One-Loop Corrections to the S-parameter in a Three-Site Higgsless Model

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Contents

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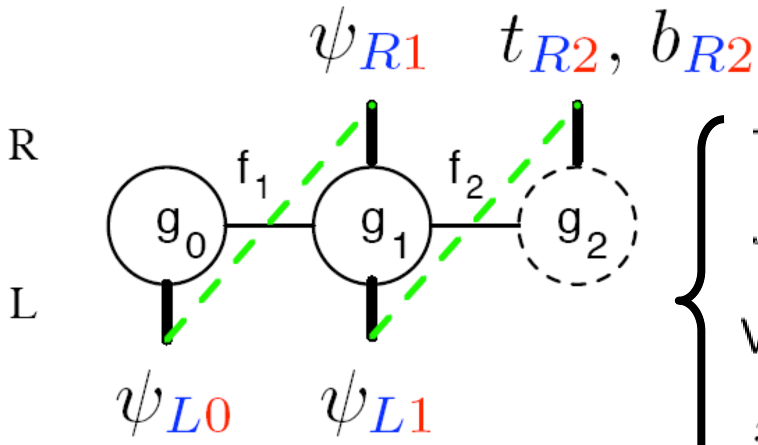
S.M, R.S. Chivukula, E.Simmons, hep-ph/0607191 & M.Tanabashi

Size of Radiative EW Corrections

The 3-Site Model

Details already mentioned by previous speaker

$$SU(2)_0 \times SU(2)_1 \times U(1)_Y \qquad g_0,\, g_2 \ll g_1$$



Takes $f_1 = f_2 \equiv f$

Works in the limit $x = \dfrac{g_0}{g_1} \ll 1$

Gauge bosons ･･･ photon, Z, Z' W, W'

Fermions ･･･ SM fermions (t,b,c,s,d,u) , heavy fermions (T,B,C,S,D,U) } **+ leptons**

In this talk, we focus on the gauge-sector (gauge bosons, NGBs)

The Size of Radiative Corrections

Tree-Level Value of the S-Parameter

$$\alpha S^{tree} = \frac{4s^2 M_W^2}{M_{W'}^2}\left(1 - \frac{x_1 M_{W'}^2}{2M_W^2}\right)$$

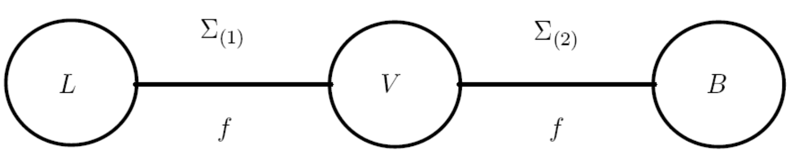
$$\frac{M_W^2}{M_{W'}^2} \approx \frac{x^2}{4} \qquad \frac{g_0}{g_1} = x$$

If $x_1 = x^2/2 \quad \alpha S^{tree} = 0!!$

R.S.Chivukula, et al PRD72 (2005)

$x_1 \cdots$ **amount of delocalization**

$$\mathcal{L}_f = \vec{J}_L^{\mu} \cdot ((1 - x_1)L_\mu + x_1 V_\mu) + J_Y^{\mu} B_\mu$$



“Duality”

J.M.Maldacena, Adv.Theor.Math.Phys. 2 (1998)

Tree-level value in 5D gauge theory ⟷ Large-N value in 4D SCGT

$$\alpha S^{tree} = s^2 x^2 \left(1 - \frac{x_1}{2x^2}\right)$$

Expected to scale like

$$\frac{x^2}{4} \simeq \frac{M_W^2}{M_{W'}^2} = \mathcal{O}\left(\frac{g_{eW}^2 N}{(4\pi)^2}\right)$$

Cf. G.Burdman and Y,Nomura, PRD69 (2004)

To be consistent with Large-N approximation

$$|\alpha S^{1-loop}| = \mathcal{O}\left(\frac{g_{eW}^2}{(4\pi)^2}\right) \sim \mathcal{O}(10^{-3})$$

Since $\alpha S^{tree} \simeq 0,\ x_1 = \mathcal{O}(x^2)$

One-loop EW corrections are potentially relevant!!

‘tHooft-Feynman Gauge Calculations

R_ξ Gauge-Fixing of $SU(2)_0 \times SU(2)_1 \times U(1)_Y$

* Details are shown in hep-ph/0607191

Taking 'tHooft-Feynman gauge for all gauge symmetries

We have vertices constructed from

Unphysical Goldstone Bosons

$$\pi_{W^\pm},\ \pi_{W'^\pm},\ \pi_Z,\ \pi_{Z'}$$

FP Ghost (Anti-Ghost)

$$C_{W^\pm},\ C_{W'^\pm},\ C_Z,\ C_{Z'},\ C_A$$

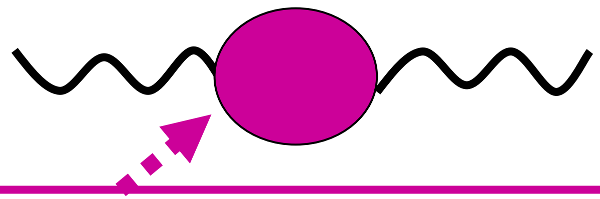
Dynamical Gauge Bosons

$$W^\pm,\ W'^\pm,\ Z,\ Z',\ A$$

Gauge Boson Self-Energies

$$\Pi^{\mu\nu} = i g^{\mu\nu} \Pi(p^2) + p^\mu p^\nu \text{ terms}$$

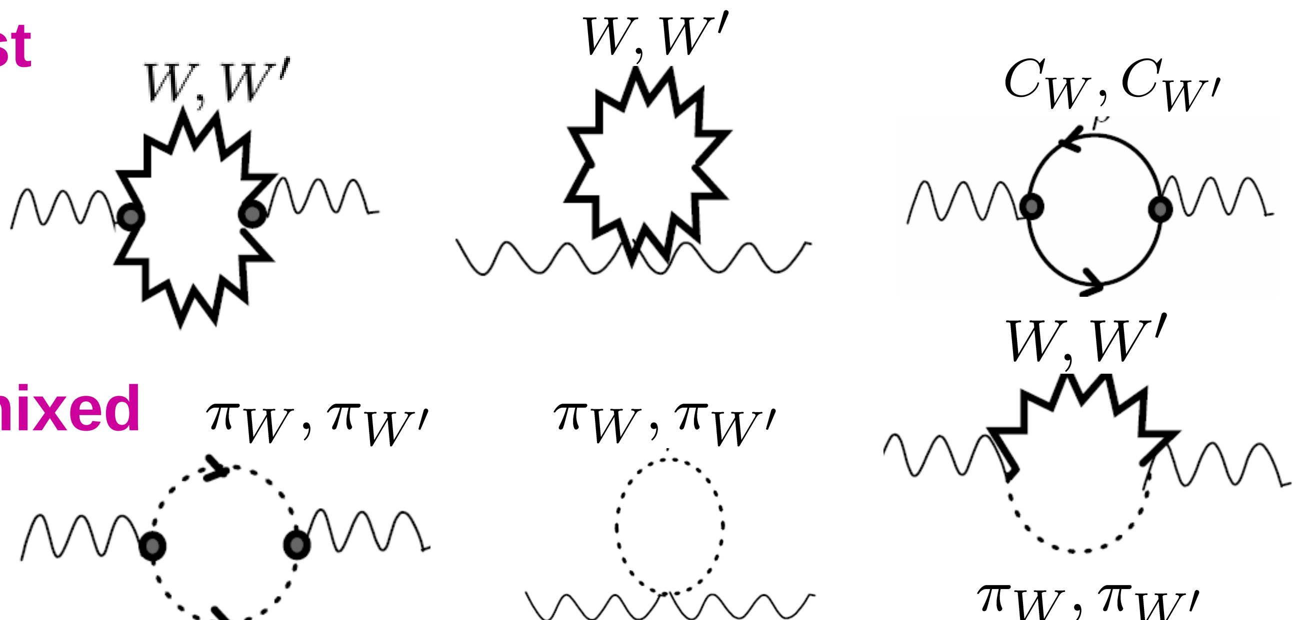
We focus on $\Pi_{ZZ},\ \Pi_{AA},\ \Pi_{ZA}$



Relevant graphs
In ‘tHooft-Feynman gauge

gauge & ghost

NGB &
gauge-NGB mixed

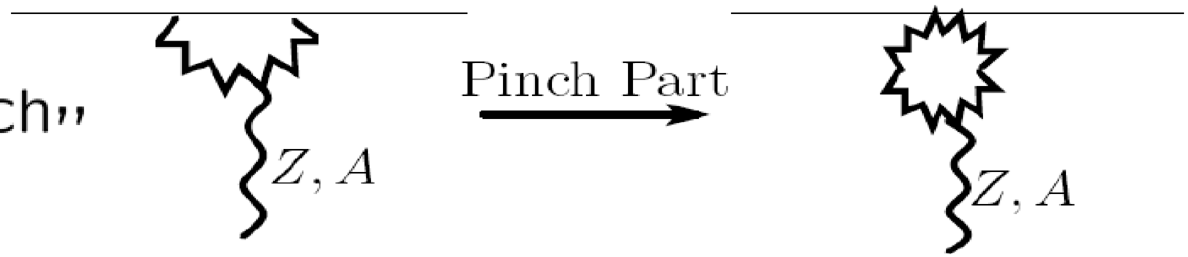


Pinch Contributions

However,
gauge boson self-energies are not gauge-invariant!! → **Details are already mentioned by previous speaker**

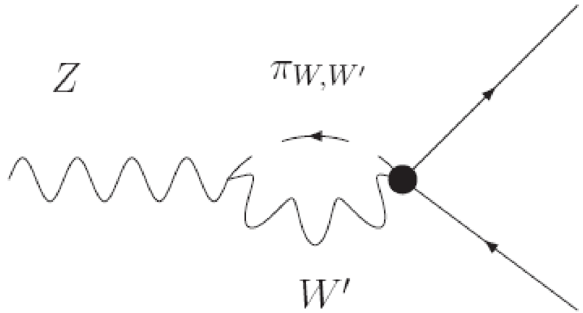
We need a "conventional" pinch part

"$\Delta\Pi^{\text{pinch}}$"



and an "extra" pinch part arising from delocalization!!

"$\Delta\Pi^{\text{delocal}}$"



as emphasized by previous speaker

“Gauge-invariant” gauge boson self-energy $\tilde{\Pi}(p^2)$

$$\tilde{\Pi} = \Pi + \Delta\Pi^{\text{pinch}} + \Delta\Pi^{\text{delocal}}$$

which should be associated with αS

$$\frac{\alpha S}{4s^2c^2} = \tilde{\Pi}'_{ZZ} - \tilde{\Pi}'_{AA} - \frac{c^2-s^2}{sc}\tilde{\Pi}'_{ZA}$$

$$\tilde{\Pi}' \equiv \frac{\tilde{\Pi}(M_Z^2)-\tilde{\Pi}(0)}{M_Z^2}$$

Result on the S-Parameter

In the limit $x = g_0/g_1 \simeq M_W/M_{W'} \gg 1$,
the leading-log approximation yields

$\Lambda \cdots$ cutoff of the effective theory

$$\alpha S_{1-loop} = \frac{\alpha}{12\pi} \log\left(\frac{M_{W'}^2}{M_W^2}\right) - \frac{41\alpha}{24\pi} \log\left(\frac{\Lambda^2}{M_{W'}^2}\right)$$

$$+ \frac{\alpha}{2\pi}\left(\frac{2x_1}{x^2}\right) \log\left(\frac{\Lambda^2}{M_{W'}^2}\right)$$

“Universal” part

- **arises from “scaling” between M_W and $M_{W'}$**
- **has coefficient precisely equal to the leading log contribution from a heavy Higgs boson!!**

$$\alpha S_{Higgs} = \frac{\alpha}{12\pi} \log\left(\frac{M_H^2}{M_W^2}\right)$$

It is easy to match S to experimental bound!!

More on S

$\Lambda \cdots$ cutoff of the effective theory

$$\alpha S_{1-loop} = \frac{\alpha}{12\pi} \log\left(\frac{M_{W'}^2}{M_W^2}\right) - \frac{41\alpha}{24\pi} \log\left(\frac{\Lambda^2}{M_{W'}^2}\right)$$

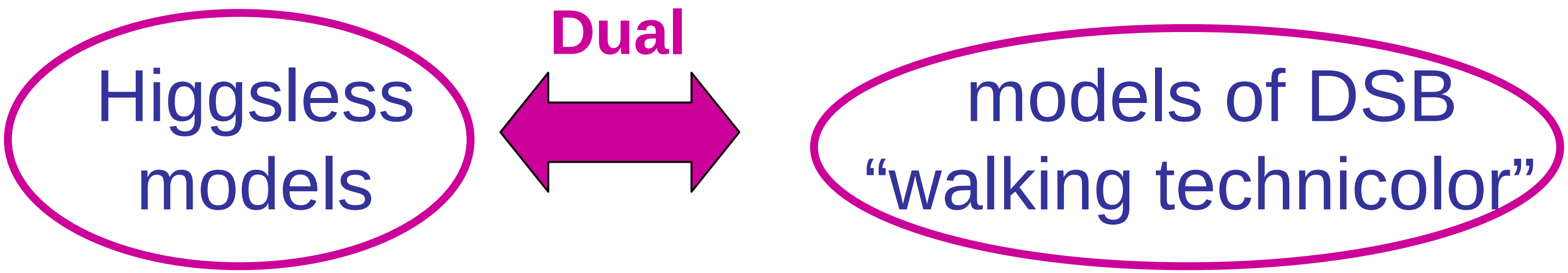
$$+\frac{\alpha}{2\pi}\left(\frac{2x_1}{x^2}\right) \log\left(\frac{\Lambda^2}{M_{W'}^2}\right)$$

"Non-universal" part

- arises from "scaling" between $M_{W'}$ and cutoff Λ
- includes "delocalization (x_1) "-dependence cancelled by the choice $x_1 = x^2/2$ as well as $\alpha S^{tree} = 0$!!
- has a cutoff-dependence which is cancelled by the scale-dependence of the appropriate counterterms

Conclusions

- We computed the one-loop corrections to the S-parameter in a 3-site Higgsless model.



In these terms our calculation is the first to compute the sub-leading 1/N corrections to the S-parameter.

- We show that the chiral-log corrections separate into a *universal* and *non-universal* parts.