The Massless Limit and Tension in Massive Gauge Theories

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Based on:

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[arXiv:2111.00017]

The Puzzle of Massless Limit

- The Principle of Continuity

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- Massive Yang-Mills Theory

$$\mathcal{L} = -\frac{1}{2}\,\mathrm{Tr}(F_{\mu\nu}F^{\mu\nu}) + m^2\,\mathrm{Tr}(A_\mu A^\mu)$$

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- **The Goal**

Massive Yang-Mills Theory

- Quantum fluctuations

$$\delta\phi_L^2 = \langle 0|\, \phi\left(\vec{x},t\right) \phi\left(\vec{y},t\right) |0\rangle \sim \left.\frac{k^3}{\omega_k}\right|_{k\sim\frac{1}{L}}$$

$$\left.\delta\phi_L\right|_{k^2\gg m^2} \sim \frac{1}{L} \qquad\qquad L = |\vec{x}-\vec{y}|$$

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- The decomposition

$$(A_0, A_i)$$

$$A_i = \zeta A_i^T \zeta^\dagger + \frac{i}{g}\zeta_{,i}\zeta^\dagger$$

$$A_{i,i}^T = 0 \qquad\qquad \zeta = e^{-ig\chi}$$

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- The Full Perturbation Theory

$$\mathcal{L}_0 = \mathrm{Tr}\left[-\chi\left(\partial^2+m^2\right)\frac{-\Delta m^2}{-\Delta+m^2}\chi - A_i^T\left(\partial^2+m^2\right)A_i^T\right]$$

$$\mathcal{L}_{int} \sim \mathrm{Tr}\left\{-2igm^2 A_i^T\chi\chi_{,i} + \frac{m^2g^2}{6}\left(\chi_{,\mu}\chi\chi^{,\mu}\chi - \chi_{,\mu}\chi^{,\mu}\chi^2\right)\right\}$$

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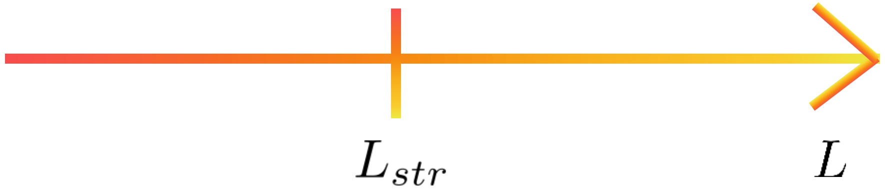
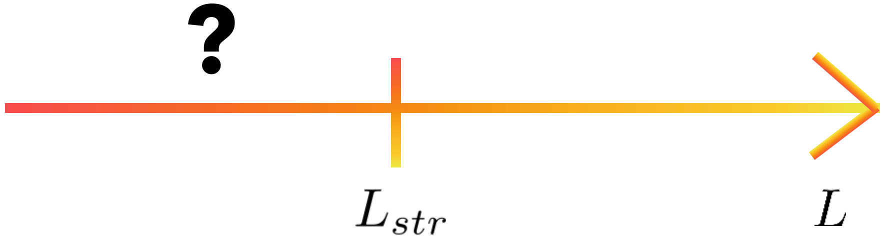
- The Strong Coupling Scale $\quad L_{str} \sim \dfrac{g}{m}$



L_{str}
L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L_{str}
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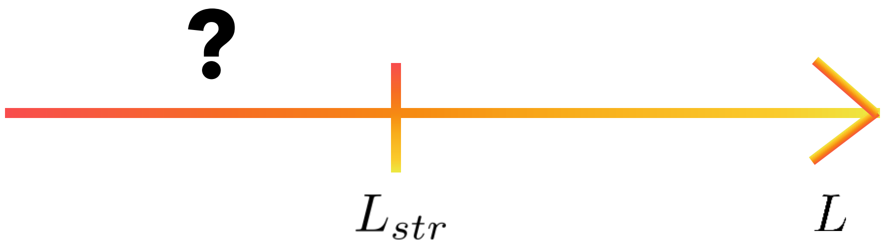

Beyond the Strong Coupling Scale

$$\mathcal{L}_0 \sim \mathrm{Tr}\left[\frac{m^2}{g^2}\zeta^\dagger_{,\mu}\zeta^{,\mu} - A_i^T\left(\partial^2 + m^2\right)A_i^T\right]$$

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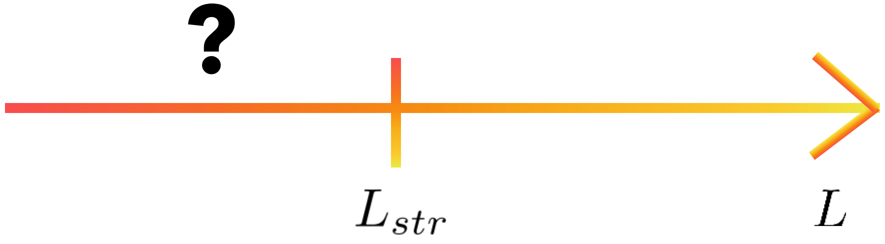

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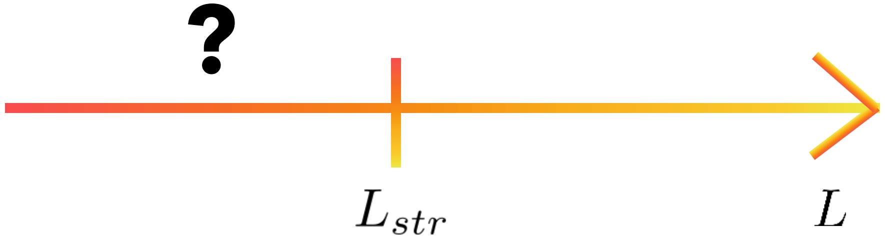
The leading corrections

$$A_i^{T(1)} \sim -i\frac{m^2}{g}\zeta^{\dagger}\zeta_{,i} \sim \frac{g}{L^3}\frac{L}{L_{str}}$$

The Massless Limit and Duality



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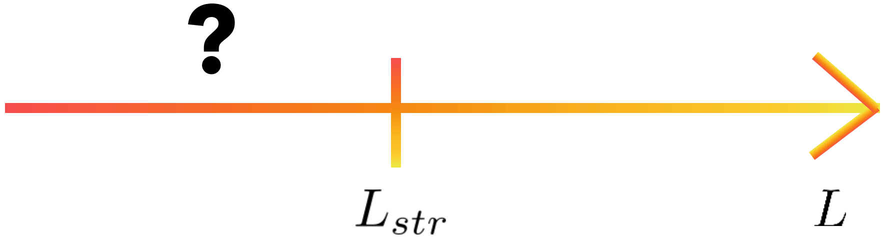

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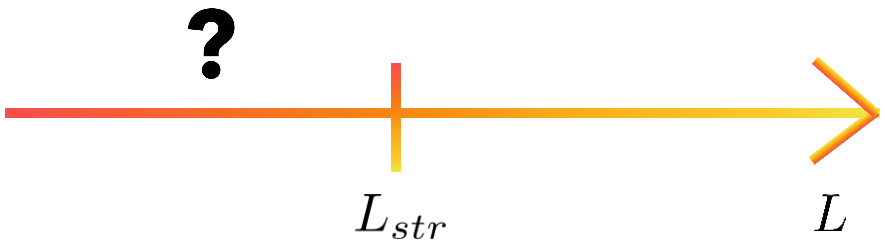
$$\mathcal{L}_P = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} + \frac{m^2}{2}A_{\mu}A^{\mu}$$

- Kalb-Ramond Theory

$$\mathcal{L}_{KB} = \frac{1}{12}H_{\mu\nu\rho}H^{\mu\nu\rho} - \frac{m^2}{4}B_{\mu\nu}B^{\mu\nu}$$

THE MASSLESS LIMIT AND DUALITY



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- DUAL THEORIES

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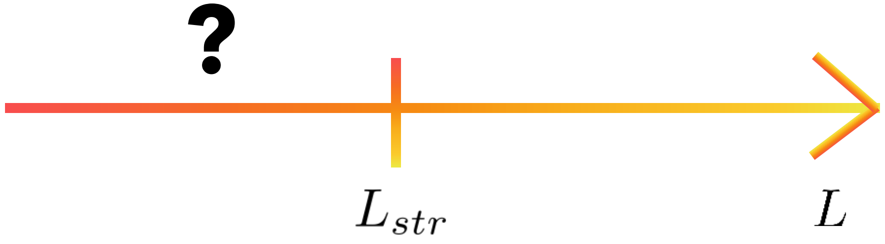

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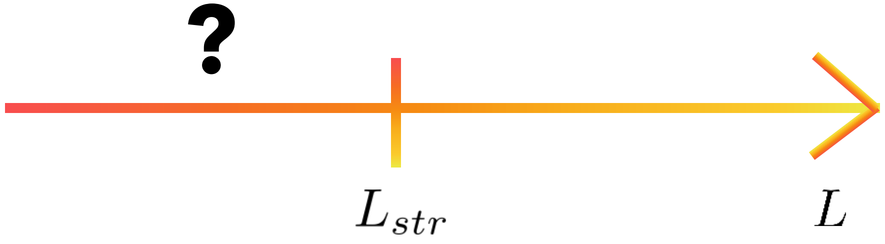

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THE COMPARISON

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$$\mathcal{L}_0 = -\frac{1}{2}\chi(\partial^2 + m^2)\frac{m^2(-\Delta)}{-\Delta + m^2}\chi - \frac{1}{2}A_i^T(\partial^2 + m^2)A_i^T$$

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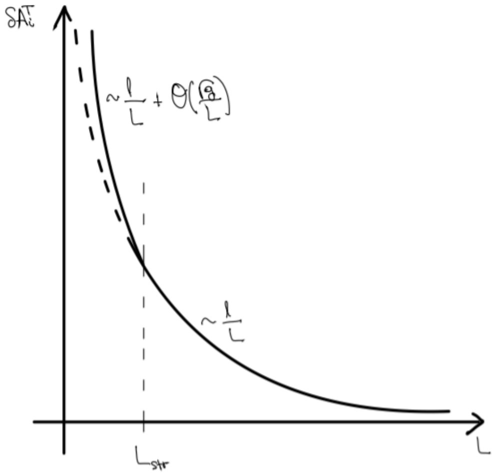

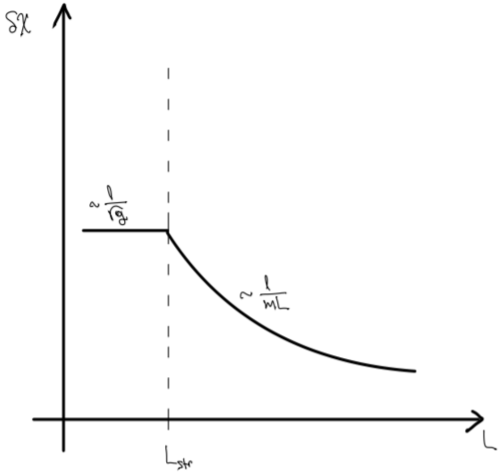

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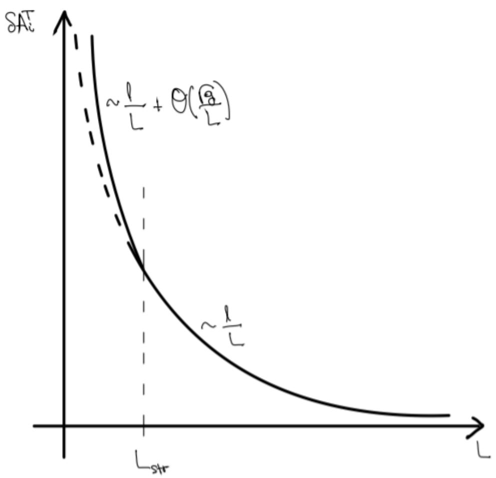

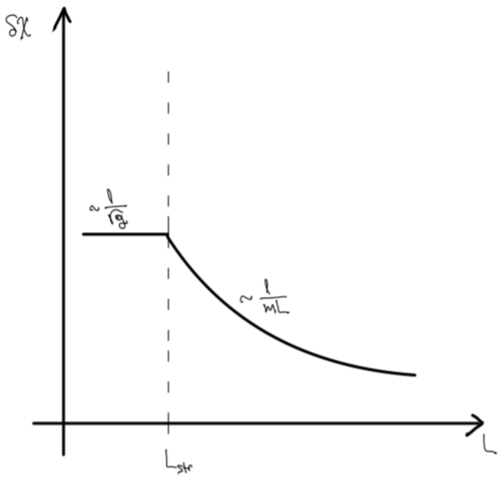

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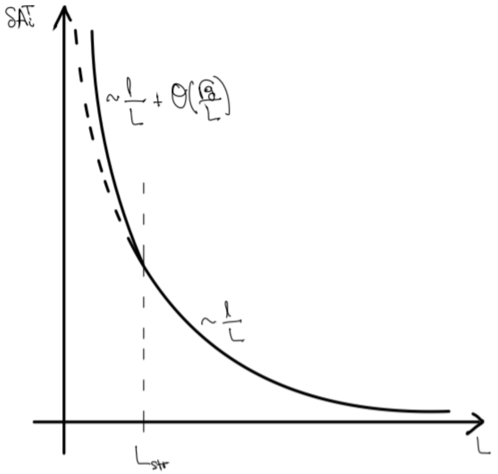

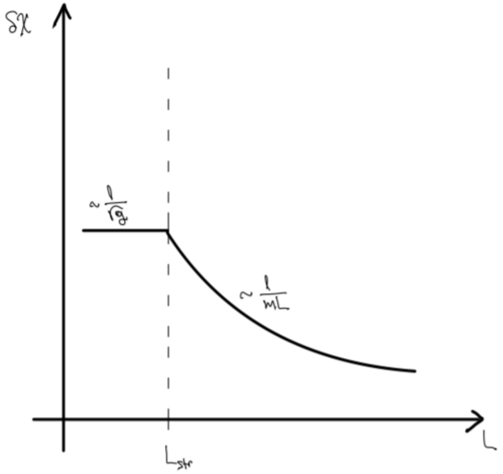

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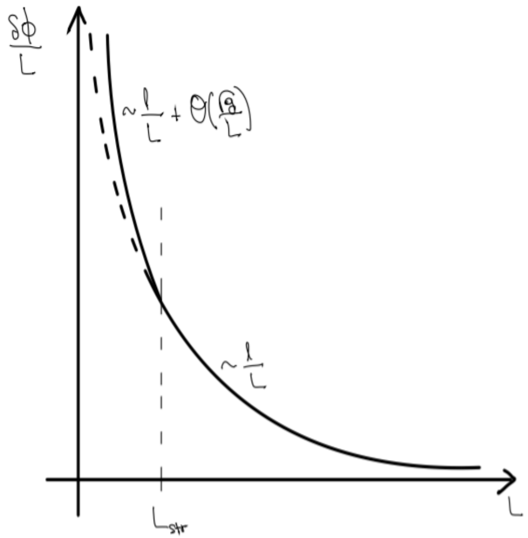

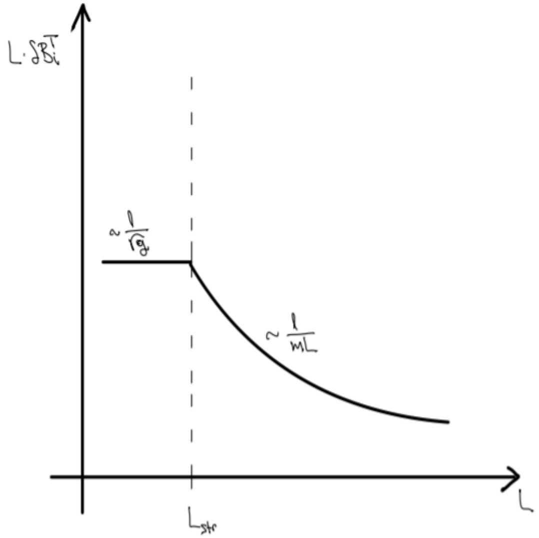

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Extension to p-forms in D-dimensions

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Thank You!