Walking technicolor and AdS/CFT

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Outline

- Template of walking technicolor
- AdS/CFT modeling

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Walking technicolor

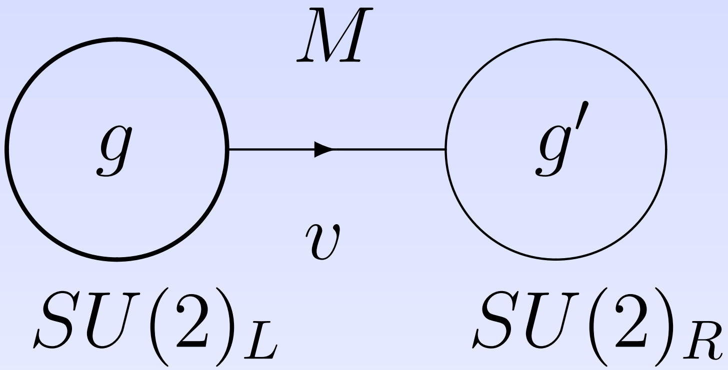
The Higgs sector of the standard model is replaced by a strongly interacting gauge theory

$$U(1)_Y \times SU(2)_L \times SU(3)_C \times SU(N_{TC})_{TC}$$

- Composite Higgs $\Rightarrow$ no hierarchy problem
- Walking dynamics $\Rightarrow$ flavor changing neutral currents suppressed
- Fermions in higher dimensional representations $\Rightarrow$ passes eletroweak precision tests

Template for walking technicolor

- Effective field theory with $SU(2)_L \times SU(2)_R$ chiral symmetry
- Included composites are Higgs, rho and axial vectors, and (eaten) pions



$M = \frac{1}{\sqrt{2}}(\sigma + i\Pi^a T^a)$ 2×2 linear sigma field, contains Higgs and the pions

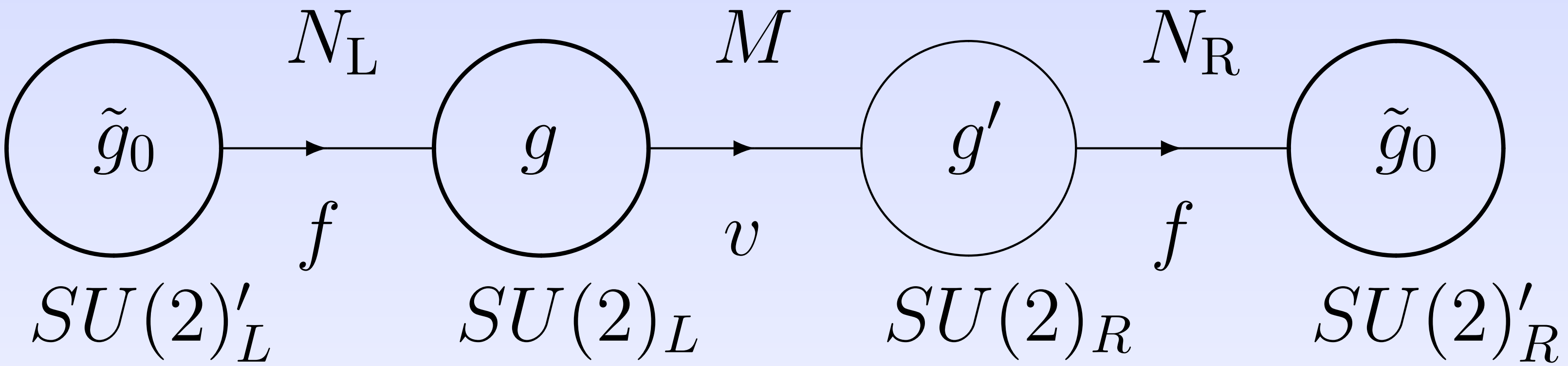
$$M \longrightarrow u_L M u_R^\dagger$$

Coupling to spin-one mesons . . .

Template for walking technicolor

- ❏ Rho and axial vector mesons introduced by hidden local gauge symmetry

$\Longrightarrow$ four-site moose



$N_L \longrightarrow u'_L N_L u_L^\dagger \,; \quad N_R \longrightarrow u_R N_R u_R'^\dagger$ nonlinear sigma

$\longrightarrow$ write down a general (parity & gauge invariant) effective field theory

Lagrangian

$$M = \frac{1}{\sqrt{2}}\left(\sigma + i\Pi^a T^a\right) \leftrightarrow v\,; \quad N_{L/R} = \exp\left(i\Pi^a_{L/R} T^a\right) \leftrightarrow f$$

$$\mathcal{L} = \mathcal{L}_{\rm kin} + \mathcal{L}_{\rm Higgs} + \mathcal{L}_{\rm MN} + \mathcal{L}_{\gamma} + \mathcal{L}_{\rm ferm}$$

$$\begin{aligned}
\mathcal{L}_{\rm kin} &= -\frac{1}{4}{\rm Tr}\left[\widetilde{W}_{\mu\nu}\widetilde{W}^{\mu\nu}\right] - \frac{1}{4}{\rm Tr}[B_{\mu\nu}B^{\mu\nu}] - \frac{1}{4}{\rm Tr}[F_{L\mu\nu}F_L^{\mu\nu}] - \frac{1}{4}{\rm Tr}[F_{R\mu\nu}F_R^{\mu\nu}] \\
\mathcal{L}_{\rm Higgs} &= \frac{1}{2}{\rm Tr}\left[D_\mu M (D^\mu M)^\dagger\right] + \frac{v^2\lambda}{2}{\rm Tr}\left[MM^\dagger\right] + \cdots \\
\mathcal{L}_{\rm MN} &= \frac{r_1}{2}{\rm Tr}\left[(D^\mu N_L)^\dagger D_\mu N_L M M^\dagger + D_\mu N_R (D^\mu N_R)^\dagger M^\dagger M\right] + \cdots \\
\mathcal{L}_{\gamma} &= -\frac{2\gamma}{v^2}{\rm Tr}\left[N_L^\dagger F_{L\mu\nu} N_L M N_R F_R^{\mu\nu} N_R^\dagger M^\dagger\right]
\end{aligned}$$

Bare parameters $g, g', v, \tilde{g}_0, f, \lambda, \gamma, r_1, r_2, r_3, s, \kappa$

Fix e, G_F, M_Z + constraints from gauge theory using Weinberg sum rules

$\Rightarrow$ parameters $M_A, \tilde{g}, S, M_H, \gamma, \kappa, r_1 + s$

AdS/CFT modeling

- A model of walking gauge theories (with $D > 4$) $\longrightarrow$ estimate for non-perturbative quantities, the S parameter
- Walking dynamics close to conformal $\Rightarrow$ AdS/CFT expected to work well?

Model of Gürsoy, Kiritsis & Nitti of (pure glue) QCD

$$\mathcal{L} \propto \int d^5x \sqrt{-g} \left[R - \frac{4}{3}(\partial\Phi)^2 + V(\Phi) \right]$$

$$V(\Phi) \longleftrightarrow \beta_{\rm QCD}(g)$$

Apply to walking dynamics by changing the beta function?

$\longrightarrow$ Adding fermions is tricky

Beta function mapping

In more detail (denoting $\lambda = g^2 N$)

- For $\lambda \to 0$ expect $\lambda = e^{\Phi}$ (and that $\log \mu$ equals the warp factor in the metric)
- $V(\Phi)$ is fixed such that the equations of motion give the renormalization equation $\frac{d\lambda}{d \log \mu} = \beta(\lambda)$

However, in general $(\lambda > 0)$

$$\lambda = f_{\lambda}\left(e^{\Phi}\right)$$

The transition function f_{λ} affects relation of $V(\Phi)$ and β

Beta function mapping

In general:

$$\beta_{\rm QCD} \overset{f_\lambda}{\longleftrightarrow} V(\Phi)$$

Our work in progress:

- "Exact" all orders QCD beta function (Ryttov, Sannino) fixes lhs

$$\beta(g) = -\frac{g^3}{(4\pi)^2}\frac{\beta_0 - \frac{2}{3}\,T(r)\,N_f\,\gamma(g^2)}{1-\frac{g^2}{8\pi^2}C_2(G)\left(1+\frac{2\beta_0'}{\beta_0}\right)}$$

- QCD Regge behavior constrains rhs

$\Rightarrow$ combine to reduce the uncertainty in the transition functions

Summary

- Walking technicolor passes all experimental contraints
- We study a $SU(2)_L \times SU(2)_R$ version of walking technicolor using effective field theory
- Exact QCD beta function can be used to reduce uncertainties in AdS/CFT modeling