Composite (Goldstone) Higgs Dynamics on the Lattice: Spectrum of SU(2) $N_f = 2$

Ari Hietanen

with R. Arthur, V. Drach, R. Lewis, C. Pica, and F. Sannino

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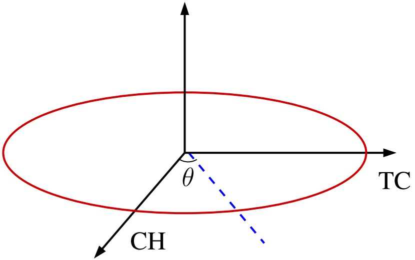
CP3 Origins

Introduction: Unified Composite Higgs

- Common Technicolor and Composite Higgs framework: G. Cacciapaglia and F. Sannino JHEP, [arXiv:1402.0233].
- SU(2) gauge theory with $N_f = 2$ ($\mathrm{SU_f}(2)$) has chiral symmetry breaking pattern: SU(4) $\rightarrow$ SP(4).
- Five Goldstones.
- The breaking direction with respect to standard model parametrized by an angle θ.



Two limits for θ

Technicolor

- $\theta = \frac{\pi}{2}$
- Breaks electroweak
- Higgs is a lightest scalar from $SU_f(2)$
- GB complex doublet
- Dark matter candidates

Goldstone Higgs

- $\theta = 0$
- Does not break EW
- One Higgs-like doublet (massless)
- The remaining GB is SM neutral

What fixes θ?

- $\mathrm{SU_f}(2)$ dynamics does not care about the value of θ.
- Effects induced by top corrections favor $\theta = \frac{\pi}{2}$
- EW gauge bosons interaction favors $\theta = 0$
- Explicit breaking of SU(4) from extended theories can pick any direction.

Mixed case $0 < \theta < \frac{\pi}{2}$

- The composite GB and technicolor Higgs (σ) mix.
- Lightest scalar state is Higgs.
- The scale of the theory $f_\Pi \sin\theta = 246 GeV$.
- The scalar meson masses are sensitive to EW corrections whereas the (axial)vector meson masses are determined by the $\mathrm{SU_f}(2)$.

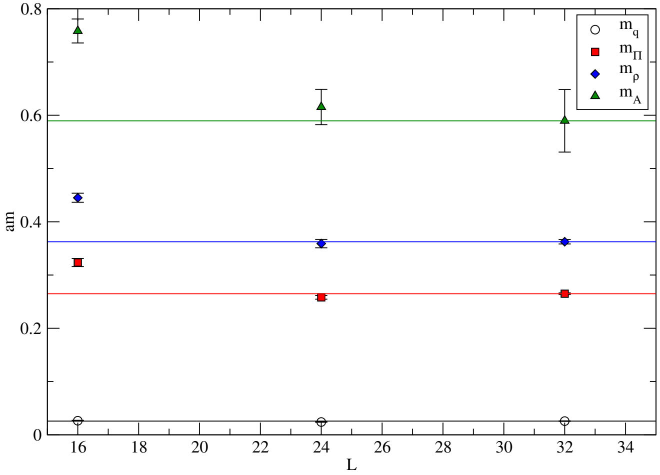
Lattice simulations

Based on AH, R. Lewis, C. Pica, F. Sannino, accepted to JHEP, arXiv:1404.2794

Simulation parameters:

β	Volume	m_0	Therm.	Conf.
2.0	$16^3 \times 32$	-0.85, -0.9, -0.94, -0.945 -0.947,-0.949	320	680
2.0	32^4	-0.947	500	2000
2.2	$16^3 \times 32$	-0.60, -0.65, -0.68, -0.70, -0.72, -0.75	320	680
2.2	$24^3 \times 32$	-0.75	500	$\sim$2000
2.2	32^4	-0.72,-0.735, -0.75	500	$\sim$2000

Finite volume effects, $\beta = 2.2$ and $m_0 = -0.75$



Chiral fits:

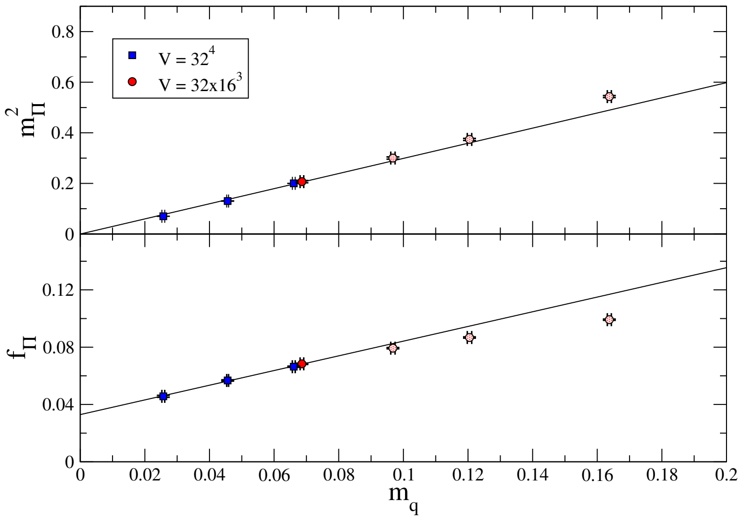
- The chiral perturbation theory has the form:

$$\frac{m_{\Pi}^2}{m_{\mathrm{q}}} = 2B\left[1 + Cx\log x + Dx + \mathcal{O}(m_{\mathrm{q}}^2)\right] ,$$

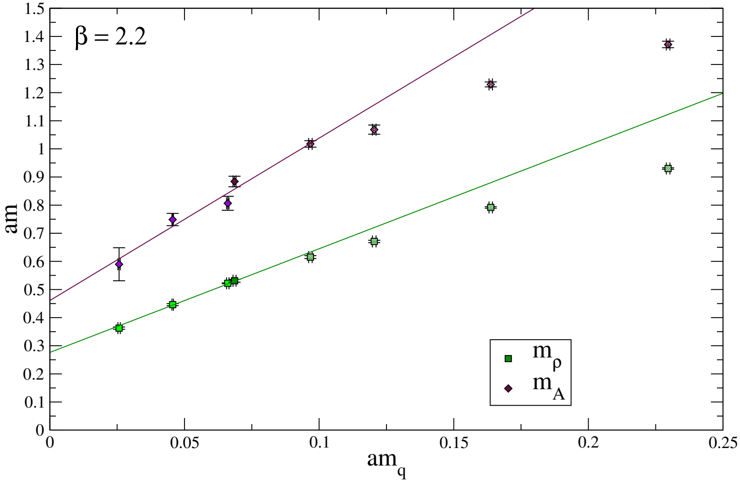
and

$$f_{\Pi} = F\left[1 + C'x\log x + D'x + \mathcal{O}(m_{\mathrm{q}}^2)\right] .$$

Chiral extrapolations: m_Π and f_Π at $\beta = 2.2$

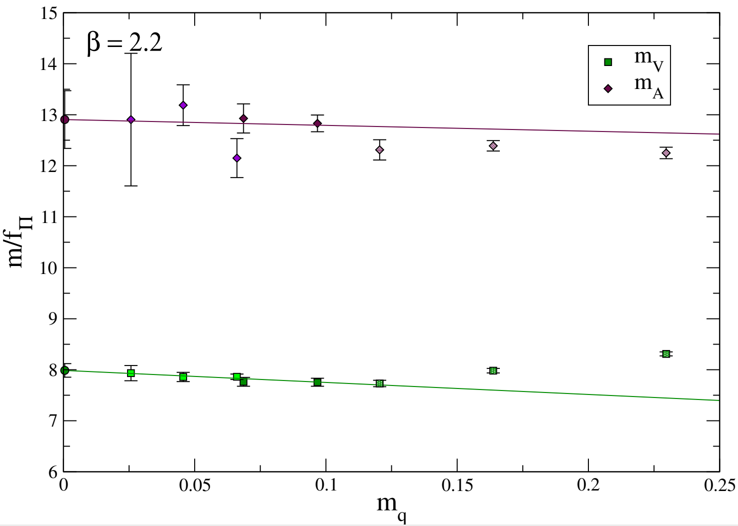


m_ρ and m_A

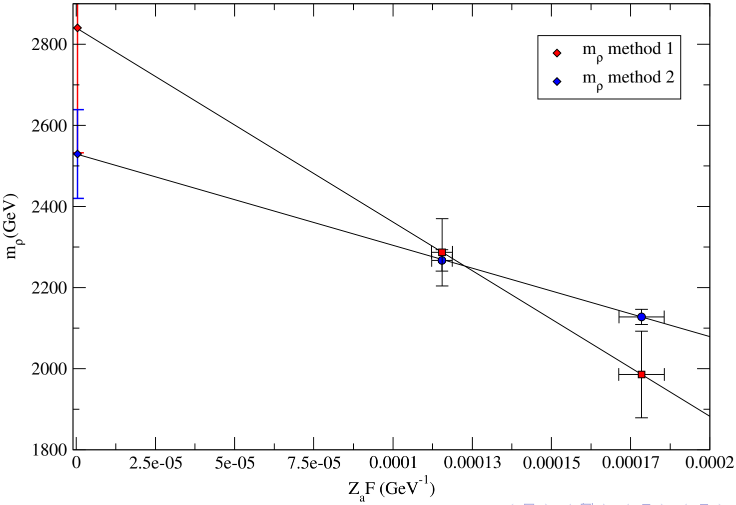


β = 2.2
am
amq
mρ
mA
0
0.05
0.1
0.15
0.2
0.25
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5

m_ρ and m_A in physical units



Continuum extrapolation



Results

	β	Method 1 (GeV)	Method 2 (GeV)
$m_\rho \sin\theta$	∞	2840(330)(560)(360)	**2520(100)(240)(310)**
$m_A \sin\theta$	∞	4000(1800)(200)(430)	**3300(400)(510)(340)**

Table: Errors: from statistics, from continuum extrapolation, and from perturbative Z_a.

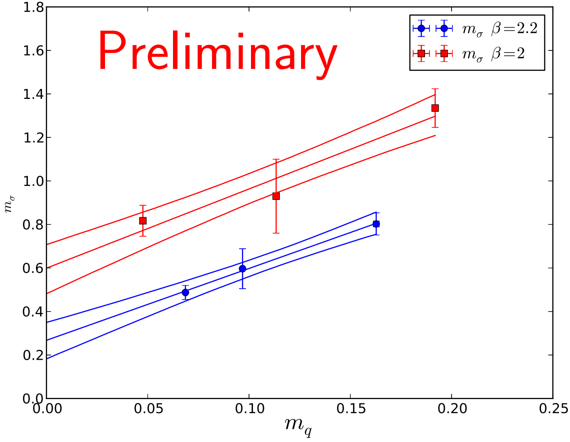
We used perturbative value for the renormalization constant Z_a

$$Z_a = 1 - \frac{g_0^2}{16\pi^2}\frac{N^2-1}{2N}15.7 \overset{N=2}{=} 1 - 0.2983/\beta.$$

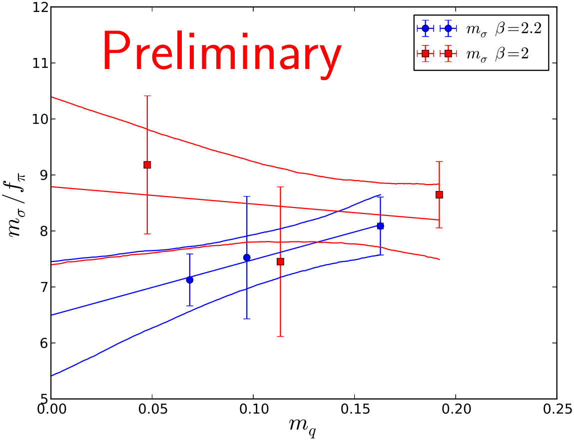
Scalar mass (preliminary)

- Increased statistics with factor of 10.
- Preliminary results with quite heavy masses.
- Results still noisy.
- We have tried different methods. Results from diluted Z_1 volume sources (by Rudy Arthur).

Scalar mass (preliminary)



Scalar mass in units of $f_\Pi \sin\theta$ (preliminary)



Conclusions

- We studied a unified model of TC and composite GB Higgs
- The vector meson mass $m_\rho \sin\theta = 2.5 \pm 0.5$TeV above current exclusion limits set by LHC.
- It is possible that the lightest new state is a scalar.
- Need to improve chiral and continuum limit, and obtain more statistics for scalar measurements.
- Scattering lengths. Talk by Vincent Drach: Friday 27th 15:15.