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

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THE STEPS ⟶ $\mathcal{L}_{eff}$

* REGULARIZED HIGGS HAMILTONIAN (THIEMANN)

* NON-ABELIAN HOLONOMIES COVARIANT EXPANSIONS

* THE EFFECTIVE HIGGS MODEL

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

* [illegible]

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

$$\hat{H}^{(\pi)} = \sum_v tr(\hat{\pi}_v \hat{\pi}_v)\, \epsilon^{ijk} \epsilon^{emn}\, Q_{ei}\, Q_{ej}\, Q_{ek}$$

$$\cdot Q_{el} \cdot Q_{em}\, Q_{en}$$

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

$$\epsilon^{ijk} \epsilon^{ilm}\, \epsilon^{npq} \epsilon^{rst} \cdot Q^j_{eq}\, Q^k_{er}\, Q^l_{es}\, Q^m_{et}$$

$$\hat{H}^{(pot)} = \sum_v P(\phi_v^2 \phi_v^2)\, \hat{V}_v$$

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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 <u>EXPAND</u> 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? ⟶ USING CERTAIN APPROXIMATION

FOR EXAMPLE: INTRODUCING A <u>SECOND SCALE</u>

OR <u>COHERENT STATES</u> (graph average)

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WE WOULD LEAVE THIS ISSUE OPEN

AND NOT WRITE THE COEFICIENTS

ONLY FOCUS ON THE TENSORIAL

CHARACTER

IN CONSTRUCTING THE THEORY (EFFECTIVE)

I ~~WOULD~~ WILL REQUIERE ~~REQ~~

(*) 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

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

$$= 1 + I_1(x_1)\, s_I^a\, A_a(v_1) + I_2(x, \bar{x}_1)\, A_a(v_1)\, \bar{A}_b(v_1)\, s_I^a\, s_I^b + \dots$$

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

$$I_1(x_1) = 1 + \frac{x}{2!} + \frac{x^2}{3!} + \dots \equiv F(x_1)$$

$$I_2(x, \bar{x}_1) = \frac{F(x+\bar{x}_1) - F(x_1)}{\bar{x}}$$

$$\vdots$$

USING THESE TOOLS IT CAN BE SHOWN THAT

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

WHERE $D = X^a D_a$

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

↓

In the MOMENTA PART

$$p(B) = \int h\,\pi\,h^{-1}\,d^3x \longrightarrow tr\left[p(B_1)\,p(B_2)\right]$$ 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].

WE ARRIVE TO (CONSIDERING THE TENSORIAL CHARACTER!)

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

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

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

THE EFFECTIVE THEORY AT FIRST ORDER

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

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An example (A first exploration)

Consider $\mathcal{L}$ to be $U(1)$ invariant

And apply the usual ideas of [redacted]

Spontaneously Symmetry Breaking

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

$\phi =$ [redacted] $(v + h)$

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) $m_1 < 6\,10^{-26}$ 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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