Title: Higgs Propagation in Loop Quantum Geometry

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Abstract:

LOOP QUANTUM GRAVITY
AND
HIGGS PROPAGATION

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P.I 2004: QUANTUM GRAVITY IN
THE AMERICAS

AND JORGE ALFARO

THE STEPS $\longrightarrow \mathcal{L}_{eff}$

* REGULARIZED HIGGS HAMILTONIAN
  (THIEMANN)

* NON-ABELIAN HOLONOMIES
  COVARIANT EXPANSIONS

* THE EFFECTIVE HIGGS MODEL

* AN EXAMPLE U(1) AND A
  CHERN-SIMONS TERM

THE REGULARIZATION OF THE HIGGS SECTOR

BASIC GRAVITATIONAL STRUCTURE HAS 2 ELEMENTS

$$\hat{Q}^i_e(v,r) = tr\left(\tau_i \, h_e\left[h_e^{-1}, (\hat{V}_v)^r\right]\right)$$

$$Q_e(v,r) = tr\left(h_e\left[h_e^{-1}, (\hat{V}_v)^r\right]\right)$$

AND MATTER FIELDS OPERATORS $\hat{\pi}, \hat{\phi}$

THE HAMILTONIAN HAS 3 PIECES

$$\hat{H}^{(\pi)} = \sum_v tr(\hat{\pi}_v \hat{\pi}_v)\, \epsilon^{ijk} \epsilon^{lmn}\, Q_{e_i} Q_{e_j} Q_{e_k}$$

$$\cdot\, Q_{e_l} \cdot Q_{e_m}\, Q_{e_n}$$

$$\hat{H}^{(\phi)} = \sum_v tr\left[\tau_I (h \phi_{e_n} h^{-1} - \phi_v)\right] \cdot tr\left[\tau_I (h \phi_{e_r} h^{-1} - \phi_v)\right]$$

$$\epsilon^{ijk} \epsilon^{ilm}\, \epsilon^{npq} \epsilon^{rst} \cdot Q^j_{e_p}\, Q^k_{e_q}\, Q^l_{e_s}\, Q^m_{e_t}$$

$$\hat{H}^{(pot)} = \sum_v P(\phi^I_v \phi^I_v)\, \hat{V}_v$$

AFTER TAKING EXPECTATION VALUES YOU END UP WITH EXPECTATION VALUES OF GRAVITATIONAL OPERATOS AND WITH CLASSICAL FIELDS EVALUATED ON THE VERTICE.

IDEA

$$\hat{H} = \sum_v \hat{G}_v \hat{\Phi}_v^2$$

$$\downarrow$$

$$\langle \hat{H} \rangle = \sum_v \langle \hat{G}_v \rangle \Phi_v^2$$

FROM HERE YOU CAN EXPAND THE FIELD AROUND A VERTEX, AND OBTAIN

$$H^{eff} = \int d^3x \;\; \Phi^2(x) + T^{aa'} \partial_a \Phi \;\; \partial_{a'} \Phi + \cdots$$

HOW? $\longrightarrow$ USING CERTAIN APPROXIMATION

FOR EXAMPLE : INTRODUCING A SECOND SCALE

OR COHERENT STATES (graph average)

WE WOULD LEAVE THIS ISSUE OPEN

AND NOT WRITE THE COEFICIENTS

ONLY FOCUS ON THE TENSORIAL

CHARACTER

IN CONSTRUCTING THE THEORY (EFFECTIVE)

I ~~[illegible]~~ ~~[illegible]~~ WILL REQUIERE ~~FOR~~

(*) GAUGE INVARIANCE UNDER THE INTERNAL GROUP

(*) SMALL CORRECTIONS (CODED IN THE COEFICIENTS)

IN EARIER WORKS (J. ALFARO, H. MORALES TECOTL , L.F URRUTIA, ME)

WE HAVE OBTAINED A COVARIANT EXPANSION OF NON-ABELIAN HOLONOMIES, USING THE BASIC STRUCTURE

$$h(\vec{v}, \vec{v}+\vec{s}_I) = P\left\{ e^{\int_{\vec{v}}^{\vec{v}+\vec{s}_I} \vec{A}\cdot d\vec{x}} \right\}$$

$$= 1 + I_1(x)\, s_I^a\, A_a(v) + I_2(x, \bar{x})\, A_a(v)\, \bar{A}_b(v)\, s_I^a s_I^b$$

$$+ \dots$$

$$X = s_I^a\, \partial_a$$

$$I_1(x) = 1 + \frac{x}{2!} + \frac{x^2}{3!} + \dots \equiv F(x)$$

$$I_2(x, \bar{x}) = \frac{F(x+\bar{x}) - F(x)}{\bar{x}}$$

$$\vdots$$

USING THESE TOOLS IT CAN BE SHOWN THAT

$$h(\vec{v},\vec{v}+\vec{x})\ \phi(\vec{v}+\vec{x})\ h^{-1} = \phi_v + D\phi_v + \frac{1}{2!}D^2\phi_v + \dots$$

WHERE $D = X^a D_a$

WE HAVE TO GENERALIZE THE TAYLOR EXPANSIONS AROUND v IN A COVARIANT WAY

$\downarrow$

In the MOMENTA PART

$$p(B) = \int h \pi h^{-1}\, d^3x \longrightarrow tr\,[p(B)\ p(B)]$$ GAUGE INV.

And we ALREADY HAVE FOR THE CONFIGURATION VARIABLE

$$h\phi h^{-1} - \phi_v$$

AFTER THE HOLONOMIES ARE

EXPANDED, LET US CONSIDER

COEFICIENTS ~~[illegible]~~ Λ ~~[illegible]~~

WE ARRIVE TO (CONSIDERING THE TENSORIAL CHARACTER!)

$$H^{(\pi)} = \int d^3x \; \mathrm{Tr}\left[\pi^2 + \lambda^2 \vec{D}\pi \cdot (\vec{D} \times \vec{D}\pi) \right]$$

$$H^{(\phi)} = \int d^3x \; \mathrm{Tr}\left[(D\phi)^2 + \lambda \underbrace{\vec{D}\phi \cdot (\vec{D} \times \vec{D}\phi)}_{\epsilon^{abc} D_a D_b \phi \cdot D_c \phi} + \lambda^2 (D^2\phi)^2 + \dots \right]$$

$$H^{(pot)} = \int d^3x \; \mathrm{Tr}\left[\frac{m^2}{2} \phi^2 + \lambda (\phi^2)^2 + \lambda^2 \right]$$

THE EFFECTIVE THEORY AT FIRST ORDER

$$A = \mathrm{Tr}\left[D_\mu\phi \cdot D^\mu\phi + \frac{\Lambda}{2} M^c \phi D_c \phi + \frac{m^2}{2}\phi^2 + \lambda(\phi^2)^2 \right]$$

An example (A first exploration)

Consider $\mathcal{L}$ to be $U(1)$ invariant and apply the usual ideas of Spontaneously Symmetry Breaking

$$\frac{\partial V}{\partial \phi} = 0 \longrightarrow \phi_0 = \sqrt{\frac{m^2}{4\lambda}}$$

$$\phi = (v + h)$$

Replacing in the extra term, we obtain

$$\mathcal{L}_{C\text{-}S} = \frac{\Lambda v^2}{2} \vec{B} \cdot \vec{A} \qquad m_0 \equiv \frac{\Lambda v^2}{2}$$

NOTE

A) THERE ARE STRONG BOUNDS ON THE m_0 (Carroll, Field, Jackiw) $m_0 \leq 6\,10^{-26}$ GeV

B) A possibility is to extend the

CONCLUSIONS

(*) WE HAVE OBTAINED A POSSIBLE CORRECTIONS IN THE HIGGS SECTOR

(*) WE NEED TO CHOOSE A METHOD OR USE NEW IDEAS TO COMPUTE THE COEFICIENTS.

(*) USING THE FULL $U(1) \times SU(2)$ TRY TO SAY SOMETHING ABOUT THE C-S TERM

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