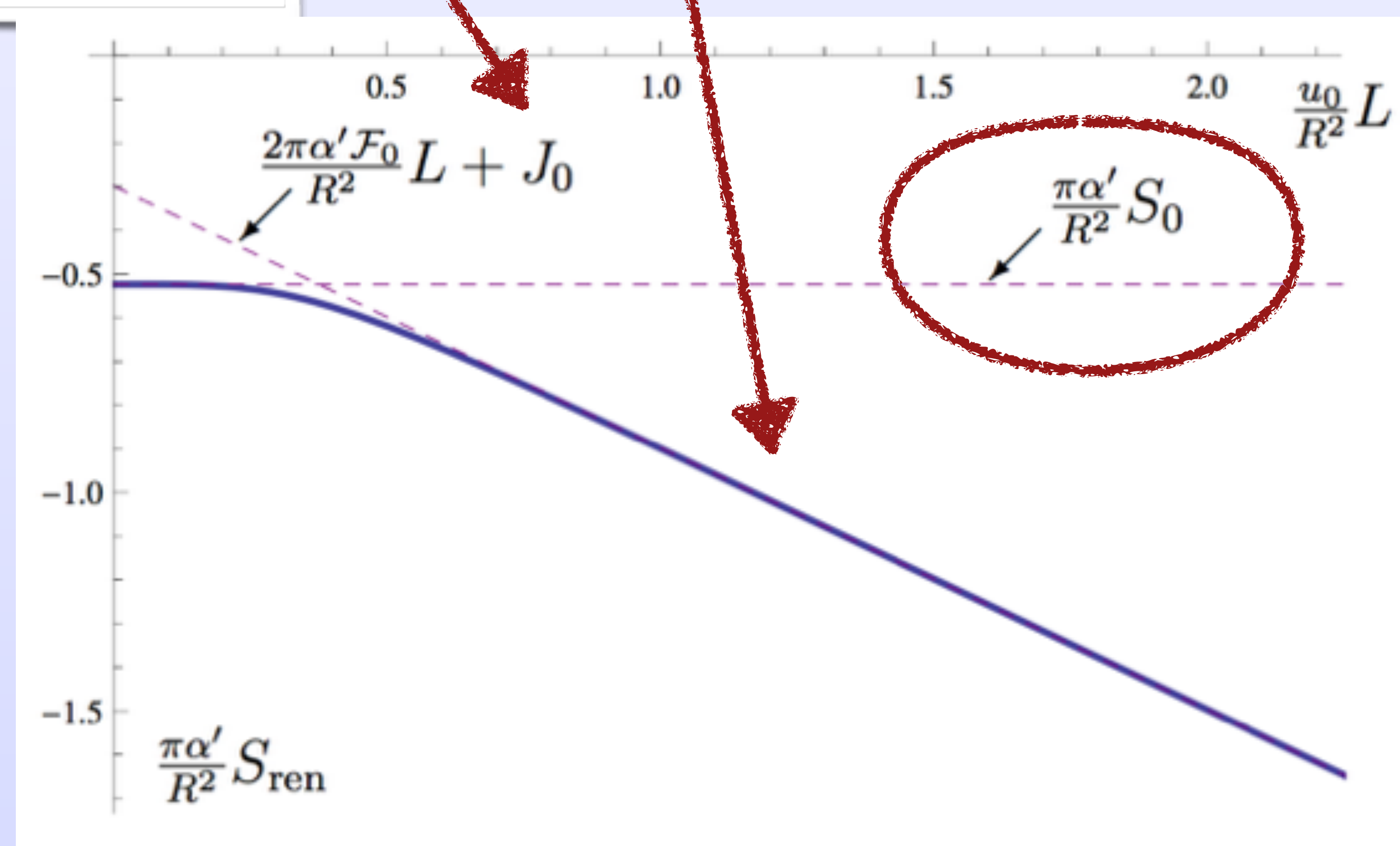
Topological Wilson Loop



Correlations and Phase Transitions II

Chiral Symmetry Breaking

$$\langle \psi_L^\dagger \mathcal{P} e^{i\int_R^L A} \psi_R \rangle = e^{-S^{F1}_{\mathrm{ren}}}$$

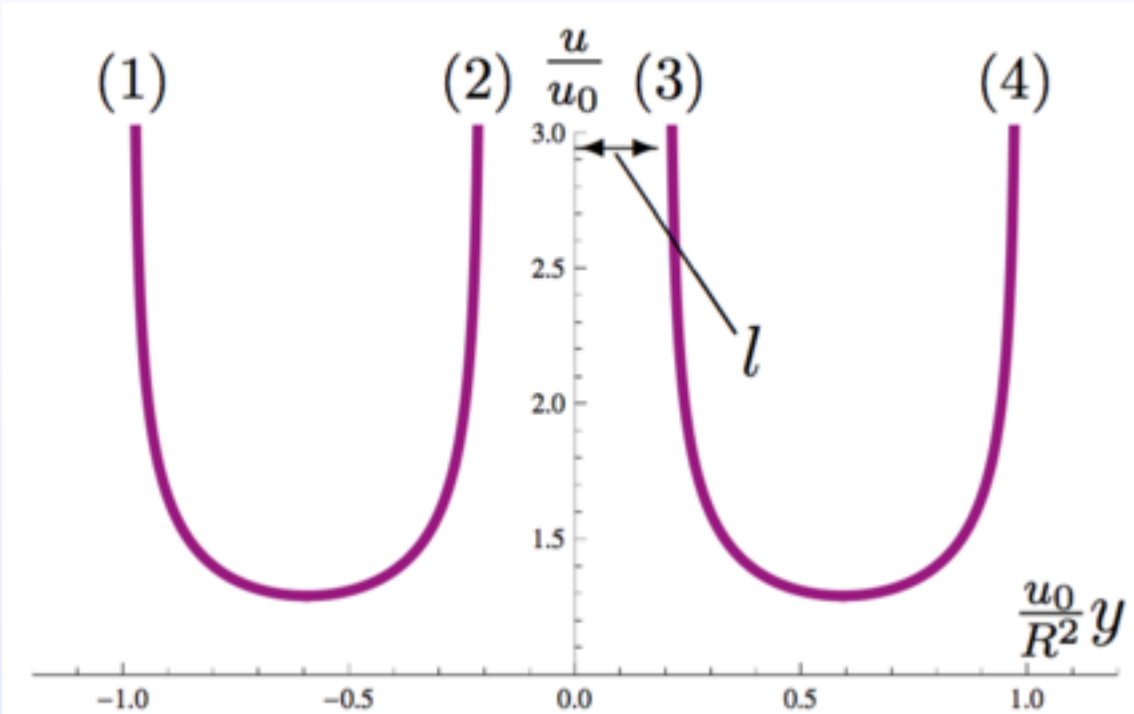


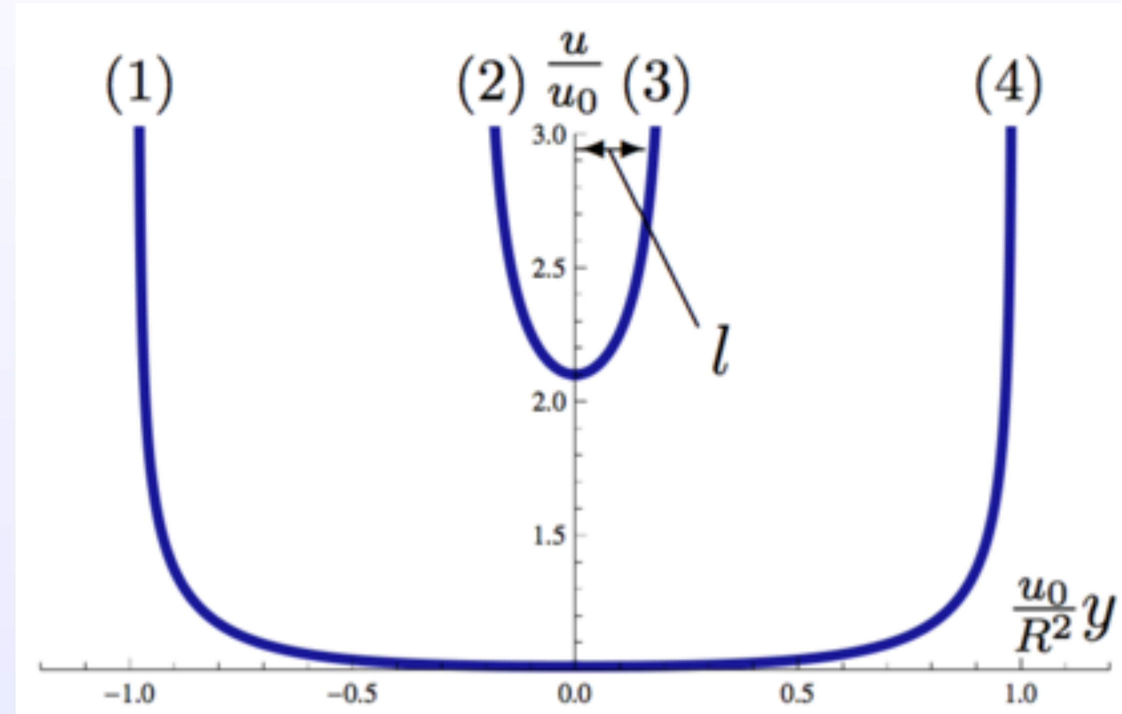
Edge Modes

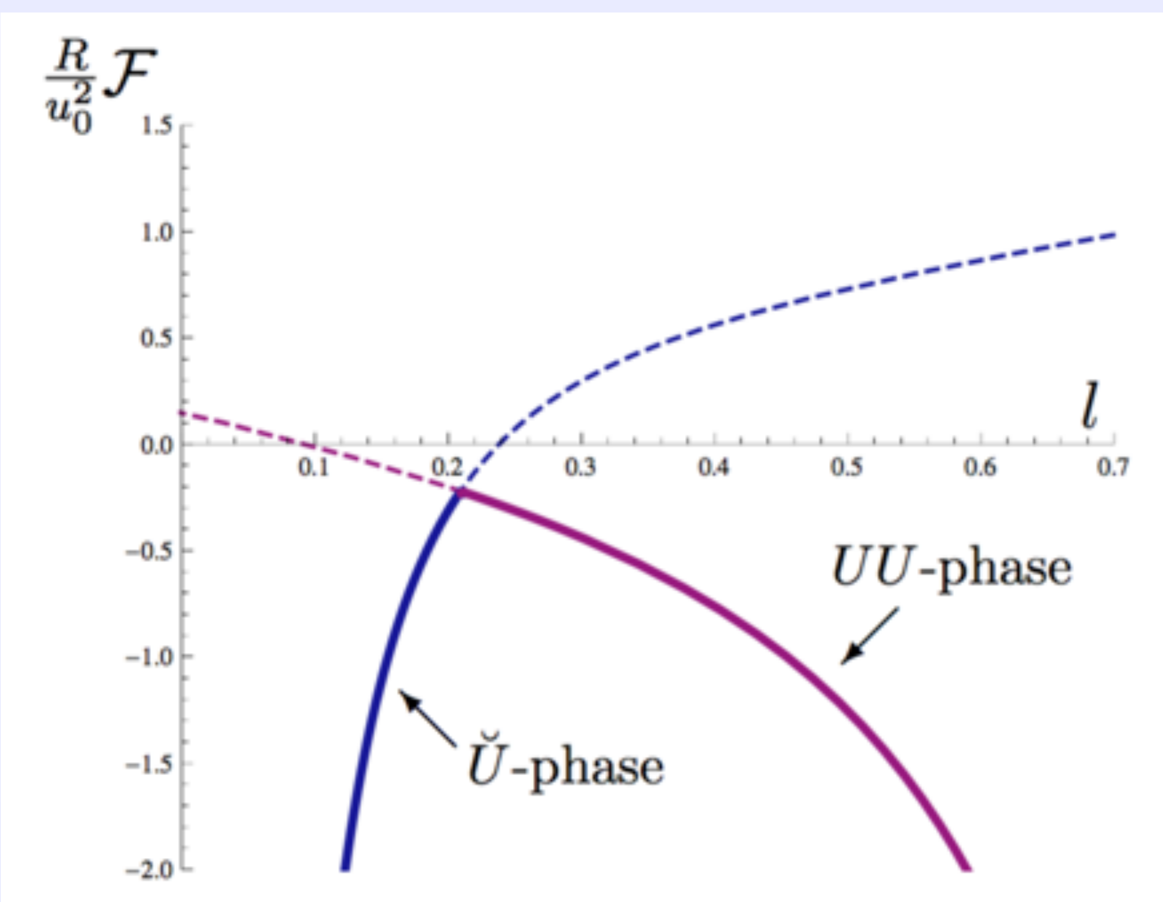
=

Nambu-Goldstone Bosons

Correlations and Phase Transitions III







Dim. 5 Correlations

$$\langle \mathcal{O}_-^{(1)} \mathcal{O}_+^{(2)} \rangle \neq 0 \quad \langle \mathcal{O}_-^{(3)} \mathcal{O}_+^{(4)} \rangle \neq 0$$

$$\langle \mathcal{O}_+^{(2)} \mathcal{O}_-^{(3)} \rangle \neq 0 \quad \langle \mathcal{O}_-^{(1)} \mathcal{O}_+^{(4)} \rangle \neq 0$$

Conclusions/Outlook

- YM-CS theory with level-changing defects in Holography

- Topological Wilson loop at large separations

- Geometric picture of level-rank duality with defects

- Strong similarities to FQH samples: $\sigma_{xy}^{U(1)\subset U(N)} = \frac{N}{k}\frac{e^2}{h}$

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- Chiral Symmetry Breaking between Edges 

- Transitions between samples, Dim. 5 correlations 

- Edge transport, Impurity scattering, Relation to 2D QCD, Backreaction, Tunneling of electrons/anyons, …