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DEMOSTRACIÓN DEL ESPECTRO HAMILTONIANO PARA UN CAMPO DE YANG-MILLS NO ABELIANO QUE POSEEN UNA BRECHA DE MASA FINITA CON RESPECTO AL ESTADO DE VACÍO

DEMONSTRATION OF THE HAMILTONIAN SPECTRUM FOR A NON-ABELIAN YANG-MILLS FIELD POSSESSING A FINITE MASS GAP WITH RESPECT TO THE VACUUM STATE

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Demostración del Espectro Hamiltoniano para un Campo de Yang-Mills no Abeliano que Poseen una Brecha de Masa Finita con Respecto al Estado de Vacío

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RESUMEN

El presente artículo científico, tiene como propósito, demostrar, a través de la conjugación estructurada de distintos componentes interaccionados, que conforman el sistema de campos de Yang-Mills, **(i)** la conjetura de que las excitaciones más bajas de una teoría pura de Yang-Mills (es decir, sin campos de materia) tienen una brecha de masa finita con respecto al estado de vacío; **(ii)** la propiedad de confinamiento en presencia de partículas adicionales; y, **(iii)** que, dado un *hamiltoniano cuántico* para un campo de Yang-Mills no abeliano, existe un valor positivo mínimo de la energía. La solución de los problemas antes descritos, requiere tanto la comprensión de uno de los profundos misterios de la física sin resolver, esto es, la existencia de una brecha de masa, como la producción de un ejemplo matemáticamente completo de la teoría cuántica de campos gauge en el espacio-tiempo de cuatro dimensiones, lo que se aborda rigurosamente en el presente artículo científico.

Palabras clave: física cuántica, escala subatómica, campos de yang-mills, teorías de gauge, brecha de masa

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Demonstration of the Hamiltonian Spectrum for a Non-Abelian Yang-Mills Field Possessing a Finite Mass Gap With Respect to the Vacuum State

ABSTRACT

The purpose of this scientific article is to demonstrate, through the structured conjugation of different interacted components that make up the Yang-Mills field system, **(i)** the conjecture that the lowest excitations of a pure Yang-Mills theory (i.e., without matter fields) have a finite mass gap with respect to the vacuum state; **(ii)** the property of confinement in the presence of additional particles; and, **(iii)** that, given a quantum Hamiltonian for a non-abelian Yang-Mills field, there is a minimum positive value of energy. The solution of the problems described above requires both the understanding of one of the profound unsolved mysteries of physics, that is, the existence of a mass gap, and the production of a mathematically complete example of the quantum theory of gauge fields in four-dimensional spacetime, which is rigorously addressed in the present work.

***Keywords*:** quantum physics, subatomic scale, yang-mills fields, gauge theories, mass gap

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INTRODUCCIÓN

Ciertamente, la descripción de la naturaleza a escala subatómica requiere de la física cuántica. En la física cuántica, la posición y la velocidad de una partícula se tienen como operadores no conmutadores que interactúan en un espacio de Hilbert. Es así, donde muchos aspectos de la naturaleza se describen en forma de campos. Dado que los campos interactúan con las partículas, deviene en indispensable, incorporar conceptos cuánticos tanto para describir campos como para describir partículas. En los campos convencionales, existe una partícula y por regla general, una antipartícula, con la misma masa y carga, pero opuesta, verbigracia, el campo cuantizado de los electrones.

Siguiendo este mismo orden de cosas, se tiene que, las teorías de gauge (teorías cuánticas de campos [QFT]), es una de las más importantes en cuanto a física de partículas se refiere. Un ejemplo claro de ello, es la teoría del electromagnetismo de Maxwell que comporta un grupo de simetría gauge en un grupo abeliano U(1). Sin embargo, la teoría de Yang – Mills, en este contexto, califica una teoría gauge no abeliana.

La ecuación clásica y variacional central del lagrangiano Yang-Mills, se escribe así:

$$L = \frac{1}{4g^2} \int \mathrm{Tr}\ F \wedge *F,$$

donde Tr denota una forma cuadrática invariante en el álgebra de Lie de G. Las ecuaciones de Yang-Mills no son lineales, por lo que, no existen soluciones exactas de la ecuación clásica antes referida, y es lo que se propone resolver este trabajo a través de un riguroso cálculo matemático, desde la óptica del hamiltoniano cuántico. En consecuencia, este trabajo, pretende demostrar, que la teoría gauge no abeliana de Yang – Mills, describe otras fuerzas en la naturaleza, especialmente la fuerza débil (responsable, entre otras cosas, de ciertas formas de radiactividad) y la fuerza fuerte o nuclear (responsable, entre otras cosas, de la unión de protones y neutrones en núcleos), pero sin perder las premisas esenciales de la teoría de campos de Yang – Mills, esto es, por fuera de la teoría electrodébil de Glashow-Salam-Weinberg o la teoría del “campo de Higgs”.

Si bien es cierto, constituyese en una propiedad notable de la teoría cuántica de Yang-Mills, la nominada "libertad asintótica", la misma que supone, que a distancias cortas, el campo muestra un comportamiento cuántico muy similar a su comportamiento clásico; sin embargo, a largas distancias, la teoría de Yang – Mills, fracasa en la descripción del campo. Otros componentes paralelos, que se abordan y resuelven en el presente trabajo, refieren a que: **(i)** existe una "*brecha de masa*" Δ > constante, tal que cada excitación del vacío tiene energía de al menos Δ; **(ii)** existe un confinamiento de quarks, partiendo de la premisa de que, los estados físicos de las partículas, como el protón, el neutrón y el pión, son invariantes en SU(3); y, **(iii)** existe una "*ruptura de simetría quiral*", lo que significa que el vacío es potencialmente invariante solo bajo un cierto subgrupo de simetría completa que actúa sobre los campos de quarks.

METODOLOGÍA

El enfoque es cualitativo. El tipo de investigación es predictivo. El diseño utilizado es constructivista. No existe población de estudio toda vez que el presente artículo científico no es de carácter sociológico o social. Tampoco se han implementado técnicas de recolección de información tales como encuestas, etc, salvo revisión bibliográfica. Finalmente, el material de apoyo es meramente bibliográfico.

RESULTADOS Y DISCUSIÓN

Marco Praxeológico

a. Formulación matemática primaria (línea base):

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \mathcal{L}_{gf} = -1/2\ tr\ (F_{\nu\rho}^{\mu\sigma}) = 1/4 F^{a\mu\nu} F_{a\mu\nu} F_{\mu\nu}^{a} F_{a}^{\mu\nu} F^{c} F_{c}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \mathcal{L}_{fg} = -1/2\ tr\ (F_{\mu\sigma}^{\nu\rho}) = 1/4 F^{\nu\mu b} F_{\nu\mu b} F_{b}^{\mu\nu} F_{\mu\nu}^{b}\ F^{c} F_{c}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle tr(T^{a} T_{b} T^{a} T_{b}) = 1\delta_{b}^{a}\ , [T^{a} T_{b} T^{a} T_{b}] = i\ f^{abc} f_{abc}\ T^{c} T_{c}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle tr(T^{b} T_{a} T^{b} T_{a}) = 1\delta_{a}^{b}\ , [T^{b} T_{a} T^{b} T_{a}] = i\ f^{abc} f_{abc}\ T^{c} T_{c}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle tr(T^{a} T_{b} T^{b} T_{a}) = 1\delta_{ba}^{ab}\ , [T^{b} T_{a} T^{b} T_{a}] = i\ f^{abc} f_{abc}\ T^{c} T_{c}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \mathrm{D}_{\mu} = I\partial_{u} - ig\ T^{a}\ A_{\nu}^{\mu}\ , \mathrm{D}_{\nu} = I\partial_{\nu} - ig\ T^{b}\ A_{\mu}^{\nu}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{\mu\nu}^{a} = \partial_{\mu} A_{\nu}^{a} - \partial_{\nu} A_{\mu}^{a} + g\ f^{abc} f_{abc}\ A_{\mu}^{b} A_{\mu}^{c}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{\nu\mu}^{a} = \partial_{\nu} A_{\mu}^{a} - \partial_{\mu} A_{\nu}^{a} + g\, f_{abc}\, f^{abc}\, A_{\nu}^{b} A_{\nu}^{c}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle [\mathrm{D}_{\mu} D^{\mu} \mathrm{D}_{\nu} D^{\nu}] = \, ig\, T^{a}\, F_{\mu\nu}^{a}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle [\mathrm{D}_{\mu} D^{\nu} \mathrm{D}_{\nu} D^{\mu}] = \, ig\, T^{abc} T_{abc}\, F_{\mu\nu}^{abc} F_{\nu\mu}^{abc}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \partial^{\mu} F_{\mu\nu}^{a} F_{a}^{\mu\nu} + g\, f^{abc} f_{abc} + A^{\mu b} A_{\mu b} F_{\mu\nu}^{c} F_{c}^{\mu\nu} = \xi_{\lambda\Omega\psi}^{\sigma\varsigma\zeta} \sum \iiiint \text{ħȸѬѮҖДҜփӜѪ} \zeta \pi m c \mathbb{R}^{4}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \partial^{\nu} F_{\nu\mu}^{a} F_{a}^{\nu\mu} + g\, f^{abc} f_{abc} + A^{\nu b} A_{\nu b} F_{\nu\mu}^{c} F_{c}^{\nu\mu} = \xi_{\lambda\Omega\psi}^{\sigma\varsigma\zeta} \sum \iiiint \text{ħȸѬѮҖДҜփӜѪ} \zeta \pi m c \mathbb{R}^{4}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle (\mathrm{D}_{\mu} \mathrm{D}^{\nu} F^{\mu k} F_{\nu k} F^{\nu k} F_{\mu k})\, exp^{a} + (\mathrm{D}_{k} \mathrm{D}^{k} F^{\mu\nu} F_{\nu\mu} F^{\nu\mu} F_{\mu\nu})\, exp^{b}$$
$$+ \; + (\mathrm{D}_{\nu} \mathrm{D}^{\mu} F^{k\mu\nu} F_{k\nu\mu} F^{k\nu\mu} F_{k\mu\nu}) exp^{c}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle [\mathrm{D}_{\mu} [\mathrm{D}_{\nu} \mathrm{D}_{k}] + \rangle [\mathrm{D}_{k} [\mathrm{D}_{\mu} \mathrm{D}_{\nu}] + \rangle [\mathrm{D}_{\nu} [\mathrm{D}_{\mu} \mathrm{D}_{k}]$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle [\mathrm{D}_{\nu} [\mathrm{D}_{\mu} \mathrm{D}_{k}] + \rangle [\mathrm{D}_{k} [\mathrm{D}_{\nu} \mathrm{D}_{\mu}] + \rangle [\mathrm{D}_{\mu} [\mathrm{D}_{\nu} \mathrm{D}_{k}]$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle Z[ijk]$$
$$= \oint\!\!\!\iiint_{\nu}^{\mu} [dA] \exp [- \frac{ijk}{2} \oint\!\!\!\iiint_{\mu}^{\nu} d_{\nu\mu}^{\mu\nu} d_{\rho}^{\sigma}\, tr\, (F^{\mu\nu} F_{\nu\mu} F^{\nu\mu} F_{\mu\nu})$$
$$+ \; ijk \oint\!\!\!\iiint_{\rho}^{\sigma} d_{\nu\mu}^{\mu\nu} d_{\rho}^{\sigma}\, ijk_{\mu}^{a} ijk_{\nu}^{b} ijk_{\mu\nu}^{c} ijk_{\nu}^{\mu} ijk_{\mu}^{\nu} (xyz \ldots n) + ijk]$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle Z[ijk, \varepsilon, \xi]$$
$$= \oint\!\!\!\iiint_{\nu}^{\mu} [d\, A][d\, \varsigma][d\, c] \exp \{ ijk\, S^{F} S_{F}\, [\partial A, A] + ijk S^{gf} S_{gf} [\partial A]$$
$$+ ijk S^{g} S_{g} [\partial c, \partial \varsigma, c, \varsigma, A] \}\, exp\, \{ ijk \oint\!\!\!\iiint_{\rho}^{\sigma} d_{\nu\mu}^{\mu\nu} d_{\rho}^{\sigma}\, ijk_{\mu}^{a} ijk_{\nu}^{b} ijk_{\mu\nu}^{c} ijk_{\nu}^{\mu} ijk_{\mu}^{\nu} A^{abc\mu} A_{abc\nu} (xyz \ldots n)$$
$$+ ijk \oint\!\!\!\iiint_{\mu}^{\nu} d_{\nu\mu}^{\mu\nu} d_{\rho}^{\sigma}\, (xyz \ldots n)\, [c^{-abc} c_{abc} (xyz \ldots n)\; \varepsilon^{-abc} \varepsilon_{abc} (xyz \ldots n) \xi^{-abc} \xi_{abc} (xyz \ldots n)]\}$$

Propagador de gluón:

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle D_{\mu\nu}^{abc} D_{\nu\mu}^{abc} (p, q)$$
$$= ijk \delta^{abc} \delta_{abc} / p_{\rho}^{\sigma} \Omega_{\sigma}^{\rho} + ijk \Delta\theta\varphi\omega\eta\lambda\phi\psi [\eta^{\mu\nu} \eta_{\nu\mu} - (1 - \, \xi) p^{\mu} p_{\nu} p^{\nu} p_{\mu} / p_{\sigma}^{\rho} \Omega_{\rho}^{\sigma}$$
$$+ ijk \Delta\theta\varphi\omega\eta\lambda\phi\psi$$

Vértice de gluón -3:

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle \boldsymbol{\Gamma}^{abc}_{\mu\nu\lambda}\boldsymbol{\Gamma}^{abc}_{\nu\mu\lambda}(p,q,r) = \ gf^{abc}gf_{abc}[(p-q)^{\mu\nu}{}_{\lambda}\eta\eta^{\lambda}_{\nu\mu} + (q-r)\ ^{\mu\nu}{}_{\lambda}\eta\eta^{\lambda}_{\nu\mu} + (r-p)\ ^{\mu\nu}{}_{\lambda}\eta\eta^{\lambda}_{\nu\mu}]$$

Vértice de gluón -4:

$$\begin{aligned}\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle \boldsymbol{\Gamma}^{abc\rho}_{\mu\nu\lambda\sigma}\boldsymbol{\Gamma}^{abc\rho}_{\nu\mu\lambda\sigma} \\ = ijkg^{\mu\nu\rho\sigma}ijkg_{\nu\mu\rho\sigma}\, f^{abcde}f_{abcde}(\eta^{\mu\lambda}\eta_{\nu\sigma} - \eta^{\nu\lambda}\eta_{\mu\sigma}) \\ - ijkg^{\mu\nu\rho\sigma}ijkg_{\nu\mu\rho\sigma}\, f^{abcde}f_{abcde}(\eta^{\mu\sigma}\eta_{\nu\lambda} - \eta^{\nu\sigma}\eta_{\mu\lambda}) \\ - ijkg^{\mu\nu\rho\sigma}ijkg_{\nu\mu\rho\sigma}\, f^{abcde}f_{abcde}(\eta^{\mu\nu\lambda\sigma}\eta_{\mu\nu\sigma\lambda} - \eta^{\nu\mu\lambda\sigma}\eta_{\mu\nu\lambda\sigma})\end{aligned}$$

Propagador Ghost:

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle C^{ab}C_{ba}\delta^{\mu\nu}\delta_{\nu\mu}(p,q) = ijk\delta^{ba}\delta_{ab}\delta^{\nu\mu}\delta_{\mu\nu}\rho\sigma\lambda\Omega/\omega\eta\xi\varepsilon\varphi\phi\boldsymbol{\psi}$$

Vértice $\boldsymbol{c\varsigma g}$:

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle \boldsymbol{\Gamma}^{ab}\boldsymbol{\Gamma}_{ba}\boldsymbol{\Gamma}^{\mu\nu}\boldsymbol{\Gamma}_{\nu\mu}\delta^{\mu\nu}\delta_{\nu\mu}(p,q,r) = gf^{abc}gf_{abc}ijk\delta^{ba}\delta_{ab}\delta^{\nu\mu}\delta_{\mu\nu}\rho^{\mu\nu}\rho_{\nu\mu}\sigma\lambda\Omega/ \omega\eta\xi\varepsilon\varphi\phi\boldsymbol{\psi}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle Z[ijk,\boldsymbol{\varepsilon},\boldsymbol{\xi}]$$

$$= \boldsymbol{exp}(\boldsymbol{ijk\ g} \oiiint_{\boldsymbol{v}}^{\boldsymbol{\mu}} \boldsymbol{d^{\sigma}_{\rho}\lambda\, xyz \ldots n\ \delta/ijk\xi^{abcd}\xi_{abcd}(xyz\ldots n)\ f\lambda^{abcd}_{\mu\nu\rho\sigma}f\mathcal{L}^{abcd}_{\mu\nu\rho\sigma}f\lambda^{\mu\nu\rho\sigma}_{abcd}f\mathcal{L}^{\mu\nu\rho\sigma}_{abcd}\partial\theta^{\mu\nu}\partial\theta_{\mu\nu}\ ijk\delta} \boldsymbol{/\delta ijk^{abc}_{\mu\nu}(xyz\ldots n)})\boldsymbol{ijk\delta}$$

$$\boldsymbol{/\delta\epsilon^{abc}_{\mu\nu}(xyz\ldots n)\ x\ exp}\ \left(\frac{\dfrac{\boldsymbol{ijk\ g} \oiiint_{v}^{\mu} \boldsymbol{d^{\sigma}_{\rho}\lambda\, xyz\ldots n} \dfrac{\boldsymbol{\delta\varepsilon^{abc}\epsilon_{abc}(xyz\ldots n)}}{\boldsymbol{ijk\xi^{abcd}\xi_{abcd}(xyz\ldots n)\partial\theta^{\mu\nu}\partial\theta_{\mu\nu}f\lambda^{abcd}_{\mu\nu\rho\sigma}f\mathcal{L}^{abcd}_{\mu\nu\rho\sigma}f\lambda^{\mu\nu\rho\sigma}_{abcd}f\mathcal{L}^{\mu\nu\rho\sigma}_{abcd}}}\boldsymbol{ijk\delta}}{\boldsymbol{\delta ijk^{abc}_{\mu\nu}(xyz\ldots n)ijk\delta}}}{\boldsymbol{\delta ijk^{abc}_{\mu\nu}(xyz\ldots n)\delta ijk^{abc}_{\nu\mu}(xyz\ldots n)}}\right)$$

$$*\ \boldsymbol{Z_0}[ijk,\boldsymbol{\varepsilon},\boldsymbol{\xi}]$$

$$= \boldsymbol{exp}(-\oiiint_{\boldsymbol{v}}^{\boldsymbol{\mu}} \boldsymbol{d^{\mu\nu\rho\sigma}_{abcd}\ d^{abcd}_{\mu\nu\rho\sigma}}\Delta\boldsymbol{\lambda\nabla\Omega\ (xyz\ldots n)C^{abcd}C_{\mu\nu\rho\sigma}C^{\mu\nu\rho\sigma}C_{abcd}\ \theta\lambda\Omega\ (x} \boldsymbol{- y)\varepsilon^{abcd}_{\mu\nu\rho\sigma}\epsilon^{\mu\nu\rho\sigma}_{abcd}(xyz\ldots n)})\boldsymbol{exp}\ \left(\frac{\boldsymbol{1}}{\boldsymbol{2}\oiiint_{v}^{\mu} \boldsymbol{d^{\mu\nu\rho\sigma}_{abcd}\ d^{abcd}_{\mu\nu\rho\sigma}}\Delta\boldsymbol{\lambda\nabla\Omega}}\right.\boldsymbol{(xyz\ldots n)\partial}\Delta\boldsymbol{ijk^{abcd}_{\mu\nu\rho\sigma}\partial\nabla^{\mu\nu\rho\sigma}_{abcd}C^{abcd}C_{\mu\nu\rho\sigma}C^{\mu\nu\rho\sigma}C_{abcd}\ \theta\lambda\Omega\ (x} \left.\boldsymbol{- y)\varepsilon^{abcd}_{\mu\nu\rho\sigma}\epsilon^{\mu\nu\rho\sigma}_{abcd}(xyz\ldots n)}\right)$$

b. Estructuras constantes antisimétricas.

$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^a, T^b = if^{abc}T^c$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^b, T^a = if^{abc}T^c$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^c, T^a = if^{abc}T^b$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^c, T^b = if^{abc}T^a$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^a, T^c = if^{abc}T^b$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^b, T^c = if^{abc}T^a$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^a, T^b = if^{bac}T^c$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^b, T^a = if^{bac}T^c$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^c, T^a = if^{bac}T^b$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^c, T^b = if^{bac}T^a$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^a, T^c = if^{bac}T^b$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^b, T^c = if^{bac}T^a$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^a, T^b = if^{cba}T^c$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^b, T^a = if^{cba}T^c$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^c, T^a = if^{cba}T^b$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^c, T^b = if^{cba}T^a$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^a, T^c = if^{cba}T^b$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, [T^b, T^c = if^{cba}T^a =$ $\xi_{\lambda\Omega\psi}^{\sigma\varsigma\zeta}\Sigma\iiiint$ħȸѬѮ̆ҖꙊҞփӜѪ$\zeta\pi mc\mathbb{R}^4$

$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle tr T^a T^b = \frac{1}{2}\delta^{ab}$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle tr T^b T^a = \frac{1}{2}\delta^{ba}$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle tr T^a T^b = \frac{1}{2}\delta^{ba}$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle tr T^b T^a = \frac{1}{2}\delta^{ab} =$ $\xi_{\lambda\Omega\psi}^{\sigma\varsigma\zeta}\Sigma\iiiint$ħȸѬѮ̆ҖꙊҞփӜѪ$\zeta\pi mc\mathbb{R}^4$

c. Campo de Gauge.

$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle A_\mu = A_\mu^a T^a$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle A_\mu = A_\mu^b T^b$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle A_\mu = A_\mu^c T^c$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle A_\mu = A_\mu^{abc} T^{abc} =$ $\xi_{\lambda\Omega\psi}^{\sigma\varsigma\zeta}\Sigma\iiiint$ħȸѬѮ̆ҖꙊҞփӜѪ$\zeta\pi mc\mathbb{R}^4$

$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu - i[A_\mu, A_\nu]$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle F_{\nu\mu} = \partial_\nu A_\mu - \partial_\mu A_\nu - i[A_\nu, A_\mu] =$ $\xi_{\lambda\Omega\psi}^{\sigma\varsigma\zeta}\Sigma\iiiint$ȸѬѮ̆ҖꙊҞփӜѪ$\zeta\pi mc\mathbb{R}^4$

d. Covariante Derivada.

$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, D_\mu\, \psi = \partial_\mu \psi - iA_\mu \psi$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, D_\nu\, \psi = \partial_\nu \psi - iA_\nu \psi$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, D_{\mu\nu}\, \psi = \partial_{\mu\nu} \psi - iA_{\mu\nu} \psi$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, D_{\nu\mu}\, \psi = \partial_{\nu\mu} \psi - iA_{\nu\mu} \psi$ $=$ $\xi_{\lambda\Omega\psi}^{\sigma\varsigma\zeta}\Sigma\iiiint$ȸѬѮ̆ҖꙊҞփӜѪ$\zeta\pi mc\mathbb{R}^4$

$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, D_\mu \psi^i = \partial_\nu \psi^i - iA_\mu^a T^a (R)_j^i \psi^j i, j$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, D_\nu \psi^i$
$= \partial_\mu \psi^i - iA_\nu^a T^a (R)_j^i \psi^j i, j$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, D_{\mu\nu} \psi^{ij}$
$= \partial_{\nu\mu} \psi^{ij} - ijA_{\mu\nu}^{abc} T^{abc} (R)_i^j \psi^j j, i$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, D_{\nu\mu} \psi^{ji}$
$= \partial_{\mu\nu} \psi^{ji} - jiA_{\nu\mu}^{abc} T^{abc} (R)_j^i \psi^i i, j$ + $\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\, D_{\mu\nu\nu\mu} \psi^{ijji}$
$= \partial_{\nu\mu\mu\nu} \psi^{jiij} - jiijA_{\mu\nu}^{abcbcacabbac} T^{abcbcacabbac} (R)_{jiij}^{ijji} \psi^{jiij} ijji, jiij$
$=$ $\xi_{\lambda\Omega\psi}^{\sigma\varsigma\zeta}\Sigma\iiiint$ħȸѬѮ̆ҖꙊҞփӜѪ$\zeta\pi mc\mathbb{R}^4$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle D_\mu\phi = \partial_\mu\phi - i[A_\mu,\phi] + \hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle D_v\phi = \partial_v\phi - i[A_v,\phi] + \hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle D_{\mu v}\phi = \partial_{\mu v}\phi - ij[A_{\mu v},\phi] + \hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle D_{v\mu}\phi = \partial_{v\mu}\phi - ji[A_{v\mu},\phi] + \hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle D_{\mu v v\mu}\phi = \partial_{\mu v v\mu}\phi - ijji[A_{\mu v v\mu},\phi] = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ħȸѬǮҖДҚψӜѪ}\varsigma\pi mc\mathbb{R}^4$$

e. Dinámicas de Yang – Mills.

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle S_{YM} = \frac{1}{2g^2}\int d^4x\, tr\, F^{\mu v}\, F_{\mu v} + \hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle S_{YM} = \frac{1}{2g^2}\int d^4x\, tr\, F^{v\mu}\, F_{v\mu} + \hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle S_{YM} = \frac{n^\infty}{ng^\infty}\iiint_{v\mu}^{\mu v} \mu v v\mu\, d^\infty x\, tr\, F^{\mu v v\mu}\, F_{\mu v v} = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ħȸѬǮҖДҚψӜѪ}\varsigma\pi mc\mathbb{R}^4$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle * F^{\mu v} = \frac{1}{2}\epsilon^{\mu v p\sigma}F_{p\sigma} + \hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle * F^{v\mu} = \frac{1}{2}\epsilon^{v\mu p\sigma}F_{p\sigma} + \hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle * F^{\mu v} = \frac{1}{2}\epsilon^{\mu v\sigma p}F_{\sigma p} + \hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle * F^{v\mu} = \frac{1}{2}\epsilon^{v\mu\sigma p}F_{\sigma p} = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ħȸѬǮҖДҚψӜѪ}\varsigma\pi mc\mathbb{R}^4$$

f. Rescaling.

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle \tilde{A}_\mu = \frac{1}{g}A_\mu + \hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle \tilde{A}_v = \frac{1}{g}A_v + \hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle \tilde{A}_{\mu v} = \frac{1}{g}A_{\mu v} + \hat{\mathrm{H}} \mid \psi\rangle$$
$$= E_\psi \mid \psi\rangle \tilde{A}_{v\mu} = \frac{1}{g}A_{v\mu} + \mathbf{F}_{\mu v} = \partial_u\tilde{A}_v - \partial_v\tilde{A}_u - ig[\tilde{A}_u,\tilde{A}_v] + \mathbf{F}_{v\mu}$$
$$= \partial_v\tilde{A}_\mu - \partial_\mu\tilde{A}_v - ig[\tilde{A}_v,\tilde{A}_u] = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ħȸѬǮҖДҚψӜѪ}\varsigma\pi mc\mathbb{R}^4$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle S_{YM} = \frac{1}{2g^2}\int d^4x\, tr\, F^{\mu v}\, F_{\mu v} = -\frac{1}{2}\int d^4x\, tr\, F^{\mu v}\, F_{\mu v}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle S_{YM} = \frac{1}{2g^2}\int d^4x\, tr\, F^{v\mu}\, F_{v\mu} = -\frac{1}{2}\int d^4x\, tr\, F^{v\mu}\, F_{v\mu}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle S_{YM} = \frac{n}{ng^\infty}\int d^\infty x\, tr\, F^{v\mu}\, F_{v\mu} = -\frac{n}{n-1}\int d^\infty x\, tr\, F^{v\mu}\, F_{v\mu}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle S_{YM} = \frac{n}{ng^\infty}\int d^\infty x\, tr\, F^{\mu v}\, F_{\mu v} = -\frac{n}{n-1}\int d^\infty x\, tr\, F^{\mu v}\, F_{\mu v}$$

g. Simetría de Gauge.

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\ A_\mu \rightarrow \Omega(x)A_\mu\Omega^{-1}(x)\ i\Omega(x)\partial_\mu\Omega^{-1}(x)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\ A_v \rightarrow \Omega(x)A_v\Omega^{-1}(x)\ i\Omega(x)\partial_v\Omega^{-1}(x)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\ A_{\mu v} \rightarrow \Omega(x)A_{\mu v}\Omega^{-1}(x)\ i\Omega(x)\partial_{\mu v}\Omega^{-1}(x)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\ A_{v\mu} \rightarrow \Omega(x)A_{v\mu}\Omega^{-1}(x)\ i\Omega(x)\partial_{v\mu}\Omega^{-1}(x)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{\mu} \rightarrow \Omega(y) A_{\mu} \Omega^{-1}(y)\; i\Omega(y) \partial_{\mu} \Omega^{-1}(y)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{v} \rightarrow \Omega(y) A_{v} \Omega^{-1}(y)\; i\Omega(y) \partial_{v} \Omega^{-1}(y)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{\mu v} \rightarrow \Omega(y) A_{\mu v} \Omega^{-1}(y)\; i\Omega(y) \partial_{\mu v} \Omega^{-1}(y)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{v\mu} \rightarrow \Omega(y) A_{v\mu} \Omega^{-1}(y)\; i\Omega(y) \partial_{v\mu} \Omega^{-1}(y)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{\mu} \rightarrow \Omega(z) A_{\mu} \Omega^{-1}(z)\; i\Omega(z) \partial_{\mu} \Omega^{-1}(z)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{v} \rightarrow \Omega(z) A_{v} \Omega^{-1}(z)\; i\Omega(z) \partial_{v} \Omega^{-1}(z)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{\mu v} \rightarrow \Omega(z) A_{\mu v} \Omega^{-1}(z)\; i\Omega(z) \partial_{\mu v} \Omega^{-1}(z)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{v\mu} \rightarrow \Omega(z) A_{v\mu} \Omega^{-1}(z)\; i\Omega(z) \partial_{v\mu} \Omega^{-1}(z)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{\mu} \rightarrow \Omega(\infty) A_{\mu} \Omega^{-1}(\infty)\; i\Omega(\infty) \partial_{\mu} \Omega^{-1}(\infty)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{v} \rightarrow \Omega(\infty) A_{v} \Omega^{-1}(\infty)\; i\Omega(\infty) \partial_{v} \Omega^{-1}(\infty)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{\mu v} \rightarrow \Omega(\infty) A_{\mu v} \Omega^{-1}(\infty)\; i\Omega(\infty) \partial_{\mu v} \Omega^{-1}(\infty)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{v\mu} \rightarrow \Omega(\infty) A_{v\mu} \Omega^{-1}(\infty)\; i\Omega(\infty) \partial_{v\mu} \Omega^{-1}(\infty)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{\mu} \rightarrow \Omega(x) A_{\mu} \Omega^{-1}(x)\; j\Omega(x) \partial_{\mu} \Omega^{-1}(x)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{v} \rightarrow \Omega(x) A_{v} \Omega^{-1}(x)\; j\Omega(x) \partial_{v} \Omega^{-1}(x)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{\mu v} \rightarrow \Omega(x) A_{\mu v} \Omega^{-1}(x)\; j\Omega(x) \partial_{\mu v} \Omega^{-1}(x)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{v\mu} \rightarrow \Omega(x) A_{v\mu} \Omega^{-1}(x)\; j\Omega(x) \partial_{v\mu} \Omega^{-1}(x)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{\mu} \rightarrow \Omega(y) A_{\mu} \Omega^{-1}(y)\; j\Omega(y) \partial_{\mu} \Omega^{-1}(y)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{v} \rightarrow \Omega(y) A_{v} \Omega^{-1}(y)\; j\Omega(y) \partial_{v} \Omega^{-1}(y)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{\mu v} \rightarrow \Omega(y) A_{\mu v} \Omega^{-1}(y)\; j\Omega(y) \partial_{\mu v} \Omega^{-1}(y)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{v\mu} \rightarrow \Omega(y) A_{v\mu} \Omega^{-1}(y)\; j\Omega(y) \partial_{v\mu} \Omega^{-1}(y)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{\mu} \rightarrow \Omega(z) A_{\mu} \Omega^{-1}(z)\; j\Omega(z) \partial_{\mu} \Omega^{-1}(z)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\, A_{v} \rightarrow \Omega(z) A_{v} \Omega^{-1}(z)\; j\Omega(z) \partial_{v} \Omega^{-1}(z)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu\nu} \rightarrow \Omega(z)A_{\mu\nu}\Omega^{-1}(z)\ j\Omega(z)\partial_{\mu\nu}\Omega^{-1}(z)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\nu\mu} \rightarrow \Omega(z)A_{\nu\mu}\Omega^{-1}(z)\ j\Omega(z)\partial_{\nu\mu}\Omega^{-1}(z)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu} \rightarrow \Omega(\infty)A_{\mu}\Omega^{-1}(\infty)\ j\Omega(\infty)\partial_{\mu}\Omega^{-1}(\infty)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\nu} \rightarrow \Omega(\infty)A_{\nu}\Omega^{-1}(\infty)\ j\Omega(\infty)\partial_{\nu}\Omega^{-1}(\infty)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu\nu} \rightarrow \Omega(\infty)A_{\mu\nu}\Omega^{-1}(\infty)\ j\Omega(\infty)\partial_{\mu\nu}\Omega^{-1}(\infty)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\nu\mu} \rightarrow \Omega(\infty)A_{\nu\mu}\Omega^{-1}(\infty)\ j\Omega(\infty)\partial_{\nu\mu}\Omega^{-1}(\infty)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{\mu\nu} \rightarrow \Omega(x)\ F_{\mu\nu}\ \Omega^{-1}(x)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{\nu\mu} \rightarrow \Omega(x)\ F_{\nu\mu}\ \Omega^{-1}(x)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{\mu\nu} \rightarrow \Omega(y)\ F_{\mu\nu}\ \Omega^{-1}(y)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{\nu\mu} \rightarrow \Omega(y)\ F_{\nu\mu}\ \Omega^{-1}(y)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{\mu\nu} \rightarrow \Omega(z)\ F_{\mu\nu}\ \Omega^{-1}(z)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{\nu\mu} \rightarrow \Omega(z)\ F_{\nu\mu}\ \Omega^{-1}(z)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{\mu\nu} \rightarrow \Omega(\infty)\ F_{\mu\nu}\ \Omega^{-1}(\infty)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{\nu\mu} \rightarrow \Omega(\infty)\ F_{\nu\mu}\ \Omega^{-1}(\infty)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu} \rightarrow \mho(x)A_{\mu}\mho^{-1}(x)\ i\mho(x)\partial_{\mu}\mho^{-1}(x)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\nu} \rightarrow \mho(x)A_{\nu}\mho^{-1}(x)\ i\mho(x)\partial_{\nu}\mho^{-1}(x)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu\nu} \rightarrow \mho(x)A_{\mu\nu}\mho^{-1}(x)\ i\mho(x)\partial_{\mu\nu}\mho^{-1}(x)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\nu\mu} \rightarrow \mho(x)A_{\nu\mu}\mho^{-1}(x)\ i\mho(x)\partial_{\nu\mu}\mho^{-1}(x)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu} \rightarrow \mho(y)A_{\mu}\mho^{-1}(y)\ i\mho(y)\partial_{\mu}\mho^{-1}(y)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\nu} \rightarrow \mho(y)A_{\nu}\Omega^{-1}(y)\ i\mho(y)\partial_{\nu}\mho^{-1}(y)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu\nu} \rightarrow \mho(y)A_{\mu\nu}\mho^{-1}(y)\ i\mho(y)\partial_{\mu\nu}\mho^{-1}(y)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\nu\mu} \rightarrow \mho(y)A_{\nu\mu}\mho^{-1}(y)\ i\mho(y)\partial_{\nu\mu}\mho^{-1}(y)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu} \rightarrow \mho(z) A_{\mu} \mho^{-1}(z)\ i\mho(z)\partial_{\mu}\mho^{-1}(z)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{v} \rightarrow \mho(z) A_{v} \mho^{-1}(z)\ i\mho(z)\partial_{v}\mho^{-1}(z)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu v} \rightarrow \mho(z) A_{\mu v} \mho^{-1}(z)\ i\mho(z)\partial_{\mu v}\mho^{-1}(z)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{v\mu} \rightarrow \mho(z) A_{v\mu} \mho^{-1}(z)\ i\mho(z)\partial_{v\mu}\mho^{-1}(z)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu} \rightarrow \mho(\infty) A_{\mu} \mho^{-1}(\infty)\ i\mho(\infty)\partial_{\mu}\mho^{-1}(\infty)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{v} \rightarrow \Omega(\infty) A_{v} \mho^{-1}(\infty)\ i\mho(\infty)\partial_{v}\mho^{-1}(\infty)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu v} \rightarrow \Omega(\infty) A_{\mu v} \mho^{-1}(\infty)\ i\mho(\infty)\partial_{\mu v}\mho^{-1}(\infty)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{v\mu} \rightarrow \Omega(\infty) A_{v\mu} \mho^{-1}(\infty)\ i\mho(\infty)\partial_{v\mu}\mho^{-1}(\infty)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu} \rightarrow \mho(x) A_{\mu} \mho^{-1}(x)\ j\mho(x)\partial_{\mu}\mho^{-1}(x)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{v} \rightarrow \mho(x) A_{v} \mho^{-1}(x)\ j\mho(x)\partial_{v}\mho^{-1}(x)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu v} \rightarrow \mho(x) A_{\mu v} \mho^{-1}(x)\ j\mho(x)\partial_{\mu v}\mho^{-1}(x)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{v\mu} \rightarrow \mho(x) A_{v\mu} \mho^{-1}(x)\ j\mho(x)\partial_{v\mu}\mho^{-1}(x)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu} \rightarrow \mho(y) A_{\mu} \mho^{-1}(y)\ j\mho(y)\partial_{\mu}\mho^{-1}(y)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{v} \rightarrow \mho(y) A_{v} \mho^{-1}(y)\ j\mho(y)\partial_{v}\mho^{-1}(y)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu v} \rightarrow \mho(y) A_{\mu v} \mho^{-1}(y)\ j\mho(y)\partial_{\mu v}\mho^{-1}(y)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{v\mu} \rightarrow \mho(y) A_{v\mu} \mho^{-1}(y)\ j\mho(y)\partial_{v\mu}\mho^{-1}(y)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu} \rightarrow \mho(z) A_{\mu} \mho^{-1}(z)\ j\mho(z)\partial_{\mu}\mho^{-1}(z)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{v} \rightarrow \mho(z) A_{v} \mho^{-1}(z)\ j\mho(z)\partial_{v}\mho^{-1}(z)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu v} \rightarrow \mho(z) A_{\mu v} \mho^{-1}(z)\ j\mho(z)\partial_{\mu v}\mho^{-1}(z)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{v\mu} \rightarrow \mho(z) A_{v\mu} \mho^{-1}(z)\ j\mho(z)\partial_{v\mu}\mho^{-1}(z)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu} \rightarrow \mho(\infty) A_{\mu} \mho^{-1}(\infty)\ j\mho(\infty)\partial_{\mu}\mho^{-1}(\infty)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{v} \rightarrow \mho(\infty) A_{v} \mho^{-1}(\infty)\ j\mho(\infty)\partial_{v}\mho^{-1}(\infty)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{\mu v} \rightarrow \mho(\infty) A_{\mu v} \mho^{-1}(\infty)\ j\mho(\infty)\partial_{\mu v}\mho^{-1}(\infty)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\ A_{v\mu} \rightarrow \mho(\infty) A_{v\mu} \mho^{-1}(\infty)\ j\mho(\infty)\partial_{v\mu}\mho^{-1}(\infty)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{\mu v} \rightarrow \mho(x)\ F_{\mu v}\, \mho^{-1}(x)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{v\mu} \rightarrow \mho(x)\ F_{v\mu}\, \mho^{-1}(x)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{\mu v} \rightarrow \mho(y)\ F_{\mu v}\, \mho^{-1}(y)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{v\mu} \rightarrow \mho(y)\ F_{v\mu}\, \mho^{-1}(y)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{\mu v} \rightarrow \mho(z)\ F_{\mu v}\, \mho^{-1}(z)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{v\mu} \rightarrow \mho(z)\ F_{v\mu}\, \mho^{-1}(z)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{\mu v} \rightarrow \mho(\infty)\ F_{\mu v}\, \mho^{-1}(\infty)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle F_{v\mu} \rightarrow \mho(\infty)\ F_{v\mu}\, \mho^{-1}(\infty)$$

h. Ecuaciones de Transportación Paralela.

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i\frac{d\omega}{d\tau} = \frac{dx^{\mu}}{d\tau} A_{\mu}(x)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j\frac{d\omega}{d\tau} = \frac{dx^{\mu}}{d\tau} A_{\mu}(x)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i\frac{d\omega}{d\tau} = \frac{dy^{\mu}}{d\tau} A_{\mu}(y)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j\frac{d\omega}{d\tau} = \frac{dy^{\mu}}{d\tau} A_{\mu}(y)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i\frac{d\omega}{d\tau} = \frac{dz^{\mu}}{d\tau} A_{\mu}(z)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j\frac{d\omega}{d\tau} = \frac{dz^{\mu}}{d\tau} A_{\mu}(z)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i\frac{d\omega}{d\tau} = \frac{d\infty^{\mu}}{d\tau} A_{\mu}(\infty)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j\frac{d\omega}{d\tau} = \frac{d\infty^{\mu}}{d\tau} A_{\mu}(\infty)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i\frac{d\omega}{d\tau} = \frac{dx^{v}}{d\tau} A_{v}(x)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j\frac{d\omega}{d\tau} = \frac{dx^{v}}{d\tau} A_{v}(x)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i\frac{d\omega}{d\tau} = \frac{dy^{v}}{d\tau} A_{v}(y)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j\frac{d\omega}{d\tau} = \frac{dy^{v}}{d\tau} A_{v}(y)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i\frac{d\omega}{d\tau} = \frac{dz^{v}}{d\tau} A_{v}(z)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j\frac{d\omega}{d\tau} = \frac{dz^{v}}{d\tau} A_{v}(z)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i\frac{d\omega}{d\tau} = \frac{d\infty^{v}}{d\tau} A_{v}(\infty)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j\frac{d\omega}{d\tau} = \frac{d\infty^{v}}{d\tau} A_{v}(\infty)\omega$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dx^{\mu v}}{d\tau} A_{\mu v}(x)\omega + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dx^{\mu v}}{d\tau} A_{\mu v}(x)\omega$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dy^{\mu v}}{d\tau} A_{\mu v}(y)\omega + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dy^{\mu v}}{d\tau} A_{\mu v}(y)\omega$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dz^{\mu v}}{d\tau} A_{\mu v}(z)\omega + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dz^{\mu v}}{d\tau} A_{\mu v}(z)\omega$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{d\infty^{\mu v}}{d\tau} A_{\mu v}(\infty)\omega + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{d\infty^{\mu v}}{d\tau} A_{\mu v}(\infty)\omega$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dx^{v\mu}}{d\tau} A_{v\mu}(x)\omega + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dx^{v\mu}}{d\tau} A_{v\mu}(x)\omega$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dy^{v\mu}}{d\tau} A_{v\mu}(y)\omega + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dy^{v\mu}}{d\tau} A_{v\mu}(y)\omega$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dz^{v\mu}}{d\tau} A_{v\mu}(z)\omega + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dz^{v\mu}}{d\tau} A_{v\mu}(z)\omega$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{d\infty^{v\mu}}{d\tau} A_{v\mu}(\infty)\omega + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{d\infty^{v\mu}}{d\tau} A_{v\mu}(\infty)\omega$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dx^{\mu}}{d\tau} A_{\mu}(x)\omega + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dx^{\mu}}{d\tau} A_{\mu}(x)\omega$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dy^{\mu}}{d\tau} A_{\mu}(y)\omega + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dy^{\mu}}{d\tau} A_{\mu}(y)\omega$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dz^{\mu}}{d\tau} A_{\mu}(z)\omega + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dz^{\mu}}{d\tau} A_{\mu}(z)\omega$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{d\infty^{\mu}}{d\tau} A_{\mu}(\infty)\omega + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{d\infty^{\mu}}{d\tau} A_{\mu}(\infty)\omega$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dx^{v}}{d\tau} A_{v}(x)\omega + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dx^{v}}{d\tau} A_{v}(x)\omega$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dy^{v}}{d\tau} A_{v}(y)\omega + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dy^{v}}{d\tau} A_{v}(y)\omega$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dz^{v}}{d\tau} A_{v}(z)\omega + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dz^{v}}{d\tau} A_{v}(z)\omega$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{d\infty^{v}}{d\tau} A_{v}(\infty)\omega + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{d\infty^{v}}{d\tau} A_{v}(\infty)\omega$$

$$\hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dx^{\mu v}}{d\tau} A_{\mu v}(x)\omega + \hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dx^{\mu v}}{d\tau} A_{\mu v}(x)\omega$$

$$\hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dy^{\mu v}}{d\tau} A_{\mu v}(y)\omega + \hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dy^{\mu v}}{d\tau} A_{\mu v}(y)\omega$$

$$\hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dz^{\mu v}}{d\tau} A_{\mu v}(z)\omega + \hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dz^{\mu v}}{d\tau} A_{\mu v}(z)\omega$$

$$\hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{d\infty^{\mu v}}{d\tau} A_{\mu v}(\infty)\omega + \hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{d\infty^{\mu v}}{d\tau} A_{\mu v}(\infty)\omega$$

$$\hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dx^{v\mu}}{d\tau} A_{v\mu}(x)\omega + \hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dx^{v\mu}}{d\tau} A_{v\mu}(x)\omega$$

$$\hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dy^{v\mu}}{d\tau} A_{v\mu}(y)\omega + \hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dy^{v\mu}}{d\tau} A_{v\mu}(y)\omega$$

$$\hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{dz^{v\mu}}{d\tau} A_{v\mu}(z)\omega + \hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{dz^{v\mu}}{d\tau} A_{v\mu}(z)\omega$$

$$\hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j \frac{d\omega}{d\tau} = \frac{d\infty^{v\mu}}{d\tau} A_{v\mu}(\infty)\omega + \hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i \frac{d\omega}{d\tau} = \frac{d\infty^{v\mu}}{d\tau} A_{v\mu}(\infty)\omega$$

$$\hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dx^{\mu}}{d\tau} A_{\mu}(x)\omega + \hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dx^{\mu}}{d\tau} A_{\mu}(x)\omega$$

$$\hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dy^{\mu}}{d\tau} A_{\mu}(y)\omega + \hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dy^{\mu}}{d\tau} A_{\mu}(y)\omega$$

$$\hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dz^{\mu}}{d\tau} A_{\mu}(z)\omega + \hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dz^{\mu}}{d\tau} A_{\mu}(z)\omega$$

$$\hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{d\infty^{\mu}}{d\tau} A_{\mu}(\infty)\omega + \hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{d\infty^{\mu}}{d\tau} A_{\mu}(\infty)\omega$$

$$\hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dx^{v}}{d\tau} A_{v}(x)\omega + \hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dx^{v}}{d\tau} A_{v}(x)\omega$$

$$\hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dy^{v}}{d\tau} A_{v}(y)\omega + \hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dy^{v}}{d\tau} A_{v}(y)\omega$$

$$\hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dz^{v}}{d\tau} A_{v}(z)\omega + \hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dz^{v}}{d\tau} A_{v}(z)\omega$$

$$\hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{d\infty^{v}}{d\tau} A_{v}(\infty)\omega + \hat{\text{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{d\infty^{v}}{d\tau} A_{v}(\infty)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j\frac{d\omega}{d\tau} = \frac{dx^{\mu v}}{d\tau}A_{\mu v}(x)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j\frac{d\omega}{d\tau} = \frac{dx^{\mu v}}{d\tau}A_{\mu v}(x)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j\frac{d\omega}{d\tau} = \frac{dy^{\mu v}}{d\tau}A_{\mu v}(y)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j\frac{d\omega}{d\tau} = \frac{dy^{\mu v}}{d\tau}A_{\mu v}(y)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j\frac{d\omega}{d\tau} = \frac{dz^{\mu v}}{d\tau}A_{\mu v}(z)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j\frac{d\omega}{d\tau} = \frac{dz^{\mu v}}{d\tau}A_{\mu v}(z)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j\frac{d\omega}{d\tau} = \frac{d\infty^{\mu v}}{d\tau}A_{\mu v}(\infty)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j\frac{d\omega}{d\tau} = \frac{d\infty^{\mu v}}{d\tau}A_{\mu v}(\infty)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j\frac{d\omega}{d\tau} = \frac{dx^{v\mu}}{d\tau}A_{v\mu}(x)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j\frac{d\omega}{d\tau} = \frac{dx^{v\mu}}{d\tau}A_{v\mu}(x)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j\frac{d\omega}{d\tau} = \frac{dy^{v\mu}}{d\tau}A_{v\mu}(y)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j\frac{d\omega}{d\tau} = \frac{dy^{v\mu}}{d\tau}A_{v\mu}(y)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j\frac{d\omega}{d\tau} = \frac{dz^{v\mu}}{d\tau}A_{v\mu}(z)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j\frac{d\omega}{d\tau} = \frac{dz^{v\mu}}{d\tau}A_{v\mu}(z)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j\frac{d\omega}{d\tau} = \frac{d\infty^{v\mu}}{d\tau}A_{v\mu}(\infty)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle i,j\frac{d\omega}{d\tau} = \frac{d\infty^{v\mu}}{d\tau}A_{v\mu}(\infty)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j,i\frac{d\omega}{d\tau} = \frac{dx^{\mu}}{d\tau}A_{\mu}(x)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j,i\frac{d\omega}{d\tau} = \frac{dx^{\mu}}{d\tau}A_{\mu}(x)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j,i\frac{d\omega}{d\tau} = \frac{dy^{\mu}}{d\tau}A_{\mu}(y)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j,i\frac{d\omega}{d\tau} = \frac{dy^{\mu}}{d\tau}A_{\mu}(y)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j,i\frac{d\omega}{d\tau} = \frac{dz^{\mu}}{d\tau}A_{\mu}(z)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j,i\frac{d\omega}{d\tau} = \frac{dz^{\mu}}{d\tau}A_{\mu}(z)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j,i\frac{d\omega}{d\tau} = \frac{d\infty^{\mu}}{d\tau}A_{\mu}(\infty)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j,i\frac{d\omega}{d\tau} = \frac{d\infty^{\mu}}{d\tau}A_{\mu}(\infty)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j,i\frac{d\omega}{d\tau} = \frac{dx^{v}}{d\tau}A_{v}(x)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j,i\frac{d\omega}{d\tau} = \frac{dx^{v}}{d\tau}A_{v}(x)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j,i\frac{d\omega}{d\tau} = \frac{dy^{v}}{d\tau}A_{v}(y)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j,i\frac{d\omega}{d\tau} = \frac{dy^{v}}{d\tau}A_{v}(y)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j,i\frac{d\omega}{d\tau} = \frac{dz^{v}}{d\tau}A_{v}(z)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j,i\frac{d\omega}{d\tau} = \frac{dz^{v}}{d\tau}A_{v}(z)\omega$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j,i\frac{d\omega}{d\tau} = \frac{d\infty^{v}}{d\tau}A_{v}(\infty)\omega + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle j,i\frac{d\omega}{d\tau} = \frac{d\infty^{v}}{d\tau}A_{v}(\infty)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{dx^{\mu\nu}}{d\tau} A_{\mu\nu}(x)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{dx^{\mu\nu}}{d\tau} A_{\mu\nu}(x)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{dy^{\mu\nu}}{d\tau} A_{\mu\nu}(y)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{dy^{\mu\nu}}{d\tau} A_{\mu\nu}(y)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{dz^{\mu\nu}}{d\tau} A_{\mu\nu}(z)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{dz^{\mu\nu}}{d\tau} A_{\mu\nu}(z)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{d\infty^{\mu\nu}}{d\tau} A_{\mu\nu}(\infty)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{d\infty^{\mu\nu}}{d\tau} A_{\mu\nu}(\infty)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{dx^{\nu\mu}}{d\tau} A_{\nu\mu}(x)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{dx^{\nu\mu}}{d\tau} A_{\nu\mu}(x)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{dy^{\nu\mu}}{d\tau} A_{\nu\mu}(y)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{dy^{\nu\mu}}{d\tau} A_{\nu\mu}(y)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{dz^{\nu\mu}}{d\tau} A_{\nu\mu}(z)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{dz^{\nu\mu}}{d\tau} A_{\nu\mu}(z)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{d\infty^{\nu\mu}}{d\tau} A_{\nu\mu}(\infty)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{d\infty^{\nu\mu}}{d\tau} A_{\nu\mu}(\infty)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i, j \frac{d\omega}{d\tau} = \frac{dx^{\mu}}{d\tau} A_{\mu}(x)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{dx^{\mu}}{d\tau} A_{\mu}(x)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i, j \frac{d\omega}{d\tau} = \frac{dy^{\mu}}{d\tau} A_{\mu}(y)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{dy^{\mu}}{d\tau} A_{\mu}(y)\omega$$

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$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i, j \frac{d\omega}{d\tau} = \frac{d\infty^{\nu}}{d\tau} A_{\nu}(\infty)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i \frac{d\omega}{d\tau} = \frac{d\infty^{\nu}}{d\tau} A_{\nu}(\infty)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dx^{\mu v}}{d\tau} A_{\mu v}(x)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j,i \frac{d\omega}{d\tau} = \frac{dx^{\mu v}}{d\tau} A_{\mu v}(x)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dy^{\mu v}}{d\tau} A_{\mu v}(y)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j,i \frac{d\omega}{d\tau} = \frac{dy^{\mu v}}{d\tau} A_{\mu v}(y)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dz^{\mu v}}{d\tau} A_{\mu v}(z)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j,i \frac{d\omega}{d\tau} = \frac{dz^{\mu v}}{d\tau} A_{\mu v}(z)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{d\infty^{\mu v}}{d\tau} A_{\mu v}(\infty)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j,i \frac{d\omega}{d\tau} = \frac{d\infty^{\mu v}}{d\tau} A_{\mu v}(\infty)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dx^{v\mu}}{d\tau} A_{v\mu}(x)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j,i \frac{d\omega}{d\tau} = \frac{dx^{v\mu}}{d\tau} A_{v\mu}(x)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dy^{v\mu}}{d\tau} A_{v\mu}(y)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j,i \frac{d\omega}{d\tau} = \frac{dy^{v\mu}}{d\tau} A_{v\mu}(y)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dz^{v\mu}}{d\tau} A_{v\mu}(z)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j,i \frac{d\omega}{d\tau} = \frac{dz^{v\mu}}{d\tau} A_{v\mu}(z)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{d\infty^{v\mu}}{d\tau} A_{v\mu}(\infty)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j,i \frac{d\omega}{d\tau} = \frac{d\infty^{v\mu}}{d\tau} A_{v\mu}(\infty)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j,i \frac{d\omega}{d\tau} = \frac{dx^{\mu}}{d\tau} A_{\mu}(x)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dx^{\mu}}{d\tau} A_{\mu}(x)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j,i \frac{d\omega}{d\tau} = \frac{dy^{\mu}}{d\tau} A_{\mu}(y)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dy^{\mu}}{d\tau} A_{\mu}(y)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j,i \frac{d\omega}{d\tau} = \frac{dz^{\mu}}{d\tau} A_{\mu}(z)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dz^{\mu}}{d\tau} A_{\mu}(z)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j,i \frac{d\omega}{d\tau} = \frac{d\infty^{\mu}}{d\tau} A_{\mu}(\infty)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{d\infty^{\mu}}{d\tau} A_{\mu}(\infty)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j,i \frac{d\omega}{d\tau} = \frac{dx^{v}}{d\tau} A_{v}(x)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dx^{v}}{d\tau} A_{v}(x)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j,i \frac{d\omega}{d\tau} = \frac{dy^{v}}{d\tau} A_{v}(y)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dy^{v}}{d\tau} A_{v}(y)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j,i \frac{d\omega}{d\tau} = \frac{dz^{v}}{d\tau} A_{v}(z)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{dz^{v}}{d\tau} A_{v}(z)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j,i \frac{d\omega}{d\tau} = \frac{d\infty^{v}}{d\tau} A_{v}(\infty)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i,j \frac{d\omega}{d\tau} = \frac{d\infty^{v}}{d\tau} A_{v}(\infty)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i\frac{d\omega}{d\tau} = \frac{dx^{\mu v}}{d\tau}A_{\mu v}(x)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i, j\frac{d\omega}{d\tau} = \frac{dx^{\mu v}}{d\tau}A_{\mu v}(x)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i\frac{d\omega}{d\tau} = \frac{dy^{\mu v}}{d\tau}A_{\mu v}(y)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i, j\frac{d\omega}{d\tau} = \frac{dy^{\mu v}}{d\tau}A_{\mu v}(y)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i\frac{d\omega}{d\tau} = \frac{dz^{\mu v}}{d\tau}A_{\mu v}(z)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i, j\frac{d\omega}{d\tau} = \frac{dz^{\mu v}}{d\tau}A_{\mu v}(z)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i\frac{d\omega}{d\tau} = \frac{d\infty^{\mu v}}{d\tau}A_{\mu v}(\infty)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i, j\frac{d\omega}{d\tau} = \frac{d\infty^{\mu v}}{d\tau}A_{\mu v}(\infty)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i\frac{d\omega}{d\tau} = \frac{dx^{v\mu}}{d\tau}A_{v\mu}(x)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i, j\frac{d\omega}{d\tau} = \frac{dx^{v\mu}}{d\tau}A_{v\mu}(x)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i\frac{d\omega}{d\tau} = \frac{dy^{v\mu}}{d\tau}A_{v\mu}(y)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i, j\frac{d\omega}{d\tau} = \frac{dy^{v\mu}}{d\tau}A_{v\mu}(y)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i\frac{d\omega}{d\tau} = \frac{dz^{v\mu}}{d\tau}A_{v\mu}(z)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i, j\frac{d\omega}{d\tau} = \frac{dz^{v\mu}}{d\tau}A_{v\mu}(z)\omega$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle j, i\frac{d\omega}{d\tau} = \frac{d\infty^{v\mu}}{d\tau}A_{v\mu}(\infty)\omega + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle i, j\frac{d\omega}{d\tau} = \frac{d\infty^{v\mu}}{d\tau}A_{v\mu}(\infty)\omega$$

h. Movimiento de partículas.

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle U[xyz_i, xyz_f; C] = Pexp(i\int_{\tau i}^{\tau f} d\tau\frac{dxyz^{\mu}}{d\tau}A_{\mu}(xyz(\tau))) = Pexp(i\int_{xyzi}^{xyzf} A)$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle U[xyz_f, xyz_i; C] = Pexp(i\int_{\tau f}^{\tau i} d\tau\frac{dxyz^{\mu}}{d\tau}A_{\mu}(xyz(\tau))) = Pexp(i\int_{xyzf}^{xyzi} A)$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle U[xyz_i, xyz_f; C] = Pexp(j\int_{\tau i}^{\tau f} d\tau\frac{dx^{\mu}}{d\tau}A_{\mu}(xyz(\tau))) = Pexp(j\int_{xyzi}^{xyzf} A)$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle U[xyz_f, xyz_i; C] = Pexp(j\int_{\tau f}^{\tau i} d\tau\frac{dxyz^{\mu}}{d\tau}A_{\mu}(xyz(\tau))) = Pexp(j\int_{xyzf}^{xyzi} A)$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle U[xyz_i, xyz_f; C] = Pexp(i\int_{\tau i}^{\tau f} d\tau\frac{dxyz^{v}}{d\tau}A_{v}(xyz(\tau))) = Pexp(i\int_{xyzi}^{xyzf} A)$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle U[xyz_f, xyz_i; C] = Pexp(i\int_{\tau f}^{\tau i} d\tau\frac{dxyz^{v}}{d\tau}A_{v}(xyz(\tau))) = Pexp(i\int_{xyzf}^{xyzi} A)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_i, xyz_f; C] = Pexp(j \int_{\tau i}^{\tau f} d\tau \frac{dxyz^{v}}{d\tau} A_{v}(xyz(\tau))) = Pexp(j \int_{xyzi}^{xyzf} A)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_f, xyz_i; C] = Pexp(j \int_{\tau f}^{\tau i} d\tau \frac{dxyz^{v}}{d\tau} A_{v}(xyz(\tau))) = Pexp(j \int_{xyzf}^{xyzi} A)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_i, xyz_f; C] = Pexp(i \int_{\tau i}^{\tau f} d\tau \frac{dxyz^{\mu v}}{d\tau} A_{\mu v}(xyz(\tau))) = Pexp(i \int_{xyzi}^{xyzf} A)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_f, xyz_i; C] = Pexp(i \int_{\tau f}^{\tau i} d\tau \frac{dxyz^{\mu v}}{d\tau} A_{\mu v}(xyz(\tau))) = Pexp(i \int_{xyzf}^{xyzi} A)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_i, xyz_f; C] = Pexp(j \int_{\tau i}^{\tau f} d\tau \frac{dxyz^{\mu v}}{d\tau} A_{\mu v}(xyz(\tau))) = Pexp(j \int_{xyzi}^{xyzf} A)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_f, xyz_i; C] = Pexp(j \int_{\tau f}^{\tau i} d\tau \frac{dxyz^{\mu v}}{d\tau} A_{\mu v}(xyz(\tau))) = Pexp(j \int_{xyzf}^{xyzi} A)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_i, xyz_f; C] = Pexp(i \int_{\tau i}^{\tau f} d\tau \frac{dxyz^{v\mu}}{d\tau} A_{v\mu}(xyz(\tau))) = Pexp(i \int_{xyzi}^{xyzf} A)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_f, xyz_i; C] = Pexp(i \int_{\tau f}^{\tau i} d\tau \frac{dxyz^{v\mu}}{d\tau} A_{v\mu}(xyz(\tau))) = Pexp(i \int_{xyzf}^{xyzi} A)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_i, xyz_f; C] = Pexp(j \int_{\tau i}^{\tau f} d\tau \frac{dxyz^{v\mu}}{d\tau} A_{v\mu}(xyz(\tau))) = Pexp(j \int_{xyzi}^{xyzf} A)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_f, xyz_i; C] = Pexp(j \int_{\tau f}^{\tau i} d\tau \frac{dxyz^{v\mu}}{d\tau} A_{v\mu}(xyz(\tau))) = Pexp(j \int_{xyzf}^{xyzi} A)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_i, xyz_f; C] = Pexp(i \int_{\tau i}^{\tau f} d\tau \frac{dxyz^{\mu}}{d\tau} A_{\mu}(xyz(\tau))) = Pexp(j \int_{xyzi}^{xyzf} A)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_f, xyz_i; C] = Pexp(i \int_{\tau f}^{\tau i} d\tau \frac{dxyz^{\mu}}{d\tau} A_{\mu}(xyz(\tau))) = Pexp(j \int_{xyzf}^{xyzi} A)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_i, xyz_f; C] = Pexp(j \int_{\tau i}^{\tau f} d\tau \frac{dxyz^{\mu}}{d\tau} A_{\mu}(xyz(\tau))) = Pexp(i \int_{xyzi}^{xyzf} A)$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_f, xyz_i; C] = Pexp(j \int_{\tau f}^{\tau i} d\tau \frac{dxyz^{\mu}}{d\tau} A_{\mu}(xyz(\tau))) = Pexp(i \int_{xyzf}^{xyzi} A)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_i, xyz_f; C] = Pexp(i \int_{\tau i}^{\tau f} d\tau \frac{dxyz^{v}}{d\tau} A_{v}(xyz(\tau))) = Pexp(j \int_{xyzi}^{xyzf} A)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_f, xyz_i; C] = Pexp(i \int_{\tau f}^{\tau i} d\tau \frac{dxyz^{v}}{d\tau} A_{v}(xyz(\tau))) = Pexp(j \int_{xyzf}^{xyzi} A)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_i, xyz_f; C] = Pexp(j \int_{\tau i}^{\tau f} d\tau \frac{dxyz^{v}}{d\tau} A_{v}(xyz(\tau))) = Pexp(i \int_{xyzi}^{xyzf} A)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_f, xyz_i; C] = Pexp(j \int_{\tau f}^{\tau i} d\tau \frac{dxyz^{v}}{d\tau} A_{v}(xyz(\tau))) = Pexp(i \int_{xyzf}^{xyzi} A)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_i, xyz_f; C] = Pexp(i \int_{\tau i}^{\tau f} d\tau \frac{dxyz^{\mu v}}{d\tau} A_{\mu v}(xyz(\tau))) = Pexp(j \int_{xyzi}^{xyzf} A)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_f, xyz_i; C] = Pexp(i \int_{\tau f}^{\tau i} d\tau \frac{dxyz^{\mu v}}{d\tau} A_{\mu v}(xyz(\tau))) = Pexp(j \int_{xyzf}^{xyzi} A)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_i, xyz_f; C] = Pexp(j \int_{\tau i}^{\tau f} d\tau \frac{dxyz^{\mu v}}{d\tau} A_{\mu v}(xyz(\tau))) = Pexp(i \int_{xyzi}^{xyzf} A)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_f, xyz_i; C] = Pexp(j \int_{\tau f}^{\tau i} d\tau \frac{dxyz^{\mu v}}{d\tau} A_{\mu v}(xyz(\tau))) = Pexp(i \int_{xyzf}^{xyzi} A)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_i, xyz_f; C] = Pexp(i \int_{\tau i}^{\tau f} d\tau \frac{dxyz^{v\mu}}{d\tau} A_{v\mu}(xyz(\tau))) = Pexp(j \int_{xyzi}^{xyzf} A)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_f, xyz_i; C] = Pexp(i \int_{\tau f}^{\tau i} d\tau \frac{dxyz^{v\mu}}{d\tau} A_{v\mu}(xyz(\tau))) = Pexp(j \int_{xyzf}^{xyzi} A)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_i, xyz_f; C] = Pexp(j \int_{\tau i}^{\tau f} d\tau \frac{dxyz^{v\mu}}{d\tau} A_{v\mu}(xyz(\tau))) = Pexp(i \int_{xyzi}^{xyzf} A)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_f, xyz_i; C] = Pexp(j \int_{\tau f}^{\tau i} d\tau \frac{dxyz^{v\mu}}{d\tau} A_{v\mu}(xyz(\tau))) = Pexp(i \int_{xyzf}^{xyzi} A)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_i, xyz_f; C] \rightarrow \Omega(xyz_i) U[xyz_i, xyz_f; C] \Omega \dagger (x_f)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle U[xyz_f, xyz_i; C] \rightarrow \Omega(xyz_j) U[xyz_f, xyz_i; C] \Omega \dagger (x_f)$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle W[C] = trPexp(i \oint A) + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle W[C] = trPexp(f \oint A)$$

i. Cuantificación del grado de libertad.

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle S_w = \int d\tau\, iw^\dagger \frac{dw}{dt} + \lambda(w^\dagger w - k) + w^\dagger A(xyz(\tau))w + [w_i, w_j^\dagger = \delta_{ij} + \mid i_1 \dots i_n\rangle$$

$$= w_{i_1}^\dagger \dots w_{i_n}^\dagger \mid \xi_{\lambda\Omega\psi}^{\sigma\varsigma\zeta} \sum \iiiint \text{ħȸѬӜӁЖДҚփӜ}\Delta\varsigma\pi mc\mathbb{R}^4\rangle$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle S_w = \int d\tau\, jw^\dagger \frac{dw}{dt} + \lambda(w^\dagger w - k) + w^\dagger A(xyz(\tau))w + [w_j, w_i^\dagger = \delta_{ji} + \mid j_1 \dots j_n\rangle$$

$$= w_{j_1}^\dagger \dots w_{j_n}^\dagger \mid \xi_{\lambda\Omega\psi}^{\sigma\varsigma\zeta} \sum \iiiint \text{ħȸѬӜӁЖДҚփӜ}\Delta\varsigma\pi mc\mathbb{R}^4\rangle$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle Z_w[A] = trPexp(i \int d\tau\;\; A(\tau) + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle Z_w[A] = trPexp(j \int d\tau\;\; A(\tau))$$

j. Término Theta.

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle S_\theta = \frac{\theta}{16\pi^2} \int d^4\, x\, tr *\; F^{\mu\nu} F_{\mu\nu} + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle S_\theta$$

$$= \frac{\theta}{16\pi^2} \int d^4\, xyz \dots .n\, tr *\; F^{\nu\mu} F_{\mu\nu} + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle S_\theta$$

$$= \frac{\theta}{16\pi^2} \int d^4\, xyz \dots .n\, tr *\; F^{\nu\mu} F_{\nu\mu} + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle S_\theta$$

$$= \frac{\theta}{16\pi^2} \int d^4\, xyz \dots .n\, tr *\; F^{\mu\nu} F_{\nu\mu}$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle S_\theta = \frac{\theta}{8\pi^2} \int d^4\, x\, \partial_\mu K^\mu + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle S_\theta = \frac{\theta}{8\pi^2} \int d^4\, xyz \dots n\, \partial_\nu K^\nu + \hat{H} \mid \psi\rangle$$

$$= E_\psi \mid \psi\rangle S_\theta = \frac{\theta}{8\pi^2} \int d^4\, xyz \dots n\, \partial_{\mu\nu} K^{\mu\nu} + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle S_\theta$$

$$= \frac{\theta}{8\pi^2} \int d^4\, xyz \dots n\, \partial_{\nu\mu} K^{\nu\mu}$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle K^\mu = \epsilon^{\mu\nu p\sigma} tr(A_\nu \partial_p A_\sigma - \frac{2i}{3} A_\nu A_p A_\sigma) + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle K^\nu$$

$$= \epsilon^{\nu\mu\sigma p} tr(A_\mu \partial_\sigma A_p A_\nu - \frac{2j}{3} A_\mu A_\sigma A_p A_\nu)$$

k. Cuantificación Canonical de Yang – Mills.

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle L = \frac{1}{2g^2}\ tr\ F^{\mu v}F_{\mu v} + \frac{\theta}{16\pi^2}\ tr *\ F^{\mu v}F_{\mu v} + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle L$$

$$= \frac{1}{2g^2}\ tr\ F^{v\mu}F_{v\mu} + \frac{\theta}{16\pi^2}\ tr *\ F^{v\mu}F_{v\mu} + L$$

$$= \frac{1}{2g^2}\ tr\ (\lim_{n\to\infty}\left(1+\frac{1}{n}\right)^n \oiiint_{v}^{\mu} \mu v v \mu (\sqrt[n]{A^2 - B^2/B^2 - A^2} + \frac{\theta}{16\pi^2} tr \sqrt[n]{A^2 . \frac{B^2}{B^2} . A^2}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle H = g^{\mu v p \sigma}\ tr\ (\pi - \frac{\theta}{16\pi^{\mu v p \sigma}} B) e^{-\frac{i\omega t}{\mu v p \sigma}} + \frac{1}{g^{\mu v p \sigma}} tr B^{\mu v p \sigma} + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle H$$

$$= g^{v\mu\sigma p}\ tr\ (\pi - \frac{\theta}{16\pi^{v\mu\sigma p}} B) e^{-i\omega t/v\mu\sigma p} + \frac{1}{g^{v\mu\sigma p}} tr B^{v\mu\sigma p}$$

l. Construcción de un Espacio de Hilbert.

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle Q(w) = \oint d^n\ x\ tr(\pi\ .\ \ \delta\, A) = \frac{1}{g^n}\oint d^n\ x\ tr\ (E_i + \frac{\theta g^{\mu v p \sigma}}{16\pi^{\mu v p \sigma}} B_i) D_{iw}$$

$$= -\frac{1}{g^{\mu v p \sigma}}\oint d^n\ x\ tr\ (D_i E_i w_{\mu v p \sigma})$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle Q(w) = \oint d^n\ xyz \dots n\ tr(\pi\ .\ \ \delta\, A.B) = \frac{1}{g^n}\oint d^n\ xyz \dots n\ tr\ (E_i + \frac{\theta g^{\mu v p \sigma}}{16\pi^{\mu v p \sigma}} B_i) D_{iw}$$

$$= -\frac{1}{g^{\mu v p \sigma}}\oint d^n\ x\ tr\ (D_i E_i w_{\mu v p \sigma})$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle Q(w) = \oint d^n\ xyz \dots n\ tr(\pi\ .\ \ \delta\, A.B) = \frac{1}{g^n}\oint d^n\ xyz \dots n\ tr\ (E_j + \frac{\theta g^{\mu v p \sigma}}{16\pi^{\mu v p \sigma}} B_j) D_{jw}$$

$$= -\frac{1}{g^{\mu v p \sigma}}\oint d^n\ x\ tr\ (D_j E_j w_{\mu v p \sigma})$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle Q(w) = \oint d^n\ xyz \dots n\ tr(\pi\ .\ \ \delta\, A.B) = \frac{1}{g^n}\oint d^n\ xyz \dots n\ tr\ (E_{i,j} + \frac{\theta g^{\mu v p \sigma}}{16\pi^{\mu v p \sigma}} B_{i,j}) D_{i,jw}$$

$$= -\frac{1}{g^{\mu v p \sigma}}\oint d^n\ x\ tr\ (D_{i,j} E_{i,j} w_{\mu v p \sigma})$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle Q(w) = \oint d^n\ xyz \dots n\ tr(\pi\ .\ \ \delta\, A.B) = \frac{1}{g^n}\oint d^n\ xyz \dots n\ tr\ (E_{j,i} + \frac{\theta g^{\mu v p \sigma}}{16\pi^{\mu v p \sigma}} B_{j,i}) D_{j,iw}$$

$$= -\frac{1}{g^{\mu v p \sigma}}\oint d^n\ x\ tr\ (D_{j,i} E_{j,i} w_{\mu v p \sigma})$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle Q(w) = \oint d^n\, xyz \ldots n\, tr(\pi\, .\;\; \delta\, A.B) = \frac{1}{g^n} \oint d^n\, xyz \ldots n\, tr\, (E_i + \frac{\theta g^{\nu\mu\sigma p}}{16\pi^{\nu\mu\sigma p}} B_i) D_{iw}$$
$$= -\frac{1}{g^{\nu\mu\sigma p}} \oint d^n\, x\, tr\, (D_i E_i w_{\nu\mu\sigma p}\,)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle Q(w) = \oint d^n\, xyz \ldots n\, tr(\pi\, .\;\; \delta\, A.B) = \frac{1}{g^n} \oint d^n\, xyz \ldots n\, tr\, (E_j + \frac{\theta g^{\nu\mu\sigma p}}{16\pi^{\nu\mu\sigma p}} B_j) D_{jw}$$
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m. Función Chern – Simons.

$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle D_i(-i\ \delta\psi/\delta A_i) = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}$ƩⅬⅬħȹѬѮӜДҜփӜѪϚ$\pi mc\mathbb{R}^4$

$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle D_j(-j\ \delta\psi/\delta A_j) = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}$ƩⅬⅬħȹѬѮӜДҜփӜѪϚ$\pi mc\mathbb{R}^4$

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$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle H\psi = g^{\mu\nu\rho\sigma} tr\, (-i\ \delta/\delta A - \frac{\theta g^{\mu\nu\rho\sigma}}{16\pi^{\mu\nu\rho\sigma}} B) exp^{\mu\nu\rho\sigma}\ \psi + 1/g^{\mu\nu\rho\sigma}\ tr\ B^{\mu\nu\rho\sigma}\psi$$
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$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle H\psi = g^{\mu\nu p\sigma} tr\,(-j, i\;\delta/\delta\mathrm{A} - \frac{\theta\, g^{\mu\nu p\sigma}}{16\pi^{\mu\nu p\sigma}} B) exp^{\mu\nu p\sigma}\,\psi + 1/g^{\mu\nu p\sigma}\; tr\; B^{\mu\nu p\sigma}\psi$$

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$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle H\psi = g^{\nu\mu\sigma p} tr\,(-i\;\delta/\delta\mathrm{A} - \frac{\theta\, g^{\nu\mu\sigma p}}{16\pi^{\nu\mu\sigma p}} B) exp^{\nu\mu\sigma p}\,\psi + 1/g^{\nu\mu\sigma p}\; tr\; B^{\nu\mu\sigma p}\psi$$

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$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W(A) = 1/16\pi^{\mu\nu p\sigma} \int d^{\mu\nu p\sigma}\epsilon^{ijk}\; tr\;(F_{ij}\;A_k + 2i/3\;A_iA_jA_k)$$

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$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle - i\,\delta\,\psi(A)/\delta A_i = -ie^{i\theta W[A]}\frac{\delta\psi_{\mu\nu\sigma p}(A)}{\delta A_i} + \frac{\theta}{16\pi^{\mu\nu\sigma p}} B_i\,\psi\,(A)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle - j\,\delta\,\psi(A)/\delta A_j = -je^{j\theta W[A]}\frac{\delta\psi_{\mu\nu\sigma p}(A)}{\delta A_j} + \frac{\theta}{16\pi^{\mu\nu\sigma p}} B_j\,\psi\,(A)$$

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$$\begin{aligned}\hat{H} \mid \psi\rangle &= E_{\psi} \mid \psi\rangle W[A] \\ &\rightarrow W[B] + 1/16\pi^{\mu\nu\sigma p}\int d^{\mu\nu\sigma p}\,x\big[i\epsilon^{ijk}\partial_i\,tr\,(\partial_j\Omega\Omega\Delta\nabla\lambda_{k,i})n^{-\Omega^{-\mu\nu\sigma p}} \\ &- 1/3\epsilon^{ijk}\,tr\,(\Omega^{-\mu\nu\sigma p}\partial_i\Omega\Omega^{-\mu\nu\sigma p}\partial_j\Omega\Omega^{-\mu\nu\sigma p}\partial_k\Omega\Omega^{-\mu\nu\sigma p}\big]\end{aligned}$$

$$\begin{aligned}\hat{H} \mid \psi\rangle &= E_{\psi} \mid \psi\rangle W[A] \\ &\rightarrow W[B] + 1/16\pi^{\mu\nu\sigma p}\int d^{\mu\nu\sigma p}\,x\big[j\epsilon^{ijk}\partial_j\,tr\,(\partial_i\Omega\Omega\Delta\nabla\lambda_{k,j})n^{-\Omega^{-\mu\nu\sigma p}} \\ &- 1/3\epsilon^{ijk}\,tr\,(\Omega^{-\mu\nu\sigma p}\partial_j\Omega\Omega^{-\mu\nu\sigma p}\partial_i\Omega\Omega^{-\mu\nu\sigma p}\partial_k\Omega\Omega^{-\mu\nu\sigma p}\big]\end{aligned}$$

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$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightarrow W[B] + 1/16\pi^{\mu\nu\sigma p} \int d^{\mu\nu\sigma p}\, x\big[k\epsilon^{ijk}\partial_k\, tr\,(\partial_k \Omega\Omega\Delta\nabla\lambda_{i,j})n^{-\Omega^{-\mu\nu\sigma p}}$$

$$- 1/3\epsilon^{ijk}\, tr\,(\Omega^{-\mu\nu\sigma p}\partial_k \Omega\Omega^{-\mu\nu\sigma p}\partial_i \Omega\Omega^{-\mu\nu\sigma p}\partial_j \Omega\Omega^{-\mu\nu\sigma p}\big]$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

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$$- 1/3\epsilon^{ijk}\, tr\,(\Omega^{-\mu\nu\sigma p}\partial_k \Omega\Omega^{-\mu\nu\sigma p}\partial_j \Omega\Omega^{-\mu\nu\sigma p}\partial_i \Omega\Omega^{-\mu\nu\sigma p}\big]$$

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$$- 1/3\epsilon^{jik}\, tr\,(\Omega^{-\mu\nu\sigma p}\partial_j \Omega\Omega^{-\mu\nu\sigma p}\partial_i \Omega\Omega^{-\mu\nu\sigma p}\partial_k \Omega\Omega^{-\mu\nu\sigma p}\big]$$

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$$\rightarrow W[B] + 1/16\pi^{\mu\nu\sigma p} \int d^{\mu\nu\sigma p}\, x\big[i\epsilon^{jik}\partial_i\, tr\,(\partial_j \Omega\Omega\Delta\nabla\lambda_{k,i})n^{-\Omega^{-\mu\nu\sigma p}}$$

$$- 1/3\epsilon^{jik}\, tr\,(\Omega^{-\mu\nu\sigma p}\partial_i \Omega\Omega^{-\mu\nu\sigma p}\partial_j \Omega\Omega^{-\mu\nu\sigma p}\partial_k \Omega\Omega^{-\mu\nu\sigma p}\big]$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightarrow W[B] + 1/16\pi^{\mu\nu\sigma p} \int d^{\mu\nu\sigma p}\, x\big[j\epsilon^{jik}\partial_j\, tr\,(\partial_i \Omega\Omega\Delta\nabla\lambda_{i,k})n^{-\Omega^{-\mu\nu\sigma p}}$$

$$- 1/3\epsilon^{jik}\, tr\,(\Omega^{-\mu\nu\sigma p}\partial_j \Omega\Omega^{-\mu\nu\sigma p}\partial_i \Omega\Omega^{-\mu\nu\sigma p}\partial_k \Omega\Omega^{-\mu\nu\sigma p}\big]$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightarrow W[B] + 1/16\pi^{\mu\nu\sigma p} \int d^{\mu\nu\sigma p}\, x\big[i\epsilon^{jik}\partial_i\, tr\,(\partial_j \Omega\Omega\Delta\nabla\lambda_{j,k})n^{-\Omega^{-\mu\nu\sigma p}}$$

$$- 1/3\epsilon^{jik}\, tr\,(\Omega^{-\mu\nu\sigma p}\partial_i \Omega\Omega^{-\mu\nu\sigma p}\partial_j \Omega\Omega^{-\mu\nu\sigma p}\partial_k \Omega\Omega^{-\mu\nu\sigma p}\big]$$

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$$- 1/3\epsilon^{jik}\, tr\,(\Omega^{-\mu\nu\sigma p}\partial_k \Omega\Omega^{-\mu\nu\sigma p}\partial_j \Omega\Omega^{-\mu\nu\sigma p}\partial_i \Omega\Omega^{-\mu\nu\sigma p}\big]$$

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$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightarrow W[B] + 1/16\pi^{\mu\nu\sigma p} \int d^{\mu\nu\sigma p}\, x\big[i\epsilon^{ikj}\partial_i\, tr\, (\partial_j \Omega\Omega\Delta\nabla\lambda_{k,i})n^{-\Omega^{-\mu\nu\sigma p}}$$

$$- 1/3\epsilon^{ikj}\, tr\, (\Omega^{-\mu\nu\sigma p}\partial_i\Omega\Omega^{-\mu\nu\sigma p}\partial_j\Omega\Omega^{-\mu\nu\sigma p}\partial_k\Omega\Omega^{-\mu\nu\sigma p}\big]$$

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$$- 1/3\epsilon^{jki}\, tr\, (\Omega^{-\mu\nu\sigma p}\partial_j\Omega\Omega^{-\mu\nu\sigma p}\partial_i\Omega\Omega^{-\mu\nu\sigma p}\partial_k\Omega\Omega^{-\mu\nu\sigma p}\big]$$

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$$- 1/3\epsilon^{jik} \, tr \, (\Omega^{-\nu\mu\rho\sigma} \partial_j \Omega \Omega^{-\nu\mu\rho\sigma} \partial_i \Omega \Omega^{-\nu\mu\rho\sigma} \partial_k \Omega \Omega^{-\nu\mu\rho\sigma}]$$

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$$- 1/3\epsilon^{jki}\, tr\, (\Omega^{-\nu\mu\rho\sigma}\partial_i \Omega\Omega^{-\nu\mu\rho\sigma}\partial_j \Omega\Omega^{-\nu\mu\rho\sigma}\partial_k \Omega\Omega^{-\nu\mu\rho\sigma}\big]$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightarrow W[B] + 1/16\pi^{\nu\mu\rho\sigma} \int d^{\nu\mu\rho\sigma}\, x\big[j\epsilon^{jki}\partial_j\, tr\, (\partial_i \Omega\Omega\Delta\nabla\lambda_{j,k}) n^{-\Omega^{-\nu\mu\rho\sigma}}$$

$$- 1/3\epsilon^{jki}\, tr\, (\Omega^{-\nu\mu\rho\sigma}\partial_j \Omega\Omega^{-\nu\mu\rho\sigma}\partial_i \Omega\Omega^{-\nu\mu\rho\sigma}\partial_k \Omega\Omega^{-\nu\mu\rho\sigma}\big]$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightarrow W[B] + 1/16\pi^{\nu\mu\rho\sigma} \int d^{\nu\mu\rho\sigma}\, x\big[i\epsilon^{jki}\partial_i\, tr\, (\partial_j \Omega\Omega\Delta\nabla\lambda_{i,k}) n^{-\Omega^{-\nu\mu\rho\sigma}}$$

$$- 1/3\epsilon^{jki}\, tr\, (\Omega^{-\nu\mu\rho\sigma}\partial_i \Omega\Omega^{-\nu\mu\rho\sigma}\partial_j \Omega\Omega^{-\nu\mu\rho\sigma}\partial_k \Omega\Omega^{-\nu\mu\rho\sigma}\big]$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightarrow W[B] + 1/16\pi^{\nu\mu\rho\sigma} \int d^{\nu\mu\rho\sigma}\, x\big[k\epsilon^{jki}\partial_k\, tr\, (\partial_k \Omega\Omega\Delta\nabla\lambda_{j,i}) n^{-\Omega^{-\nu\mu\rho\sigma}}$$

$$- 1/3\epsilon^{jki}\, tr\, (\Omega^{-\nu\mu\rho\sigma}\partial_k \Omega\Omega^{-\nu\mu\rho\sigma}\partial_j \Omega\Omega^{-\nu\mu\rho\sigma}\partial_i \Omega\Omega^{-\nu\mu\rho\sigma}\big]$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightarrow W[B] + 1/16\pi^{\nu\mu\rho\sigma} \int d^{\nu\mu\rho\sigma}\, x\big[k\epsilon^{jki}\partial_k\, tr\, (\partial_k \Omega\Omega\Delta\nabla\lambda_{i,j}) n^{-\Omega^{-\nu\mu\rho\sigma}}$$

$$- 1/3\epsilon^{jki}\, tr\, (\Omega^{-\nu\mu\rho\sigma}\partial_k \Omega\Omega^{-\nu\mu\rho\sigma}\partial_i \Omega\Omega^{-\nu\mu\rho\sigma}\partial_j \Omega\Omega^{-\nu\mu\rho\sigma}\big]$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightarrow W[B] + 1/16\pi^{\nu\mu p\sigma} \int d^{\nu\mu p\sigma}\, x\big[i\epsilon^{kij}\partial_i\, tr\, (\partial_j \Omega\Omega\Delta\nabla\lambda_{k,i})n^{-\Omega^{-\nu\mu p\sigma}}$$

$$- 1/3\epsilon^{kij}\, tr\, (\Omega^{-\nu\mu p\sigma}\partial_i\Omega\Omega^{-\nu\mu p\sigma}\partial_j\Omega\Omega^{-\nu\mu p\sigma}\partial_k\Omega\Omega^{-\nu\mu p\sigma}\big]$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightarrow W[B] + 1/16\pi^{\nu\mu p\sigma} \int d^{\nu\mu p\sigma}\, x\big[j\epsilon^{kij}\partial_j\, tr\, (\partial_i \Omega\Omega\Delta\nabla\lambda_{k,j})n^{-\Omega^{-\nu\mu p\sigma}}$$

$$- 1/3\epsilon^{kij}\, tr\, (\Omega^{-\nu\mu p\sigma}\partial_j\Omega\Omega^{-\nu\mu p\sigma}\partial_i\Omega\Omega^{-\nu\mu p\sigma}\partial_k\Omega\Omega^{-\nu\mu p\sigma}\big]$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightarrow W[B] + 1/16\pi^{\nu\mu p\sigma} \int d^{\nu\mu p\sigma}\, x\big[i\epsilon^{kij}\partial_i\, tr\, (\partial_j \Omega\Omega\Delta\nabla\lambda_{i,k})n^{-\Omega^{-\nu\mu p\sigma}}$$

$$- 1/3\epsilon^{kij}\, tr\, (\Omega^{-\nu\mu p\sigma}\partial_i\Omega\Omega^{-\nu\mu p\sigma}\partial_j\Omega\Omega^{-\nu\mu p\sigma}\partial_k\Omega\Omega^{-\nu\mu p\sigma}\big]$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightarrow W[B] + 1/16\pi^{\nu\mu p\sigma} \int d^{\nu\mu p\sigma}\, x\big[j\epsilon^{kij}\partial_j\, tr\, (\partial_i \Omega\Omega\Delta\nabla\lambda_{j,k})n^{-\Omega^{-\mu\nu p\sigma}}$$

$$- 1/3\epsilon^{kij}\, tr\, (\Omega^{-\nu\mu p\sigma}\partial_j\Omega\Omega^{-\nu\mu p\sigma}\partial_i\Omega\Omega^{-\nu\mu p\sigma}\partial_k\Omega\Omega^{-\nu\mu p\sigma}\big]$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightarrow W[B] + 1/16\pi^{\nu\mu p\sigma} \int d^{\nu\mu p\sigma}\, x\big[k\epsilon^{kij}\partial_k\, tr\, (\partial_k \Omega\Omega\Delta\nabla\lambda_{i,j})n^{-\Omega^{-\nu\mu p\sigma}}$$

$$- 1/3\epsilon^{kij}\, tr\, (\Omega^{-\nu\mu p\sigma}\partial_k\Omega\Omega^{-\nu\mu p\sigma}\partial_i\Omega\Omega^{-\nu\mu p\sigma}\partial_j\Omega\Omega^{-\nu\mu p\sigma}\big]$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightarrow W[B] + 1/16\pi^{\nu\mu p\sigma} \int d^{\nu\mu p\sigma}\, x\big[k\epsilon^{kij}\partial_k\, tr\, (\partial_k \Omega\Omega\Delta\nabla\lambda_{j,i})n^{-\Omega^{-\nu\mu p\sigma}}$$

$$- 1/3\epsilon^{kij}\, tr\, (\Omega^{-\nu\mu p\sigma}\partial_k\Omega\Omega^{-\nu\mu p\sigma}\partial_j\Omega\Omega^{-\nu\mu p\sigma}\partial_i\Omega\Omega^{-\nu\mu p\sigma}\big]$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightarrow W[B] + 1/16\pi^{\nu\mu p\sigma} \int d^{\nu\mu p\sigma}\, x\big[j\epsilon^{kji}\partial_j\, tr\, (\partial_i \Omega\Omega\Delta\nabla\lambda_{k,j})n^{-\Omega^{-\nu\mu p\sigma}}$$

$$- 1/3\epsilon^{kji}\, tr\, (\Omega^{-\nu\mu p\sigma}\partial_j\Omega\Omega^{-\nu\mu p\sigma}\partial_i\Omega\Omega^{-\nu\mu p\sigma}\partial_k\Omega\Omega^{-\nu\mu p\sigma}\big]$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightarrow W[B] + 1/16\pi^{\nu\mu p\sigma} \int d^{\nu\mu p\sigma}\, x\big[i\epsilon^{kji}\partial_i\, tr\, (\partial_j \Omega\Omega\Delta\nabla\lambda_{k,i})n^{-\Omega^{-\nu\mu p\sigma}}$$

$$- 1/3\epsilon^{kji}\, tr\, (\Omega^{-\nu\mu p\sigma}\partial_i\Omega\Omega^{-\nu\mu p\sigma}\partial_j\Omega\Omega^{-\nu\mu p\sigma}\partial_k\Omega\Omega^{-\nu\mu p\sigma}\big]$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightharpoonup W[B] + 1/16\pi^{\nu\mu\rho\sigma} \int d^{\nu\mu\rho\sigma}\, x\big[j\epsilon^{kji}\partial_j\, tr\,(\partial_i \Omega\Omega\Delta\nabla\lambda_{j,k})n^{-\Omega^{-\nu\mu\rho\sigma}}$$

$$- 1/3\epsilon^{kji}\, tr\,(\Omega^{-\nu\mu\rho\sigma}\partial_j\Omega\Omega^{-\nu\mu\rho\sigma}\partial_i\Omega\Omega^{-\nu\mu\rho\sigma}\partial_k\Omega\Omega^{-\nu\mu\rho\sigma}\big]$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightharpoonup W[B] + 1/16\pi^{\nu\mu\rho\sigma} \int d^{\nu\mu\rho\sigma}\, x\big[i\epsilon^{kji}\partial_i\, tr\,(\partial_j \Omega\Omega\Delta\nabla\lambda_{i,k})n^{-\Omega^{-\nu\mu\rho\sigma}}$$

$$- 1/3\epsilon^{kji}\, tr\,(\Omega^{-\nu\mu\rho\sigma}\partial_i\Omega\Omega^{-\nu\mu\rho\sigma}\partial_j\Omega\Omega^{-\nu\mu\rho\sigma}\partial_k\Omega\Omega^{-\nu\mu\rho\sigma}\big]$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightharpoonup W[B] + 1/16\pi^{\nu\mu\rho\sigma} \int d^{\nu\mu\rho\sigma}\, x\big[k\epsilon^{kji}\partial_k\, tr\,(\partial_k \Omega\Omega\Delta\nabla\lambda_{j,i})n^{-\Omega^{-\nu\mu\rho\sigma}}$$

$$- 1/3\epsilon^{kji}\, tr\,(\Omega^{-\nu\mu\rho\sigma}\partial_k\Omega\Omega^{-\nu\mu\rho\sigma}\partial_j\Omega\Omega^{-\nu\mu\rho\sigma}\partial_i\Omega\Omega^{-\nu\mu\rho\sigma}\big]$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle W[A]$$

$$\rightharpoonup W[B] + 1/16\pi^{\nu\mu\rho\sigma} \int d^{\nu\mu\rho\sigma}\, x\big[k\epsilon^{kji}\partial_k\, tr\,(\partial_k \Omega\Omega\Delta\nabla\lambda_{i,j})n^{-\Omega^{-\nu\mu\rho\sigma}}$$

$$- 1/3\epsilon^{kji}\, tr\,(\Omega^{-\nu\mu\rho\sigma}\partial_k\Omega\Omega^{-\nu\mu\rho\sigma}\partial_i\Omega\Omega^{-\nu\mu\rho\sigma}\partial_j\Omega\Omega^{-\nu\mu\rho\sigma}\big]$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle n(\Omega) = 1/32\pi^{\mu\nu\sigma p}\int_{S^3} d^{\mu\nu\sigma p} S\epsilon^{ikj}\, tr(\Omega^{-\mu\nu\sigma p}\partial_i\Omega\Omega^{-\mu\nu\sigma p}\partial_k\Omega\Omega^{-\mu\nu\sigma p}\partial_j\Omega\Omega^{-\mu\nu\sigma p})$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle n(\Omega) = 1/32\pi^{\mu\nu\sigma p}\int_{S^3} d^{\mu\nu\sigma p} S\epsilon^{ijk}\, tr(\Omega^{-\mu\nu\sigma p}\partial_i\Omega\Omega^{-\mu\nu\sigma p}\partial_j\Omega\Omega^{-\mu\nu\sigma p}\partial_k\Omega\Omega^{-\mu\nu\sigma p})$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle n(\Omega) = 1/32\pi^{\mu\nu\sigma p}\int_{S^3} d^{\mu\nu\sigma p} S\epsilon^{jki}\, tr(\Omega^{-\mu\nu\sigma p}\partial_j\Omega\Omega^{-\mu\nu\sigma p}\partial_k\Omega\Omega^{-\mu\nu\sigma p}\partial_i\Omega\Omega^{-\mu\nu\sigma p})$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle n(\Omega) = 1/32\pi^{\mu\nu\sigma p}\int_{S^3} d^{\mu\nu\sigma p} S\epsilon^{jik}\, tr(\Omega^{-\mu\nu\sigma p}\partial_j\Omega\Omega^{-\mu\nu\sigma p}\partial_i\Omega\Omega^{-\mu\nu\sigma p}\partial_k\Omega\Omega^{-\mu\nu\sigma p})$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle n(\Omega) = 1/32\pi^{\mu\nu\sigma p}\int_{S^3} d^{\mu\nu\sigma p} S\epsilon^{kij}\, tr(\Omega^{-\mu\nu\sigma p}\partial_k\Omega\Omega^{-\mu\nu\sigma p}\partial_i\Omega\Omega^{-\mu\nu\sigma p}\partial_j\Omega\Omega^{-\mu\nu\sigma p})$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle n(\Omega) = 1/32\pi^{\mu\nu\sigma p}\int_{S^3} d^{\mu\nu\sigma p} S\epsilon^{kji}\, tr(\Omega^{-\mu\nu\sigma p}\partial_k\Omega\Omega^{-\mu\nu\sigma p}\partial_j\Omega\Omega^{-\mu\nu\sigma p}\partial_i\Omega\Omega^{-\mu\nu\sigma p})$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle n(\Omega) = 1/32\pi^{\nu\mu\rho\sigma}\int_{S^3} d^{\nu\mu\rho\sigma} S\epsilon^{ikj}\, tr(\Omega^{-\nu\mu\rho\sigma}\partial_i\Omega\Omega^{-\nu\mu\rho\sigma}\partial_k\Omega\Omega^{-\nu\mu\rho\sigma}\partial_j\Omega\Omega^{-\nu\mu\rho\sigma})$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle n(\Omega) = 1/32\pi^{\nu\mu\rho\sigma}\int_{S^3} d^{\nu\mu\rho\sigma} S\epsilon^{ijk}\, tr(\Omega^{-\nu\mu\rho\sigma}\partial_i\Omega\Omega^{-\nu\mu\rho\sigma}\partial_j\Omega\Omega^{-\nu\mu\rho\sigma}\partial_k\Omega\Omega^{-\nu\mu\rho\sigma})$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle n(\Omega) = 1/32\pi^{\nu\mu\rho\sigma}\int_{S^3} d^{\nu\mu\rho\sigma} S\epsilon^{jki}\, tr(\Omega^{-\nu\mu\rho\sigma}\partial_j\Omega\Omega^{-\nu\mu\rho\sigma}\partial_k\Omega\Omega^{-\nu\mu\rho\sigma}\partial_i\Omega\Omega^{-\nu\mu\rho\sigma})$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle n(\Omega) = 1/32\pi^{\nu\mu\rho\sigma}\int_{S^3} d^{\nu\mu\rho\sigma} S\epsilon^{jik}\, tr(\Omega^{-\nu\mu\rho\sigma}\partial_j\Omega\Omega^{-\nu\mu\rho\sigma}\partial_i\Omega\Omega^{-\nu\mu\rho\sigma}\partial_k\Omega\Omega^{-\nu\mu\rho\sigma})$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle n(\Omega) = 1/32\pi^{\nu\mu\rho\sigma}\int_{S^3} d^{\nu\mu\rho\sigma} S\epsilon^{kij}\, tr(\Omega^{-\nu\mu\rho\sigma}\partial_k\Omega\Omega^{-\nu\mu\rho\sigma}\partial_i\Omega\Omega^{-\nu\mu\rho\sigma}\partial_j\Omega\Omega^{-\nu\mu\rho\sigma})$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle n(\Omega) = 1/32\pi^{\nu\mu\rho\sigma}\int_{S^3} d^{\nu\mu\rho\sigma} S\epsilon^{kji}\, tr(\Omega^{-\nu\mu\rho\sigma}\partial_k\Omega\Omega^{-\nu\mu\rho\sigma}\partial_j\Omega\Omega^{-\nu\mu\rho\sigma}\partial_i\Omega\Omega^{-\nu\mu\rho\sigma})$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\psi\,(A) = e^{i\Theta W[A]}\psi_0(A)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\psi\,(B) = e^{i\Theta W[B]}\psi_0(B)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\psi\,(\partial\Delta\nabla\omega) = e^{i\Theta W[\partial\Delta\nabla\omega]}\psi_{\phi}\psi\partial\Delta\nabla\vartheta\varphi\tau(A)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\psi\,(\partial\Delta\nabla\omega) = e^{i\Theta W[\partial\Delta\nabla\omega]}\psi_{\phi}\psi\partial\Delta\nabla\vartheta\varphi\tau(B)$$

n. Dinámica hamiltoniana de partículas según la teoría de Yang-Mills.

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle = 1/\pi\epsilon^{ijke_{i\Theta W[\partial\Delta\nabla\omega]}}(-i\partial/\partial x + \Phi/\partial\pi R)exp^{\mu\nu\sigma p} + \psi_{\phi}\psi\partial\Delta\nabla\vartheta\varphi\tau(A) \quad + \quad \psi = \frac{1}{{}^{\mu\nu\sigma p}\sqrt{\frac{1}{\pi\epsilon^{ijk}}e^{\frac{i\Theta W[\partial\Delta\nabla\omega]}{R}}}} = E = \frac{1}{\pi e R^2}(n + \frac{\phi}{2\pi_{\varphi}}) = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ћ}ȹ\text{ӉЖ}\check{\text{ȝ}}\text{ЖД}\text{К}\text{ц}\breve{\text{Ж}}\text{Ꜫ}\varsigma\pi mc\mathbb{R}^4$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle = 1/\pi\epsilon^{ijke_{i\Theta W[\partial\Delta\nabla\omega]}}(-i\partial/\partial x + \Phi/\partial\pi R)exp^{\nu\mu\rho\sigma} + \psi_{\phi}\psi\partial\Delta\nabla\vartheta\varphi\tau(A) \quad + \quad \psi = \frac{1}{{}^{\nu\mu\rho\sigma}\sqrt{\frac{1}{\pi\epsilon^{ijk}}e^{\frac{i\Theta W[\partial\Delta\nabla\omega]}{R}}}} = E = \frac{1}{\pi e R^2}(n + \frac{\phi}{2\pi_{\varphi}}) = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ћ}ȹ\text{ӉЖ}\check{\text{ȝ}}\text{ЖД}\text{К}\text{ц}\breve{\text{Ж}}\text{Ꜫ}\varsigma\pi mc\mathbb{R}^4$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle = 1/\pi\epsilon^{ijke_{i\Theta W[\partial\Delta\nabla\omega]}}(-i\partial/\partial x + \Phi/\partial\pi R)exp^{\mu\nu\sigma p} + \psi_{\phi}\psi\partial\Delta\nabla\vartheta\varphi\tau(B) \quad + \quad \psi = \frac{1}{{}^{\mu\nu\sigma p}\sqrt{\frac{1}{\pi\epsilon^{ijk}}e^{\frac{i\Theta W[\partial\Delta\nabla\omega]}{R}}}} = E = \frac{1}{\pi e R^2}(n + \frac{\phi}{2\pi_{\varphi}}) = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ћ}ȹ\text{ӉЖ}\check{\text{ȝ}}\text{ЖД}\text{К}\text{ц}\breve{\text{Ж}}\text{Ꜫ}\varsigma\pi mc\mathbb{R}^4$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle = 1/\pi\epsilon^{ijke_{i\Theta W[\partial\Delta\nabla\omega]}}(-i\partial/\partial x + \Phi/\partial\pi R)exp^{\nu\mu\rho\sigma} + \psi_{\phi}\psi\partial\Delta\nabla\vartheta\varphi\tau(B) \quad + \quad \psi = \frac{1}{{}^{\nu\mu\rho\sigma}\sqrt{\frac{1}{\pi\epsilon^{ijk}}e^{\frac{i\Theta W[\partial\Delta\nabla\omega]}{R}}}} = E = \frac{1}{\pi e R^2}(n + \frac{\phi}{2\pi_{\varphi}}) = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ћ}ȹ\text{ӉЖ}\check{\text{ȝ}}\text{ЖД}\text{К}\text{ц}\breve{\text{Ж}}\text{Ꜫ}\varsigma\pi mc\mathbb{R}^4$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle = 1/\pi\epsilon^{ikje_{i\Theta W[\partial\Delta\nabla\omega]}}(-i\partial/\partial x + \Phi/\partial\pi R)exp^{\mu\nu\sigma p} + \psi_{\phi}\psi\partial\Delta\nabla\vartheta\varphi\tau(A) \quad + \quad \psi = \frac{1}{{}^{\mu\nu\sigma p}\sqrt{\frac{1}{\pi\epsilon^{ikj}}e^{\frac{i\Theta W[\partial\Delta\nabla\omega]}{R}}}} = E = \frac{1}{\pi e R^2}(n + \frac{\phi}{2\pi_{\varphi}}) = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ћ}ȹ\text{ӉЖ}\check{\text{ȝ}}\text{ЖД}\text{К}\text{ц}\breve{\text{Ж}}\text{Ꜫ}\varsigma\pi mc\mathbb{R}^4$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle = 1/\pi\epsilon^{ikje_{i\Theta W[\partial\Delta\nabla\omega]}}(-i\partial/\partial x + \Phi/\partial\pi R)exp^{\nu\mu\rho\sigma} + \psi_{\phi}\psi\partial\Delta\nabla\vartheta\varphi\tau(A) \quad + \quad \psi = \frac{1}{{}^{\nu\mu\rho\sigma}\sqrt{\frac{1}{\pi\epsilon^{ikj}}e^{\frac{i\Theta W[\partial\Delta\nabla\omega]}{R}}}} = E = \frac{1}{\pi e R^2}(n + \frac{\phi}{2\pi_{\varphi}}) = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ћ}ȹ\text{ӉЖ}\check{\text{ȝ}}\text{ЖД}\text{К}\text{ц}\breve{\text{Ж}}\text{Ꜫ}\varsigma\pi mc\mathbb{R}^4$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle = 1/\pi\epsilon^{ikje_{i\Theta W[\partial\Delta\nabla\omega]}}(-i\partial/\partial x + \Phi/\partial\pi R)exp^{\mu\nu\sigma p} + \psi_{\phi}\psi\partial\Delta\nabla\vartheta\varphi\tau(B) \quad + \quad \psi = \frac{1}{{}^{\mu\nu\sigma p}\sqrt{\frac{1}{\pi\epsilon^{ikj}}e^{\frac{i\Theta W[\partial\Delta\nabla\omega]}{R}}}} = E = \frac{1}{\pi e R^2}(n + \frac{\phi}{2\pi_{\varphi}}) = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ћ}ȹ\text{ӉЖ}\check{\text{ȝ}}\text{ЖД}\text{К}\text{ц}\breve{\text{Ж}}\text{Ꜫ}\varsigma\pi mc\mathbb{R}^4$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle = 1/\pi\epsilon^{ikje_{i\theta W[\partial\Delta\nabla\omega]}}(-i\partial/\partial x + \Phi/\partial\pi R)exp^{\nu\mu p\sigma} + \psi_{\phi}\psi\partial\Delta\nabla\vartheta\varphi\tau(B) \quad + \quad \psi = \frac{1}{\nu\mu p\sigma\sqrt{\frac{1}{\pi\epsilon^{ikj}}e^{\frac{i\theta W[\partial\Delta\nabla\omega]}{R}}}} = E = \frac{1}{\pi e R^2}(n + \frac{\phi}{2\pi_{\varphi}}) = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ħȸѬӞЖДҜɥӜѪ}\varsigma\pi mc\mathbb{R}^4$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle = 1/\pi\epsilon^{jkie_{j\theta W[\partial\Delta\nabla\omega]}}(-j\partial/\partial x + \Phi/\partial\pi R)exp^{\mu\nu\sigma p} + \psi_{\phi}\psi\partial\Delta\nabla\vartheta\varphi\tau(A) \quad + \quad \psi = \frac{1}{\mu\nu\sigma p\sqrt{\frac{1}{\pi\epsilon^{jki}}e^{\frac{j\theta W[\partial\Delta\nabla\omega]}{R}}}} = E = \frac{1}{\pi e R^2}(n + \frac{\phi}{2\pi_{\varphi}}) = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ħȸѬӞЖДҜɥӜѪ}\varsigma\pi mc\mathbb{R}^4$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle = 1/\pi\epsilon^{jkie_{j\theta W[\partial\Delta\nabla\omega]}}(-j\partial/\partial x + \Phi/\partial\pi R)exp^{\nu\mu p\sigma} + \psi_{\phi}\psi\partial\Delta\nabla\vartheta\varphi\tau(A) \quad + \quad \psi = \frac{1}{\nu\mu p\sigma\sqrt{\frac{1}{\pi\epsilon^{jki}}e^{\frac{j\theta W[\partial\Delta\nabla\omega]}{R}}}} = E = \frac{1}{\pi e R^2}(n + \frac{\phi}{2\pi_{\varphi}}) = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ħȸѬӞЖДҜɥӜѪ}\varsigma\pi mc\mathbb{R}^4$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle = 1/\pi\epsilon^{jkie_{j\theta W[\partial\Delta\nabla\omega]}}(-j\partial/\partial x + \Phi/\partial\pi R)exp^{\mu\nu\sigma p} + \psi_{\phi}\psi\partial\Delta\nabla\vartheta\varphi\tau(B) \quad + \quad \psi = \frac{1}{\mu\nu\sigma p\sqrt{\frac{1}{\pi\epsilon^{jki}}e^{\frac{j\theta W[\partial\Delta\nabla\omega]}{R}}}} = E = \frac{1}{\pi e R^2}(n + \frac{\phi}{2\pi_{\varphi}}) = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ħȸѬӞЖДҜɥӜѪ}\varsigma\pi mc\mathbb{R}^4$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle = 1/\pi\epsilon^{jkie_{j\theta W[\partial\Delta\nabla\omega]}}(-j\partial/\partial x + \Phi/\partial\pi R)exp^{\nu\mu p\sigma} + \psi_{\phi}\psi\partial\Delta\nabla\vartheta\varphi\tau(B) \quad + \quad \psi = \frac{1}{\nu\mu p\sigma\sqrt{\frac{1}{\pi\epsilon^{jki}}e^{\frac{j\theta W[\partial\Delta\nabla\omega]}{R}}}} = E = \frac{1}{\pi e R^2}(n + \frac{\phi}{2\pi_{\varphi}}) = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ħȸѬӞЖДҜɥӜѪ}\varsigma\pi mc\mathbb{R}^4$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle = 1/\pi\epsilon^{jike_{j\theta W[\partial\Delta\nabla\omega]}}(-j\partial/\partial x + \Phi/\partial\pi R)exp^{\mu\nu\sigma p} + \psi_{\phi}\psi\partial\Delta\nabla\vartheta\varphi\tau(A) \quad + \quad \psi = \frac{1}{\mu\nu\sigma p\sqrt{\frac{1}{\pi\epsilon^{jik}}e^{\frac{j\theta W[\partial\Delta\nabla\omega]}{R}}}} = E = \frac{1}{\pi e R^2}(n + \frac{\phi}{2\pi_{\varphi}}) = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ħȸѬӞЖДҜɥӜѪ}\varsigma\pi mc\mathbb{R}^4$$

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$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle = 1/\pi\epsilon^{kije_{k\theta W[\partial\Delta\nabla\omega]}}(-k\partial/\partial x + \Phi/\partial\pi R)exp^{\nu\mu p\sigma} + \psi_{\phi}\psi\partial\Delta\nabla\vartheta\varphi\tau(A) \quad + \quad \psi = \frac{1}{\sqrt[\nu\mu p\sigma]{\frac{1}{\pi\epsilon^{kij}}e^{\frac{k\Theta W[\partial\Delta\nabla\omega]}{R}}}} = E = \frac{1}{\pi e R^2}\left(n + \frac{\phi}{2\pi_{\varphi}}\right) = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ħȸѬЗ̆ЖДКцӁѪ}\zeta\pi mc\mathbb{R}^4$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle = 1/\pi\epsilon^{kije_{k\theta W[\partial\Delta\nabla\omega]}}(-k\partial/\partial x + \Phi/\partial\pi R)exp^{\mu\nu\sigma p} + \psi_{\phi}\psi\partial\Delta\nabla\vartheta\varphi\tau(B) \quad + \quad \psi = \frac{1}{\sqrt[\mu\nu\sigma p]{\frac{1}{\pi\epsilon^{kij}}e^{\frac{k\Theta W[\partial\Delta\nabla\omega]}{R}}}} = E = \frac{1}{\pi e R^2}\left(n + \frac{\phi}{2\pi_{\varphi}}\right) = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint \text{ħȸѬЗ̆ЖДКцӁѪ}\zeta\pi mc\mathbb{R}^4$$

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o. Ángulo Theta.

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle H = 1/2m\partial^2/\partial x^2 + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle H = 1/2m\partial^2/\partial y^2 + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle H$$
$$= 1/2m\partial^2/\partial z^2 + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle H$$
$$= 1/2m\partial^{ijk}/\partial n^{\mu\nu\sigma p}/\partial\psi^{\frac{i\theta W[\partial\Delta\nabla\omega]}{R}} - \partial i\varphi\Phi\omega\Omega\Delta\nabla\phi\sigma\lambda\xi\Psi\mathbb{R}^{\alpha\beta\psi_{\text{ЙЖфп}}}\infty\mathbb{R}^4 + \hat{H} \mid \psi\rangle$$
$$= E_{\psi} \mid \psi\rangle H$$
$$= 1/2m\partial^{ikj}/\partial n^{\mu\nu\sigma p}/\partial\psi^{\frac{i\theta W[\partial\Delta\nabla\omega]}{R}} - \partial i\varphi\Phi\omega\Omega\Delta\nabla\phi\sigma\lambda\xi\Psi\mathbb{R}^{\alpha\beta\psi_{\text{ЙЖфп}}}\infty\mathbb{R}^4 + \hat{H} \mid \psi\rangle$$
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$$= E_{\psi} \mid \psi\rangle H = 1/2m\partial^{kji}/\partial n^{\mu\nu\sigma p}/\partial\psi^{\frac{k\theta W[\partial\Delta\nabla\omega]}{R}} - \partial k\varphi\Phi\omega\Omega\Delta\nabla\phi\sigma\lambda\xi\Psi\mathbb{R}^{\alpha\beta\psi_{\text{ЙЖфп}}}\infty\mathbb{R}^4$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle H = 1/2m\partial^2/\partial x^2 + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle H = 1/2m\partial^2/\partial y^2 + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle H$$
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$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \varphi_{\mu\nu\sigma p}(A') = e^{i\theta n} \varphi_{\mu\nu\sigma p}(Ai)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \varphi_{\mu\nu\sigma p}(A') = e^{i\theta n} \varphi_{\mu\nu\sigma p}(Bi)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \varphi_{\mu\nu\sigma p}(B') = e^{i\theta n} \varphi_{\mu\nu\sigma p}(Ai)$$

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$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \varphi_{\mu\nu\sigma p}(A') = e^{k\theta n} \varphi_{\mu\nu\sigma p}(Ak)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \varphi_{\mu\nu\sigma p}(A') = e^{k\theta n} \varphi_{\mu\nu\sigma p}(Bk)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \varphi_{\mu\nu\sigma p}(B') = e^{k\theta n} \varphi_{\mu\nu\sigma p}(Ak)$$

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$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \varphi_{\mu\nu\sigma p}(A') = e^{ijk\theta n} \varphi_{\mu\nu\sigma p}(Ai, Aj, Ak)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \varphi_{\mu\nu\sigma p}(A') = e^{ijk\theta n} \varphi_{\mu\nu\sigma p}(Bi, Bj, Bk)$$

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$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \varphi_{\nu\mu\rho\sigma}(A') = e^{k\theta n}\varphi_{\nu\mu\rho\sigma}(Ak)$$

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p. Ondas de Bloch.

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle iV\nabla V^{\mu v\sigma p} + iV\nabla V^{ijk} + iV\nabla V^{\mu v} + iV\nabla V_{vu} = \lambda\nabla\Delta_{j}^{i}k$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle iV\nabla V^{v\mu p\sigma} + iV\nabla V^{ijk} + iV\nabla V^{\mu v} + iV\nabla V_{vu} = \lambda\nabla\Delta_{j}^{i}k$$

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$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle iV\nabla V^{v\mu p\sigma} + iV\nabla V^{ikj} + iV\nabla V^{\mu v} + iV\nabla V_{vu} = \lambda\nabla\Delta_{k}^{i}j$$

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$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle iV\nabla V^{v\mu p\sigma} + iV\nabla V^{jki} + iV\nabla V^{\mu v} + iV\nabla V_{vu} = \lambda\nabla\Delta_{k}^{j}i$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle kV\nabla V^{\mu v\sigma p} + kV\nabla V^{kij} + kV\nabla V^{\mu v} + kV\nabla V_{vu} = \lambda\nabla\Delta_{i}^{k}j$$

$$\hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle iV\nabla V^{\nu\mu\rho\sigma} + iV\nabla V^{kij} + iV\nabla V^{\mu\nu} + iV\nabla V_{\nu u} = \lambda\nabla\Delta_i^k j$$

$$\hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle iV\nabla V^{\mu\nu\sigma p} + iV\nabla V^{kji} + iV\nabla V^{\mu\nu} + iV\nabla V_{\nu u} = \lambda\nabla\Delta_j^k i$$

$$\hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle iV\nabla V^{\nu\mu\rho\sigma} + iV\nabla V^{kji} + iV\nabla V^{\mu\nu} + iV\nabla V_{\nu u} = \lambda\nabla\Delta_j^k i$$

$$\hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{i\theta n'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{i\theta m'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{i\theta m',n'} \mid \psi\rangle$$

$$\hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{j\theta n'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{j\theta m'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{j\theta m',n'} \mid \psi\rangle$$

$$\hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{k\theta n'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{k\theta m'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{k\theta m',n'} \mid \psi\rangle$$

$$\hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{ijk\theta n'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{ijk\theta m'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{ijk\theta m',n'} \mid \psi\rangle$$

$$\hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{ikj\theta n'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{ikj\theta m'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{ikj\theta m',n'} \mid \psi\rangle$$

$$\hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{jik\theta n'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{jik\theta m'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{jik\theta m',n'} \mid \psi\rangle$$

$$\hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{jki\theta n'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{jki\theta m'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{jki\theta m',n'} \mid \psi\rangle$$

$$\hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{kij\theta n'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{kij\theta m'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{kij\theta m',n'} \mid \psi\rangle$$

$$\hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{kji\theta n'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{kji\theta m'} \mid \psi\rangle + \hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle = e^{kji\theta m',n'} \mid \psi\rangle$$

$$\hat{\text{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\Omega \mid \psi\rangle \mid \theta\rangle = \sum_{\nabla\nu\mu}^{\Delta\mu\nu} \lambda ijk \iiint \mid d_{\nu\mu}^{\mu\nu} tr\rangle^{ijk}\sqrt{\partial e^{i\theta n'}\partial e^{i\theta m'}\partial e^{j\theta n'}\partial e^{j\theta m'}\partial e^{k\theta n'}\partial e^{k\theta m'}\partial e^{ijk\theta}}^{\infty} \mid \psi\rangle \mid n\rangle \mid m\rangle \mid \xi\sigma\mathbb{R}^4\rangle$$

q. Instantones.

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle S_{\theta} = \theta/16\pi^2 \bar{\int}\underline{\int} d^{ijk}x\ tr * F^{\mu\nu}F_{\nu\mu} = \theta/8\pi^2 \bar{\int}\underline{\int} d^{ijk}x\ \partial_{\mu\nu}K^{\nu\mu}$$
$$= e^{\mu\nu p\sigma} tr\ (A_{\mu\nu}\partial_p A_{\sigma} - 2ijk/3\ A_{\mu\nu}\partial_p A_{\sigma})\ e^{\nu\mu\sigma p} tr\ (A_{\nu\mu}\partial_{\sigma}A_p - 2ijk/3\ A_{\nu\mu}\partial_{\sigma}A_p)$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle A_{\mu\nu} \mapsto i\Omega\partial_{\mu\nu}\Omega^{-ijk} + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle A_{\mu\nu} \mapsto j\Omega\partial_{\mu\nu}\Omega^{-ijk} + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle A_{\mu\nu}$$
$$\mapsto k\Omega\partial_{\mu\nu}\Omega^{-ijk}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle A_{\nu\mu} \mapsto i\Omega\partial_{\nu\mu}\Omega^{-ijk} + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle A_{\nu\mu} \mapsto j\Omega\partial_{\nu\mu}\Omega^{-ijk} + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle A_{\nu\mu}$$
$$\mapsto k\Omega\partial_{\nu\mu}\Omega^{-ijk}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle v(\Omega) = 1/24\pi^2 \oint_{\nu\mu}^{\mu\nu} S_{\infty}^{\mu\nu\nu\mu}\, d^{ijk^{\mu\nu\nu\mu}} S\varepsilon^{ijk}\, tr\ (\Omega\partial_i\Omega^{-i})\ (\Omega\partial_j\Omega^{-j})\ (\Omega\partial_k\Omega^{-k})$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle S_{YM} = 1/8g^2 \int d^{ijk}\, x\ tr\ (F_{\mu\nu} \tilde{\mp} * F_{\nu\mu}) exp^2 \mp 1/4g^2 \int d^{ijk}\, x\ tr\ F_{\mu\nu} * F^{\nu\mu}$$
$$\gtreqless 16\pi^2/g^{ijk} \mid \mu\nu \mid \pm \mid \nu\mu \mid$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle S_{YM} = 1/8g^2 \int d^{ijk}\, x\ tr\ (F_{\nu\mu} \pm * F_{\mu\nu}) exp^2 \mp_2 1/4g^2 \int d^{ijk}\, x\ tr\ F_{\nu\mu} * F^{\mu\nu}$$
$$\gtreqless 16\pi^2/g^{ijk} \mid \nu\mu \mid \pm \mid \mu\nu \mid$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle e^{-S_{instanton}} = e^{\partial\pi^2 |\mu\nu| \pm |\nu\mu| / g^{ijk}} e^{ijk\theta|\nu\mu|\pm|\mu\nu|}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \Omega(x) = x_{\mu}\sigma^{\mu}/\sqrt{x_{\mu}^{i}} + A_{\mu} \mapsto i\Omega\partial_{\mu}\Omega^{ijk} = 1/x_{ijk}^{\mu}\eta_{\mu\nu}^{i}\sigma^{i} + A_{\mu}$$
$$= 1/x^{ijk} + \rho^{ijk}\eta_{\mu\nu}^{i}x^{\nu}\sigma^{i} + F_{\mu\nu} = 2\rho^{ijk}/(x^{ijk} + \rho^{ijk}) exp^{ijk}\eta_{\mu\nu}^{i}\sigma^{i}$$

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$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle V(x) = \lambda(x_{\mu\nu\rho\sigma}^{ijk} + a_{\mu\nu\rho\sigma}^{ijk})exp_{\mu\nu\rho\sigma}^{ijk} \, {}_{\mu\nu\rho\sigma}^{\quad ijk}\frac{\partial\theta}{\frac{\Delta\nabla\Omega}{\xi\mathbb{R}^4}} = \delta\varphi\phi\phi\Phi d\omega(\tau)$$

$$= a\, tanh/cosh + senh\,(w/\pi^2(\tau - \tau_{\mu\nu\rho\sigma}^{ijk}))$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle V(x) = \lambda(x_{ijk}^{\mu\nu\rho\sigma} + a_{ijk}^{\mu\nu\rho\sigma})exp_{ijk}^{\mu\nu\rho\sigma} \, {}_{ijk}^{\quad \mu\nu\rho\sigma}\frac{\partial\theta}{\frac{\Delta\nabla\Omega}{\xi\mathbb{R}^4}} = \delta\varphi\phi\phi\Phi d\omega(\tau)$$

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$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle a \mid e^{-HT} \mid -a\rangle = N \oint_{x(0)=-a}^{x(T)=+a} Dx(\tau)\, e^{S_{E[x(\tau)]}} + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle a \mid e^{+HT} \mid +a\rangle$$

$$= N \oint_{x(T)=+a}^{x(0)=-a} Dx(\tau)\, e^{S_{E[x(\tau)]}}$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle b \mid e^{-HT} \mid -b\rangle = N \oint_{x(0)=-b}^{x(T)=+b} Dx(\tau)\, e^{S_{E[x(\tau)]}} + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle b \mid e^{+HT} \mid +b\rangle$$

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$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle c \mid e^{-HT} \mid -c\rangle = N \oint_{x(0)=-c}^{x(T)=+c} Dx(\tau)\, e^{S_{E[x(\tau)]}} + \hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle c \mid e^{+HT} \mid +c\rangle$$

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$$= N \oint_{z(T)=+c}^{z(0)=-c} Dz(\tau)\, e^{S_{E[z(\tau)]}}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle a \mid e^{-HT} \mid -a\rangle = N \oint_{x(0)=-a}^{x(T)=+a} Dx(\mu\nu\rho\sigma)\, e^{S_{E[x(\mu\nu\rho\sigma)]}} + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle a \mid e^{+HT}$$

$$\mid +a\rangle = N \oint_{x(T)=+a}^{x(0)=-a} Dx(\mu\nu\rho\sigma)\, e^{S_{E[x(\mu\nu\rho\sigma)]}}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle b \mid e^{-HT} \mid -b\rangle = N \oint_{x(0)=-b}^{x(T)=+b} Dx(\mu\nu\rho\sigma)\, e^{S_{E[x(\mu\nu\rho\sigma)]}} + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle b \mid e^{+HT}$$

$$\mid +b\rangle = N \oint_{x(T)=+b}^{x(0)=-b} Dx(\mu\nu\rho\sigma)\, e^{S_{E[x(\mu\nu\rho\sigma)]}}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle c \mid e^{-HT} \mid -c\rangle = N \oint_{x(0)=-c}^{x(T)=+c} Dx(\mu\nu\rho\sigma)\, e^{S_{E[x(\mu\nu\rho\sigma)]}} + \hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle c \mid e^{+HT} \mid +c\rangle$$

$$= N \oint_{x(T)=+c}^{x(0)=-c} Dx(\mu\nu\rho\sigma)\, e^{S_{E[x(\mu\nu\rho\sigma)]}}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle a \mid e^{-HT} \mid -a\rangle = N \oint_{y(0)=-a}^{y(T)=+a} Dy(\mu\nu\rho\sigma)\, e^{S_{E[y(\mu\nu\rho\sigma)]}} + \hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle a \mid e^{+HT}$$

$$\mid +a\rangle = N \oint_{y(T)=+a}^{y(0)=-a} Dy(\mu\nu\rho\sigma)\, e^{S_{E[y(\mu\nu\rho\sigma)]}}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle b \mid e^{-HT} \mid -b\rangle = N \oint_{y(0)=-b}^{y(T)=+b} Dy(\mu\nu\rho\sigma)\, e^{S_{E[y(\mu\nu\rho\sigma)]}} + \hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle b \mid e^{+HT}$$

$$\mid +b\rangle = N \oint_{y(T)=+b}^{y(0)=-b} Dy(\mu\nu\rho\sigma)\, e^{S_{E[y(\mu\nu\rho\sigma)]}}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle c \mid e^{-HT} \mid -c\rangle = N \oint_{y(0)=-c}^{y(T)=+c} Dy(\mu\nu\rho\sigma)\, e^{S_{E[y(\mu\nu\rho\sigma)]}} + \hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle c \mid e^{+HT} \mid +c\rangle$$

$$= N \oint_{y(T)=+c}^{y(0)=-c} Dy(\mu\nu\rho\sigma)\, e^{S_{E[y(\mu\nu\rho\sigma)]}}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle a \mid e^{-HT} \mid -a\rangle = N \oint_{z(0)=-a}^{z(T)=+a} Dz(\mu\nu\rho\sigma)\, e^{S_{E[z(\mu\nu\rho\sigma)]}} + \hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle a \mid e^{+HT}$$

$$\mid +a\rangle = N \oint_{z(T)=+a}^{z(0)=-a} Dz(\mu\nu\rho\sigma)\, e^{S_{E[z(\mu\nu\rho\sigma)]}}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle b \mid e^{-HT} \mid -b\rangle = N \oint_{z(0)=-b}^{z(T)=+b} Dz(\mu\nu\rho\sigma)\, e^{S_{E[z(\mu\nu\rho\sigma)]}} + \hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle b \mid e^{+HT} \mid +b\rangle$$

$$= N \oint_{z(T)=+b}^{z(0)=-b} Dz(\mu\nu\rho\sigma)\, e^{S_{E[z(\mu\nu\rho\sigma)]}}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle c \mid e^{-HT} \mid -c\rangle = N \oint_{z(0)=-c}^{z(T)=+c} Dz(\mu\nu\rho\sigma)\, e^{S_{E[z(\mu\nu\rho\sigma)]}} + \hat{\mathrm{H}} \mid \psi\rangle = E_\psi \mid \psi\rangle\langle c \mid e^{+HT} \mid +c\rangle$$

$$= N \oint_{z(T)=+c}^{z(0)=-c} Dz(\mu\nu\rho\sigma)\, e^{S_{E[z(\mu\nu\rho\sigma)]}}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle a \mid e^{-HT} \mid -a\rangle = N \oint_{x(0)=-a}^{x(T)=+a} Dx(ijk)\, e^{S_{E[x(ijk)]}} + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle a \mid e^{+HT} \mid +a\rangle$$

$$= N \oint_{x(T)=+a}^{x(0)=-a} Dx(ijk)\, e^{S_{E[x(ijk)]}}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle b \mid e^{-HT} \mid -b\rangle = N \oint_{x(0)=-b}^{x(T)=+b} Dx(ijk)\, e^{S_{E[x(ijk)]}} + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle b \mid e^{+HT} \mid +b\rangle$$

$$= N \oint_{x(T)=+b}^{x(0)=-b} Dx(ijk)\, e^{S_{E[x(ijk)]}}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle c \mid e^{-HT} \mid -c\rangle = N \oint_{x(0)=-c}^{x(T)=+c} Dx(ijk)\, e^{S_{E[x(ijk)]}} + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle c \mid e^{+HT} \mid +c\rangle$$

$$= N \oint_{x(T)=+c}^{x(0)=-c} Dx(ijk)\, e^{S_{E[x(ijk)]}}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle a \mid e^{-HT} \mid -a\rangle = N \oint_{y(0)=-a}^{y(T)=+a} Dy(ijk)\, e^{S_{E[y(ijk)]}} + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle a \mid e^{+HT} \mid +a\rangle$$

$$= N \oint_{y(T)=+a}^{y(0)=-a} Dy(ijk)\, e^{S_{E[y(ijk)]}}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle b \mid e^{-HT} \mid -b\rangle = N \oint_{y(0)=-b}^{y(T)=+b} Dy(ijk)\, e^{S_{E[y(ijk)]}} + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle b \mid e^{+HT} \mid +b\rangle$$

$$= N \oint_{y(T)=+b}^{y(0)=-b} Dy(ijk)\, e^{S_{E[y(ijk)]}}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle c \mid e^{-HT} \mid -c\rangle = N \oint_{y(0)=-c}^{y(T)=+c} Dy(ijk)\, e^{S_{E[y(ijk)]}} + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle c \mid e^{+HT} \mid +c\rangle$$

$$= N \oint_{y(T)=+c}^{y(0)=-c} Dy(ijk)\, e^{S_{E[y(ijk)]}}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle a \mid e^{-HT} \mid -a\rangle = N \oint_{z(0)=-a}^{z(T)=+a} Dz(ijk)\, e^{S_{E[z(ijk)]}} + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle a \mid e^{+HT} \mid +a\rangle$$

$$= N \oint_{z(T)=+a}^{z(0)=-a} Dz(ijk)\, e^{S_{E[z(ijk)]}}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle b \mid e^{-HT} \mid -b\rangle = N \oint_{z(0)=-b}^{z(T)=+b} Dz(ijk)\, e^{S_{E[z(ijk)]}} + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle b \mid e^{+HT} \mid +b\rangle$$

$$= N \oint_{z(T)=+b}^{z(0)=-b} Dz(ijk)\, e^{S_{E[z(ijk)]}}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle c \mid e^{-HT} \mid -c\rangle = N \oint_{z(0)=-c}^{z(T)=+c} Dz(ijk)\, e^{S_{E[z(ijk)]}} + \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle\langle c \mid e^{+HT} \mid +c\rangle$$

$$= N \oint_{z(T)=+c}^{z(0)=-c} Dz(ijk)\, e^{S_{E[z(ijk)]}}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle x(\tau) = \varkappa(\tau) + \delta x(\tau) = \hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle S_E[x(\tau)]$$

$$= S_{instanton}$$

$$+ \oint_{ijk}^{\mu\nu\rho\sigma} d(\tau)\delta(\tau)\, \partial(\tau)\, \Omega(\tau)\, \varphi(\tau)\, \phi(\tau)\, \xi(\tau)\, \lambda(\tau)\frac{\omega}{p}.\mathbb{R}^4/x^n \oint_{x(0)=-a}^{x(T)=+a} D\infty(\tau)\, e^{-S_{E[x(\tau)]}}$$

$$= e^{-Sinstanton} \oint_{\delta x(0)=0}^{\delta x(T)=0} D\delta(\tau)\, e^{d(\tau)\delta(\tau)\, \partial(\tau)\, \Omega(\tau)\, \varphi(\tau)\, \phi(\tau)\, \xi(\tau)\, \lambda(\tau)\frac{\omega}{p}.\frac{\mathbb{R}^4}{x^n}}$$

$$\approx e^{-S_{instanton}}/d\omega_{\lambda\nu/\lambda\sigma}^{\lambda\mu/\lambda\rho}\Delta\nabla\Omega\eta\varphi\phi$$

r. Análisis de Campos Yang – Mills (Teorización Final).

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle S_{YM} + S_{gf\mu\nu} \oint_{ijk=m}^{ijk=n} \lambda\, 1/g^{\mu\nu\rho\sigma} \oint_{\nu}^{\mu} d_{\varphi}^{\omega}\theta\Omega\, tr\, [\frac{1}{2}\dot{F}_{\mu\nu}\dot{F}^{\mu\nu} + n\dot{F}^{\mu\nu}\dot{D}_{\mu}\lambda\partial/\Delta\nabla\, \delta\, A_{\nu}$$

$$+ \dot{D}^{\mu}\lambda\partial/\Delta\nabla\, \delta\, A^{\nu}\dot{D}_{\mu}\lambda\partial/\Delta\nabla\, \delta\, A_{\nu} - \dot{D}^{\mu}\lambda\partial/\Delta\nabla\, \delta\, A^{\nu}\dot{D}_{\nu}\lambda\partial/\Delta\nabla\, \delta\, A_{\mu} - i\dot{F}^{\mu\nu}\dot{F}_{\mu\nu}[\delta\, A_{\mu}, \delta\, A_{\nu}]$$

$$- 2ijk\dot{D}^{\mu}\lambda\partial/\Delta\nabla\, \delta\, A^{\nu}[\delta\, A_{\mu}, \delta\, A_{\nu}] - 1/2[\delta\, A^{\mu}, \delta\, A^{\nu}][\delta\, A_{\mu}, \delta\, A_{\nu}]]$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle S_{YM} + S_{gf\nu\mu} \oint_{ijk=m}^{ijk=n} \lambda\, 1/g^{\mu\nu\rho\sigma} \oint_{\mu}^{\nu} d_{\varphi}^{\omega} \theta \Omega\; tr\, [\frac{1}{2} \dot{\mathrm{F}}_{\nu\mu} \dot{\mathrm{F}}^{\nu\mu} + n \dot{\mathrm{F}}^{\nu\mu} \dot{\mathrm{D}}_{\nu} \lambda\partial/\Delta\nabla\, \delta\, A_{\mu}$$

$$+ \dot{\mathrm{D}}^{\nu} \lambda\partial/\Delta\nabla\, \delta\, A^{\mu} \dot{\mathrm{D}}_{\nu} \lambda\partial/\Delta\nabla\, \delta\, A_{\mu} - \dot{\mathrm{D}}^{\nu} \lambda\partial/\Delta\nabla\, \delta\, A^{\mu} \dot{\mathrm{D}}_{\mu} \lambda\partial/\Delta\nabla\, \delta\, A_{\nu} - i \dot{\mathrm{F}}^{\nu\mu} \dot{\mathrm{F}}_{\nu\mu} [\delta\, A_{\nu}\, , \delta\, A_{\mu}]$$

$$- 2ijk \dot{\mathrm{D}}^{\nu} \lambda\partial/\Delta\nabla\, \delta\, A^{\mu} [\delta\, A_{\nu}\, , \delta\, A_{\mu}] - 1/2 [\delta\, A^{\nu}\, , \delta\, A^{\mu}][\delta\, A_{\nu}\, , \delta\, A_{\mu}]]$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \oint_{\nu}^{\mu} d^{\mu\nu}\, n\; tr\; \dot{\mathrm{D}}^{\mu} \lambda\partial/\Delta\nabla\, \delta\, A^{\nu} \dot{\mathrm{D}}_{\nu} \lambda\partial/\Delta\nabla\, \delta\, A_{\mu} = - \oint_{\nu}^{\mu} d^{\mu\nu}\, n\; tr\; \delta A_{\nu} \dot{\mathrm{D}}^{\mu} \dot{\mathrm{D}}^{\nu} A_{\mu}$$

$$= - \oint_{\nu}^{\mu} d^{\mu\nu}\, n\; tr\; \delta A_{\nu} ([\dot{\mathrm{D}}^{\mu} \dot{\mathrm{D}}^{\nu}] + \dot{\mathrm{D}}^{\nu} \dot{\mathrm{D}}^{\mu}) \delta\, A_{\mu}$$

$$= \oint_{\nu}^{\mu} d^{\mu\nu}\, [(\dot{\mathrm{D}}^{\mu}\; \delta\, A_{\mu})\; exp^{u\nu} + ijk\; \delta\, A_{\nu} [\dot{\mathrm{F}}^{\mu\nu}\, , \delta\, A_{\mu}]]$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \oint_{\mu}^{\nu} d^{\nu\mu}\, n\; tr\; \dot{\mathrm{D}}^{\nu} \lambda\partial/\Delta\nabla\, \delta\, A^{\mu} \dot{\mathrm{D}}_{\mu} \lambda\partial/\Delta\nabla\, \delta\, A_{\nu} = - \oint_{\mu}^{\nu} d^{\nu\mu}\, n\; tr\; \delta A_{\mu} \dot{\mathrm{D}}^{\nu} \dot{\mathrm{D}}^{\mu} A_{\nu}$$

$$= - \oint_{\mu}^{\nu} d^{\nu\mu}\, n\; tr\; \delta A_{\mu} ([\dot{\mathrm{D}}^{\nu} \dot{\mathrm{D}}^{\mu}] + \dot{\mathrm{D}}^{\mu} \dot{\mathrm{D}}^{\nu}) \delta\, A_{\nu}$$

$$= \oint_{\mu}^{\nu} d^{\nu\mu}\, [(\dot{\mathrm{D}}^{\nu}\; \delta\, A_{\nu})\; exp^{\nu u} + ijk\; \delta\, A_{\mu} [\dot{\mathrm{F}}^{\nu\mu}\, , \delta\, A_{\nu}]]$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \oint_{\nu}^{\mu} D\omega\; \delta(G(\text{Ậ}^{\omega}, \delta A^{\omega}))\; \det\; (\partial G(\text{Ậ}^{\omega}, \delta A^{\omega})/\partial\omega)$$

$$= \xi_{\lambda\Omega\psi}^{\sigma\varsigma\zeta} \text{Ʃ⨌ħȸѬѮҖДҚɥӜѪϚ} \pi mc \mathbb{R}^{4}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \oint_{\mu}^{\nu} D\omega\; \delta(G(\text{Ậ}^{\omega}, \delta A^{\omega}))\; \det\; (\partial G(\text{Ậ}^{\omega}, \delta A^{\omega})/\partial\omega)$$

$$= \xi_{\lambda\Omega\psi}^{\sigma\varsigma\zeta} \text{Ʃ⨌ħȸѬѮҖДҚɥӜѪϚ} \pi mc \mathbb{R}^{4}$$

$$\hat{\mathrm{H}} \mid \psi\rangle = E_{\psi} \mid \psi\rangle det(\partial G(\text{Ậ}^{\omega}, \delta A^{\omega})/\partial\omega)$$

$$= \oint_{\nu}^{\mu} DcDc^{\dagger}\, exp(-1/g^{\mu\nu} \oint_{\nu}^{\mu} d^{\mu\nu}\;\; tr[-e^{\dagger} (\dot{\mathrm{D}}^{\mu\nu\rho\sigma} c + ijkc^{\dagger} [(\dot{\mathrm{D}}^{\mu\nu\rho\sigma} \delta A_{\mu\nu\rho\sigma}, c]])$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle det(\partial G(\breve{\dot{A}}^{\omega}, \delta A^{\omega})/\partial\omega)$$

$$= \oint_{\mu}^{v} DcDc^{\dagger}\, exp(-1/g^{v\mu} \oint_{\mu}^{v} d^{v\mu}\;\; tr[-e^{\dagger}(\dot{D}^{v\mu\rho\sigma}c + ijkc^{\dagger}[(\dot{D}^{v\mu\rho\sigma}\delta A_{v\mu\rho\sigma}, c]])$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle 1/g^{\mu v} \oint_{v}^{\mu} d^{\mu v}\;\; n\, tr[1/2\dot{F}_{\mu v}\, \dot{F}^{\mu v} + n\, \dot{F}^{\mu v}\dot{D}_{\mu}\delta A_{v} + \dot{D}^{\mu}\delta A^{v}\dot{D}_{\mu}\delta A_{v} - nijk\dot{F}^{\mu v}[\delta A_{\mu}, \delta A_{v}]$$

$$+ \dot{D}_{\mu}c^{\dagger}\dot{D}^{\mu}c - nijk\dot{D}^{\mu}\delta A^{v}[\delta A_{\mu}, \delta A_{v}] - 1/2[\delta A^{\mu}, \delta A^{v}]\; [\delta A_{\mu}, \delta A_{v}] + ic^{\dagger}[\dot{D}^{\mu}\delta A_{\mu}, c]]$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle 1/g^{v\mu} \oint_{\mu}^{v} d^{v\mu}\;\; n\, tr[1/2\dot{F}_{v\mu}\, \dot{F}^{v\mu} + n\, \dot{F}^{v\mu}\dot{D}_{v}\delta A_{\mu} + \dot{D}^{v}\delta A^{\mu}\dot{D}_{v}\delta A_{\mu} - nijk\dot{F}^{v\mu}[\delta A_{v}, \delta A_{\mu}]$$

$$+ \dot{D}_{v}c^{\dagger}\dot{D}^{v}c - nijk\dot{D}^{v}\delta A^{\mu}[\delta A_{v}, \delta A_{\mu}] - 1/2[\delta A^{v}, \delta A^{\mu}]\; [\delta A_{v}, \delta A_{\mu}] + ic^{\dagger}[\dot{D}^{v}\delta A_{v}, c]]$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle e^{-S_{eff}[\breve{\dot{A}},\delta,A,c]} = \oint_{v}^{\mu} D\delta ADcDc^{\dagger}\, e^{-S[\breve{\dot{A}},\delta,A,c]} = \; e^{-S_{eff}[\breve{\dot{A}}]}$$

$$= det^{m}\Delta_{gauge}\nabla_{gauge}det^{n}\Delta_{ghost}\nabla_{ghost}e^{\overline{\frac{1}{2g^{\breve{\dot{A}},\delta,A,c}\oint_{v}^{\mu} d_{v}^{\mu}\, n\, tr\dot{F}_{\mu v}\dot{F}^{\mu v}}}} = \Delta_{gauge\, gauge}^{\mu v\qquad\; \mu v}\nabla$$

$$= \dot{D}^{\mu v}\delta^{\mu v} + 2ijk\; [\dot{F}^{\mu v}\Delta_{ghost\, ghost}^{\mu v\qquad \mu v}\nabla - c^{\dagger} = S_{eff}[\breve{\dot{A}}, \delta, A, c]$$

$$= 1/2g_{v}^{\mu} \oint_{v}^{\mu} d_{v}^{\mu}\, n\, tr\; \dot{F}_{\mu v}\; \dot{F}^{\mu v} + 1/2Trlog\Delta_{gauge\, gauge}^{\mu v\qquad\; \mu v}\nabla - Trlog\Delta_{ghost\, ghost}^{\mu v\qquad \mu v}\nabla$$

$$= \xi_{\lambda\Omega\psi}^{\sigma\varsigma\zeta}\Sigma\iiiint \text{ħȸѬǮҖДҞɥӜѪϚ}\pi mc\mathbb{R}^{4}$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle e^{-S_{eff}[\breve{\dot{A}},\delta,A,c]} = \oint_{\mu}^{v} D\delta ADcDc^{\dagger}\, e^{-S[\breve{\dot{A}},\delta,A,c]} = \; e^{-S_{eff}[\breve{\dot{A}}]}$$

$$= det^{m}\Delta_{gauge}\nabla_{gauge}det^{n}\Delta_{ghost}\nabla_{ghost}e^{\overline{\frac{1}{2g^{\breve{\dot{A}},\delta,A,c}\oint_{\mu}^{v} d_{\mu}^{v}\, n\, tr\dot{F}_{v\mu}\dot{F}^{v\mu}}}} = \Delta_{gauge\, gauge}^{v\mu\qquad\; v\mu}\nabla$$

$$= \dot{D}^{v\mu}\delta^{v\mu} + 2ijk\; [\dot{F}^{v\mu}\Delta_{ghost\, ghost}^{v\mu\qquad v\mu}\nabla - c^{\dagger} = S_{eff}[\breve{\dot{A}}, \delta, A, c]$$

$$= 1/2g_{\mu}^{v} \oint_{\mu}^{v} d_{\mu}^{v}\, n\, tr\; \dot{F}_{v\mu}\; \dot{F}^{v\mu} + 1/2Trlog\Delta_{gauge\, gauge}^{v\mu\qquad\; v\mu}\nabla - Trlog\Delta_{ghost\, ghost}^{v\mu\qquad v\mu}\nabla$$

$$= \xi_{\lambda\Omega\psi}^{\sigma\varsigma\zeta}\Sigma\iiiint \text{ħȸѬǮҖДҞɥӜѪϚ}\pi mc\mathbb{R}^{4}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \Delta^{\mu\nu}_{ghost\,ghost}{}^{\mu\nu}\nabla = -\partial^{\mu}_{\nu} + \Delta\nabla_{\mu} - \Delta\nabla_{\nu}, \Delta\nabla_{\mu} = ijk\partial^{\mu\nu}\breve{A}_{\mu\nu} + ijk\breve{A}_{\mu\nu}\partial^{\mu\nu}, \Delta\nabla_{\nu} = [\breve{A}^{\mu\nu}, [\breve{A}_{\mu\nu}]]$$

$$= Trlog\Delta^{\mu\nu}_{ghost\,ghost}{}^{\mu\nu}\nabla = Trlog(-\partial^{\mu\nu} + \Delta\nabla_{\mu} - \Delta\nabla_{\nu})$$

$$= Trlog(-\partial^{\mu\nu}) + Trlog\,(1 + (-\partial^{\mu\nu})exp^{-n}(\Delta\nabla_{\mu} - \Delta\nabla_{\nu}))$$

$$= Tr\log(-\partial^{\mu\nu}) + Tr\,((-\partial^{\mu\nu})exp^{-n}\,(\Delta\nabla_{\mu} - \Delta\nabla_{\nu}))\,1/2Tr((-\partial^{\mu\nu})exp^{-n}\,(\Delta\nabla_{\mu}$$

$$- \Delta\nabla_{\nu}))\,exp^{\infty} \ldots \omega\delta\lambda\varphi\theta\Omega\eta\xi\phi \oiiint_{\infty}^{\infty} \partial\pi^{\infty}_{\infty} = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi} \Sigma \iiiint ħ\text{ȹѬ}\text{Ѯ}\text{ЖДЌ}\text{ɸ}\text{Ӂ}\text{Ѫ}\text{Ϛ}\pi mc\mathbb{R}^{4}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \Delta^{\nu\mu}_{ghost\,ghost}{}^{\nu\mu}\nabla = -\partial^{\nu}_{\mu} + \Delta\nabla_{\nu} - \Delta\nabla_{\mu}, \Delta\nabla_{\nu} = ijk\partial^{\nu\mu}\breve{A}_{\nu\mu} + ijk\breve{A}_{\nu\mu}\partial^{\nu\mu}, \Delta\nabla_{\mu} = [\breve{A}^{\nu\mu}, [\breve{A}_{\nu\mu}]]$$

$$= Trlog\Delta^{\nu\mu}_{ghost\,ghost}{}^{\nu\mu}\nabla = Trlog(-\partial^{\nu\mu} + \Delta\nabla_{\nu} - \Delta\nabla_{\mu})$$

$$= Trlog(-\partial^{\nu\mu}) + Trlog\,(1 + (-\partial^{\nu\mu})exp^{-n}(\Delta\nabla_{\nu} - \Delta\nabla_{\mu}))$$

$$= Tr\log(-\partial^{\nu\mu}) + Tr\,((-\partial^{\nu\mu})exp^{-n}\,(\Delta\nabla_{\nu} - \Delta\nabla_{\mu}))\,1/2Tr((-\partial^{\nu\mu})exp^{-n}\,(\Delta\nabla_{\nu}$$

$$- \Delta\nabla_{\mu}))\,exp^{\infty} \ldots \omega\delta\lambda\varphi\theta\Omega\eta\xi\phi \oiiint_{\infty}^{\infty} \partial\pi^{\infty}_{\infty} = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi} \Sigma \iiiint ħ\text{ȹѬ}\text{Ѯ}\text{ЖДЌ}\text{ɸ}\text{Ӂ}\text{Ѫ}\text{Ϛ}\pi mc\mathbb{R}^{4}$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle S_{quad} = 1/2g^{\mu}_{\nu} \oint_{\nu}^{\mu} d^{\mu}_{\nu}\, n\, tr\,(\partial_{\mu}\breve{A}_{\nu}\partial^{\mu}\breve{A}^{\nu} - \partial_{\mu}\breve{A}^{\nu}\partial_{\nu}\breve{A}^{\mu}$$

$$= 1/2g^{\mu\nu} \oint_{\nu}^{\mu} d^{\mu\nu}k/(n\pi^{\mu\nu})\, tr\,[\breve{A}_{\mu}(k)\,\breve{A}_{\nu}(-k)]\,(k^{\mu}k^{\nu} - k_{\mu}k_{\nu} + k^{\mu}_{\nu}\delta^{\mu}_{\nu})$$

$$= Trlog\,\Delta^{\mu\nu}_{ghost\,ghost}{}^{\mu\nu}\nabla$$

$$= C(adj)/8\pi^{2}(16\pi^{2}) \oint_{\nu}^{\mu} d^{\mu}_{\nu}\, k^{\rho}_{\sigma}\delta\Omega\lambda^{\dagger}/8\pi^{2}\, tr[\breve{A}_{\mu}(k)\,\breve{A}_{\nu}(-k)]\,(k^{\mu}k^{\nu} - k_{\mu}k_{\nu} + k^{\mu}_{\nu}\delta^{\mu}_{\nu})$$

$$= log\,\Lambda^{\mu\nu}_{UV}/k^{\rho}_{\sigma}\lambda\Omega\phi\xi\delta\varphi\eta c^{\dagger}\theta$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle S_{quad} = 1/2 g_{v}^{\mu} \oint_{\mu}^{v} d_{\mu}^{v}\, n\, tr\, (\partial_{v} \breve{A}_{\mu} \partial^{v} \breve{A}^{\mu} - \partial_{v} \breve{A}^{\mu} \partial_{\mu} \breve{A}^{v}$$

$$= 1/2 g^{v\mu} \oint_{\mu}^{v} d^{v\mu} k/(n\pi^{v\mu})\, tr\, [\breve{A}_{v}(k)\, \breve{A}_{\mu}(-k)]\, (k^{v}k^{\mu} - k_{v}k_{\mu} + k_{\mu}^{v}\delta_{\mu}^{v})$$

$$= Trlog\, \Delta_{ghost\, ghost}^{v\mu \quad v\mu}\nabla$$

$$= C(adj)/8\pi^{2}(16\pi^{2}) \oint_{\mu}^{v} d_{\mu}^{v}\, k_{\rho}^{\sigma} \delta\Omega\lambda^{\dagger}/8\pi^{2}\, tr[\breve{A}_{v}(k)\, \breve{A}_{\mu}(-k)]\, (k^{v}k^{\mu} - k_{v}k_{\mu} + k_{\mu}^{v}\delta_{\mu}^{v})$$

$$= log\, \Lambda_{VU}^{v\mu}/k_{\rho}^{\sigma}\lambda\Omega\phi\xi\delta\varphi\eta c^{\dagger}\theta$$

$$\hat{H} \mid \psi\rangle = E_{\psi} \mid \psi\rangle \Delta\nabla_{gauge}^{\mu v} = \Delta\nabla_{ghost}^{\mu v} \partial\delta_{v\rho}^{\mu\sigma} + nijk[\dot{F}^{\mu v}, \infty] = Tr\, log\Delta\nabla_{gauge}^{\mu v}$$

$$= 16Tr\, log\Delta\nabla_{ghost}^{\mu v} + \dot{F}_{\mu v} terms$$

$$= -1/2(2ijk)exp^{\mu v}Tr((-\partial^{\mu v})exp^{-\mu v}[\dot{F}_{\mu v}, [(-\partial^{\mu v})exp^{-\mu v}\dot{F}^{\mu v}, \infty]])$$

$$= 1/2 \oiiint_{v}^{\mu} d_{v}^{\mu} k_{\rho}^{\sigma}/(16\pi^{2})\, tr_{adj}[\breve{A}_{\mu}(k)\, \breve{A}_{v}(-k)] \oiiint_{v}^{\mu} d_{v}^{\mu} p_{\rho}^{\sigma}/(16\pi^{2}) - 16(k^{\rho}\delta^{\mu\sigma}$$

$$- k^{\sigma}\delta^{\mu\rho})\, (k_{\sigma}\delta_{\rho}^{v} - k_{\rho}\delta_{\sigma}^{v}))/\rho^{\mu v}\sigma^{\mu v}(\rho_{v}^{\mu} + k_{v}^{\mu}) = \dot{F}_{\mu v} terms$$

$$= 16C(adj)/(32\pi^{2}) \oiiint_{v}^{\mu} \frac{d^{\mu v} d_{\mu v} k_{v}^{\mu}}{16\pi^{2}} tr[\breve{A}_{\mu}(k)\, \breve{A}_{v}(-k)]\, (k^{\mu}k^{v} - k_{\mu}k_{v}$$

$$+ k_{v}^{\mu}\delta_{v}^{\mu})\, log\, \Lambda_{UV}^{\mu v}/k_{\sigma}^{\rho}\lambda\Omega\phi\xi\delta\varphi\eta c^{\dagger}\theta = 1/2\, Tr\, \log\, \Delta\nabla_{gauge}^{\mu v}$$

$$= 1/2[16/4 - 8]\, C(adj)/16\pi^{2} \oint_{v}^{\mu} d_{v}^{\mu}\, k_{\rho}^{\sigma}\delta\Omega\lambda^{\dagger}/8\pi^{2}\, tr[\breve{A}_{\mu}(k)\, \breve{A}_{v}(-k)]\, (k^{\mu}k^{v} - k_{\mu}k_{v}$$

$$+ k_{v}^{\mu}\delta_{v}^{\mu}) = log\, \Lambda_{UV}^{\mu v}/k_{\rho}^{\sigma}\lambda\Omega\phi\xi\delta\varphi\eta c^{\dagger}\theta$$

$$\hat{H} \mid \psi\rangle = E_\psi \mid \psi\rangle \Delta\nabla^{v\mu}_{gauge} = \Delta\nabla^{v\mu}_{ghost}\partial\delta^{v\sigma}_{\mu\rho} + nijk[\dot{F}^{v\mu}, \infty] = Tr\ log\Delta\nabla^{v\mu}_{gauge}$$

$$= 16Tr\ log\Delta\nabla^{v\mu}_{ghost} + \dot{F}_{v\mu}terms$$

$$= -1/2(2ijk)exp^{v\mu}Tr((-\partial^{v\mu})exp^{-v\mu}[\dot{F}_{v\mu}, [(-\partial^{v\mu})exp^{-v\mu}\dot{F}^{v\mu}, \infty]])$$

$$= 1/2 \oiiint_{\mu}^{v} d^v_\mu k^\rho_\sigma/(16\pi^2)\ tr_{adj}[\breve{A}_v(k)\ \breve{A}_\mu(-k)] \oiiint_{\mu}^{v} d^v_\mu p^\rho_\sigma\ /(16\pi^2) - 16(k^\sigma\delta^{v\rho}$$

$$- k^\rho\delta^{v\sigma})\ (k_\rho\delta^\mu_\sigma - k_\sigma\delta^\mu_\rho))/\rho^{v\mu}\sigma^{v\mu}(\rho^v_\mu + k^v_\mu) = \dot{F}_{v\mu}terms$$

$$= 16C(adj)/(32\pi^2) \oiiint_{\mu}^{v} \frac{d^{v\mu}d_{v\mu}k^v_\mu}{16\pi^2} tr[\ \breve{A}_v(k)\ \breve{A}_\mu(-k)]\ (k^v k^\mu - k_v k_\mu$$

$$+ k^v_\mu\delta^v_\mu)\ log\ \Lambda^{v\mu}_{VU}/k^\sigma_\rho\lambda\Omega\phi\xi\delta\varphi\eta c^\dagger\theta = 1/2\ Tr\ \log\ \ \Delta\nabla^{v\mu}_{gauge}$$

$$= 1/2[16/4 - 8]\ C(adj)/16\pi^2 \oint_{\mu}^{v} d^v_\mu\ k^\rho_\sigma\delta\Omega\lambda^\dagger/8\pi^2\ tr[\breve{A}_v(k)\ \breve{A}_\mu(-k)]\ (k^v k^\mu - k_v k_\mu$$

$$+ k^v_\mu\delta^v_\mu) = log\ \Lambda^{v\mu}_{VU}/k^\rho_\sigma\lambda\Omega\phi\xi\delta\varphi\eta c^\dagger\theta$$

CONCLUSIONES

En mérito al análisis de campo antes descrito – marco praxeológico (campos de gauge y campos fantasma), bajo el marco metodológico de las teorías de Yang-Mills y bajo un esquema estrictamente hamiltoniano, sin perjuicio de las demás variables conjugadas (verbigracia, sistemas lagrangiano y algebra de Lie, etc), que conforman el sistema de campos de Yang-Mills, queda demostrado: **(i)** que, las excitaciones más bajas de una teoría pura de Yang-Mills (es decir, sin campos de materia) tienen una brecha de masa finita con respecto al estado de vacío; **(ii)** que, la propiedad de confinamiento en tratándose de física de partículas; y, **(iii)** que, para un hamiltoniano cuántico relativo a un campo de Yang-Mills no abeliano, en efecto existe un valor positivo mínimo de energía, calculado a través de la siguiente constante universal[2]:

$$\mu := \inf \mathrm{Spec}(\hat{H})\backslash 0 > 0 = \xi^{\sigma\varsigma\zeta}_{\lambda\Omega\psi}\Sigma\iiiint ħф ꟾӜ Ѯ Ж Ҵ Қ ȹ Ӝ Ճ \varsigma\pi mc\mathbb{R}^4$$

En consecuencia, este trabajo, demuestra que la teoría gauge no abeliana de Yang – Mills, describe otras fuerzas en la naturaleza, especialmente la fuerza débil (responsable, entre otras cosas, de ciertas formas de radiactividad) y la fuerza fuerte o nuclear (responsable, entre otras cosas, de la unión de protones y

[2] *C. N. Yang & R. L. Mills, Physical Review, 96, 191 (1954).*

neutrones en núcleos), sin perder las premisas esenciales de la teoría de campos de Yang – Mills, esto es, por fuera de la teoría electrodébil de Glashow-Salam-Weinberg o la teoría del “campo de Higgs”.

Si bien es cierto, constituyese en una propiedad notable de la teoría cuántica de Yang-Mills, la nominada "*libertad asintótica*", la misma que, permite determinar, que a distancias cortas el campo muestra un comportamiento cuántico muy similar a su comportamiento clásico; sin embargo, a largas distancias, la teoría de Yang – Mills, como queda demostrado, también aplica a largas distancias en el campo.

Finalmente, queda demostrado concluyentemente, que: **(i)** en los campos de Yang – Mills, existe una "brecha de masa", es decir, $\Delta >$ constante, por lo que, cada excitación del vacío tiene energía de al menos Δ; **(ii)** en los campos de Yang – Mills, existe un confinamiento de quarks, partiendo de la premisa de que, los estados físicos de las partículas, como el protón, el neutrón y el pión, son invariantes; y, **(iii)** en los campos de Yang – Mills, existe una ruptura de simetría quiral, lo que significa que el vacío es potencialmente invariante bajo un cierto subgrupo de simetría completa que actúa sobre los campos de quarks.

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APÉNDICE A.

1. Formalización matemática relativa a gravedad cuántica desde la perspectiva de la teoría cuántica de campos curvos.

1.1. Análisis geométrico en espacios cuánticos curvos.

$$\mathcal{R}^{\alpha}_{\beta\mu\nu} = \partial_\mu \Upsilon^{\alpha}_{\beta\nu} - \partial_\nu \Upsilon^{\alpha}_{\mu\beta} + \Upsilon^{\alpha}_{\mu\lambda}\Upsilon^{\lambda}_{\nu\beta} - \Upsilon^{\alpha}_{\nu\lambda}\Upsilon^{\lambda}_{\mu\beta}, \Upsilon^{\alpha}_{\mu\nu} = \Gamma^{\alpha}_{\mu\nu} + \kappa^{\alpha}_{\mu\nu} + \mathcal{L}^{\alpha}_{\mu\nu}, \Gamma^{\alpha}_{\mu\nu}$$
$$= \frac{1}{2}\mathcal{g}^{\alpha\lambda}\left(\partial_\mu \mathcal{g}_{\lambda\nu} + \partial_\nu \mathcal{g}_{\lambda\mu} - \partial_\lambda \mathcal{g}_{\mu\nu}\right), \kappa^{\alpha}_{\mu\nu} = \frac{1}{2}\left(\mathcal{T}^{\alpha}_{\mu\nu} + \mathcal{T}_{\mu}{}^{\alpha}{}_{\nu} + \mathcal{T}_{\nu}{}^{\alpha}{}_{\mu}\right), \mathcal{L}^{\alpha}_{\mu\nu}$$
$$= \frac{1}{2}\left(\mathcal{Q}^{\alpha}_{\mu\nu} + \mathcal{Q}_{\mu}{}^{\alpha}{}_{\nu} + \mathcal{Q}_{\nu}{}^{\alpha}{}_{\mu}\right), \mathcal{Q}_{\alpha\mu\nu} = \nabla_\alpha \mathcal{g}_{\mu\nu} = \partial_\alpha \mathcal{g}_{\mu\nu} - \Upsilon^{\beta}_{\alpha\mu}\mathcal{g}_{\beta\nu} - \Upsilon^{\beta}_{\alpha\nu}\mathcal{g}_{\mu\beta}, \mathcal{P}^{\alpha}_{\mu\nu}$$
$$= -\frac{1}{2}\mathcal{L}^{\alpha}_{\mu\nu} + \frac{1}{4}\left(\mathcal{Q}^{\alpha} - \tilde{\mathcal{Q}}^{\alpha}\right)\mathcal{g}_{\mu\nu} - \frac{1}{4}\delta^{\alpha}\left({}^{\mu}_{\nu}\mathcal{Q}^{\nu}_{\mu}\right), \mathcal{Q} = -\mathcal{Q}_{\lambda\mu\nu}\mathcal{P}^{\lambda\mu\nu}$$

1.2. Principio variacional en espacios cuánticos curvos.

$$\delta = \int f(\mathcal{Q}, \mathcal{L}_m)\sqrt{-\mathcal{g}}\,d^4\chi, \delta\mathcal{S} = \int \left[\left(f_{\mathcal{Q}}\delta\mathcal{Q} + f_{\mathcal{L}_m}\delta\mathcal{L}_m\right)\sqrt{-\mathcal{g}} + f\delta\sqrt{-\mathcal{g}}\right]d^4\chi, \delta\mathcal{Q}$$
$$= 2\mathcal{P}_{\alpha\nu\rho}\nabla^{\alpha}\delta\mathcal{g}^{\nu\rho} - \left(\mathcal{P}_{\mu\alpha\beta}\mathcal{Q}^{\alpha\beta}_{\nu} - 2\mathcal{Q}^{\alpha\beta}{}^{\xi}_{\psi}\mathcal{P}_{\alpha\beta\nu}\right)\delta\mathcal{g}^{\mu\nu}, \mathcal{T}_{\mu\nu} = -\frac{2}{\sqrt{-\mathcal{g}}}\frac{\delta\left(\sqrt{-\mathcal{g}}\mathcal{L}_m\right)}{\delta\mathcal{g}^{\mu\nu}}$$
$$= \mathcal{g}_{\mu\nu}\mathcal{L}_m - 2\frac{\partial\mathcal{L}_m}{\partial\mathcal{g}^{\mu\nu}}, \delta\sqrt{-\mathcal{g}} = -\frac{1}{2}\sqrt{-\mathcal{g}}\mathcal{g}_{\mu\nu}\delta\mathcal{g}^{\mu\nu}, \delta\mathcal{S}$$
$$= \int \left[(f_{\mathcal{Q}}\left(2\mathcal{P}_{\alpha\nu\rho}\nabla^{\alpha}\delta\mathcal{g}^{\nu\rho} - (\mathcal{P}_{\mu\alpha\beta}\mathcal{Q}^{\alpha\beta}_{\nu} - 2\mathcal{Q}^{\alpha\beta}_{\mu}\mathcal{P}_{\alpha\beta\nu})\delta\mathcal{g}^{\mu\nu}\right)\right.$$
$$\left. + \frac{1}{2}f_{\mathcal{L}_m}\left(\mathcal{g}_{\mu\nu}\mathcal{L}_m - \mathcal{T}_{\mu\nu}\right)\delta\mathcal{g}^{\mu\nu}) - \frac{1}{2}f\mathcal{g}_{\mu\nu}\delta\mathcal{g}^{\mu\nu}\right]\sqrt{-\mathcal{g}}d^4\chi\frac{2}{\sqrt{-\mathcal{g}}}\nabla_\alpha\left(f_{\mathcal{Q}}\sqrt{-\mathcal{g}}\mathcal{P}^{\alpha}_{\mu\nu}\right)$$
$$+ f_{\mathcal{Q}}\left(\mathcal{P}_{\mu\alpha\beta}\mathcal{Q}^{\alpha\beta}_{\nu} - 2\mathcal{Q}^{\alpha\beta}_{\mu}\mathcal{P}_{\alpha\beta\nu}\right) + \frac{1}{2}f\mathcal{g}_{\mu\nu}$$
$$= \frac{1}{2}f_{\mathcal{L}_m}\left(\mathcal{g}_{\mu\nu}\mathcal{L}_m - \mathcal{T}_{\mu\nu}\right)\frac{2}{\sqrt{-\mathcal{g}}}\nabla_\alpha\left(\sqrt{-\mathcal{g}}f_{\mathcal{Q}}\mathcal{P}^{\alpha}_{\mu\nu}\right) + f_{\mathcal{Q}}q_{\mu\nu} + \frac{1}{2}f(\mathcal{Q})\mathcal{g}_{\mu\nu}$$
$$= -\mathcal{T}_{\mu\nu}\frac{2}{\sqrt{-\mathcal{g}}}\nabla_\alpha\left(f_{\mathcal{Q}}\sqrt{-\mathcal{g}}\mathcal{P}^{\alpha\mu}_{\nu}\right) + f_{\mathcal{Q}}\mathcal{P}^{\mu}_{\alpha\beta}\mathcal{Q}^{\alpha\beta}_{\nu} + \frac{1}{2}\delta^{\mu}_{\nu}f = \frac{1}{2}f_{\mathcal{L}_m}\left(\delta^{\mu}_{\nu}\mathcal{L}_m - \mathcal{T}^{\mu}_{\nu}\right)$$

$$\delta = \int\left[f(\mathcal{Q}, \mathcal{L}_m)\sqrt{-\mathcal{g}} + \lambda^{\beta\gamma}_{\alpha}\mathcal{T}^{\alpha}_{\beta\gamma} + \xi^{\beta\mu\nu}_{\alpha}\mathcal{R}^{\alpha}_{\beta\mu\nu}\right]d^4\chi, \delta\left(\lambda^{\beta\gamma}_{\alpha}\mathcal{T}^{\alpha}_{\beta\gamma}\right) = 2\lambda^{\beta\gamma}_{\alpha}\delta\zeta^{\alpha}_{\beta\gamma}, \delta\left(\xi^{\beta\mu\nu}_{\alpha}\mathcal{R}^{\alpha}_{\beta\mu\nu}\right)$$
$$= \xi^{\beta\mu\nu}_{\alpha}\left[\nabla_\mu\left(\delta\zeta^{\alpha}_{\nu\beta}\right) - \nabla_\nu\left(\delta\zeta^{\alpha}_{\mu\beta}\right)\right] = 2\zeta^{\beta\mu\nu}_{\alpha}\nabla_\beta\left(\delta\zeta^{\alpha}_{\mu\nu}\right) \simeq 2\left(\nabla_\beta\xi^{\nu\beta\mu}_{\alpha}\right)\delta\xi^{\alpha}_{\mu\nu}, \delta\mathcal{S}$$
$$= \int\left(4\sqrt{-\mathcal{g}}f_{\mathcal{Q}}\mathcal{P}^{\mu\nu}_{\alpha} + \mathcal{H}^{\mu\nu}_{\alpha} + 2\nabla_\beta\xi^{\nu\beta\mu}_{\alpha} + 2\lambda^{\mu\nu}_{\alpha}\right)d^4\chi\delta\zeta^{\alpha}_{\mu\nu}, \mathcal{H}^{\mu\nu}_{\alpha}$$
$$= \sqrt{-\mathcal{g}}f_{\mathcal{L}_m}\frac{\delta\mathcal{L}_m}{\delta\zeta^{\alpha}_{\mu\nu}}, \nabla_\mu\nabla_\nu\left(4\sqrt{-\mathcal{g}}f_{\mathcal{Q}}\mathcal{P}^{\mu\nu}_{\alpha} + \mathcal{H}^{\mu\nu}_{\alpha} + 2\nabla_\beta\xi^{\nu\beta\mu}_{\alpha} + 2\lambda^{\mu\nu}_{\alpha}\right)$$

1.3. Modelo Klein – Gordon en espacios cuánticos curvos.

$$\delta_\phi = -\frac{1}{2}\left(\nabla_\alpha\phi\nabla^\alpha\phi + \xi\mathcal{R}\phi^2 + \frac{m_0^2}{2}\phi^2\right)\sqrt{-g}\,d^4\chi(\boxdot + m_0^2 + \xi\mathcal{R})\phi f_\mathcal{Q}\mathfrak{G}_{\mu\nu} + \frac{1}{2}g_{\mu\nu}(f - f_\mathcal{Q}\mathcal{Q})$$

$$+ 2f_{\mathcal{Q}\mathcal{Q}}(\partial_\alpha\mathcal{Q})\mathcal{P}^\alpha_{\mu\nu}$$

$$= \frac{1}{2}f_{\mathcal{L}_m}(g_{\mu\nu}\mathcal{L}_m - \mathcal{T}_{\mu\nu})\int \Delta\Sigma\Psi_\alpha \int \mathfrak{G}_{\mu\nu} + \frac{1}{2}g_{\mu\nu}(\Sigma - \mathcal{Q}) + \Psi_\alpha\,\mathcal{P}^\alpha_{\mu\nu}$$

$$= \frac{1}{2}\Delta(g_{\mu\nu}\mathcal{L}_m - \mathcal{T}_{\mu\nu}) \int_{\zeta^\dagger \leftrightarrow \blacksquare\triangle}^{\otimes \triangleq \propto^\star} \mathcal{R}^\diamond \frac{1}{2}\Delta(\mathcal{T} - 4\mathcal{L}_m) + 2(\Sigma - \mathcal{Q}) + \partial_\alpha\mathcal{Q}\left(\mathcal{Q}^\alpha\right.$$

$$\left.- \tilde{\mathcal{Q}}^\alpha\right)\frac{\partial^2 \circledcirc^*}{\partial\mathcal{Q}}\log f_\mathcal{Q}\left(\boxtimes + m_{eff}^2\right)\phi, m_{eff}^2$$

$$= m_0^2 + \xi\left[\frac{1}{2}\Delta(\mathcal{T} - 4\mathcal{L}_m) + 2(\Sigma - \mathcal{Q}) + \partial_\alpha\mathcal{Q}(\mathcal{Q}^\alpha - \tilde{\mathcal{Q}}^\alpha)\frac{\partial^2 \circledcirc^*}{\partial\mathcal{Q}}\log f_\mathcal{Q}\right]$$

$$\delta = \frac{e^2}{\hbar c}\epsilon^{\lambda\mu\nu}\int d^2\chi dt\left[\frac{1}{8\pi}\mathfrak{a}_\lambda^\mathcal{T}\kappa\partial_\mu\mathfrak{a}_\nu - \frac{\mathrm{A}_\lambda^1}{2\varpi}(t_1 \oplus t_2)^\mathcal{T}\partial_\mu\mathfrak{a}_\nu - \frac{\mathrm{A}_\lambda^2}{2\varpi}(t_1' \oplus t_2')^\mathcal{T}\partial_\mu\mathfrak{a}_\nu\right]$$

$$\mathrm{A}_\mu^1 t_1 \oplus \mathrm{A}_\mu^2 t_2 = \kappa\mathfrak{a}_\mu \Longrightarrow \kappa^{-1}\left(\mathrm{A}_\mu^1 t_1 \oplus \mathrm{A}_\mu^2 t_2\right) = \mathfrak{a}_\mu$$

1.4. Ecuaciones de Balance Energía – Momentum en espacios cuánticos curvos.

$$\nabla_\mu\omega_\nu^\mu = \mathfrak{D}_\mu\omega_\nu^\mu - \frac{1}{2}\mathcal{Q}_\rho\omega_\nu^\rho - \mathcal{L}^\alpha_{\mu\nu}\omega_\lambda^\mu, \mathfrak{D}_\mu\left[\frac{1}{2}f_{\mathcal{L}_m}\left(\delta_\nu^\mu\mathcal{L}_m - \mathcal{T}_\nu^\mu\right)\right]$$

$$= \frac{1}{2}\partial_\nu f + \mathfrak{D}_\mu\left(f_\mathcal{Q}\mathcal{P}^\mu_{\alpha\beta}\mathcal{Q}_\nu^{\alpha\beta}\right) + \mathfrak{D}_\mu\left[\frac{2}{\sqrt{-g}}\nabla_\alpha\left(f_\mathcal{Q}\sqrt{-g}\mathcal{P}_\nu^{\alpha\mu}\right)\right]\frac{1}{2\sqrt{-g}}\nabla_\alpha\nabla_\mu\mathcal{H}_\nu^{\alpha\mu}$$

$$- \frac{1}{2}f_{\mathcal{L}_m}\mathfrak{D}_\mu\mathcal{T}_\nu^\mu$$

$$= \frac{1}{2}f_\mathcal{Q}\partial_\nu\mathcal{Q} + \nabla_\mu\left(f_\mathcal{Q}\mathcal{P}^\mu_{\alpha\beta}\mathcal{Q}_\nu^{\alpha\beta}\right) + \frac{1}{2}\mathcal{Q}_\mu\left(f_\mathcal{Q}\mathcal{P}^\mu_{\alpha\beta}\mathcal{Q}_\nu^{\alpha\beta}\right) + \mathcal{L}^\rho_{\mu\nu}\left(f_\mathcal{Q}\mathcal{P}^\mu_{\alpha\beta}\mathcal{Q}_\rho^{\alpha\beta}\right)$$

$$+ \frac{2}{\sqrt{-g}}\mathcal{L}^\rho_{\mu\nu}\nabla_\alpha\left(\sqrt{-g}f_\mathcal{Q}\mathcal{P}_\rho^{\alpha\mu}\right) + \frac{1}{\sqrt{-g}}\mathcal{Q}_\mu\nabla_\alpha\left(\sqrt{-g}f_\mathcal{Q}\mathcal{P}_\nu^{\alpha\mu}\right), \mathfrak{D}_\mu\mathcal{T}_\nu^\mu$$

$$= \frac{1}{f_{\mathcal{L}_m}\sqrt{-g}}\left[\nabla_\alpha\nabla_\mu\mathcal{H}_\nu^{\alpha\mu} - 2\mathcal{Q}_\mu\nabla_\alpha\left(f_\mathcal{Q}\sqrt{-g}\mathcal{P}_\nu^{\alpha\mu}\right)\right], \nabla_\mu\left(4\sqrt{-g}f_\mathcal{Q}\mathcal{P}_\alpha^{\mu\nu} + \mathcal{H}_\alpha^{\mu\nu}\right.$$

$$\left.+ 2\nabla_\beta\xi_\alpha^{\nu\beta\mu} + 2\lambda_\alpha^{\mu\nu}\right) = \sqrt{-g}\mathrm{A}_\alpha^\nu, \nabla_\nu\left(\sqrt{-g}\mathrm{A}_\alpha^\nu\right) = \sqrt{-g}\nabla_\nu\mathrm{A}_\alpha^\nu + \frac{\sqrt{-g}}{2}\mathcal{Q}_\nu\mathrm{A}_\alpha^\nu, \mathfrak{D}_\mu\mathcal{T}_\nu^\mu$$

$$= \frac{1}{f_{\mathcal{L}_m}}\left[\frac{2}{\sqrt{-g}}\nabla_\alpha\nabla_\mu\mathcal{H}_\nu^{\alpha\mu} + \nabla_\mu\mathrm{A}_\nu^\mu - \nabla_\mu\left(\frac{1}{\sqrt{-g}}\nabla_\alpha\mathcal{H}_\nu^{\alpha\mu}\right)\right], \mathcal{T}_\nu^\mu$$

$$= (p + \dot{\rho})\mu_\mu\mu^\nu + p\delta_\nu^\mu + 3\mathcal{H}\mathrm{B}_\mu$$

$$\frac{d^2\chi^\mu}{ds^2} + \Gamma^\mu_{\alpha\beta}\mu^\alpha\mu^\beta = \frac{\hbar^{\mu\nu}}{p + \rho}(\mathrm{B}_\nu - \mathfrak{D}_\nu\rho) = \mathfrak{F}^\mu$$

1.5. Método Friedmann-Lemaître-Robertson-Walker para espacios cuánticos curvos.

$$ds^2 = -dt^2 + \alpha^2(t)(d\chi^2 + d\gamma^2 + dz^2)3\mathcal{H}^2\frac{1}{4f_Q}[f - f_{\mathcal{L}_m}(\rho + \mathcal{L}_m)]\mathcal{H} + \underline{3\mathcal{H}^2} + \frac{\dot{f}_Q}{f_Q}\mathcal{H} = \frac{1}{4f_Q}[f + f_{\mathcal{L}_m}(\rho - \mathcal{L}_m)]\frac{d}{dt}(f_Q, \mathcal{H}) = \frac{f_{\mathcal{L}_m}}{4}(p + \dot{\rho})$$

$$q = -1 - \frac{\mathcal{H}}{\mathcal{H}^2} = \frac{1}{4f_Q\mathcal{H}^2}\left(2Qf_Q + 4\hat{f}_Q\mathcal{H} - f - f_{\mathcal{L}_m}(\rho - \mathcal{L}_m)\right)2\bar{\bar{\mathcal{H}}} + 3\mathcal{H}^2 = \frac{1}{4f_Q}\left[f + f_{\mathcal{L}_m}(\rho + 2p - \mathcal{L}_m) - 2\frac{\dot{f}_Q}{f_Q}\mathcal{H}, 3\mathcal{H}^2 = \rho_{eff} + 2\widehat{\mathcal{H}} + 3\mathcal{H}^2 - \rho_{eff}\right]$$

$$\overline{\rho_{eff}} = \frac{1}{4\tilde{f}_Q}[f - f_{\mathcal{L}_m}(\rho + \mathcal{L}_m)], \rho_{eff} = 2\frac{\hat{f}_Q}{f_Q}\mathcal{H} - \frac{1}{4f_Q}[f + f_{\mathcal{L}_m}(\rho + 2p - \mathcal{L}_m)], \hat{\rho}_{eff} + 3\mathcal{H}(\rho_{eff} + p_{eff}), \rho_{eff} = \frac{1}{4}\Delta[\delta - (\rho + \mathcal{L}_m)], p_{eff} = 2\frac{\hat{f}_Q}{f_Q}\mathcal{H} - \frac{1}{4}\Delta[\delta + (\rho + 2p - \mathcal{L}_m)]$$

$$\tilde{\rho} + 3\mathcal{H}(p + \dot{\rho}) = \frac{1}{\Delta}\frac{d}{dt}[\Delta(\delta - \mathcal{L}_m)] + 3\mathcal{H}\left\{8\frac{\dot{f}_Q}{f_Q}\frac{\mathcal{H}}{\Delta} - \left[\left(1 + \frac{\widehat{\Delta}}{\Delta}\rho + p\right)\right]\right\} = \Gamma$$

$$q = \frac{1}{2} + \frac{3}{2}\frac{p_{eff}}{\rho_{eff}} = \frac{1}{2} + 12\frac{2\dot{f}_Q\mathcal{H} - \left(\frac{1}{4}\right)[f + f_{\mathcal{L}_m}(\rho + 2p - \mathcal{L}_m)]}{f - f_{\mathcal{L}_m}(\rho + \mathcal{L}_m)}\frac{d}{dt}(1 + z)\mathcal{H}(z)\frac{d}{dz}q(z) - 1 + (1 + z)\frac{\mathcal{H}'(z)}{\mathcal{H}(z)}$$

1.6. Solución de Sitter para espacios cuánticos curvos.

$$f(Q) = \mathcal{F}_0 Q + 4\Lambda, 6\mathcal{H}_0^2 = 12\mathcal{F}_0\mathcal{H}_0^2 + \frac{4\Lambda}{8\mathcal{F}_0}, \mathcal{H}_0 = \sqrt{\frac{\Lambda}{6\mathcal{F}_0}}$$

1.7. Modelos cosmológicos aplicables, bajo la óptica de la teoría cuántica de campos curvos.

17.1. Modelo A – Partícula o Antipartícula Masiva.

$$\begin{aligned}3\mathcal{H}^2 = -\frac{\beta}{2\alpha} + \frac{\rho}{\alpha}2\widehat{\mathcal{H}} + 3\mathcal{H}^2 - 3\mathcal{H}^2(\gamma-1) - \frac{\beta\gamma}{2\alpha}, \rho_{eff} = \frac{\rho}{\alpha} - \frac{\beta}{2\alpha}, p_{eff} \\ = 3\mathcal{H}^2(\gamma-1) + \frac{\beta\gamma}{2\alpha}\ddot{\rho} \\ + 3\mathcal{H}''(p+\rho)\mathcal{H}(z)[(12\mathcal{H}_0^2\alpha+\beta)(1+z)^{3\gamma} - \beta/12\alpha\,]^{\frac{1}{2}}\end{aligned}$$

17.2. Modelo B – Partícula o Antipartícula Supermasiva.

$$\begin{aligned}3\mathcal{H}^2 = -\frac{2}{\alpha}(1-\gamma^2)\rho^2 - \frac{\beta}{2\alpha}2\widehat{\mathcal{H}} + 3\mathcal{H}^2 - \frac{\beta}{2\alpha} - \frac{(\gamma-1)(\beta+12\alpha\mathcal{H}^2)}{4\alpha(\gamma+1)}, \rho_{eff} \\ = -\frac{2}{\alpha}(1-\gamma^2)\rho^2 - \frac{\beta}{2\alpha}, p_{eff} \\ = \frac{\beta}{2\alpha} + \frac{(\gamma-1)(\beta+12\alpha\mathcal{H}^2)}{4\alpha(\gamma+1)}\hat{\rho} + \frac{6\gamma}{\gamma+1}\mathcal{H}\rho(\alpha)\rho_0\alpha^{-\frac{3\gamma}{(\gamma+1)}}\tilde{\rho} + 6\gamma\mathcal{H}\rho \\ = 3\gamma^2/\gamma + 1\mathcal{H}\rho = \Gamma\mathcal{H}(z)\left[(12\mathcal{H}_0^2\alpha+\beta)(1+z)^{12\gamma/1+\gamma} - \beta/12\alpha\,\right]^{\frac{1}{2}}\end{aligned}$$

$$\begin{aligned}\delta_{eff} = -\frac{e^2}{4\pi\hbar c}\epsilon^{\lambda\mu\nu}\int d^2\chi dt\big[\mathrm{A}_\lambda^1\partial_\mu\mathrm{A}_\nu^1(t_1\oplus t_2)^{\mathcal{T}}\kappa^{-1}(t_1\oplus t_2)^{\mathcal{T}} \\ + \mathrm{A}_\lambda^2\partial_\mu\mathrm{A}_\nu^2(t_1'\oplus t_2')^{\mathcal{T}}\kappa^{-1}(t_1'\oplus t_2')^{\mathcal{T}}\big]\end{aligned}$$

$$\begin{aligned}\delta_{eff} = -\frac{e^2}{4\pi\hbar c}\epsilon^{\lambda\mu\nu}\int d^2\chi dt\big[\mathrm{A}_\lambda^0\partial_\mu\mathrm{A}_\nu^0(t_1\oplus t_2)^{\mathcal{T}}\kappa^{-1}(t_1\oplus t_2)^{\mathcal{T}} \\ + \left(\mathrm{A}_\lambda^0\partial_\mu\delta\mathrm{A}_\nu^1 + \delta\mathrm{A}_\nu^1\partial_\mu\mathrm{A}_\lambda^0\right)(t_1\oplus t_2)^{\mathcal{T}}\kappa^{-1}(t_1\oplus t_2)^{\mathcal{T}} \\ + \left(\mathrm{A}_\lambda^0\partial_\mu\delta\mathrm{A}_\nu^2 + \delta\mathrm{A}_\nu^2\partial_\mu\mathrm{A}_\lambda^0\right)(t_1'\oplus t_2')^{\mathcal{T}}\kappa^{-1}(t_1'\oplus t_2')^{\mathcal{T}} + \mathcal{O}(\delta\Lambda)^2\big]\end{aligned}$$

$$\tilde{v}_1 = (t_1\oplus t_2)^{\mathcal{T}}\kappa^{-1}(t_1\oplus t_2)^{\mathcal{T}}, \tilde{v}_2 = (t_1'\oplus t_2')^{\mathcal{T}}\kappa^{-1}(t_1'\oplus t_2')^{\mathcal{T}}$$

$$\delta_{\varkappa} = -\int d^2\chi dt\,\delta^{\mu\nu}j_\mu^{\mathfrak{I}}\mathfrak{a}_\nu$$

$$j^\lambda = \frac{e^2}{\hbar c}\epsilon^{\lambda\mu\nu}\left[-\partial_\mu(\mathrm{A}_\nu^1 t_1\oplus\mathrm{A}_\nu^2 t_2) + \kappa\partial_\mu\mathfrak{a}_\nu\right] \Longrightarrow \kappa^{-1}j^\lambda = \frac{e^2}{\hbar c}\epsilon^{\lambda\mu\nu}\left[-\kappa^{-1}\partial_\mu(\mathrm{A}_\nu^1 t_1\oplus\mathrm{A}_\nu^2 t_2) + \partial_\mu\mathfrak{a}_\nu\right]$$

$$\mathcal{Q}_1 = -e(t_1\oplus t_2)^{\mathcal{T}}\kappa^{-1}\ell$$

$$\mathcal{Q}_2 = -e(t_1'\oplus t_2')^{\mathcal{T}}\kappa^{-1}\ell$$

$$\theta_\delta = \pi\ell_e^{\mathfrak{I}}\kappa^{-1}\ell\,\beth 2\pi$$

1.8. Partículas y antipartículas deformantes en espacios curvos. Comportamiento y dinámica cuántica.

$$m_{eff}^2 = m_0^2 + \xi\left[3\mathcal{H}^2(8-6\gamma) - \frac{6}{4}\left(\frac{\beta\gamma}{\alpha}\right)\right] = m_0^2 + m_{\mathcal{QL}_m}^2, m_{eff}^2$$
$$= m_0^2 + \xi\left[\left(\frac{2-\gamma}{1+\gamma}\right)\left(12\mathcal{H}^2 + \frac{\beta}{\alpha} - \frac{2\beta}{\alpha}\right)\right] m_0^2 + m_{\mathcal{QL}_m}^2 dt$$

2. Sistema alternativo al Modelo Estándar: Comportamiento de Hiperpartículas, Hipopartículas, Hiperantipartículas e Hipoantipartículas en un espacio cuántico curvo.

2.1. Deformación de campo.

$$\psi(\chi_2, \chi_1 \cdots \chi_\eta) = c\psi(\chi_2, \chi_1 \cdots \chi_\eta), \psi(\chi_2, \chi_1 \cdots \chi_\eta) = c\psi(\chi_2, \chi_1 \cdots \chi_\eta) = c^4\psi(\chi_2, \chi_1 \cdots \chi_\eta)$$

2.2. Transformación matricial.

$$\psi^{\mathcal{J}}\left(\{\chi_j\}_{j=1}^{\eta}\right)\Big|_{\chi_j \leftrightarrow \chi_{j+1}} = \sum_{\mathcal{J}} (\mathcal{R}_j)_{\mathcal{J}}^{\mathcal{J}}\, \psi^{\mathcal{J}}\left(\{\chi_j\}_{j=1}^{\eta}\right)$$

2.3. Conmutaciones.

$$\hat{\psi}_{i,\alpha}^{-}\hat{\psi}_{j,\beta}^{+} = \sum_{cd} \Re_{\beta d}^{\alpha c}\, \hat{\psi}_{j,c}^{+}\hat{\psi}_{i,d}^{-} + \delta_{\alpha\beta}\delta_{ij}, \hat{\psi}_{i,\alpha}^{+}\hat{\psi}_{j,\beta}^{+} = \sum_{cd} \Re_{\alpha\beta}^{cd}\, \hat{\psi}_{j,c}^{+}\hat{\psi}_{i,d}^{+}, \hat{\psi}_{i,\alpha}^{-}\hat{\psi}_{j,\beta}^{-}$$
$$= \sum_{cd} \Re_{dc}^{\beta\alpha}\, \hat{\psi}_{j,c}^{-}\hat{\psi}_{i,d}^{-}, \hat{e}_{ij}$$
$$\equiv \sum_{\alpha=1}^{m} \hat{\psi}_{i,\alpha}^{+}\hat{\psi}_{j,\alpha}^{-}\left[\hat{e}_{ij}, \hat{\psi}_{\kappa,\beta}^{+}\right]\delta_{j\kappa}\hat{\psi}_{i,\beta}^{+}\left[\hat{e}_{ij}, \hat{\psi}_{\kappa,\beta}^{-}\right] - \delta_{j\kappa}\hat{\psi}_{j,\beta}^{-}\left[\hat{e}_{ij}, \hat{e}_{\kappa l}\right]\delta_{j\kappa}\hat{e}_{il} - \delta_{il}\hat{e}_{\kappa j}$$

$$\hat{\psi}_{i,\alpha}^{+}\hat{\psi}_{j,\beta}^{+} = -\hat{\psi}_{j,\alpha}^{+}\hat{\psi}_{i,\beta}^{+}\, \big|\psi\rangle \hat{\psi}_{i_1,\alpha_1}^{+}\hat{\psi}_{i_2,\alpha_2}^{+} \bigotimes \hat{\psi}_{i_\eta,\alpha_\eta}^{+}\, |0\rangle$$

$$z_{\mathcal{R}} = \left(e^{-\beta\epsilon}\right) \equiv Tr\left[e^{-\beta\epsilon\hat{\eta}}\right] = \sum_{\eta=0}^{\infty} d_\eta\, e^{-\hat{\eta}\beta\epsilon}\hat{\xi}_{ij}\hat{\psi}_{i,\alpha}^{+}\hat{\xi}_{ij}^{\dagger}\hat{\psi}_{j,\alpha}^{+} \otimes \hat{\xi}_{ij}\hat{\psi}_{j,\alpha}^{+}\hat{\xi}_{ij}^{\dagger}\hat{\psi}_{i,\alpha}^{+}$$

$$\hat{\xi}_{ij}\big|0, i\alpha, j\beta\rangle = \left(\hat{\xi}_{ij}\hat{\psi}_{i,\alpha}^{+}\hat{\xi}_{ij}^{\dagger}\right)\left(\hat{\xi}_{ij}\hat{\psi}_{j,\beta}^{+}\hat{\xi}_{ij}^{\dagger}\right)\hat{\xi}_{ij}|0\rangle = \hat{\psi}_{j,\alpha}^{+}\hat{\psi}_{i,\beta}^{+}|0\rangle = \sum_{\alpha',\beta'} \Re_{\alpha\beta}^{\beta'\alpha'}\, |0, i\beta', j\alpha'\rangle$$

$$\hat{\mathcal{H}} = \sum_{1 \le i,j \le \mathcal{N}} \hbar_{ij}\, \hat{e}_{ij} = \sum_{\substack{1 \le i,j \le \mathcal{N} \\ 1 \le \alpha \le m}} \hbar_{ij}\hat{\psi}_{i,\alpha}^{+}\, \hat{\psi}_{j,\alpha}^{-}$$

$$\langle\bar{\eta}_\kappa\rangle_\beta \equiv \frac{Tr\left[\bar{\eta}_\kappa e^{-\beta\hat{\mathcal{H}}}\right]}{Tr\left[e^{-\beta\hat{\mathcal{H}}}\right]} = \frac{z_{\mathcal{R}}'\left(e^{-\beta\epsilon_\kappa}\right)e^{-\beta\epsilon_\kappa}}{z_{\mathcal{R}}\left(e^{-\beta\epsilon_\kappa}\right)}$$

$$\hat{\mathcal{H}} = \sum_{i,\alpha} \mathcal{J}_i\left(\hat{\chi}_{i,\alpha}^{+}\hat{\gamma}_{i+1,\alpha}^{-} + \hat{\chi}_{i,\alpha}^{-}\hat{\gamma}_{i+1,\alpha}^{+}\right) - \sum_{i,\alpha} \mu_i\hat{\gamma}_{i,\alpha}^{+}\, \hat{\gamma}_{i,\alpha}^{-}$$

$$\widehat{\mathcal{H}} = \sum_{i,\alpha} \mathcal{J}_i(\hat{\psi}^+_{i,\alpha}\hat{\psi}^-_{i+1,\alpha} + \hat{\psi}^-_{i,\alpha}\hat{\psi}^+_{i+1,\alpha}) - \sum_i \mu_i \hat{\eta}_i$$

2.4. Conmutadores.

$$[\hat{e}_{ij}, \hat{\psi}^+_{\kappa,\beta}] = \sum_\alpha (\hat{\psi}^+_{i,\alpha}\hat{\psi}^-_{j,\alpha}\hat{\psi}^+_{\kappa,\beta} - \hat{\psi}^+_{\kappa,\beta}\hat{\psi}^+_{i,\alpha}\hat{\psi}^-_{j,\alpha})$$

$$= \sum_\alpha \hat{\psi}^+_{i,\alpha}\left(\sum_{c,d} \mathfrak{R}^{\alpha c}_{\beta d}\,\hat{\psi}^+_{\kappa,c}\hat{\psi}^-_{i,d} + |\delta_{j\kappa}\delta_{\alpha\beta}|^\dagger\right) - \sum_\alpha \hat{\psi}^+_{\kappa,\beta}\,\hat{\psi}^+_{i,\alpha}\hat{\psi}^-_{j,\alpha}$$

$$= \sum_{\alpha,c,d} |\mathfrak{R}^{\alpha c}_{\beta d}\hat{\psi}^+_{i,\alpha}\hat{\psi}^+_{\kappa,c}|^\dagger \hat{\psi}^-_{j,d} + \delta_{j\kappa}\hat{\psi}^+_{i,\beta} - \sum_\alpha \hat{\psi}^+_{\kappa,\beta}\,\hat{\psi}^+_{i,\alpha}\hat{\psi}^-_{j,\alpha} = |\delta_{j\kappa}\hat{\psi}^+_{i,\beta}|^{\circledcirc}$$

$$[\hat{e}_{ij}, \hat{\psi}^-_{\kappa,\beta}] = -\delta_{i\kappa}\hat{\psi}^-_{j,\beta}, [\hat{e}_{ij}, \hat{e}_{\kappa l}] = \sum_\beta [\hat{e}_{ij}\hat{\psi}^+_{\kappa,\beta}]\,\hat{\psi}^-_{l,\beta} + \sum_\beta \hat{\psi}^+_{\kappa,\beta}\,[\hat{e}_{ij}\hat{\psi}^-_{l,\beta}]$$

$$= \sum_\beta |\delta_{j\kappa}\hat{\psi}^+_{i,\beta}\hat{\psi}^-_{l,\beta}|^{\otimes} - \sum_\beta |\delta_{j\kappa}\hat{\psi}^+_{i,\beta}\hat{\psi}^-_{l,\beta}|^{\otimes} = \delta_{j\kappa}\hat{e}_{il} - \delta_{il}\hat{e}_{j\kappa}$$

$$\hat{\psi}^-_{i,\alpha} = \sum_{\kappa=1}^{\eta} \mathcal{U}^{\circledast}_{\kappa i}\,\tilde{\psi}^-_{\kappa,\alpha}, \hat{\psi}^+_{i,\alpha} = \sum_{\kappa=1}^{\eta} \mathcal{U}^{\circledast}_{\kappa i}\,\tilde{\psi}^+_{\kappa,\alpha}$$

$$\widehat{\mathcal{H}} = \sum_{\substack{1\le\kappa,\rho\le\mathcal{N}\\ 1\le i\le m}} \hbar'_{\kappa\rho}\tilde{\psi}^+_{\kappa,\alpha}\tilde{\psi}^-_{\rho,\alpha} \equiv \sum_{1\le\kappa,\rho\le\mathcal{N}} \hbar'_{\kappa\rho}\tilde{e}_{\kappa\rho}$$

$$\mathcal{Z}(\beta) \equiv Tr[e^{-\beta\widehat{\mathcal{H}}}] = \prod_\kappa z_{\mathcal{R}}\left(e^{-\beta\epsilon_\kappa}\right), \mathcal{F}(\beta) = -\frac{1}{\beta}\ln \mathcal{Z}(\beta) = -\frac{1}{\beta}\sum_\kappa \ln z_{\mathcal{R}}\left(e^{-\beta\epsilon_\kappa}\right)$$

$$\langle\hat{\eta}^l_\kappa\rangle_\beta = \frac{Tr[\hat{\eta}^l_\kappa e^{-\beta\widehat{\mathcal{H}}}]}{Tr[e^{-\beta\widehat{\mathcal{H}}}]} = \frac{(\chi\partial_\chi)^l z_{\mathcal{R}}(\chi)}{z_{\mathcal{R}}(\chi)}\Bigg|_{\chi=e^{-\beta\epsilon_\kappa}} \langle\tilde{e}_{\kappa\rho}\rangle_\beta = \delta_{\kappa\rho}\langle\bar{\eta}_\kappa\rangle_\beta$$

$$\langle\hat{e}_{ij}\rangle_\beta = \sum_\kappa \mathcal{U}_{\kappa i}\,\mathcal{U}^{\circledast}_{\kappa j}\langle\bar{\eta}_\kappa\rangle_\beta$$

$$\widehat{\mathcal{H}}_1 = -\sum_\nu \widehat{\mathrm{A}}_\nu - \sum_\rho \widehat{\mathrm{B}}_\rho, \widehat{\mathcal{H}}_2 = -\sum_{\langle ij\rangle} \hat{\hbar}_{ij} - \sum_l \mu_l\,\hat{\gamma}^+_{l,\alpha}\hat{\gamma}^-_{l,\alpha}$$

$$\widehat{\mathcal{H}}_2 = \sum_{\langle ij\rangle, 1\le\alpha\le m} (\mathcal{J}_{ij}\hat{\psi}^+_{j,\alpha}\hat{\psi}^-_{i,\alpha} + \hbar\otimes c) - \sum_l \mu_l\hat{\eta}_l$$

2.5. Parapartículas y paraantipartículas en espacios cuánticos curvos. Partículas masivas y supermasivas y antipartículas masivas y supermasivas. Comportamiento y dinámica cuántica.

$$\hat{\psi}_i\hat{\psi}_j = \omega\hat{\psi}_j\hat{\psi}_i\left[\left[\hat{\psi}_\kappa^\dagger\hat{\psi}_l\right]_\pm\hat{\psi}_m\right] = 2\delta_{\kappa m}\hat{\psi}_l\left[\left[\hat{\psi}_l^\dagger\hat{\psi}_\kappa\right]_\pm\hat{\psi}_m\right]\sum_{\alpha_j',\alpha_{j+1}'}\mathfrak{R}_{\alpha_j'\alpha_{j+1}'}^{\alpha_j\alpha_{j+1}}\psi_{\alpha_1\otimes\alpha_j'\alpha_{j+1}'\otimes\alpha_\eta}$$

$$= \psi_{\alpha_1\otimes\alpha_j\alpha_{j+1}\otimes\alpha_\eta}\left|\begin{matrix}\alpha_1\alpha_2\otimes\alpha_\eta\\ \eta_1\eta_2\otimes\eta_\eta\end{matrix}\right\rangle = \hat{\psi}_{\eta_1,\alpha_1}^{(1)+}\hat{\psi}_{\eta_2,\alpha_2}^{(2)+}\bigotimes\hat{\psi}_{\eta_\eta,\alpha_\eta}^{(\eta)+}|0\rangle\hat{\psi}_{\eta,\alpha}^{(i)+}$$

$$\equiv \frac{1}{\sqrt{\eta!}}\sum_{\alpha_1\alpha_2\otimes\alpha_\eta}\psi_{\alpha_1\alpha_2\otimes\alpha_\eta}^{\alpha}\hat{\psi}_{i,\alpha_1}^{+}\hat{\psi}_{i,\alpha_2}^{+}\bigotimes\hat{\psi}_{i,\alpha_\eta}^{+}\sum_{\alpha_1\alpha_2\otimes\alpha_\eta}\psi_{\alpha_1\alpha_2\otimes\alpha_\eta}^{\beta*}\psi_{\alpha_1\alpha_2\otimes\alpha_\eta}^{\alpha}$$

$$= \delta_{\alpha\beta}\left\langle\begin{matrix}\beta_1\beta_2\otimes\beta_\eta\\ \eta_1'\eta_2'\otimes\eta_\eta'\end{matrix}\middle|\begin{matrix}\alpha_1\alpha_2\otimes\alpha_\eta\\ \eta_1\eta_2\otimes\eta_\eta\end{matrix}\right\rangle = \prod_{j=1}^{\eta}\delta_{\eta_j,\eta_j'},\delta_{\alpha_j\beta_j}$$

$$\mathcal{U}\mathcal{R}_{j,j+1}\mathcal{U}^\dagger = -\chi_{j,j+1}\mathcal{U}\left|\chi_1\cdots\chi_\eta\right\rangle$$

$$= \left|f_{\chi_\eta}f_{\chi_{\eta-1}}\cdots f_{\chi_2}(\chi_1)\cdots f_{\chi_\eta}(\chi_{\eta-1}),\chi_\eta\right\rangle\mathfrak{X}_{\mathcal{R},\eta} \cong \mathfrak{X}_{\prod\boxtimes\mathcal{R},\eta}\left(\prod\boxtimes\mathcal{R}\right)_{\mathcal{CD}}^{\mathcal{AB}} \equiv \prod_{\kappa l}^{ij}\mathfrak{R}_{cd}^{\alpha\beta}$$

$$\mathfrak{Y}_\eta = \left\{\hat{\psi}_{\alpha_1}^{+}\hat{\psi}_{\alpha_2}^{+}\boxtimes\hat{\psi}_{\alpha_\eta}^{+}|0\rangle\middle|1\leq\alpha_j\leq m,j\middle|\right\}$$

$$\mathcal{R}_{j,j+1} = \underset{(1)}{\mathbb{I}}\otimes\underset{(j-1)}{\mathbb{I}}\otimes\underset{(j,j+1)}{\mathfrak{R}}\otimes\underset{(j+2)}{\mathbb{I}}\otimes\underset{(\eta)}{\mathbb{I}}\mathcal{R}_{j,j+1}\psi = \psi\left(\ln\mathfrak{a}^{\otimes\eta}\right)\mathbb{C}_{\mathcal{R}}^{(\eta)}\langle\hat{\psi}_\alpha^{+}\rangle$$

$$\cong \frac{\mathfrak{a}^{\otimes\eta}}{\sum_{j=1}^{\eta-1}\left[\left(\mathbb{I}-\mathcal{R}_{j,j+1}\right)\mathfrak{a}^{\otimes\eta}\right]}\left\{|\psi\rangle\in\mathcal{V}\middle|\mathcal{H}_j\middle||\psi\rangle = |\psi\rangle,1\leq j\leq\kappa\right\}$$

$$\cong \frac{\mathcal{V}}{\sum_{j=1}^{\kappa}\left[\left(\mathbb{I}-\mathcal{H}_j\right)\mathcal{V}\right]} \cong \left\{\sum_{j=1}^{\kappa}\left[\left(\mathbb{I}-\mathcal{H}_j\right)\mathcal{V}\right]\right\}^\perp = \bigcap_{j=1}^{\kappa}\left[\left(\mathbb{I}-\mathcal{H}_j\right)\mathcal{V}\right]^\perp$$

$$\langle\Lambda_1|\Lambda_2\rangle = \prod_{\alpha,\beta}\left\langle\hat{e}_{-\beta}^\dagger\middle|\hat{e}_{-\alpha}\middle|\Lambda\right\rangle = \left\langle\Lambda\middle|\prod_{\alpha,\beta}\hat{e}_\beta\,\hat{e}_{-\alpha}\middle|\Lambda\right\rangle\psi^{\alpha_1\alpha_2\alpha_3}(\chi_2,\chi_1,\chi_3)$$

$$= \sum_{\beta_1,\beta_2}\mathfrak{R}_{\beta_1\beta_2}^{\alpha_1\alpha_2}\psi^{\beta_1\beta_2\beta_3}(\chi_1,\chi_2,\chi_3)$$

$$|\psi\rangle = \frac{1}{\sqrt{\eta!}}\sum_{\mathcal{I},\chi_1\boxtimes\chi_\eta}\psi^{\mathcal{I}}\left(\chi_1\cdots\chi_\eta\right)\hat{\psi}_{\chi_1,\alpha_1}^{+}\cdots\hat{\psi}_{\chi_\eta,\alpha_\eta}^{+}|0\rangle$$

$$\hat{\gamma}_\alpha^-\hat{\gamma}_\beta^+ = \sum_{c,d}\mathcal{R}_{\beta d}^{\alpha c}\,\hat{\gamma}_c^+\hat{\gamma}_d^- + \delta_{\alpha\beta},\hat{\gamma}_\alpha^+\hat{\gamma}_\beta^+ = \sum_{c,d}\mathcal{R}_{\alpha\beta}^{cd}\,\hat{\gamma}_c^+\hat{\gamma}_d^+,\hat{\gamma}_\alpha^-\hat{\gamma}_\beta^- = \sum_{c,d}\mathcal{R}_{dc}^{\beta\alpha}\,\hat{\gamma}_c^-\hat{\gamma}_d^-,\hat{\chi}_\alpha^-\hat{\chi}_\beta^+$$

$$= \sum_{c,d}\mathcal{R}_{d\beta}^{c\alpha}\,\hat{\chi}_c^+\hat{\chi}_d^- + \delta_{\alpha\beta},\hat{\chi}_\alpha^+\hat{\chi}_\beta^+ = \sum_{c,d}\mathcal{R}_{\beta\alpha}^{dc}\,\hat{\chi}_c^+\hat{\chi}_d^+,\hat{\chi}_\alpha^-\hat{\chi}_\beta^-$$

$$= \sum_{c,d}\mathcal{R}_{cd}^{\alpha\beta}\,\hat{\chi}_c^-\hat{\chi}_d^-\left[\hat{\chi}_\alpha^+,\hat{\gamma}_\beta^+\right]\otimes\left[\hat{\chi}_\alpha^-,\hat{\gamma}_\beta^-\right]\sum_\alpha\hat{\chi}_\alpha^+\hat{\chi}_\alpha^- = \sum_\alpha\hat{\gamma}_\alpha^+\hat{\gamma}_\alpha^-$$

$$|\eta,\alpha\rangle \equiv \frac{1}{\sqrt{\eta!}} \sum_{\alpha_1\alpha_2\otimes\alpha_\eta} \psi^{\alpha}_{\alpha_1\alpha_2\otimes\alpha_\eta}\, \hat{\gamma}^{+}_{\alpha_1}\hat{\gamma}^{+}_{\alpha_2} \cdots \hat{\gamma}^{+}_{\alpha_\eta}|0\rangle$$

$$\hat{\gamma}^{\pm}_{\alpha}|\eta,\alpha\rangle = \sum_{\beta=1}^{d_{\eta\pm1}} \hat{\Upsilon}^{\dagger}_{\alpha,\beta\alpha}\hat{\Upsilon}^{\pm}_{\alpha,\beta\alpha}\,|\eta\pm1,\beta\rangle, \hat{\chi}^{\pm}_{\alpha}|\eta,\alpha\rangle = \sum_{\beta=1}^{d_{\eta\pm1}} \hat{\mathrm{X}}^{\dagger}_{\alpha,\beta\alpha}\hat{\mathrm{X}}^{\pm}_{\alpha,\beta\alpha}\,|\eta\pm1,\beta\rangle \sum_{\beta} \hat{\Upsilon}^{\pm}_{\alpha,\beta\alpha}\,\psi^{\beta}_{\alpha_0\alpha_1\otimes\alpha_\eta}$$
$$= \frac{1}{\sqrt{\eta+1}}\bar{\Upsilon}^{\alpha_0\alpha_1\otimes\alpha_\eta}_{\alpha,\beta_1\otimes\beta_\eta} \sum_{\beta} \hat{\mathrm{X}}^{\pm}_{\alpha,\beta\alpha}\,\psi^{\beta}_{\alpha_\eta\alpha_1\otimes\alpha_0}$$
$$= \frac{1}{\sqrt{\eta+1}}\bar{\mathrm{X}}^{\alpha_\eta\otimes\alpha_1\alpha_0}_{\beta_\eta\otimes\beta_1,\alpha}\psi^{\alpha}_{\beta_1\otimes\beta_\eta} \sum_{\beta} \hat{\Upsilon}^{\pm}_{\alpha,\beta\alpha}\,\psi^{\beta}_{\alpha_2\otimes\alpha_\eta} = \sqrt{\eta}\psi^{\alpha}_{\alpha\alpha_2\otimes\alpha_\eta} \sum_{\beta} \hat{\mathrm{X}}^{\pm}_{\alpha,\beta\alpha}\,\psi^{\beta}_{\alpha_\eta\otimes\alpha_2}$$
$$= \sqrt{\eta}\psi^{\alpha}_{\alpha_\eta\otimes\alpha_2\alpha} + \langle\bar{\mathcal{R}}_{\eta-1,\eta} + \bar{\mathcal{R}}_{\eta,\eta-1}\rangle[\hat{\eta},\hat{\chi}^{\pm}_{\alpha}] = \pm\hat{\chi}^{\pm}_{\alpha}, [\hat{\eta},\hat{\gamma}^{\pm}_{\alpha}] = \pm\hat{\gamma}^{\pm}_{\alpha}$$

$$\hat{\mathcal{T}}^{\pm}_{\alpha\beta}|\eta,\alpha\rangle = \sum_{\beta=1}^{d_\eta} \hat{\mathcal{T}}^{\pm}_{\alpha\beta,\beta\alpha}\,|\eta,\beta\rangle \sum_{\beta} \hat{\mathcal{T}}^{+}_{\alpha\beta,\beta\alpha}\,\psi^{\dagger\beta}_{\alpha_1\alpha_2\otimes\alpha_\eta} \sum_{\alpha'_1\otimes\alpha'_\eta} \psi^{\alpha}_{\alpha'_1\alpha'_2\otimes\alpha'_\eta}$$
$$\boxtimes \left\| \boxed{\alpha} \begin{matrix}\alpha_1\\ \mathcal{R}\\ \alpha'_1\end{matrix} \right\| \left| \boxed{\alpha} \begin{matrix}\alpha_2\\ \mathcal{R}\\ \alpha'_2\end{matrix} \right| \otimes \left\langle \boxed{\alpha} \begin{matrix}\alpha_\eta\\ \mathcal{R}\\ \alpha'_\eta\end{matrix} \right\rangle \left| \frac{\partial\beta}{\partial t} + \frac{\partial\varphi}{\partial\omega} - \frac{\partial\lambda}{\partial\delta} + \frac{\partial\xi}{\partial\Gamma} - \frac{\partial\Delta}{\partial\phi} \right| \otimes \left| \frac{\partial\epsilon}{\partial\zeta} - \frac{\partial\varepsilon}{\partial\theta} + \frac{\partial\kappa}{\partial\varpi} - \frac{\partial\sigma}{\partial\rho} \right.$$
$$\left. + \frac{\partial\tau}{\partial\Lambda} \right| d\Psi d\varsigma \sum_{\beta} \hat{\mathcal{T}}^{-}_{\alpha\beta,\beta\alpha}\,\psi^{\star\beta}_{\alpha_1\alpha_2\otimes\alpha_\eta} \sum_{\alpha'_1\otimes\alpha'_\eta} \psi^{\alpha}_{\alpha'_1\alpha'_2\otimes\alpha'_\eta}$$
$$\boxtimes \left\| \boxed{\alpha} \begin{matrix}\alpha_1\\ \mathcal{R}\\ \alpha'_1\end{matrix} \right\| \left| \boxed{\alpha} \begin{matrix}\alpha_2\\ \mathcal{R}\\ \alpha'_2\end{matrix} \right| \otimes \left\langle \boxed{\alpha} \begin{matrix}\alpha_\eta\\ \mathcal{R}\\ \alpha'_\eta\end{matrix} \right\rangle \left| \frac{\partial\beta}{\partial t} + \frac{\partial\varphi}{\partial\omega} - \frac{\partial\lambda}{\partial\delta} + \frac{\partial\xi}{\partial\Gamma} - \frac{\partial\Delta}{\partial\phi} \right| \otimes \left| \frac{\partial\epsilon}{\partial\zeta} - \frac{\partial\varepsilon}{\partial\theta} + \frac{\partial\kappa}{\partial\varpi} - \frac{\partial\sigma}{\partial\rho} + \frac{\partial\tau}{\partial\Lambda} \right| d\Psi d\varsigma$$

$$\hat{\jmath}_{\Lambda}\hat{\chi}^{+}_{\alpha} = \sum_{\beta,\mathrm{B}} \omega^{\beta\mathrm{B}}_{\alpha\Lambda}\hat{\chi}^{+}_{\beta}\hat{\jmath}_{\mathrm{\beta}}, \hat{\mathcal{R}}_{\Lambda}\hat{\chi}^{+}_{\alpha}$$
$$= \sum_{\beta,\mathrm{B}} \omega^{\beta\mathrm{B}}_{\alpha\Lambda}\hat{\chi}^{+}_{\beta}\hat{\mathcal{R}}_{\mathrm{\beta}} \left\langle \begin{matrix}\mu^{+}\\ \mu^{-}\end{matrix} \right\rangle \left\langle \begin{matrix}\mu^{-}\\ \mu^{+}\end{matrix} \right\rangle [\mu^{+}]^{\mathrm{B}\beta}_{\alpha\Lambda} \begin{pmatrix}\alpha & \cdots & \beta\\ \vdots & \ddots & \vdots\\ \beta & \cdots & \alpha\end{pmatrix} [\mu^{-}]^{\Lambda\alpha}_{\beta\mathrm{B}} \begin{pmatrix}\beta & \cdots & \alpha\\ \vdots & \ddots & \vdots\\ \alpha & \cdots & \beta\end{pmatrix} \begin{vmatrix}\mu^{+}_{1q} & \mu^{+}_{2q}\\ \nu^{+}_{1q} & \nu^{+}_{2q}\end{vmatrix} \oint \mathcal{R}'$$

$$\left\| \begin{matrix}- & \omega^{+} & +\\ i & \kappa & j\end{matrix} \right\| = \sum_{\alpha=1}^{m} \hat{\psi}^{+}_{j,\alpha}\hat{\psi}^{-}_{i,\alpha} \left\| \begin{matrix}+ & \omega^{-} & -\\ i & \kappa & j\end{matrix} \right\| = \sum_{\alpha=1}^{m} \hat{\psi}^{+}_{i,\alpha}\hat{\psi}^{-}_{j,\alpha}$$

$$\hat{\eta}_i = \sum_{\alpha=1}^{m} \hat{\psi}^{+}_{i,\alpha}\hat{\psi}^{-}_{i,\alpha} = \sum_{\alpha=1}^{m} \hat{\gamma}^{+}_{i,\alpha}\hat{\gamma}^{-}_{i,\alpha} = \sum_{\alpha=1}^{m} \hat{\psi}'^{+}_{i,\alpha}\hat{\psi}'^{-}_{i,\alpha}\,\hat{\psi}^{+}_{i_1,\alpha_1}\hat{\psi}^{+}_{i_2,\alpha_2} \otimes \hat{\psi}^{+}_{i_\eta,\alpha_\eta}|\Omega\rangle$$

$$\Big|\psi\rangle = \frac{1}{\eta_j}\hat{\eta}_j|\psi\rangle = \frac{1}{\eta_j}\sum_{\alpha=1}^{m} \hat{\psi}^{+}_{j,\alpha}\hat{\psi}^{-}_{j,\alpha}|\psi\rangle\,\hat{\psi}^{+}_{i,\alpha}(\mathcal{P}_1)\hat{\psi}^{+}_{j,\beta}(\mathcal{P}_2) = \sum_{cd} \mathfrak{R}^{cd}_{\alpha\beta}\,\hat{\psi}^{+}_{j,c}(\mathcal{P}_2)\hat{\psi}^{+}_{i,d}(\mathcal{P}_1)$$

$$\hat{\gamma}^{+}_{i,\alpha}\hat{\gamma}^{+}_{j,\beta}|\mathfrak{G}\rangle = \hat{\psi}^{+}_{i,\alpha}\hat{\psi}^{+}_{j,\beta}|\mathfrak{G}\rangle \equiv |\mathfrak{G}, i\alpha, j\beta\rangle$$

$$\hat{c}_l = \sum_{c=1}^{4} c\left\|\hat{\gamma}_{l,c}^{+}\hat{\gamma}_{l,c}^{-}\right\|, \hat{c}_i = |\mathfrak{G}, i\alpha', j\beta'\rangle = \sum_{c} \hat{\gamma}_{i,c}^{+}\hat{\gamma}_{i,c}^{-}\,\hat{\gamma}_{i,\alpha'}^{+}\hat{\gamma}_{j,\beta'}^{+}|\mathfrak{G}\rangle = \beta'\hat{\gamma}_{i,\beta'}^{+}\hat{\gamma}_{j,\alpha'}^{+}|\mathfrak{G}\rangle$$
$$= \beta'|\mathfrak{G}, i\beta', j\alpha'\rangle$$

2.6. Efecto Hall en campos cuánticos curvos.

$${}_{\beta}^{\alpha}\hat{v}_1^{\dagger} = {}_{\nabla\triangle}^{\Delta\boxtimes}\left\|\frac{\hat{v}_1^{\circledast}}{1-\alpha v_1-\beta v_2}\right\|_{\Delta\star}^{\nabla\diamond}, {}_{\beta}^{\alpha}\hat{v}_2^{\triangleq} = {}_{\nabla\between}^{\Delta\wr}\left\|\frac{\hat{v}_2^{\circledast}}{1-\alpha v_2-\beta v_1}\right\|_{\Delta\odot}^{\nabla\odot}$$

$$\delta_z = \langle\frac{\bar{v}_1-\bar{v}_2}{\bar{v}_1+\bar{v}_2}\rangle = \left|\frac{\Delta v}{\tilde{v}_\zeta}\right|^{\ddagger}\int\frac{\partial^2\ \bowtie}{\partial\ \triangleq}d\mathfrak{H}$$

$$\xi_{eff} = -(j_\varsigma + 2j_\varrho)\frac{\psi_0}{ec_\phi}d\varphi, j_\varrho = \frac{\hat{v}_2^{\circledast}}{\hbar}\xi_{eff} = -\frac{\hat{v}_2^{\circledast}}{1+2\hat{v}_2^{\circledast}}j_\varsigma$$
$$\kappa = \begin{pmatrix}\kappa_1 & \cdots & \beta\mathcal{J}\\ \vdots & \ddots & \vdots\\ \beta\mathcal{J}^{\mathcal{T}} & \cdots & \kappa_2\end{pmatrix}t_1\oplus t_2{}_1^2(1,2)\kappa = \begin{Vmatrix}3 & 1 & 1\\ 1 & 3 & 2\\ 1 & 2 & 3\end{Vmatrix}, t = \begin{Vmatrix}1\\1\\1\end{Vmatrix}$$

$$\mathcal{Q}_1 = -e(t_1\oplus t_2)^{\mathfrak{I}}\kappa^{-1}\mathbb{I}, \mathcal{Q}_2 = e(t_1'\oplus t_2')^{\mathfrak{I}}\kappa^{+1}\mathbb{J}, \theta_\delta = \pi\mathbb{I}^{\mathfrak{I}}\kappa^{-1}\mathbb{I}, \ell_1 \equiv \sum_{i=1}^{\dim t_1}\ell_i, \ell_2$$
$$\equiv \sum_{i=1}^{\dim t_2}\ell_{i+\dim t_1}$$

$$\delta\mathfrak{E}_{1,\chi} = -\frac{2\Phi_0}{ec}j_{1,\gamma} - \frac{\Phi_0}{ec}j_{2,\gamma}$$

$$\delta\mathfrak{E}_{1,\gamma} = -\frac{2\Phi_0}{ec}j_{1,\chi} - \frac{\Phi_0}{ec}j_{2,\chi}$$

$$\delta\mathfrak{E}_{2,\chi} = -\frac{\Phi_0}{ec}j_{1,\gamma} - \frac{2\Phi_0}{ec}j_{2,\gamma}$$

$$\delta\mathfrak{E}_{2,\gamma} = -\frac{\Phi_0}{ec}j_{1,\chi} + \frac{2\Phi_0}{ec}j_{2,\chi}$$

$$j_{1,\chi} = \sigma_{\chi\chi}^1\left[\xi - \frac{2\Phi_0}{ec}j_{1,\gamma} - \frac{\Phi_0}{ec}j_{2,\gamma}\right] - \sigma_{\chi\gamma}^1\left[\frac{2\Phi_0}{ec}j_{1,\chi} + \frac{\Phi_0}{ec}j_{2,\chi}\right]$$

$$j_{2,\chi} = \sigma_{\chi\chi}^2\left[-\frac{\Phi_0}{ec}j_{1,\gamma} - \frac{2\Phi_0}{ec}j_{2,\gamma}\right] - \sigma_{\chi\gamma}^2\left[\frac{\Phi_0}{ec}j_{1,\chi} + \frac{2\Phi_0}{ec}j_{2,\chi}\right]$$

$$j_{1,\gamma} = \sigma_{\chi\chi}^{1}\left[\frac{2\Phi_0}{ec} j_{1,\chi} + \frac{\Phi_0}{ec} j_{2,\chi}\right] + \sigma_{\chi\gamma}^{1}\left[\xi - \frac{2\Phi_0}{ec} j_{1,\gamma} - \frac{\Phi_0}{ec} j_{2,\gamma}\right]$$
$$j_{2,\gamma} = \sigma_{\chi\chi}^{2}\left[\frac{\Phi_0}{ec} j_{1,\chi} + \frac{2\Phi_0}{ec} j_{2,\chi}\right] + \sigma_{\chi\gamma}^{2}\left[-\frac{\Phi_0}{ec} j_{1,\gamma} - \frac{2\Phi_0}{ec} j_{2,\gamma}\right]$$

$$j_{1,\gamma} = \frac{\hat{v}_1^{\circledast}\left(1 + 2\hat{v}_2^{\circledast}\right)}{1 + 2\left(\hat{v}_1^{\circledast} + \hat{v}_2^{\circledast}\right) + 3\hat{v}_1^{\circledast}\hat{v}_2^{\circledast}} \frac{e^2}{\hbar} \mathfrak{E}$$

$$j_{2,\gamma} = \frac{\hat{v}_1^{\circledast}\hat{v}_2^{\circledast}}{1 + 2\left(\hat{v}_1^{\circledast} + \hat{v}_2^{\circledast}\right) + 3\hat{v}_1^{\circledast}\hat{v}_2^{\circledast}} \frac{e^2}{\hbar} \mathfrak{E}$$

$$j_{1,\chi} = \frac{\hat{v}_1^{\circledast 2} + \left(1 + 2\hat{v}_2^{\circledast}\right)^2}{\left[1 + 2\left(\hat{v}_1^{\circledast} + \hat{v}_2^{\circledast}\right) + 3\hat{v}_1^{\circledast}\hat{v}_2^{\circledast}\right]^2} \sigma_{\chi\chi} \mathfrak{E}$$

$$j_{2,\chi} = \frac{\hat{v}_1^{\circledast} + \hat{v}_2^{\circledast} + 2\left(\hat{v}_1^{\circledast 2} + \hat{v}_2^{\circledast 2}\right)}{\left[1 + 2\left(\hat{v}_1^{\circledast} + \hat{v}_2^{\circledast}\right) + 3\hat{v}_1^{\circledast}\hat{v}_2^{\circledast}\right]^2} \sigma_{\chi\chi} \mathfrak{E}$$

$$\hat{v}_1^{\circledast 2} + \left(1 + 2\hat{v}_2^{\circledast}\right)^2 = \hat{v}_1^{\circledast} + \hat{v}_2^{\circledast} + 2\left(\hat{v}_1^{\circledast 2} + \hat{v}_2^{\circledast 2}\right)$$

$$\hat{v}_2^{\circledast 2} + \left(1 + 2\hat{v}_1^{\circledast}\right)^2 = \hat{v}_1^{\circledast} + \hat{v}_2^{\circledast} + 2\left(\hat{v}_1^{\circledast 2} + \hat{v}_2^{\circledast 2}\right)$$

$$\left(1 + \hat{v}_1^{\circledast}\right)^2 + \left(1 + \hat{v}_2^{\circledast}\right)^2$$

2.7. Análisis matricial para espacios cuánticos curvos.

$$\kappa_i = \sigma_i \mathbb{I} + \rho_i \mathbb{J}, \kappa^{-1} = \sigma_i \mathbb{I} - \frac{\sigma_i \rho_i}{\rho_i \, dim \, \kappa_i + \sigma_i} \mathcal{J}$$
$$\kappa^{-1} = \begin{Vmatrix} \sigma_1 \mathbb{I} + \lambda_1 \mathcal{J}_1 & \lambda' \mathcal{J} \\ \lambda' \mathcal{J}^{\mathcal{T}} & \sigma_2 \mathbb{J} + \lambda_2 \mathcal{J}_2 \end{Vmatrix}$$

$$\mathcal{Q}_1 = -e(t_1 \bigoplus t_2)^{\mathfrak{J}} \kappa^{-1} \mathbb{I} = -e \sum_{i,j=1}^{\eta} \kappa_{ij}^{-1} \mathbb{I}_j - e \sum_{i=1}^{\eta} \sum_{j=1+\eta}^{\eta+m} \kappa_{ij}^{-1} \mathbb{I}_j$$
$$= -e \sum_{i,j=1}^{\eta} \left(\sigma_1 \delta_{ij} + \lambda_1\right) \mathbb{I}_j - e\eta\lambda' \sum_{j=1}^{m} \mathbb{I}_j = -e[(\sigma_1 + \eta\lambda_1)\ell_1 + \eta\lambda'\ell_2]$$

$$\mathbb{I}^{\mathcal{T}}\kappa^{-1}\mathbb{I} = \sum_{i,j=1}^{\eta} \mathbb{J}_i\mathbb{I}_j\kappa_{ij}^{-1} + \sum_{i,j=1+\eta}^{\eta+m} \mathbb{J}_i\mathbb{I}_j\kappa_{ij}^{-1} + 2\sum_{i=1}^{\eta}\sum_{j=1+\eta}^{\eta+m} \mathbb{J}_i\mathbb{I}_j\kappa_{ij}^{-1}$$
$$= \sum_{i,j=1}^{\eta} \mathbb{J}_i\mathbb{I}_j\left(\sigma_1\delta_{ij} + \lambda_1\right) + \sum_{i,j=1+\eta}^{\eta+m} \mathbb{J}_i\mathbb{I}_j\left(\sigma_2\delta_{ij} + \lambda_2\right) + 2\lambda'\sum_{i=1}^{\eta}\mathbb{J}_i\sum_{j=1+\eta}^{m+\eta}\mathbb{I}_j$$
$$= \sigma_1\sum_{i=1}^{\eta}\mathbb{J}_i^2 + \sigma_2\sum_{i=1}^{m}\mathbb{J}_{i+\eta}^2 + \lambda_1\ell_1^2 + \lambda_2\ell_2^2 + 2\lambda'\ell_1\ell_2$$

$$\sigma_1\sum_{i=1}^{\eta}\mathbb{J}_i^2\,(\text{ג}2) \longrightarrow \sigma_1(\mathcal{J}_\kappa + \delta_1)^2 + \sigma_2\left(\mathcal{J}_j - \delta_1\right)^2 + \sigma_1(\text{ד}2)$$
$$= 2\sigma_1\delta_1\left(\mathcal{J}_\kappa + \mathcal{J}_j\right) + 2\sigma_1\delta_1^2 + \sigma_1\sum_{i=1}^{\eta}\mathbb{J}_i^2\,(\text{ג}2) = \sigma_1\sum_{i=1}^{\eta}\mathbb{J}_i^2\,(\text{א}2)$$

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FE DE ERRATAS – 10 de enero del 2025.

En todas las ecuaciones contenidas en todos los artículos publicados por este autor, hasta la actualidad (10 de enero del 2025), en tanto corresponda por rigor matemático, se incorporará cualquiera de estos formatos de fracción $\square\frac{\square}{\square}$, $\frac{\square}{\square}\square$, $\square\frac{\square}{\square}\square$, $\frac{\square}{\square}$, ${}^{\square}\!/_{\square}$, $\square/\square$ o $\frac{\square}{\square}$, según sea el caso.

APÉNDICE B.

1. Partículas y antipartículas relativistas.

1.1. Gravedad relativista en espacios cuánticos curvos.

$$\langle \mu, \nu \rangle = g(\mu, \nu)$$

$$\mathrm{A}^{\mu}_{\nu\rho}\mathrm{B}^{\rho}_{\mu} = \sum_{\mu=0}^{3}\sum_{\rho=0}^{3}\mathrm{A}^{\mu}_{\nu\rho}\mathrm{B}^{\rho}_{\mu}$$

$$\langle \mu, \nu \rangle = u^{\mu}v^{\nu}g\left(\partial_{\mu}, \partial_{\nu}\right) = g_{\mu\nu}u^{\mu}v^{\nu}$$

$$\left(\nabla_{\mu} - \partial_{\mu}\right)v^{\nu} = \Gamma^{\nu}_{\mu\rho}v^{\rho}$$

$$\nabla_{\mu}\nabla_{\nu}f = \nabla_{\nu}\nabla_{\mu}f\forall f \in \mathfrak{C}^{1}(\mathcal{M})\nabla_{\mu}g_{\nu\rho}$$

$$\Gamma^{\lambda}_{\mu\nu} = \frac{1}{2}g^{\lambda\kappa}\left(\partial_{\mu}g_{\kappa\nu} + \partial_{\nu}g_{\kappa\mu} - \partial_{\kappa}g_{\mu\nu}\right)\left[\nabla_{\mu}\nabla_{\nu} - \nabla_{\nu}\nabla_{\mu}\right]v^{\rho} = \mathcal{R}^{\rho}_{\lambda\mu\nu}v^{\lambda}$$

$$\mathcal{S} = \frac{c^{4}}{32\pi\mathcal{G}}\int\sqrt{-g}\mathcal{R}d^{4}\chi + \int\sqrt{-g}\mathcal{L}_{m}d^{4}\chi$$

$$\mathcal{G} \coloneqq \mathcal{R}_{\mu\nu} - \frac{1}{2}\mathcal{R}g_{\mu\nu} = \frac{16\pi\mathcal{G}}{c^{4}}\mathcal{T}_{\mu\nu}$$

$$\mathcal{T}_{\mu\nu} = \frac{-2}{\sqrt{-g}}\frac{\delta\left(\sqrt{-g}\mathcal{L}_{m}\right)}{\delta g_{\mu\nu}}$$

$$\mathcal{R}^{\rho}_{\sigma\mu\nu} = \partial_{\mu}\Gamma^{\rho}_{\sigma\nu} + \Gamma^{\alpha}_{\sigma\nu}\Gamma^{\rho}_{\alpha\mu} - \partial_{\nu}\Gamma^{\rho}_{\sigma\mu} + \Gamma^{\alpha}_{\sigma\mu}\Gamma^{\rho}_{\alpha\nu}$$

1.2. Presión y densidad (Modelo Tolman-Oppenheimer-Volkoff - TOV).

$$ds^{2} = e^{2\mathrm{v}(r)}dt^{2} - e^{2\phi(r)}dr^{2} - r^{2}d\Omega^{2}$$

$$\mathcal{T}^{\mu\nu} = (\rho + p)u^{\mu}u^{\nu} - pg^{\mu\nu}$$

$$\mathcal{G}_{tt} = -e^{2(\nu-\phi)}\left(\frac{1}{r^{2}} - 2\frac{\phi'}{r}\right) + \frac{e^{2\nu}}{r^{2}}$$

$$\mathcal{G}_{rr} = -\left(\frac{1}{r^{2}} - 2\frac{\nu'}{r}\right) + \frac{e^{2\phi}}{r}$$

$$\mathcal{G}_{\theta\theta} = -r^{2}e^{-2\phi}\left(\nu'' + \nu'^{2} - \phi'\nu' + \frac{\nu' - \phi'}{r}\right)$$

$$\mathcal{T}_{\mu\nu} = (\rho + p)u_{\mu}u_{\nu} - pg_{\mu\nu}$$

$$\mathcal{T}_{tt} = \rho e^{2\nu}$$

$$\mathcal{T}_{rr} = -pe^{2\phi}$$

$$\mathcal{T}_{\theta\theta} = -pr^2$$

$$e^{2(\nu-\phi)}\left(\frac{1}{r^2} - 2\frac{\phi'}{r}\right) - \frac{e^{2\nu}}{r^2} = -16\pi\rho e^{2\nu} - \left(\frac{1}{r^2} - 2\frac{\nu'}{r}\right) + \frac{e^{2\phi}}{r}$$

$$= -16\pi p e^{2\phi} e^{-2\phi}\left(\nu'' + \nu'^2 - \phi'\nu' + \frac{\nu' - \phi'}{r}\right) = 16\pi p$$

$$\frac{1}{r^2}\frac{d}{dr}\left[r\left(1 - e^{-2\phi(r)}\right)\right] = 16\pi\rho$$

$$e^{-2\phi(r)} = 1 - \frac{16\pi}{r}\int_0^r \rho(s)s^2 ds = 1 - \frac{2m(r)}{r}$$

$$m(r) = 4\pi\int_0^r s^2\rho(s)ds$$

$$\frac{dp}{dr} = -\frac{[m(r) + 8\pi r^3 p(r)][\rho(r) + p(r)]}{r^2\left(1 - \frac{2m(r)}{r}\right)}$$

$$\frac{dm}{dr} = 8\pi r^2\rho(r)$$

1.3. Termodinámica (Modelo Tolman-Oppenheimer-Volkoff – TOV).

$$\mathcal{T}d\mathcal{S} = d\mathfrak{E} + pd\mathcal{V} - \mu d\mathcal{N}$$

$$\mathcal{T}d(s\mathcal{V}) = d(\rho\mathcal{V}) + pd\mathcal{V} - \mu d(n\mathcal{V})$$

$$\mathcal{T}sd\mathcal{V} + \mathcal{T}\mathcal{V}ds = \rho d\mathcal{V} + \mathcal{V}d\rho + pd\mathcal{V} - \mu n d\mathcal{V} - \mu\mathcal{V}dn$$

$$\mathcal{T}ds = d\rho - \mu dn$$

$$s = \frac{1}{\mathcal{T}}(p + \rho - un)$$

$$\mathcal{S} = \int_0^{\mathcal{R}} s(r)d\mathcal{V}^{(3)} = \int_0^{\mathcal{R}} s(r)\, e^{\phi(r)} r^2 dr d\Omega = 4\pi\int_0^{\mathcal{R}} \frac{r^2 s(r)}{\sqrt{1 - \frac{2m(r)}{r}}}$$

$$\mathcal{N} = 4\pi\int_0^{\mathcal{R}} \frac{r^2 n(r)}{\sqrt{1 - \frac{2m(r)}{r}}} dr$$

$$\mathcal{L}(m, m', n) = \left[s\left(\rho(m')\right), n + \lambda n(r)\right]\left[1 - \frac{2m(r)}{r}\right]^{-\frac{1}{2}} r^2 \langle\frac{\partial\mathcal{L}}{\partial n}\frac{\partial\mathcal{L}}{\partial m}\rangle + \langle\frac{d}{dr}\frac{\partial\mathcal{L}}{\partial m'}\frac{\partial s}{\partial n}\frac{\mu}{\mathcal{T}}\rangle + |\lambda|$$

$$\frac{\partial \mathcal{L}}{\partial m} = [s(r) + \lambda n(r)]\left[1 - \frac{2m(r)}{r}\right]^{-\frac{3}{2}} r$$

$$\frac{\partial \mathcal{L}}{\partial m'} = \frac{\partial s}{\partial m'}\left[1 - \frac{2m(r)}{r}\right]^{-\frac{1}{2}} r^2 = \frac{\partial s}{\partial \rho}\frac{\partial \rho}{\partial m'}\left[1 - \frac{2m(r)}{r}\right]^{-\frac{1}{2}} r^2$$

$$\frac{\partial \mathcal{L}}{\partial m'} = \frac{1}{\mathcal{T}}\frac{1}{8\pi r^2}\left[1 - \frac{2m(r)}{r}\right]^{-\frac{1}{2}} r^2 = \frac{1}{4\pi \mathcal{T}}\left[1 - \frac{2m(r)}{r}\right]^{-\frac{1}{2}}$$

$$\frac{d}{dr}\frac{\partial \mathcal{L}}{\partial m'} = \frac{\left(\frac{m'}{r} - \frac{m}{r^2}\right) - \left(1 - \frac{2m(r)}{r}\right)\frac{\mathcal{T}'}{\mathcal{T}}}{8\pi \mathcal{T}(r - 2m)^{3/2}}$$

$$\frac{\partial \mathcal{L}}{\partial m} = \frac{p + \rho}{\mathcal{T}}\left[1 - \frac{2m(r)}{r}\right]^{-\frac{3}{2}} r$$

$$\frac{\mathcal{T}'}{\mathcal{T}} r^2 \left[1 - \frac{2m}{r}\right] = -(m + 8\pi r^3 p)$$

$$dp = d(\mathcal{T}s) - d\rho + (\mu n) = s d\mathcal{T} + \mathcal{T} ds - d\rho + n d\mu + \mu dn$$

$$dp = s d\mathcal{T} + n d\mu$$

$$\frac{dp}{dr} = s\mathcal{T}' + n\mu' = s\mathcal{T}' + n\lambda\mathcal{T}' = \frac{\mathcal{T}'}{\mathcal{T}}(\rho + p)$$

$$\frac{dp}{dr} = -\frac{[m(r) + 8\pi r^3 p(r)][\rho(r) + p(r)]}{r^2\left(1 - \frac{2m(r)}{r}\right)}$$

$$\mathcal{T}s = \rho(m, m') + p\big(\rho(m, m')\big) - \mu n$$

$$\mathcal{L}(m, m', n) = \left[s\big(\rho(m, m')\big), n + \lambda n(r)\right]\left[1 - \frac{2m(r)}{r}\right]^{-\frac{1}{2}} r^2$$

$$\mu = \lambda \mathcal{T}$$

$$\frac{\partial \mathcal{L}}{\partial m} = (s + \lambda n) r \left[1 - \frac{2m(r)}{r}\right]^{-\frac{3}{2}} + \left[1 - \frac{2m(r)}{r}\right]^{-\frac{1}{2}} r^2 \frac{\partial s}{\partial m}$$

$$\frac{\partial \mathcal{L}}{\partial m'} = \left[1 - \frac{2m(r)}{r}\right]^{-\frac{1}{2}} r^2 \frac{\partial s}{\partial m'}$$

$$\frac{\partial s}{\partial m'} = \frac{\partial s}{\partial \rho}\frac{\partial \rho}{\partial \phi'}\frac{\partial \phi'}{\partial m'} = \frac{1}{\mathcal{T}}\frac{\partial \rho}{\partial \phi'}\frac{1}{(r - 2m)} = \frac{1}{16\pi \mathcal{T}}\left[\frac{2}{r^2}\frac{df}{d\mathcal{R}} + \frac{1}{r}\frac{df'}{d\mathcal{R}}\right]$$

$$\frac{\partial s}{\partial m}=\frac{\partial s}{\partial \rho}\left[\frac{\partial \rho}{\partial \phi}\frac{\partial \phi}{\partial m}+\frac{\partial \rho}{\partial \phi'}\frac{\partial \phi'}{\partial m}\right]=\frac{1}{\mathcal{T}}\frac{1}{16\pi}\left[\frac{-2}{r}\left(\frac{2r\phi'-1}{r^2}\frac{df}{d\mathcal{R}}-\frac{df''}{d\mathcal{R}}+\left(\phi'-\frac{2}{r}\right)\frac{df'}{d\mathcal{R}}\right)+\frac{1}{r}\left(\frac{2}{r}\frac{df}{d\mathcal{R}}+\frac{df'}{d\mathcal{R}}\right)\right]$$

$$\frac{\partial \mathcal{L}}{\partial m}=(s+\lambda n)r\left[1-\frac{2m(r)}{r}\right]^{-\frac{3}{2}}+\frac{1}{8\pi\mathcal{T}}\left[1-\frac{2m(r)}{r}\right]^{-\frac{1}{2}}\left(3\frac{df''}{d\mathcal{R}}+2r\frac{df}{d\mathcal{R}}\right)$$

$$\frac{\partial \mathcal{L}}{\partial m'}=\frac{1}{8\pi\mathcal{T}}\left[1-\frac{2m}{r}\right]^{\frac{1}{2}}\left(2\frac{df}{d\mathcal{R}}+r\frac{df'}{d\mathcal{R}}\right)$$

$$\begin{aligned}\frac{\mathcal{T}'}{8\pi\mathcal{T}^2}\left(\frac{2}{r^2}\frac{df}{d\mathcal{R}}+\frac{1}{r}\frac{df'}{d\mathcal{R}}\right)r^2 &\\ =\frac{1}{8\pi\mathcal{T}}\left(-\frac{4}{r^3}\frac{df}{d\mathcal{R}}-\frac{1}{r^2}\frac{df'}{d\mathcal{R}}+\frac{2}{r^2}\frac{df'}{d\mathcal{R}}+\frac{1}{r}\frac{df''}{d\mathcal{R}}\right)r^2 &\\ +\frac{1}{8\pi\mathcal{T}}\left(\frac{2}{r^2}\frac{df}{d\mathcal{R}}+\frac{1}{r}\frac{df'}{d\mathcal{R}}\right)(2r+rm'-5m)\left(1-\frac{2m}{r}\right)^{-1}-\frac{1}{8\pi\mathcal{T}}\left(\frac{2}{r}\frac{df''}{d\mathcal{R}}+\frac{3}{r^2}\frac{df'}{d\mathcal{R}}\right)r^2 &\\ -\frac{\rho+p}{\mathcal{T}}r\left(1-\frac{2m}{r}\right)^{-1}&\end{aligned}$$

$$\begin{aligned}\frac{dp}{dr}=-(\rho+p)\left(1-\frac{2m}{r}\right)^{-1}\left(\frac{2}{r}\frac{df}{d\mathcal{R}}+\frac{df'}{d\mathcal{R}}\right)^{-1}\Bigg[16\pi p+\frac{2m}{r^3}\frac{df}{d\mathcal{R}}+\frac{1}{2}f(\mathcal{R})-\frac{\mathcal{R}}{2}\frac{df}{d\mathcal{R}}&\\ -\frac{2}{r}\left(1-\frac{2m}{r}\right)\frac{df'}{d\mathcal{R}}\Bigg]&\end{aligned}$$

1.4. Ecuaciones de campo (Modelo Tolman-Oppenheimer-Volkoff - TOV).

$$\mathcal{S}=\frac{1}{32\pi}\int d^4\chi\sqrt{-g}f(\mathcal{R})\mathcal{L}+\mathcal{S}_m$$

$$\frac{df(\mathcal{R})}{d\mathcal{R}}\mathcal{R}_{\mu\nu}-\frac{1}{2}f(\mathcal{R})g_{\mu\nu}-[\nabla_\mu\nabla_\nu-g_{\mu\nu}\Box]\frac{df(\mathcal{R})}{d\mathcal{R}}=16\pi\mathcal{T}_{\mu\nu}$$

$$\nabla_\mu\mathcal{G}^{\mu\nu}=0=\nabla_\mu\mathcal{T}^{\mu\nu}$$

$$16\pi\nabla_\mu\mathcal{T}^{\mu\nu}=(\nabla^\mu f')\mathcal{R}_{\mu\nu}+f'\nabla^\mu\mathcal{R}_{\mu\nu}-\frac{1}{2}g_{\mu\nu}\nabla^\mu f-[\Box\nabla_\nu-\nabla_\nu\Box]f'$$

$$(\nabla^\mu f')\mathcal{R}_{\mu\nu}+f'\nabla^\mu\left(\mathcal{R}_{\mu\nu}-\frac{1}{2}\mathcal{R}\right)-\mathcal{R}_{\mu\nu}\nabla^\mu f'$$

$$\mathcal{R}f(\mathcal{R})-2\frac{df(\mathcal{R})}{d\mathcal{R}}+3\Box\frac{df(\mathcal{R})}{d\mathcal{R}}=16\pi\mathcal{T}$$

$$\mathcal{S}=\frac{1}{32\pi}\int d^4\chi\sqrt{-g}f(\mathcal{R},\mathcal{T})+\int d^4\chi\,\mathcal{L}\sqrt{-g}\mathcal{L}_m$$

$$\begin{aligned}\partial_{\mathcal{R}}f(\mathcal{R},\mathcal{T})\mathcal{R}_{\mu\nu}-\frac{1}{2}f(\mathcal{R},\mathcal{T})g_{\mu\nu}+(g_{\mu\nu}\Box-\nabla_\mu\nabla_\nu)\partial_{\mathcal{R}}f(\mathcal{R},\mathcal{T})&\\ =16\pi\mathcal{T}_{\mu\nu}-\partial_{\mathcal{T}}f(\mathcal{R},\mathcal{T})\mathcal{T}_{\mu\nu}-\partial_{\mathcal{T}}f(\mathcal{R},\mathcal{T})\Theta_{\mu\nu}&\end{aligned}$$

$$\nabla^{\mu}\mathcal{T}_{\mu\nu} = \frac{\partial_{\mathcal{T}} f}{8\pi - \partial_{\mathcal{T}} f}\left[\left(\mathcal{T}_{\mu\nu} + \Theta_{\mu\nu}\right)\nabla^{\mu}\ln(\partial_{\mathcal{T}} f) + \nabla^{\mu}\Theta_{\mu\nu} - \frac{1}{2}\nabla_{\nu}\mathcal{T}\right]$$

$$f(\mathcal{R},\mathcal{T}) = \mathcal{R} + 2\chi\mathcal{T}$$

$$\mathcal{G}_{\mu\nu} = 16\pi\mathcal{T}_{\mu\nu} + \chi\mathcal{T}g_{\mu\nu} + 2\chi\left(\mathcal{T}_{\mu\nu} + pg_{\mu\nu}\right)$$

$$(8\pi + 3\chi)\rho = \chi p - e^{-2\phi}\left(\frac{1}{r^2} - \frac{2\phi'}{r}\right) + \frac{1}{r^2}$$

$$(8\pi + 3\chi)p = \chi\rho + e^{-2\phi}\left(\frac{1}{r^2} - \frac{2\nu'}{r}\right) - \frac{1}{r^2}$$

$$8\pi\rho_{eff} = (8\pi + 3\chi)\rho - \chi p$$

$$8\pi p_{eff} = (8\pi + 3\chi)p - \chi\rho$$

$$\rho = \frac{8\pi}{\alpha^2 - \chi^2}\left(\alpha\rho_{eff} + \chi p_{eff}\right)$$

$$p = \frac{8\pi}{\alpha^2 - \chi^2}\left(\chi\rho_{eff} + \alpha p_{eff}\right)$$

$$8\pi\rho_{eff} = e^{-2\phi}\left(\frac{1}{r^2} - \frac{2\phi'}{r}\right) + \frac{1}{r^2}$$

$$8\pi p_{eff} = -e^{-2\phi}\left(\frac{1}{r^2} - \frac{2\nu'}{r}\right) - \frac{1}{r^2}$$

$$e^{-2\phi} = 1 - \frac{2m(r)}{r}$$

$$m(r) = \int_0^r 4\pi\rho_{eff}(s)s^2 ds$$

$$(4\pi + \chi)\nabla^{\mu}\mathcal{T}_{\mu\nu} = \frac{1}{2}\chi\nabla_{\nu}(\mathcal{T} + 2p) - \frac{dp}{dr} - \frac{d\nu}{dr}(\rho + p) + \frac{\chi}{8\pi + 2\chi}(\rho' - p')$$

1.4.1. Ecuaciones de Campo Oppenheimer – Snyder.

$$ds^2 = e^{\nu}dt^2 - e^{\lambda}dr^2 - r^2(d\theta^2 + sin^2\theta d\varphi^2) - 8\pi\mathcal{T}_1^1 = e^{-\lambda}\left(\frac{\nu'}{r} + \frac{1}{r^2}\right) - \frac{1}{r^2} + 8\pi\mathcal{T}_4^4$$

$$= e^{-\lambda}\left(\frac{\lambda'}{r} - \frac{1}{r^2}\right) + \frac{1}{r^2} - 8\pi\mathcal{T}_2^2 = -8\pi\mathcal{T}_3^3$$

$$= e^{-\lambda}\left(\frac{\nu''}{2} + \frac{\nu'^2}{4} - \frac{\nu'\lambda'}{4} + \frac{\nu' - \lambda'}{2r}\right) - e^{\nu}\left(\frac{\ddot{\lambda}}{2} + \frac{\dot{\lambda}^2}{4} - \frac{\dot{\lambda}\dot{\nu}}{4}\right)8\pi\mathcal{T}_1^4 = 8\pi e^{\nu-\lambda}\mathcal{T}_1^4$$

$$= -e^{-\lambda}\frac{\dot{\lambda}}{r}$$

$$\lambda = -\ln\left\{1 - \frac{8\pi}{r}\int_0^r \mathcal{T}_4^4 r^2 dr\right\} 8\pi(\mathcal{T}_4^4 - \mathcal{T}_1^1) = \frac{e^{\lambda}(\lambda' - \nu')}{r}$$

$$\mathcal{V} = 4\pi \int_0^{r_b} e^{\frac{\lambda}{2}} r^2 dr$$

$$ds^2 = d\tau^2 - e^{\varpi} d\mathcal{R}^2 - e^{\omega}(d\theta^2 + sin^2\theta d\varphi^2) 8\pi\mathcal{T}_1^1 = 0 = e^{-\omega} - e^{-\varpi}\frac{\omega'^2}{4} + \ddot{\omega} + \frac{3}{4}\dot{\omega}^2 = 0$$

$$8\pi\mathcal{T}_2^2 = -8\pi\mathcal{T}_3^3 = 0 = -e^{-\varpi}\left(\frac{\omega''}{2} + \frac{\omega'^2}{4} - \frac{\varpi'\omega'}{4}\right) + \frac{\ddot{\varpi}}{2} + \frac{\dot{\varpi}^2}{4} + \frac{\ddot{\omega}}{2} + \frac{\dot{\omega}^2}{4} + \frac{\dot{\varpi}\dot{\omega}}{4}$$

$$8\pi\mathcal{T}_4^4 = 8\pi\rho = e^{-\omega} - e^{-\varpi}\left(\omega'' + \frac{3}{4}\omega'^2 - \frac{\varpi'\omega'}{2}\right) + \frac{\dot{\omega}^2}{4} + \frac{\dot{\varpi}\dot{\omega}}{4}$$

$$8\pi e^{\ddot{\omega}}\mathcal{T}_4^1 = -8\pi\mathcal{T}_1^4 = 0 = \frac{\omega'\dot{\omega}}{2} - \frac{\dot{\varpi}\omega'}{2} + \dot{\omega}'$$

$$e^{\varpi} = e^{\omega}\omega'^2/4f^2(\mathcal{R})$$

$$e^{\omega} = (\mathcal{F}r + \mathcal{G})^{\frac{4}{3}}$$

$$8\pi\rho = \frac{4}{3}\left(\frac{r + \mathcal{G}}{\mathcal{F}}\right)^{-1}\left(\frac{r + \mathcal{G}'}{\mathcal{F}'}\right)^{-1}$$

$$\mathcal{F}\mathcal{F}' = 9\pi\mathcal{R}^2\rho_0(\mathcal{R})$$

$$\mathcal{F} = \left\langle \begin{matrix} -\frac{3}{2}r_0^{1/2}(\mathcal{R}/\mathcal{R}_b)^{3/2} & \mathcal{R} < \mathcal{R}_b \\ -\frac{3}{2}r_0^{1/2} & \mathcal{R} > \mathcal{R}_b \end{matrix} \right\rangle$$

$$e^{\omega/2} = (\mathcal{F}r + \mathcal{G})^{2/3} = r$$

$$g^{44} = e^{-\nu} = \dot{t}^2 - t'^2/r'^2 = \dot{t}^2(1 - \dot{r}^2)$$

$$g^{11} = e^{-\lambda} = -(1 - \dot{r}^2)$$

$$g^{14} = 0 = \dot{t}\dot{r} - t'/r'$$

$$\frac{t'}{\dot{t}} = \dot{r}r' = \left\langle \begin{matrix} -(r_0\mathcal{R})^{1/2}\left[\mathcal{R}^{3/2} - \frac{3}{2}r_0^{1/2}\tau\right]^{-2/3} & \mathcal{R} > \mathcal{R}_b \\ r_0^{1/2}\mathcal{R}\mathcal{R}_b^{-3/2}\left[1 - \frac{3}{2}r_0^{1/2}\tau\mathcal{R}_b^{-3/2}\right]^{1/3} & \mathcal{R} < \mathcal{R}_b \end{matrix} \right\rangle$$

$$\chi = \frac{2}{3} r_0^{1/2}\left(\mathcal{R}^{3/2} - r^{3/2}\right) - 2(rr_0)^{\frac{1}{2}} + r_0 + \ln\frac{r^{1/2} + r_0^{1/2}}{r^{1/2} - r_0^{1/2}}$$

$$\gamma = \frac{1}{2}[(\mathcal{R}/\mathcal{R}_b)^2 - 1] + \mathcal{R}_b r / r_0 \mathcal{R}$$

$$e^{\lambda} = (1 - r_0/r)^{-1}$$

$$e^{\nu} = (1 - r_0/r)$$

$$t = \mathcal{M}(\gamma) = \frac{2}{3} r_0^{1/2}\left(\mathcal{R}_b^{3/2} - r_0^{3/2}\gamma^{3/2}\right) - 2r_0\gamma^{\frac{1}{2}} + r_0 \ln\frac{\gamma^{\frac{1}{2}} + 1}{\gamma^{\frac{1}{2}} - 1}$$

$$t \sim -r_0 \ln\left\{\frac{1}{2}[(\mathcal{R}/\mathcal{R}_b)^2 - 3] + \mathcal{R}_b/r_0\left(1 - 3r_0^{1/2}/2\mathcal{R}_b^2\right)^{2/3}\right\}$$

$$e^{-\lambda} \simeq 1 - (\mathcal{R}/\mathcal{R}_b)^2\left\{e^{t/r_0} + \frac{1}{2}[3 - (\mathcal{R}/\mathcal{R}_b)^2]\right\}^{-1}$$

$$e^{\nu} \simeq e^{\lambda - 2t/r_0}\left\{e^{-t/r_0} + \frac{1}{2}[3 - (\mathcal{R}/\mathcal{R}_b)^2]\right\}$$

1.5. Dinámica relativista (Modelo Tolman-Oppenheimer-Volkoff - TOV).

$$16\pi\rho = \frac{1}{2}f(\mathcal{R}) + \left[\frac{1}{r^2} + \frac{e^{-2\phi}(2r\phi' - 1)}{r^2} - \frac{\mathcal{R}}{2}\right]\frac{df}{d\mathcal{R}} + e^{-2\phi}\left(\phi' - \frac{2}{r}\right)\frac{df'}{d\mathcal{R}} - e^{-2\phi}\frac{df''}{d\mathcal{R}}$$

$$16\pi\rho = -\frac{1}{2}f(\mathcal{R}) + \left[-\frac{1}{r^2} + \frac{\mathcal{R}}{2} + \frac{e^{-2\phi}(2r\nu' + 1)}{r^2}\right]\frac{df}{d\mathcal{R}} + e^{-2\phi}\left(\nu' - \frac{2}{r}\right)\frac{df'}{d\mathcal{R}}$$

$$\nabla^{\mu}\mathcal{T}_{\mu\nu} = 0 \mapsto p' = -(\rho + p)\nu'$$

$$\frac{dp}{dr} = -(\rho + p)\left(1 - \frac{2m}{r}\right)^{-1}\left(\frac{2}{r}\frac{df}{d\mathcal{R}} + \frac{df'}{d\mathcal{R}}\right)^{-1}\left[16\pi p + \frac{2m}{r^3}\frac{df}{d\mathcal{R}} + \frac{1}{2}f(\mathcal{R}) - \frac{\mathcal{R}}{2}\frac{df}{d\mathcal{R}} - \frac{2}{r}\left(1 - \frac{2m}{r}\right)\frac{df'}{d\mathcal{R}}\right]$$

$$\phi' = \frac{1}{r}\left(m' - \frac{m}{r}\right)\left(1 - \frac{2m}{r}\right)^{-1}$$

$$\frac{dp}{dr} = -(\rho + p)\frac{8\pi pr + \frac{m}{r^2} - \frac{\chi(\rho - 3p)r}{2}}{\left(1 - \frac{2m}{r}\right)\left[1 - \frac{\chi}{8\pi + 2\chi}\left(1 - \frac{d\rho}{dp}\right)\right]}$$

$$\mathcal{L}(m, m', n) = \left[s\left(\rho_{eff}(m')\right), n + \lambda n(r)\right]\left[1 - \frac{2m(r)}{r}\right]^{-\frac{1}{2}} r^2$$

$$\mathcal{L}(m,m',n) = k\frac{\rho_{eff}+p_{eff}}{\mathcal{T}}\left[1-\frac{2m(r)}{r}\right]^{-\frac{1}{2}}r^2$$

$$\frac{\partial\mathcal{L}}{\partial m} = k\frac{\rho_{eff}+p_{eff}}{\mathcal{T}}\left[1-\frac{2m(r)}{r}\right]^{-\frac{3}{2}}r$$

$$\frac{\partial\mathcal{L}}{\partial m'} = \frac{k}{\mathcal{T}}\left[1-\frac{2m(r)}{r}\right]^{-\frac{1}{2}}r^2\frac{\partial\rho_{eff}}{\partial m'}$$

$$\frac{\partial\mathcal{L}}{\partial m'} = \frac{k}{4\pi\mathcal{T}}\left[1-\frac{2m(r)}{r}\right]^{-\frac{1}{2}}$$

$$\frac{d}{dr}\frac{\partial\mathcal{L}}{\partial m'} = \frac{k}{4\pi r^2\mathcal{T}}(m'r-m)\left[1-\frac{2m}{r}\right]^{-\frac{3}{2}} - \frac{k}{4\pi\mathcal{T}}\frac{\mathcal{T}}{\mathcal{T}'}\left[1-\frac{2m}{r}\right]^{-\frac{1}{2}} = k\frac{\left(\frac{m'}{r}-\frac{m}{r^2}\right)-\left(1-\frac{2m}{r}\right)\frac{\mathcal{T}'}{\mathcal{T}}}{8\pi\mathcal{T}\left(1-\frac{2m}{r}\right)^{\frac{3}{2}}}$$

$$8\pi\rho_{eff}+m = -r^2\left(1-\frac{2m}{r}\right)\frac{\mathcal{T}'}{\mathcal{T}}$$

$$\frac{\mathcal{T}'}{\mathcal{T}} = \frac{p'}{p+\rho} = \frac{1}{8\pi+4\chi}\left(\frac{\alpha p'_{eff}+\chi\rho'_{eff}}{p_{eff}+\rho_{eff}}\right)$$

$$\frac{dp_{eff}}{dr} = -(8\pi+4\chi)\frac{(4\pi p_{eff}r^3+m)(p_{eff}+\rho_{eff})}{r^2\left(1-\frac{2m}{r}\right)\left(\alpha+\chi\frac{\partial\rho_{eff}}{\partial p_{eff}}\right)}$$

2. Geometría diferencial y características topológicas tanto de las partículas y antipartículas supermasivas como de las partículas y antipartículas masivas, en espacios cuánticos curvos.

2.1. Métrica tensorial por curvatura de Perelman – Hamilton – Ricci (PHR) en dimensión $\mathbb{R}^4$.

$$\nabla_i\nabla_j f + \mathcal{R}_{ij} + \frac{1}{2t}g_{ij}$$

$$\nabla_i\mathcal{R} = 2\mathcal{R}_{ij}\nabla_j f$$

$$\mathcal{R} - 2Ric(\mathcal{X},\mathcal{X}) + 2\frac{\det\mathcal{H}essf}{|\nabla f|^2} \le \mathcal{R} - 2Ric(\mathcal{X},\mathcal{X}) + \frac{\left(1-\mathcal{R}+Ric(\mathcal{X},\mathcal{X})\right)^2}{2|\nabla f|^2} \le 1$$

$$|\nabla\mathcal{R}| \le \eta\mathcal{R}^{\frac{3}{2}}, |\mathcal{R}_t| \le \eta\mathcal{R}^2$$

$$f_t = f'' + a_1 f' + b_1 g' + c_1 f + d_1 g$$

$$g_t = f'' + a_2 f' + b_2 g' + c_2 f + d_2 g$$

$$\mathcal{R}m \geq -\phi\big(\mathcal{R}(t+1)\big)\mathcal{R}$$

$$2\sqrt{t_0 - t_\gamma} \int_{t_\gamma}^{t_0} \sqrt{t_0 - t}\,(\mathcal{R}(\gamma(t), t) + |\dot{\gamma}(t)|^2) dt \geq \mathfrak{C}(\mathcal{A}) r_0^2$$

$$\square \hbar \geq -\mathfrak{C}(\mathcal{A})\hbar - \big(6 - 1/\sqrt{\tau}\big)\phi$$

$$\frac{d}{d\tau}\big(\log\big(\hbar_0(\tau)/\sqrt{\tau}\big)\big) \leq \mathfrak{C}(\mathcal{A}) + \frac{6\sqrt{\tau}+1}{2\tau - 4r^2\sqrt{\tau}} - \frac{1}{2\tau} \leq \mathfrak{C}(\mathcal{A}) + \frac{50}{\sqrt{\tau}}$$

$$\frac{d}{dt}\mathcal{R} = \triangle\,\mathcal{R} + 2|Ric|^2 = \triangle\,\mathcal{R} + 2|Ric^\circ|^2 + \frac{2}{3}\mathcal{R}^2$$

$$\mathcal{R}_{mint}(t) \geq -\frac{3}{2}\frac{1}{t + 1/4}$$

$$\frac{d}{dt}\mathcal{V} \leq -\mathcal{R}_{min}\mathcal{V}$$

$$\frac{d}{dt}\hat{\mathcal{R}}(t) \geq \frac{2}{3}\hat{\mathcal{R}}\mathcal{V}^{-1}\int(\mathcal{R}_{min} - \mathcal{R})\, d\mathcal{V}$$

$$\left|2t\mathcal{R}_{ij} + g_{ij}\right| < \xi$$

$$Vol\,\mathcal{B}\big(x, t, \rho(x,t)\big) \leq \omega\rho^3(x,t)\int(4|\nabla_\alpha|^2 + \mathcal{R}\alpha^2) = 4\triangle\alpha - \lambda^-\alpha$$

$$\int_{\mathcal{M}_z} -4\alpha\alpha_z = \int_{\mathcal{M}_z^+}(4|\nabla_\alpha|^2 + \mathcal{R}\alpha^2 - \lambda^-\alpha^2) \geq \frac{r_0^{-2}}{2}\int_{\mathcal{M}_z^+}\alpha^2 \left|\int_{\mathcal{M}_z} 2\alpha\alpha_z - \left(\int_{\mathcal{M}_z}\alpha^2\right)_z\right|$$

$$\leq const \bigotimes \int_{\mathcal{M}_z} \epsilon r_0^{-1}\alpha^2 \int_{\mathcal{M}_0^+}\alpha^2 \geq \exp\left(\frac{\epsilon^{-1}}{10}\right)\int_{\mathcal{M}_{\epsilon^{-1}r_0}^+}\alpha^2$$

$$\delta\mathcal{F}\big(v_{ij}, \hbar\big) = \int_{\mathcal{M}}^{\square} e^{-f}\left[-\triangle\,v + \nabla_i\nabla_j v_{ij} - \mathcal{R}_{ij}v_{ij} - v_{ij}\nabla_i f\nabla_j f + 2\langle\nabla f, \nabla\hbar\rangle + (\mathcal{R} + |\nabla f|^2)\left(\frac{v}{2} - \hbar\right)\right]$$

$$= \int_{\mathcal{M}}^{\square} e^{-f}\left[-v_{ij}\big(\mathcal{R}_{ij} + \nabla_i\nabla_j f\big) + \left(\frac{v}{2} - \hbar\right)(2\triangle f - |\nabla f|^2 + \mathcal{R})\right]$$

$$\big(g_{ij}\big)_t = -2\big(\mathcal{R}_{ij} + \nabla_i\nabla_j f\big)$$

$$f_t = -\mathcal{R} - \triangle f$$

$$\mathcal{F}_t^m = 2\int\left|\mathcal{R}_{ij} + \nabla_i\nabla_j f\right|^2 dm$$

$$\left(g_{ij}\right)_t = -2\mathcal{R}_{ij}, f_t = -\triangle f + |\nabla f|^2 - \mathcal{R}$$

$$\mathcal{F}_t = 2\int \left|\mathcal{R}_{ij} + \nabla_i\nabla_j f\right|^2 e^{-f} d\mathcal{V}$$

$$\mathcal{F}_t \geq \frac{2}{n}\int (\mathcal{R} + \triangle f)^2 e^{-f} d\mathcal{V} \geq \frac{2}{n}\left(\int (\mathcal{R} + \triangle f) e^{-f} d\mathcal{V}\right)^2 = \frac{2}{n}\mathcal{F}^2$$

$$\begin{aligned}\frac{d\bar{\lambda}(t)}{dt} \geq\ & 2\mathcal{V}^{2/n}\int \left|\mathcal{R}_{ij} + \nabla_i\nabla_j f\right|^2 e^{-f} d\mathcal{V} \\ & + \frac{2}{n}\mathcal{V}^{(2-n)/n}\lambda \int -\mathcal{R} d\mathcal{V} \\ & \geq 2\mathcal{V}^{2/n}\left[\int \left|\mathcal{R}_{ij} + \nabla_i\nabla_j f - \frac{1}{n}(\mathcal{R} + \triangle f) g_{ij}\right|^2 e^{-f} d\mathcal{V}\right. \\ & \left. + \frac{1}{n}\left(\int (\mathcal{R} + \triangle f)^2 e^{-f} d\mathcal{V} - \left(\int (\mathcal{R} + \triangle f) e^{-f} d\mathcal{V}\right)^2\right)\right]\end{aligned}$$

$$\mathcal{W}\left(g_{ij}, f, \tau\right) = \int_{\mathcal{M}}^{\square} \left[\tau(|\nabla f|^2 + \mathcal{R}) + f + n\right](8\pi\tau)^{-n/2} e^{-f} d\mathcal{V}$$

$$\int_{\mathcal{M}}^{\square} (8\pi\tau)^{-n/2} e^{-f} d\mathcal{V} = 1$$

$$\left(g_{ij}\right)_t = -2\mathcal{R}_{ij}, f_t = -\triangle f + |\nabla f|^2 - \mathcal{R} + \frac{n}{2\tau}, \tau_t = -1$$

$$\frac{d\mathcal{W}}{dt} = \int_{\mathcal{M}}^{\square} 2\tau \left|\mathcal{R}_{ij} + \nabla_i\nabla_j f - \frac{1}{2\tau} g_{ij}\right|^2 (8\pi\tau)^{-n/2} e^{-f} d\mathcal{V}$$

$$\mathcal{W}\left(\frac{1}{2}\tau^{-1} g_{ij}, f^{\tau}, \frac{1}{2}\right) = \mathcal{W}\left(g_{ij}, f^{\tau}, \tau\right) = \mu\left(g_{ij}, \tau\right) \leq c$$

$$\int_{\mathbb{R}^n}^{\square} \left[\frac{1}{2}|\nabla f|^2 + f - n\right](2\pi)^{-\frac{n}{2}} e^{-f} d\chi$$

$$\langle\mathfrak{E}\rangle = -\tau^2 \int_{\mathcal{M}}^{\square} \left(\mathcal{R} + |\nabla f|^2 - \frac{n}{2\tau}\right) dm \frac{\partial^2}{(\partial\beta)^2}\log\mathcal{Z}$$

$$\mathcal{S} = -\int_{\mathcal{M}}^{\square} \left(\tau(\mathcal{R} + |\nabla f|^2) + f - n\right) dm$$

$$\sigma = 2\tau^4 \int_{\mathcal{M}}^{\square} \left|\mathcal{R}_{ij} + \nabla_i\nabla_j f - \frac{1}{2\tau} g_{ij}\right|^2 dm$$

$$\tilde{g}_{ij} = g_{ij}, \tilde{g}_{\alpha\beta} = \tau g_{\alpha\beta}, \tilde{g}_{00} = \frac{\mathcal{N}}{2\tau} + \mathcal{R}, \tilde{g}_{i\alpha} = \tilde{g}_{i0} = \tilde{g}_{\alpha 0}$$

$$\tilde{g}_{ij}^m = \tilde{g}_{ij}, \tilde{g}_{\alpha\beta}^m = \left(1 - \frac{2f}{\mathcal{N}}\right)\tilde{g}_{\alpha\beta}, \tilde{g}_{00}^m = \tilde{g}_{00} - 2f_\tau - \frac{f}{\tau}, \tilde{g}_{i0}^m = -\nabla_i f, \tilde{g}_{i\alpha}^m = \tilde{g}_{\alpha 0}^m$$

$$g_{\alpha\beta}^m = \left(1 - \frac{2f}{\mathcal{N}}\right)\tilde{g}_{\alpha\beta}, g_{00}^m = \tilde{g}_{00}^m - |\nabla f|^2 = \frac{1}{\tau}\left(\frac{\mathcal{N}}{2} - [\tau(2 \triangle f - |\nabla f|^2 + \mathcal{R}) + f - n]\right) g_{i0}^m = g_{\alpha 0}^m = g_{i\alpha}^m = 0$$

$$\int_0^{\tau(q)} \sqrt{\frac{\mathcal{N}}{2\tau} + \mathcal{R} + |\dot{\gamma}_{\mathcal{M}}(\tau)|^2} d\tau = \sqrt{2\mathcal{N}\tau(q)} + \frac{1}{\sqrt{2\mathcal{N}}} \int_0^{\tau(q)} \sqrt{\tau}\,(\mathcal{R} + |\dot{\gamma}_{\mathcal{M}}(\tau)|^2) d\tau + \mathcal{O}\left(\mathcal{N}^{-3/2}\right)$$

$$\int_{\mathcal{M}}^{\square} \tau(q)^{-n/2} \exp\left(-\frac{1}{\sqrt{2\tau(q)}}\mathcal{L}(\chi)\right) d\chi + \mathcal{O}(\mathcal{N}^{-1})$$

$$\mathcal{L}(\gamma) = \int_{\tau_2}^{\tau_1} \sqrt{\tau}\left(\mathcal{R}\big(\gamma(\tau)\big) + |\gamma(\tau)|^2\right) d\tau$$

$$\begin{aligned}
\int_{\tau_1}^{\tau_2} \sqrt{\tau}\left(\langle \mathcal{Y}, \nabla\mathcal{R}\rangle + 2\langle \nabla_{\mathcal{Y}}\mathcal{X}, \mathcal{X}\rangle\right) d\tau &= \int_{\tau_1}^{\tau_2} \sqrt{\tau}\left(\langle \mathcal{Y}, \nabla\mathcal{R}\rangle + 2\langle \nabla_{\mathcal{X}}\mathcal{Y}, \mathcal{X}\rangle\right) d\tau \\
&= \int_{\tau_1}^{\tau_2} \sqrt{\tau}\left(\langle \mathcal{Y}, \nabla\mathcal{R}\rangle + 2\frac{d}{d\tau}\langle \mathcal{Y}, \mathcal{X}\rangle - 2\langle \mathcal{Y}, \nabla_{\mathcal{X}}\mathcal{X}\rangle - 4Ric\,(\mathcal{Y}, \mathcal{X})\right) d\tau \\
&= 2\sqrt{\tau}\mathcal{X}, \mathcal{Y}\big|_{\tau_1}^{\tau_2} + \int_{\tau_1}^{\tau_2} \sqrt{\tau}\,\langle \mathcal{Y}, \nabla\mathcal{R} - 2\nabla_{\mathcal{X}}\mathcal{X} - 4Ric\,(\mathcal{X}, \odot) - \frac{1}{\tau}\mathcal{X}\rangle\, d\tau
\end{aligned}$$

$$\nabla_{\mathcal{X}}\mathcal{X} - \frac{1}{2}\nabla\mathcal{R} + \frac{1}{2\tau}\mathcal{X} + 2Ric(\mathcal{X}, \odot)$$

$$\mathcal{L}_{\bar{\tau}}(q, \bar{\tau}) = \sqrt{\bar{\tau}}(\mathcal{R} + |\mathcal{X}|^2) - \langle \mathcal{X}, \nabla\mathcal{L}\rangle = 2\sqrt{\bar{\tau}}\mathcal{R} - \sqrt{\bar{\tau}}(\mathcal{R} + |\mathcal{X}|^2)$$

$$\begin{aligned}
\frac{d}{d\tau}\left(\mathcal{R}\big(\gamma(\tau)\big) + |\mathcal{X}(\tau)|^2\right) &= \mathcal{R}_\tau + \langle \nabla\mathcal{R}, \mathcal{X}\rangle + 2\langle \nabla_{\mathcal{X}}\mathcal{X}, \mathcal{X}\rangle + 2Ric\,(\mathcal{X}, \mathcal{X}) \\
&= \mathcal{R}_\tau + \frac{1}{\tau}\mathcal{R} + 2\langle \nabla\mathcal{R}, \mathcal{X}\rangle - 2Ric\,(\mathcal{X}, \mathcal{X}) - \frac{1}{\tau}(\mathcal{R} + |\mathcal{X}|^2) = -\mathcal{H}(\mathcal{X}) - \frac{1}{\tau}(\mathcal{R} + |\mathcal{X}|^2)
\end{aligned}$$

$$\bar{\tau}^{3/2}(\mathcal{R} + |\mathcal{X}|^2)(\bar{\tau}) = -\mathcal{K} + \frac{1}{2}\mathcal{L}(q, \bar{\tau})$$

$$\mathcal{L}_{\bar{\tau}} = 2\sqrt{\bar{\tau}}\mathcal{R} - \frac{1}{2\bar{\tau}}\mathcal{L} + \frac{1}{\bar{\tau}}\mathcal{K}$$

$$\delta_{\mathcal{Y}}^{2}(\mathcal{L}) = \int_{0}^{\bar{\tau}} \sqrt{\tau}\left(\mathcal{Y} \bigotimes \mathcal{Y} \bigotimes \mathcal{R} + 2\langle \nabla_{\mathcal{Y}}\nabla_{\mathcal{Y}}\mathcal{X}, \mathcal{X}\rangle + 2\left|\nabla_{\mathcal{Y}}\mathcal{X}\right|^{2}\right) d\tau$$

$$= \int_{0}^{\bar{\tau}} \sqrt{\tau}\left(\mathcal{Y} \bigotimes \mathcal{Y} \bigotimes \mathcal{R} + 2\langle \nabla_{\mathcal{Y}}\nabla_{\mathcal{Y}}\mathcal{Y}, \mathcal{X}\rangle + 2\langle \mathcal{R}(\mathcal{Y},\mathcal{X})\mathcal{Y},\mathcal{X}\rangle + 2|\nabla_{\mathcal{X}}\mathcal{Y}|^{2}\right) d\tau$$

$$\frac{d}{d\tau}\langle \nabla_{\mathcal{Y}}\mathcal{Y}, \mathcal{X}\rangle = \langle \nabla_{\mathcal{X}}\nabla_{\mathcal{Y}}\mathcal{Y}, \mathcal{X}\rangle + \langle \nabla_{\mathcal{Y}}\mathcal{Y}, \nabla_{\mathcal{X}}\mathcal{X}\rangle + 2\mathcal{Y} \bigotimes Ric\,(\mathcal{Y},\mathcal{X}) - \mathcal{X} \bigotimes Ric\,(\mathcal{Y},\mathcal{Y})$$

$$\begin{aligned}\delta_{\mathcal{Y}}^{2}(\mathcal{L}) = {} & 2\langle \nabla_{\mathcal{Y}}\mathcal{Y}, \mathcal{X}\rangle\sqrt{\bar{\tau}} \\ & + \int_{0}^{\bar{\tau}} \sqrt{\tau}\Big(\nabla_{\mathcal{Y}}\nabla_{\mathcal{Y}}\mathcal{R} + 2\langle \mathcal{R}(\mathcal{Y},\mathcal{X}),\mathcal{Y},\mathcal{X}\rangle + 2|\nabla_{\mathcal{X}}\mathcal{Y}|^{2} + 2\nabla_{\mathcal{X}}Ric(\mathcal{Y},\mathcal{Y}) \\ & - 4\nabla_{\mathcal{Y}}Ric(\mathcal{Y},\mathcal{X})\Big) d\tau\end{aligned}$$

$$\nabla_{\mathcal{X}}\mathcal{Y} = -Ric(\mathcal{Y},\odot) + \frac{1}{2\tau}\mathcal{Y}$$

$$\begin{aligned}\frac{d}{d\tau}\langle \mathcal{Y},\mathcal{Y}\rangle = {} & 2Ric(\mathcal{Y},\mathcal{Y}) + 2\langle \nabla_{\mathcal{X}}\mathcal{Y},\mathcal{Y}\rangle = \frac{1}{\tau}\langle \mathcal{Y},\mathcal{Y}\rangle \mathcal{H}_{ess_{\mathcal{L}}}(\mathcal{Y},\mathcal{Y}) \\ & \leq \int_{0}^{\bar{\tau}} \sqrt{\tau}\Big(\nabla_{\mathcal{Y}}\nabla_{\mathcal{Y}}\mathcal{R} + 2\langle \mathcal{R}(\mathcal{Y},\mathcal{X}),\mathcal{Y},\mathcal{X}\rangle + 2\nabla_{\mathcal{X}}Ric(\mathcal{Y},\mathcal{Y}) - 4\nabla_{\mathcal{Y}}Ric(\mathcal{Y},\mathcal{X}) \\ & + 2|Ric(\mathcal{Y},\odot)|^{2} - \frac{2}{\tau}Ric(\mathcal{Y},\mathcal{Y}) + \frac{1}{2\tau\bar{\tau}}\Big) d\tau\end{aligned}$$

$$\begin{aligned}\frac{d}{d\tau}Ric\big(\mathcal{Y}(\tau),\mathcal{Y}(\tau)\big) &= Ric_{\tau}(\mathcal{Y},\mathcal{Y}) + \nabla_{\mathcal{X}}Ric(\mathcal{Y},\mathcal{Y}) + 2Ric(\nabla_{\mathcal{X}}\mathcal{Y},\mathcal{Y}) \\ &= Ric_{\tau}(\mathcal{Y},\mathcal{Y}) + \nabla_{\mathcal{X}}Ric(\mathcal{Y},\mathcal{Y}) + \frac{1}{\tau}Ric(\mathcal{Y},\mathcal{Y}) - 2|Ric(\mathcal{Y},\odot)|^{2}\end{aligned}$$

$$\mathcal{H}_{ess_{\mathcal{L}}}(\mathcal{Y},\mathcal{Y}) \leq \frac{1}{\sqrt{\bar{\tau}}} - 2\sqrt{\bar{\tau}}Ric(\mathcal{Y},\mathcal{Y}) - \int_{0}^{\bar{\tau}} \sqrt{\tau}\,\mathcal{H}(\mathcal{X},\mathcal{Y})d\tau$$

$$\begin{aligned}\mathcal{H}(\mathcal{X},\mathcal{Y}) = {} & -\nabla_{\mathcal{Y}}\nabla_{\mathcal{Y}}\mathcal{R} - 2\langle \mathcal{R}(\mathcal{Y},\mathcal{X}),\mathcal{Y},\mathcal{X}\rangle - 4\left(\nabla_{\mathcal{X}}Ric(\mathcal{Y},\mathcal{Y}) - \nabla_{\mathcal{Y}}Ric(\mathcal{Y},\mathcal{X})\right) - 2Ric_{\tau}(\mathcal{Y},\mathcal{Y}) \\ & + 2|Ric(\mathcal{Y},\odot)|^{2} - \frac{1}{\tau}Ric(\mathcal{Y},\mathcal{Y})\end{aligned}$$

$$\triangle\,\mathcal{L} \leq -2\sqrt{\tau}\mathcal{R} + \frac{n}{\sqrt{\tau}} - \frac{1}{\tau}\mathcal{K}$$

$$\begin{aligned}\frac{d}{d\tau}|\mathcal{Y}|^{2} = {} & 2Ric(\mathcal{Y},\mathcal{Y}) + 2\langle \nabla_{\mathcal{X}}\mathcal{Y},\mathcal{Y}\rangle = 2Ric(\mathcal{Y},\mathcal{Y}) + 2\langle \nabla_{\mathcal{Y}}\mathcal{X},\mathcal{Y}\rangle = 2Ric(\mathcal{Y},\mathcal{Y}) + \frac{1}{\sqrt{\bar{\tau}}}\mathcal{H}_{ess_{\mathcal{L}}}(\mathcal{Y},\mathcal{Y}) \\ & \leq \frac{1}{\bar{\tau}} - \frac{1}{\sqrt{\bar{\tau}}}\int_{0}^{\bar{\tau}} \tau^{1/2}\,\mathcal{H}\big(\mathcal{X},\tilde{\mathcal{Y}}\big)d\tau\end{aligned}$$

$$\frac{d}{d\tau}\log \mathcal{J}(\tau) \leq \frac{n}{2\bar{\tau}} - \frac{1}{2}\bar{\tau}^{-3/2}\mathcal{K}$$

$$\frac{d}{d\tau}l(\tau) = \frac{1}{2\bar{\tau}}l + \frac{1}{2}(\mathcal{R} + |\mathcal{X}|^2) = -\frac{1}{2}\bar{\tau}^{-\frac{3}{2}}\mathcal{K}$$

$$l_{\bar{\tau}} - \triangle l + |\nabla l|^2 - \mathcal{R} + \frac{n}{2\bar{\tau}} \geq 2 \triangle l - |\nabla l|^2 + \mathcal{R} + \frac{l-n}{\bar{\tau}} \leq \bar{\mathcal{L}}_{\bar{\tau}} + \triangle \bar{\mathcal{L}} \leq 2n$$

$$|\nabla l|^2 + \mathcal{R} \leq \frac{\mathfrak{C} l}{\tau}$$

$$\frac{d}{d\tau}\log\, |\mathcal{Y}|^2 \leq \frac{1}{\tau}(\mathfrak{C} l + 1)$$

$$d_t - \triangle d \geq -(n-1)\left(\frac{2}{3}\mathcal{K}r_0 + r_0^{-1}\right)$$

$$\frac{d}{dt}dist_t(x_0, x_1) \geq -2(n-1)\left(\frac{2}{3}\mathcal{K}r_0 + r_0^{-1}\right)at$$

$$\triangle d \leq \sum_{k=1}^{n-1} s''_{\mathcal{Y}_k}(\gamma) = \int_{r_0}^{d(x,t_0)} -Ric(\mathcal{X},\mathcal{X})\, ds + \int_0^{r_0}\left(\frac{s^2}{r_0^2}\left(-Ric(\mathcal{X},\mathcal{X})\right) + \frac{n-1}{r_0^2}\right)ds$$

$$= \int_{\gamma}^{\square} -Ric(\mathcal{X},\mathcal{X}) + \int_0^{r_0}\left(Ric(\mathcal{X},\mathcal{X})\left(1 - \frac{s^2}{r_0^2}\right) + \frac{n-1}{r_0^2}\right)ds$$

$$\leq d_t + (n-1)\left(\frac{2}{3}\mathcal{K}r_0 + r_0^{-1}\right)$$

$$\frac{2(\phi')^2}{\phi} - \phi'' \geq (2\mathrm{A} + 100n)\phi' - \mathfrak{C}(\mathrm{A})\phi$$

$$\square \hbar = (\bar{\mathcal{L}} + 2n + 1)(-\phi'' + (d_t - \triangle d - 2\mathrm{A})\phi') - 2 < \nabla\phi\nabla\bar{\mathcal{L}} > + (\bar{\mathcal{L}}_t - \triangle \bar{\mathcal{L}})\phi$$

$$\nabla\hbar = (\bar{\mathcal{L}} + 2n + 1)\nabla\phi + \phi\nabla\bar{\mathcal{L}}$$

$$\square \hbar = (\bar{\mathcal{L}} + 2n + 1)\left(-\phi'' + (d_t - \triangle d - 2\mathrm{A})\phi' + \frac{2(\phi')^2}{\phi}\right) + (\bar{\mathcal{L}}_t - \triangle \bar{\mathcal{L}})\phi$$

$$\square \hbar \geq -(\bar{\mathcal{L}} + 2n + 1)\mathfrak{C}(\mathrm{A})\phi - 2n\phi \geq -\left(2n + \mathfrak{C}(\mathrm{A})\right)\hbar$$

$$\square^{\dagger} v = -2(\mathcal{T} - t)\left|\mathcal{R}_{ij} + \nabla_i\nabla_j f - \frac{1}{2(\mathcal{T} - t)}g_{ij}\right|^2$$

$$-\frac{d}{dt}f(\gamma(t), t) \leq \frac{1}{2}(\mathcal{R}(\gamma(t), t) + |\dot{\gamma}(t)|^2) - \frac{1}{2(\mathcal{T} - t)}f(\gamma(t), t)$$

$$|\mathcal{R}m|(x,t) \leq 4|\mathcal{R}m|\overline{(x,t)}$$

$$(x,t) \in \mathcal{M}_\alpha, 0 < t \leq \bar{t}, d(x,t) \leq d\overline{(x,t)} + \mathcal{A}|\mathcal{R}m|^{-1/2}\overline{(x,t)}$$

$$\bar{t} - \frac{1}{2}\alpha Q^{-1} \leq t \leq \bar{t}, dist_{\bar{t}}(x,\bar{x}) \leq \frac{1}{10}\mathcal{A}Q^{-\frac{1}{2}} \leq \alpha t^{-1} + 2\epsilon^{-2}$$

$$\beta(1 - \mathrm{A}^{-2}) \leq -\int_{\mathcal{M}} \hbar\upsilon$$

$$= \int_{\mathcal{M}} [(-2\triangle f + |\nabla f|^2 - \mathcal{R})\bar{t} - f + n]\hbar\upsilon = \int_{\mathcal{M}} \left[-\bar{t}\left|\nabla\tilde{f}\right|^2 - \tilde{f} + n\right]\tilde{u}$$

$$+ \int_{\mathcal{M}} \left[\bar{t}\left(\frac{|\nabla\hbar|^2}{\hbar} - \mathcal{R}\hbar\right) - \hbar\log\hbar\right]u \leq \int_{\mathcal{M}} \left[-\bar{t}\left|\nabla\tilde{f}\right|^2 - \tilde{f} + n\right]\tilde{u} + \mathcal{A}^{-2} + 100\epsilon^2$$

$$\mathcal{R}_t + 2\langle\mathcal{X}, \nabla\mathcal{R}\rangle + 2Ric(\mathcal{X},\mathcal{X})$$

$$\frac{d}{dt}\mathrm{A}^t \leq -2\pi - \frac{1}{2}\mathcal{R}^t_{mint}\mathrm{A}^t \int_{\mathcal{D}_c} \left(-Tr\left(Ric^{\mathcal{T}}\right)\right) + \int_{c} (-k_g) - \int_{\mathcal{D}_c} \left(-\frac{1}{2}\mathcal{R} - \mathcal{K}\right) + \int_{c} (-k_g)$$

$$= \int_{\mathcal{D}_c} \left(-\frac{1}{2}\mathcal{R}\right) - 2\pi$$

$$\frac{d}{dt}\mathcal{R} = \triangle\mathcal{R} + 2|Ric|^2 = \triangle\mathcal{R} + \frac{2}{3}\Re^2 + 2|Ric^\circ|^2$$

$$\frac{d}{dt}g(\mathcal{X},\mathcal{X}) = 2Ric(\mathcal{X},\mathcal{X}) - 2g(\mathcal{X},\mathcal{X})k^2$$

$$|\mathcal{H},\mathcal{S}| = \left(k^2 + Ric(\mathcal{S},\mathcal{S})\right)\mathcal{S}$$

$$\frac{d}{dt}k^2 = (k^2)'' - 2g\left((\nabla_{\mathcal{S}}\mathcal{H})^\perp, (\nabla_{\mathcal{S}}\mathcal{H})^\perp\right) + 2k^4$$

$$\frac{d}{dt}k \leq k'' + k^3 + const \bigotimes (k+1)$$

$$\frac{d}{dt}\mathcal{L} \leq \int (const - k^2)\, ds$$

$$\frac{d}{dt}\Theta \leq \int const \bigotimes (k+1)\, ds$$

$$\frac{d}{dt}u = u'' + \left(k^2 + Ric(\mathcal{S}, \mathcal{S})\right)u$$

$$\frac{d}{dt}\mu^t \leq (2n-1)|\mathcal{R}m^t|\mu^t \int_{\mathrm{A}} \left(-Tr\left(Ric^{\mathcal{T}}\right)\right) + \int_{\partial\mathrm{A}} (-k_g) \leq \int_{\mathrm{A}} \left(-Tr\left(Ric^{\mathcal{T}}\right) + \mathcal{K}\right)$$

$$\leq \int_{\mathrm{A}} \left(-Tr\left(Ric^{\mathcal{T}}\right) + \mathcal{R}m^{\mathcal{T}}\right) \leq (2n-1)|\mathcal{R}m|\mu$$

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APÉNDICE C.

Modelo Brout-Englert-Higgs para espacios cuánticos curvos, a propósito de la fenomenología de las partículas y antipartículas supermasivas e hiperpartículas.

1. Nociones preliminares.

$$\mathcal{L} = -\frac{1}{4}\mathcal{W}_{\mu\nu}^{a}\mathcal{W}_{a}^{\mu\nu} + \left(\mathcal{D}_{\mu}\phi_{\alpha}\right)^{\dagger}\mathcal{D}^{\mu}\phi_{\alpha} - \mathcal{V}(\phi) + \mathcal{L}_{r}$$

$$\mathcal{W}_{\mu\nu}^{\alpha} = \partial_{\mu}\mathcal{W}_{\nu}^{\alpha} - \partial_{\nu}\mathcal{W}_{\mu}^{\alpha} - gf^{abc}\mathcal{W}_{\mu}^{b}\mathcal{W}_{\nu}^{c}$$

$$\mathcal{D}_{\mu}^{ij} = \partial_{\mu}\delta^{ij} - ig\mathcal{W}_{\mu}^{\alpha}\mathcal{T}_{a}^{\mathcal{R}_{\alpha}ij}$$

$$\mathcal{L} = -\frac{1}{4}\mathcal{W}_{\mu\nu}^{a}\mathcal{W}_{a}^{\mu\nu} + \left(\mathcal{D}_{\mu}\phi\right)^{\dagger}\mathcal{D}^{\mu}\phi - \lambda((\phi\phi^{\dagger})^{2} - f^{2})^{2}$$

$$\phi(\chi) = \upsilon + \eta(\chi)$$

$$\mathcal{L} = \partial_{\mu}\phi_{i}^{\dagger}\partial^{\mu}\phi_{i} - \mathcal{V}(\phi)$$

$$\mathcal{V}(\phi) = -\frac{\mu^{2}}{2}\phi^{2} + \lambda\phi^{4}$$

$$\mathcal{V}(\phi) = -\frac{\mu^{2}}{2}r^{2} + \lambda r^{4}$$

$$\mathcal{O}_{\Phi} = \mathcal{O}_{\Phi}^{\mathcal{G}} \Longrightarrow g(\bar{g})\Phi = \Phi\forall\bar{g} \in \mathcal{G}$$

$$\mathcal{O}_{\Phi} = \mathcal{O}_{\Phi}^{\mathcal{H}_{i}} \Longrightarrow \hbar\left(\bar{\hbar}\right)\Phi = \Phi\forall\bar{\hbar} \in \mathcal{H}_{i}$$

$$\mathcal{Z} = \int d^{\mathcal{N}}\phi e^{-i\left(\frac{\mu^{2}}{2}\phi^{2}+\lambda\phi^{4}\right)} = \Omega(\mathcal{N})\int d^{\mathcal{N}-1}dre^{-i\left(\frac{\mu^{2}}{2}r^{2}+\lambda r^{4}\right)} = \Omega(\mathcal{N})f(\mu,\lambda)$$

$$\langle\phi_{j}g(\phi^{2})\rangle = \int d^{\mathcal{N}}\phi\phi_{j}g(\phi^{2})e^{-i\left(\frac{\mu^{2}}{2}\phi^{2}+\lambda\phi^{4}\right)} = 0$$

$$\langle g(\phi^{2})\rangle = \int d^{\mathcal{N}}\phi g(\phi^{2})e^{-i\left(\frac{\mu^{2}}{2}\phi^{2}+\lambda\phi^{4}\right)} = \Omega(\mathcal{N})\hbar(\mu,\lambda)$$

$$\mathcal{Z}[j] = \int d^{\mathcal{N}}\phi_{i}e^{-i\left(\frac{\mu^{2}}{2}\phi^{2}+\lambda\phi^{4}+j\phi\right)}, \langle\phi_{i}g(\phi^{2})\rangle_{j\neq0} \neq 0$$

$$\langle\phi_{i}\rangle_{j\neq0} = \delta_{i_{1}}f(j)\lim_{j\mapsto0}f(j) = \upsilon \neq 0, \lim_{j\mapsto0}\langle\phi_{i}\rangle_{j} = \upsilon\delta_{i_{1}}0 = f(0) \neq \lim_{j\mapsto0}f(j)$$

$$m_{r} = \langle\left(\int d^{d}\chi\phi_{i}(\chi)\right)^{2}\rangle\lim_{j\mapsto0}\lim_{\mathcal{V}\mapsto\infty}f(j)$$

2. Simetría de campo en espacios cuánticos curvos.

$$\mathcal{V}(\phi,\phi^{\dagger}) = -\frac{1}{2}\mu^2\phi^{\dagger}\phi + \frac{1}{2}\frac{\mu^2}{f^2}(\phi^{\dagger}\phi)^2\phi \mapsto e^{-i\theta}\phi \approx \phi - i\theta\phi$$

$$\mathcal{L} = \frac{1}{2}\left(\partial_\mu\sigma\partial^\mu\sigma + \partial_\mu\chi\partial^\mu\chi\right) + \frac{\mu^2}{2}(\sigma^2+\chi^2) - \frac{1}{2}\frac{\mu^2}{f^2}(\sigma^2+\chi^2)^2\sigma \mapsto \sigma + \theta_\chi\chi \mapsto \chi + \theta_\sigma$$

$$\sigma^2 + \chi^2 = \frac{f^2}{\sqrt{2}} = \phi^{\dagger}\phi\sigma \mapsto \sigma + \frac{v}{\sqrt{2}}\chi \mapsto \chi$$

$$\mathcal{V} = \frac{\mu^2}{f^2}\left(\phi\phi^{\dagger} - \frac{f^2}{\sqrt{2}}\right)^2$$

$$\begin{aligned}\mathcal{L} &= \frac{1}{2}\left(\partial_\mu\sigma\partial^\mu\sigma + \partial_\mu\chi\partial^\mu\chi\right) + \frac{\mu^2 v}{\sqrt{2}}\left(\frac{v^2}{f^2}-1\right)\sigma + \frac{\mu^2 v^2}{4}\left(\frac{v^2}{2f^2}-1\right) - \mu^2\left(\frac{3}{2}\frac{v^2}{f^2}-\frac{1}{2}\right)\sigma^2 \\ &\quad - \mu^2\left(\frac{1}{2}\frac{v^2}{f^2}-\frac{1}{2}\right)\chi^2 + \frac{\sqrt{2}\mu^2}{f}\frac{v}{f}\sigma(\sigma^2+\chi^2) + \frac{\mu^2}{2f^2}(\sigma^2+\chi^2)^2 \\ &\triangleq \frac{1}{2}\left(\partial_\mu\sigma\partial^\mu\sigma + \partial_\mu\chi\partial^\mu\chi\right) - \mu^2\sigma^2 + \frac{\sqrt{2}\mu^2}{f}\sigma(\sigma^2+\chi^2) + \frac{1}{2}\frac{\mu^2}{f^2}(\sigma^2+\chi^2)^2 \\ &\quad - \frac{\mu^2 f^2}{8}\sigma \mapsto \sigma + \theta_\chi\chi \mapsto \chi - \theta(\sigma - v)v \mapsto v + \theta_\chi\end{aligned}$$

3. Teorema de Goldstone para espacios cuánticos curvos.

$$\delta\phi_i = i\mathcal{T}_a^{ij}\phi_j\theta^a$$

$$\mathcal{L} = \frac{1}{2}\partial_\mu\phi_i\partial^\mu\phi^i - \mathcal{V}(\phi)$$

$$0 = \frac{\partial\mathcal{V}}{\partial\phi_i}\delta\phi^i = i\frac{\partial\mathcal{V}}{\partial\phi_i}\mathcal{T}_{ij}^a\phi^j\theta_a\frac{\partial^2\mathcal{V}}{\partial\phi_\kappa\partial\phi_i}\bigg|_{\phi=v} = \left(\left(\mathcal{M}(v)\right)^2\right)_{\kappa i}$$

$$\mathcal{L} = \frac{1}{2}\partial_\mu\psi_i\partial^\mu\psi^i - \frac{1}{2}(\mathcal{M}^2)_{\kappa i}\mathcal{V}(\phi)\psi_\kappa\psi_i(\mathcal{M}^2)^{\kappa i}\mathcal{T}_{ij}^a v^j t_{ij}^a v^j \tau_{ij}^a v^j \neq 0$$

$$\phi^i\phi_i = \frac{v^i v_i}{\sqrt{2}} \triangleq \frac{f^2}{\sqrt{2}} > 0$$

3.1. Cuantización.

$$\Omega[j] = \frac{\mathcal{Z}[j]}{\mathcal{Z}[0]} = \frac{1}{\mathcal{Z}[0]}\int\mathcal{D}\phi\,\exp\left(i\int d^4\chi(\mathcal{L} + j_i\phi_i)\right)$$

$$\begin{aligned}0 = \delta\Omega[j] &= \int\mathcal{D}\phi e^{i\delta + i\int d^4\chi j_i\phi_i}\left(\frac{\partial\delta\phi_i}{\partial\phi_j} + \delta\left(i\delta + i\int d^4\chi j_i\phi_i\right)\right)\int d^4\chi j_i\mathcal{T}_{i\kappa}^a\frac{\delta\Omega[\mathfrak{J}]}{i\delta j_\kappa}\delta\Omega \\ &\equiv \delta(e^{\Omega_c}) = e^{\Omega_c}\delta\Omega_c\end{aligned}$$

$$0 = \int d^4\chi j_i \mathcal{T}^a_{i\kappa} \frac{\delta\Omega_c[\mathfrak{J}]}{i\delta j_\kappa} \frac{\delta\Omega_c[\mathfrak{J}]}{i\delta j_i} \langle\phi_i\rangle$$

$$i\Gamma[\phi] = i\int d^4\chi j_i\, \phi_i + \Omega_c[\mathfrak{J}]j_i \frac{\delta\Gamma[\phi]}{i\delta\phi_i} \int d^4\chi \frac{\delta\Gamma[\phi]}{\delta\phi_i} \mathcal{T}^a_{i\kappa}\langle\phi_\kappa\rangle \frac{i\delta^2\Gamma}{\delta\phi_i(\chi)\delta\phi_j(\gamma)}$$

$$= \left(\left(\mathcal{D}(\chi-\gamma)\right)^{-1}\right)_{i\kappa} \int d^4\chi \left(\frac{i\delta^2\Gamma}{\delta\phi_i(\chi)\delta\phi_j(\gamma)} \mathcal{T}^a_{i\kappa}\langle\phi_\kappa\rangle\right) \left(\left(\mathcal{G}(\wp = 0)\right)^{-1}\right)_{ij} \mathcal{T}^a_{i\kappa}\langle\phi_\kappa\rangle$$

4. Sistema de simetrías Brout-Englert-Higgs.

$$\mathcal{L} = \partial_\mu\phi^\dagger\partial^\mu\phi - \mathcal{V}(\phi)$$

$$\mathcal{L} = -\frac{1}{4}\mathcal{W}^a_{\mu\nu}\mathcal{W}^{\mu\nu}_a + \left(\mathcal{D}_\mu\phi_\alpha\right)^\dagger \mathcal{D}^\mu\phi_\alpha - \mathcal{V}(\phi)$$

$$\mathcal{W}^\alpha_{\mu\nu} = \partial_\mu\mathcal{W}^\alpha_\nu - \partial_\nu\mathcal{W}^\alpha_\mu - gf^{abc}\mathcal{W}^b_\mu\mathcal{W}^c_\nu$$

$$\mathcal{D}_\mu = \partial_\mu + g\mathcal{T}^{\mathcal{R}}$$

$$\mathcal{X} = \begin{pmatrix} \phi_1 & -\phi_2^\dagger \\ \phi_1 & \phi_1^\dagger \end{pmatrix}$$

$$\mathcal{L} = -\frac{1}{4}\mathcal{W}^a_{\mu\nu}\mathcal{W}^{\mu\nu}_a + \frac{1}{2}tr\left(\left(\mathcal{D}_\mu\mathcal{X}\right)^\dagger\mathcal{D}_\mu\mathcal{X}\right) - \lambda\left(\frac{1}{2}tr(\mathcal{X}^\dagger\mathcal{X}) - f^2\right)^2$$

$$\mathcal{X} = \rho\alpha$$

$$\phi^\dagger\phi = f^2$$

$$\mathcal{X} = \upsilon\alpha$$

$$\phi^c_i = \upsilon_j\eta^j_i$$

$$\mathcal{X}^c = \upsilon 1$$

$$\mathfrak{G}\times\mathfrak{C} \mapsto \mathfrak{G}'\times\mathfrak{C}' = \mathcal{H}'$$

$$g\left(\bar{\hbar}'\right)\phi^c_i = \phi^c_i$$

$$\mathcal{A}^\dagger\mathcal{X}^c\mathcal{A} = \upsilon\mathcal{A}^\dagger 1\mathcal{A} = \upsilon 1$$

5. Campos de Gauge en espacios cuánticos curvos.

$$\mathcal{Z} = \int \mathcal{D}\phi_i\mathcal{D}\mathcal{W}^a_\mu e^{i\int d^d\chi\mathcal{L}}$$

$$\mathcal{W}_\mu \mapsto g\mathcal{W}_\mu g^{-1} - i\left(\partial_\mu g\right)g^{-1} \approx \mathcal{T}^a\left(\mathcal{W}^a_\mu + \mathcal{D}^{ab}_\mu\theta^b\right) + \mathcal{O}(\theta^2)$$

$$\mathcal{D}^{ab}_\mu = \delta^{ab}\partial_\mu + gf^{abc}\mathcal{W}^c_\mu$$

$$\mathfrak{C}^a = \partial^\mu \mathcal{W}_\mu^a$$

$$\Delta^{-1}[\mathcal{W}_\mu^a] = \int \mathcal{D}g\delta(\mathfrak{C}^a[\mathcal{W}_\mu^{ag}])$$

$$1 = \Delta[\mathcal{W}_\mu^a] = \int \mathcal{D}g\delta(\mathfrak{C}^a[\mathcal{W}_\mu^{ag}])$$

$$\begin{aligned}\mathcal{Z} &= \int \mathcal{D}\mathcal{W}_\mu^a\, \Delta[\mathcal{W}_\mu^a] \int \mathcal{D}g\delta(\mathfrak{C}^a[\mathcal{W}_\mu^{ag}]) \exp(i\delta[\mathcal{W}_\mu^a]) \\ &= \left(\int \mathcal{D}g\right) \int \mathcal{D}\mathcal{W}_\mu^a\, \Delta[\mathcal{W}_\mu^a]\delta(\mathfrak{C}^a[\mathcal{W}_\mu^{ag}]) \exp(i\delta[\mathcal{W}_\mu^a])\end{aligned}$$

$$\Delta[\mathcal{W}_\mu^a] = \left(\det \frac{\delta\mathfrak{C}^a(\chi)}{\delta\theta^b(\gamma)}\right)_{\mathfrak{C}^a=0} = \det \mathcal{M}^{ab}(\chi,\gamma)$$

$$\mathcal{M}^{ab}(\chi,\gamma) = \frac{\delta\mathfrak{C}^a(\chi)}{\delta\theta^b(\gamma)} = \int d^4z \sum_{ij} \frac{\delta\mathfrak{C}^a(\chi)}{\delta\omega_j^i(z)} \frac{\delta\omega_j^i(z)}{\delta\theta^b(\gamma)}$$

$$\mathcal{M}^{ab}(\chi,\gamma) = \frac{\delta\mathfrak{C}^a(\chi)}{\delta\mathcal{W}_\mu^c(\gamma)} \mathcal{D}_\mu^{cb}(\gamma)$$

$$\det \mathcal{M} \sim \int \mathcal{D}c^a\mathcal{D}\bar{c}^a \exp\left(-i\int d^4\chi d^4\gamma \bar{c}^a(\chi)\mathcal{M}^{ab}(\chi,\gamma)c^b(\gamma)\right)$$

$$\mathcal{M}^{ab}(\chi,\gamma) = \partial^\mu \mathcal{D}_\mu^{ab}\delta(\chi-\gamma)$$

$$\mathcal{Z} = \int \mathcal{D}\mathcal{W}_\mu^a\mathcal{D}c^a\mathcal{D}\bar{c}^a \exp\left(i\delta - \frac{i}{2\xi}\int d^4\chi(\partial^\mu\mathcal{W}_a^\mu)^2 - i\int d^4\chi\bar{c}^a\partial^\mu\mathcal{D}_\mu^{ab}c^b\right)$$

$$\mathfrak{C}^a = \partial^\mu \mathcal{W}_\mu^a + ig\zeta\phi_i\mathcal{T}_{ij}^a v_j + \Lambda^a$$

$$\begin{aligned}\mathcal{Z} = \int \mathcal{D}\mathcal{W}_\mu^a\mathcal{D}c^a\mathcal{D}\bar{c}^a \exp\Big(i\delta \\ - \frac{i}{2\xi}\int d^4\chi\left|\partial^\mu\mathcal{W}_a^\mu + ig\zeta\phi_i\mathcal{T}_{ij}^a v_j\right|^2 - i\int d^4\chi\bar{c}^a\left(\partial^\mu\mathcal{D}_\mu^{ab} - \zeta g^2 v_i\mathcal{T}_{ij}^a\mathcal{T}_{j\kappa}^b\phi_\kappa\right)c^b\Big)\end{aligned}$$

$$\phi(\chi) = v + \varphi(\chi)$$

$$\mathcal{L} = -\frac{1}{4}\mathcal{W}_{\mu\nu}^a\mathcal{W}_a^{\mu\nu} + \frac{1}{2}\left((\partial_\mu\delta_{ij} - ig\mathcal{W}_\mu^a\mathcal{T}_{ij}^a)\phi_j\right)^\dagger - (\partial_\mu\delta_{i\kappa} - ig\mathcal{W}_\mu^b\mathcal{T}_{j\kappa}^b)\phi - \lambda(\phi^2 - f^2)^2$$

$$\mathcal{L} = -\frac{1}{4}\mathcal{W}_{\mu\nu}^{a}\mathcal{W}_{a}^{\mu\nu} + \frac{1}{2}\left(\mathcal{D}_{\mu}^{ij}\varphi_{j}\right)^{\dagger}\left(\mathcal{D}_{i\kappa}^{\mu}\varphi_{\kappa}\right) + \frac{g^{2}f^{2}}{2}\mathcal{T}_{ij}^{a}\mathcal{T}_{j\kappa}^{b}\eta_{j}^{\dagger}\eta_{\kappa}\mathcal{W}_{\mu}^{a}\mathcal{W}_{\mu}^{b} - \lambda f^{2}|\eta\varphi|^{2}$$
$$+ \frac{ig^{2}\xi f^{2}}{2}|\varphi\mathcal{T}^{a}\eta|^{2} + i\xi g^{2}f^{2}\eta_{i}^{\dagger}\mathcal{T}_{ij}^{a}\mathcal{T}_{j\kappa}^{b}\eta_{\kappa}\bar{c}^{a}c^{b} - 2\lambda f\left((\eta\varphi) + (\eta\varphi)^{\dagger}\right)\varphi^{2}$$
$$- \lambda(\varphi^{2})^{2} + i\bar{c}^{a}\xi g^{2}f\left(\eta_{i}\mathcal{T}_{ij}^{a}\mathcal{T}_{j\kappa}^{b}\varphi_{\kappa}^{\dagger} + \eta_{i}^{\dagger}\mathcal{T}_{ij}^{a}\mathcal{T}_{j\kappa}^{b}\varphi_{\kappa}\right)c^{b} - \frac{i}{2\xi}\left(\partial^{\mu}\mathcal{W}_{\mu}^{a}\right)^{2}$$
$$- i\bar{c}^{a}\partial^{\mu}\mathcal{D}_{\mu}^{ab}c^{b}$$

$$\mathcal{D}_{\mu\nu}^{ab} = \delta^{ab}\left(\left(\left(g_{\mu\nu} - \frac{\kappa_{\mu}\kappa_{\nu}}{\kappa^{2}}\right)\frac{-i}{\kappa^{2} - m_{\mathcal{W}}^{2}}\right) - \frac{i\xi\kappa_{\mu}\kappa_{\nu}}{\kappa^{2}(\kappa^{2} - \xi m_{\mathcal{W}}^{2})}\right)$$

$$\mathcal{F}\left[\mathcal{W}_{\mu}^{a}\right] = \int d^{d}\chi\,\mathcal{W}_{\mu}^{a}\mathcal{W}_{\mu}^{a}$$

$$\mathcal{W}_{\mu}^{a} \mapsto \mathcal{W}_{\mu}^{a} + \partial_{\mu}\omega^{a} + igf^{abc}\mathcal{W}_{\mu}^{b}\omega^{c}$$

$$\delta = \sum_{\chi}\left(\phi^{\dagger}(\chi)\phi(\chi) + \gamma(\phi^{\dagger}(\chi)\phi(\chi) - 1)^{2} - \kappa\sum_{\pm\mu}\phi(\chi)^{\dagger}\mathcal{U}_{\mu}^{\mathfrak{R}}(\chi)\,\phi(\chi+\mu)\right.$$
$$\left. + \frac{\beta}{d_{\mathcal{F}}}\sum_{\mu<\nu}\Re tr\left(1 - \mathcal{U}(\chi)_{\mu\nu}\right)\right)$$

$$\mathcal{U}(\chi)_{\mu\nu} = \mathcal{U}_{\mu}(\chi)\mathcal{U}_{\nu}(\chi+\mu)\mathcal{U}_{\mu}(\chi+\nu)^{\dagger}\mathcal{U}_{\nu}(\chi)^{\dagger}$$

$$\mathcal{U}_{\mu}(\chi) = \exp\left(i\mathcal{W}_{\mu}^{a}\sigma_{a}\right)$$

$$\beta = \frac{2\mathfrak{C}_{\mathfrak{F}}}{g^{2}}$$

$$-a^{2}(2\lambda v^{2}) = \frac{1-2\gamma}{\kappa} - 2d$$

$$\frac{1}{2\lambda} = \frac{\kappa^{2}}{2\gamma}$$

6. Métrica de Elitzur – Higgs para espacios cuánticos curvos.

$$\langle f(\mathcal{W})\rangle = \int \mathcal{D}\mu f(\mathcal{W}) = \int \mathcal{D}\mu^{g^{-1}} f(\mathcal{W}) = \int \mathcal{D}\mu f\left(\mathcal{W}^{g}\right) = \int \mathcal{D}\mu f\left(\mathcal{W}\right)^{g} = \langle f(\mathcal{W})^{g}\rangle$$

7. Construcción de Osterwalder-Seiler-Fradkin-Shenker para espacios cuánticos curvos.

$$g = \alpha^{-1}$$

$$\delta = -\kappa\mathcal{H}\left(\mathcal{V}_{\mu}\right) - \beta\delta_{\mathcal{YM}}$$

$$\langle\mathcal{O}\rangle=\frac{\int\prod_{\chi,\mu}d\mathcal{V}_\mu(\chi)\mathcal{O}e^{-\kappa\mathcal{H}(\mathcal{V}_\mu)-\beta\delta_{\mathcal{YM}}}}{\int\prod_{\chi,\mu}d\mathcal{V}_\mu(\chi)e^{-\kappa\mathcal{H}(\mathcal{V}_\mu)-\beta\delta_{\mathcal{YM}}}}=\frac{\int\prod_{\chi,\mu}d\mathcal{V}_\mu(\chi)e^{-\kappa\mathcal{H}(\mathcal{V}_\mu)}\mathcal{O}e^{-\beta\delta_{\mathcal{YM}}}}{\int\prod_{\chi,\mu}d\mathcal{V}_\mu(\chi)e^{-\kappa\mathcal{H}(\mathcal{V}_\mu)}e^{-\beta\delta_{\mathcal{YM}}}}$$

$$e^{-\beta\delta_{\mathcal{YM}}}=\prod_{\chi,\mu\nu}\left(1+\rho_{\mu\nu}\right)$$

$$\langle\mathcal{O}\rangle=\frac{\int\prod_{\chi,\mu}d\mathcal{V}_\mu(\chi)e^{-\kappa\mathcal{H}(\mathcal{V}_\mu)}\mathcal{O}\prod_{\chi,\mu\nu}\left(1+\rho_{\mu\nu}\right)}{\int\prod_{\chi,\mu\nu}d\mathcal{V}_\mu(\chi)e^{-\kappa\mathcal{H}(\mathcal{V}_\mu)}\mathcal{O}\prod_{\chi,\mu\nu}\left(1+\rho_{\mu\nu}\right)}$$

$$\int\prod_{\chi,\mu\nu\in\mathcal{Q}}d\mathcal{V}_\mu(\chi)\,e^{-\kappa\mathcal{H}(\mathcal{V}_\mu)}\mathcal{O}\prod_{\chi,\mu\nu}\rho_{\mu\nu}<c_1c_2^\eta$$

8. Estructuras cuánticas diagramáticas en espacios cuánticos curvos.

$$\mathcal{Q}_{\mathcal{L}}=\frac{1}{2}\langle\left|\sum_\chi\phi(\chi)\right|^2\rangle$$

$$\mathcal{Q}_{\mathcal{C}}=\frac{1}{2\mathcal{N}_t\mathcal{V}_{d-1}^2}\sum_t\langle tr\left|\sum_{\vec{\chi},\vec{\gamma}}\mathcal{U}_0(t,\vec{\chi})^\dagger\mathcal{U}_0(t,\vec{\gamma})\right|\rangle$$

$$tr(\Sigma^3)$$

$$\sum=\mathcal{T}^a\phi^a$$

$$\langle\mathcal{O}\rangle=\int\mathcal{DW}\left(\int_{Selected\ stratum}\mathcal{D}\phi\mathcal{O}e^{i\delta}+\int_{Other\ strata}\mathcal{D}\phi\mathcal{O}e^{i\delta}\right)=\langle\mathcal{O}\rangle_\delta+\langle\mathcal{O}\rangle_o$$

9. Espectro de Masa y Brecha de Masa según las teorías cuánticas de campo de Yang – Mills - Higgs.

$$\mathcal{H}(\gamma)=\phi^\dagger(\gamma)\phi(\gamma)=\det\chi(\gamma)$$

$$\mathcal{V}_\mu^c(\gamma)=\frac{1}{\det\chi(\gamma)}tr\left(\mathcal{T}^c\chi^\dagger(\gamma)\exp\left(i\mathcal{T}_b\omega_\mu^b(\gamma)\right)\chi(\gamma+\epsilon_\mu)\right)$$
$$=\frac{1}{\mathcal{H}(\gamma)}tr\left(\tau^c\chi^\dagger(\gamma)\mathcal{D}_\mu\chi(\gamma)\right)+\mathcal{O}(a^2)$$

$$\mathcal{V}_\mu(\gamma)=\mathcal{T}^c\mathcal{V}_\mu^c(\gamma)$$

$$\delta = \beta \sum_{\gamma\mu<\nu} \left(1 - \frac{1}{2} \Re tr \mathcal{V}_{\mu\nu}(\gamma)\right)$$

$$+ \sum_{\gamma} \left(\mathcal{H}^2(\gamma) - 3 \log \mathcal{H}(\gamma) + \lambda(\mathcal{H}(\gamma) - 1)^2 \right.$$

$$\left. - \kappa \sum_{\mu>0} \mathcal{H}(\gamma+\mu)\, \mathcal{H}(\gamma) tr \mathcal{V}_{\mu}(\gamma) \right)$$

10. Dinámica perturbativa de la invariante de gauge en espacios cuánticos curvos.

$$\langle \mathcal{O}^{\dagger}\mathcal{O}\rangle = v^2 \eta_i \eta_j \langle \mathcal{O}_i'^{\dagger} \mathcal{O}_j' \rangle + v\eta_i \langle (\mathcal{O}_i'^{\dagger} \mathcal{O}'' + \mathcal{O}''^{\dagger}\mathcal{O}_i') \rangle + \langle \mathcal{O}''\mathcal{O}''\rangle$$

$$\mathcal{H}(\chi) = \langle \phi^{\dagger}\phi \rangle \langle \chi \rangle$$

$$\langle (\phi^{\dagger}\phi)(\chi)(\phi^{\dagger}\phi)(\gamma)\rangle$$
$$= dv^4 + 4v^2 \langle \Re[\eta_i^{\dagger}\eta_i]^{\dagger}(\chi) \Re[\eta_j^{\dagger}\eta_j](\gamma)\rangle$$
$$+ 2v \left(\langle (\eta_i^{\dagger}\eta_i)(\chi) \Re[\eta_j^{\dagger}\eta_j](\gamma) \rangle + (\chi \leftrightarrow \gamma) \right) + \langle (\eta_i^{\dagger}\eta_i)(\chi)(\eta_j^{\dagger}\eta_j)(\gamma)\rangle$$

$$\langle (\phi^{\dagger}\phi)(\chi)(\phi^{\dagger}\phi)(\gamma)\rangle$$
$$= d'v^4 + 4v^2 \langle \Re[\eta_i^{\dagger}\eta_i]^{\dagger}(\chi) \Re[\eta_j^{\dagger}\eta_j](\gamma)\rangle_{\mathfrak{I}\ell} + \langle \Re[\eta_i^{\dagger}\eta_i]^{\dagger}(\chi) \Re[\eta_j^{\dagger}\eta_j](\gamma)\rangle_{\mathfrak{I}\ell}^2$$
$$+ \mathcal{O}(g^2, \lambda)$$

$$\mathcal{D}_{\mathcal{H}}(\mathcal{P}^2) = 4v^2 \mathcal{D}_{\eta}(\mathcal{P}^2)^{\mathfrak{I}\ell} + 2 \int d^4 q \mathcal{D}_{\eta}^{\mathfrak{I}\ell}((\mathcal{P}-q)^2) \mathcal{D}_{\eta}^{\mathfrak{I}\ell}(q^2) = \frac{4v^2}{\mathcal{P}^2 - m_{\hbar}^2 + i\epsilon} + \prod(\mathcal{P}^2)$$

$$\approx \frac{4v^2}{(\mathcal{P}^2 - m_{\hbar}^2)\left(1 + \frac{\mathcal{P}^2 - m_{\hbar}^2}{4v^2} \prod(\mathcal{P}^2)\right) + i\epsilon}$$

$$\prod(\mathcal{P}^2) = -2i\pi^2 \left(\ln \frac{m_{\hbar}^2}{\mu^2} + \frac{m_{\hbar}^2}{\wp^2} \left(\frac{1}{r(\wp^2)} - r(\wp^2) \right) \ln r(\wp^2) \right)$$

$$r(\wp^2) = \frac{2m_{\hbar}^2 - \wp^2 - i\epsilon \pm \sqrt{(\wp^2 - 2m_{\hbar}^2 + i\epsilon)^2 - 4m_{\hbar}^2}}{2m_{\hbar}^2}$$

$$\langle (\phi^{\dagger}\phi)(\chi)(\phi^{\dagger}\phi)(\gamma)\rangle_c = 4v^2 \langle \Re[\eta_i^{\dagger}\eta_i]^{\dagger}(\chi) \Re[\eta_j^{\dagger}\eta_j](\gamma)\rangle_c + \mathcal{O}(v) = 4v^2 \mathcal{D}_{\eta}(\chi - \gamma) + \mathcal{O}(v)$$

$$\mathcal{O}_{2\mathcal{H}} = \mathcal{H}(\gamma)\mathcal{H}(\gamma)$$

$$\mathcal{O}_{\omega-\mathscr{b}a\ell\ell} = (\omega_{\mu\nu}^{a} \omega_{a}^{\mu\nu})(\gamma)$$

$$\mathcal{W}(\chi) = tr(\mathcal{T}^a \chi^{\dagger} \mathcal{D}_{\mu} \chi)(\gamma)$$

$$\langle tr(\mathcal{T}^a\chi^\dagger\mathcal{D}_\mu\chi)(z)tr(\mathcal{T}^b\chi^\dagger\mathcal{D}_\mu\chi)(\gamma)\rangle = v^2c^{ab}_{\kappa\ell}\langle\omega^{\kappa\mu}(z)\omega^{\ell}_{\mu}(\gamma)\rangle + \mathcal{O}(v)$$

$$\mathcal{D}(t) = \langle\mathcal{O}(t)\mathcal{O}(0)\rangle = \sum_\eta |\langle\eta|\mathcal{O}\rangle|^2 e^{-\mathfrak{E}_\eta t}\left\langle \underset{\sim}{t \gg \mathfrak{E}_1^{-1}} \right\rangle e^{-\mathfrak{E}_0 t}$$

$$\mathcal{O}(t) = \sum_{\vec{\chi}} \mathcal{O}(\vec{\chi}, t)$$

$$m(t) = \ln - \frac{\mathcal{D}(t)}{\mathcal{D}(t+a)}$$

$$\mathcal{D}^{ij}(\wp^2) = \frac{\delta^{ij}}{\mathcal{Z}(\wp^2 + m_r^2 + \prod(\wp^2) + \delta m^2)}$$

$$\mathcal{D}^{ij}(\mu^2) = \frac{\delta^{ij}}{\mu^2 + m_r^2}$$

$$\frac{\partial\mathcal{D}^{ij}}{\partial\wp}(\mu^2) = -\frac{2\mu\delta^{ij}}{(\mu^2 + m_r^2)^2}$$

$$\mathcal{Z} = \frac{2\mu - \frac{d\prod(\wp^2)}{d\wp}(\mu^2)}{2\mu}$$

$$\delta m^2 = \frac{(\mu^2 + m_r^2)\frac{d\prod(\wp^2)}{d\wp}(\mu^2) - 2\mu\prod(\mu^2)}{2\mu}$$

10.1. Simetría QED.

$$\frac{1}{2}tr\left((\mathcal{D}_\mu\chi)^\dagger\mathcal{D}^\mu\chi\right)$$

$$\mathcal{O}_\mathcal{Z} = \sin\theta_\mathcal{W}\, d\mathcal{O}^3_{1_{\bar{3}}} + \cos\theta_\mathcal{W}\mathcal{D}\mathscr{b} \approx \sin\theta_\mathcal{W}\,\omega^3 + \cos\theta_\mathcal{W}\mathscr{b} + \mathcal{O}(v^{-1}) = z + \mathcal{O}(v^{-1})$$

$$\mathcal{O}_\Gamma = \sin\theta_\mathcal{W}\, d\mathcal{O}^3_{1_{\bar{3}}} - \cos\theta_\mathcal{W}\mathcal{D}\mathscr{b} \approx \sin\theta_\mathcal{W}\,\omega^3 - \cos\theta_\mathcal{W}\mathscr{b} + \mathcal{O}(v^{-1}) = \gamma + \mathcal{O}(v^{-1})$$

$$\begin{aligned}\left\langle(\mathcal{O}^3_{1_{\bar{3}}})_\mu\middle|(\mathcal{O}^3_{1_{\bar{3}}})_\nu\middle|(\mathcal{O}_\Gamma)_\rho\right\rangle &\approx v^4\langle\omega^+_\mu|\omega^-_\nu|\gamma_\rho\rangle + \mathcal{O}(v^3)\\ &= v^4\left(\sin\theta_\mathcal{W}\langle\omega^+_\mu|\omega^-_\nu|\omega^3_\rho\rangle + \cos\theta_\mathcal{W}\langle\omega^+_\mu|\omega^-_\nu|\mathscr{b}_\rho\rangle\right)\\ &+ \mathcal{O}(v^3)\underset{\approx}{tree - level} v^4\sin\theta_\mathcal{W}\langle\omega^+_\mu|\omega^-_\nu|\omega^3_\rho\rangle_{\mathfrak{I}\ell}\end{aligned}$$

$$tr\tau^a\chi^\dagger\mathcal{D}_\mu\chi = v^2\omega^{\mathscr{b}}_\mu tr\tau^a\tau^{\mathscr{b}} + \mathcal{O}(v) = \omega^a_\mu + \mathcal{O}(v)$$

10.2. Otras simetrías de gauge.

$$\mathcal{O}_\psi(\gamma) = (\chi\epsilon)^\dagger(\gamma)\psi(\gamma)$$

$$\mathcal{O}_{\mathcal{N}\mathfrak{E}} = \binom{\mathcal{N}}{\mathfrak{E}} = (\chi\epsilon)^{\dagger}\binom{\nu}{e} = \binom{\phi_2\nu - \phi_1 e}{\phi_1^{\star}\nu + \phi_2^{\star}e} \approx \upsilon\binom{\nu}{e} + \mathcal{O}(\upsilon^0)$$

$$\mathcal{L}_{\mathcal{Y}} = g_{\mathcal{Y}}(\bar{\mathcal{O}}_{\mathcal{N}\mathfrak{E}}\psi_{\mathfrak{R}} - \bar{\psi}_{\mathfrak{R}}\mathcal{O}_{\mathcal{N}\mathfrak{E}})$$

$$\mathcal{L}_{\mathcal{Y}} = g_{\mathcal{Y}}(\bar{\mathcal{O}}_{\mathcal{N}\mathfrak{E}}\Omega\psi_{\mathfrak{R}} - \bar{\psi}_{\mathfrak{R}}\Omega^{\dagger}\mathcal{O}_{\mathcal{N}\mathfrak{E}})$$

$$\mathcal{L}_{\mathcal{Y}} = g_{\nu}(\phi_2\bar{\nu}_{\mathcal{L}} - \phi_1\bar{e}_{\mathcal{L}})\mathcal{N}_{\mathcal{R}} + g_{\varepsilon}(\phi_1^{*}\bar{\nu}_{\mathcal{L}} - \phi_2^{*}\bar{e}_{\mathcal{L}})\mathfrak{E}_{\mathfrak{R}} + \hbar.c$$

10.3. Simetría QCD.

$$\mathcal{O}_{\sigma} = \bar{\mu}_{\mathcal{L}}\sigma\mu_{\mathcal{L}} + \bar{d}_{\mathcal{L}}\sigma d_{\mathcal{L}} + \bar{\mu}_{\mathfrak{R}}\sigma\mu_{\mathfrak{R}} + \bar{d}_{\mathfrak{R}}\sigma d_{\mathfrak{R}}$$

$$\psi = \begin{pmatrix} (\chi\epsilon)^{\dagger}\psi_{\mathcal{L}} \\ \mathcal{U}_{\mathcal{R}} \\ \mathcal{D}_{\mathcal{R}} \end{pmatrix}$$

$$\pi^{a} = \bar{\psi}\tau^{a}\gamma_5\psi$$

$$\pi^{+} = \bar{\mathcal{D}}_{\mathcal{R}}((\chi\epsilon)^{\dagger}\psi_{\mathcal{L}})^{\mu} + \overline{((\chi\epsilon)^{\dagger}\psi_{\mathcal{L}})^{d}}\mathcal{U}_{\mathcal{R}}$$

$$\pi^{-} = \bar{\mathcal{U}}_{\mathcal{R}}((\chi\epsilon)^{\dagger}\psi_{\mathcal{L}})^{d} + \overline{((\chi\epsilon)^{\dagger}\psi_{\mathcal{L}})^{\mu}}\mathcal{D}_{\mathcal{R}}$$

$$\pi^{0} = \bar{\mathcal{D}}_{\mathcal{R}}((\chi\epsilon)^{\dagger}\psi_{\mathcal{L}})^{d} + \overline{((\chi\epsilon)^{\dagger}\psi_{\mathcal{L}})^{d}}\mathcal{U}_{\mathcal{R}} - \bar{\mathcal{U}}_{\mathcal{R}}((\chi\epsilon)^{\dagger}\psi_{\mathcal{L}})^{\mu} + \overline{((\chi\epsilon)^{\dagger}\psi_{\mathcal{L}})^{\mu}}\mathcal{D}_{\mathcal{R}}$$

$$\mathcal{N}_{\mathcal{L}} = \epsilon^{\mathcal{IJK}}c_{ij\kappa\ell}q_i^{\mathcal{J}}q_j^{\mathcal{J}}q_{\kappa}^{\mathcal{K}}(\chi\epsilon)_{\tilde{\imath}l}^{\dagger}$$

$$\Delta_{\mathcal{L}} = \epsilon^{\mathcal{IJK}}q_i^{\mathcal{J}}q_j^{\mathcal{J}}q_{\kappa}^{\mathcal{K}}(\chi\epsilon)_{\tilde{\imath}i}^{\dagger}(\chi\epsilon)_{\tilde{\jmath}j}^{\dagger}(\chi\epsilon)_{\tilde{\kappa}\kappa}^{\dagger}$$

$$c_{ij\kappa\ell}^{\wp} = \alpha_1\epsilon_{ij}\delta_{\kappa\ell} + \alpha_2\epsilon_{i\kappa}\delta_{j\ell} + \alpha_3\epsilon_{j\kappa}\delta_{i\ell}$$

$$\mathcal{N}^{rst} = \epsilon^{\mathcal{IJK}}\mathcal{F}_{uvw}^{rst}\psi_{\mathcal{I}\mu}(\psi_{\mathcal{J}\upsilon}^{\mathcal{T}}\mathcal{C}\gamma_5\psi_{\kappa\omega})$$

$$\begin{aligned}\langle\phi^{\dagger}\phi\rangle = \mathcal{W}^{a}tr\left(\mathcal{T}_{ij}^{a}\chi_j^{\dagger}\mathcal{D}_{\mu}\chi_i\right)\sin\theta_{\mathcal{W}}\,d\mathcal{O}_{1\bar{3}}^{3} + \cos\theta_{\mathcal{W}}\,\mathcal{D}\mathscr{b}\sin\theta_{\mathcal{W}}\,d\mathcal{O}_{1\bar{3}}^{3} \\ - \cos\theta_{\mathcal{W}}\,\mathcal{D}\mathscr{b}\begin{vmatrix}\nu_{\mathcal{R}} \\ de_{\mathcal{R}}\end{vmatrix}d(\chi\epsilon)^{\dagger}\begin{vmatrix}\nu_{\mathcal{L}} \\ e_{\mathcal{L}}\end{vmatrix}d\epsilon^{\mathcal{IJK}}\mathcal{F}_{uvw}^{rst}\psi_{\mathcal{I}\mu}(\psi_{\mathcal{J}\upsilon}^{\mathcal{T}}\mathcal{C}\gamma_5\psi_{\kappa\omega})\end{aligned}$$

$$\mathcal{O}_{0^{+}}^{ab} = tr(\chi\tau^{a}\tau^{b}\gamma)$$

$$\begin{aligned}\sigma_{\xi^{+}\xi^{-}\mapsto\bar{\mathcal{F}}\mathcal{F}}(\delta) &= \sum_{i}\int_0^1 d\chi\int_0^1 d\gamma f_i(\chi)f_i(\gamma)\,\sigma_{\bar{\imath}i\mapsto\bar{f}f}(\chi\wp_1,\gamma\wp_2) \\ &= \theta(4m_{\hbar}^2 - \delta)\sigma_{e^{+}e^{-}\mapsto\bar{f}f} \\ &+ \theta(\delta - 4m_{\hbar}^2)\bigotimes\sum_{i}\int_0^1 d\chi\int_0^1 d\gamma f_i(\chi)f_i(\gamma)\sigma_{\bar{\imath}i\mapsto\bar{f}f}(\chi\wp_1,\gamma\wp_2)\end{aligned}$$

$$f_i(\chi) = \alpha_i\delta(\chi) + c_i\delta(\chi - 1)$$

10.4. Simetrías amplias de gauge.

$$\left\langle \mathcal{O}_\mu^{1_0^-}(\chi) \middle| \mathcal{O}_\mu^{\dagger 1_0^-}(\gamma) \right\rangle = \frac{v^4 g^2}{4} \langle \omega_\mu^8(\chi) | \omega_\mu^8(\gamma) \rangle + \mathcal{O}(\eta)$$

$$\mathcal{O}_\mu^{1_0^-}(\chi) = i(\phi^\dagger \mathcal{D}_\mu \phi)(\chi)$$

$$\mathcal{O}^{0_1^+} = \epsilon_{abc} \phi_a \mathcal{D}_\mu \phi_b \mathcal{D}_\mu \mathcal{D}_\nu \mathcal{D}_\nu \phi_c$$

$$\mathcal{O}_\mu^{1_1^-} = \epsilon_{abc} \phi_a \mathcal{D}_\nu \phi_b \mathcal{D}_\mu \mathcal{D}_\nu \phi_c$$

$$\mathcal{O}_\mu^{1_0^-} = -\frac{v^2 g}{2} \omega_\mu^8 + \frac{v}{\sqrt{2}} \partial_\mu \eta - \sqrt{2} g v \omega_\mu^8 \eta + \mathcal{O}(\eta^2)$$

11. Representación de Higgs en espacios cuánticos curvos.

$$\mathcal{O}_\mu^\Gamma = \frac{\partial^\nu}{\partial^2} tr(\phi^a \mathcal{T}^a \omega_{\mu\nu}) \approx -v tr\left(\mathcal{T}^3 \left(\delta_{\mu\nu} - \frac{\partial_\mu \partial_\nu}{\partial^2}\right) \omega^\nu\right) + \mathcal{O}(\eta)$$

$$\langle \mathcal{O}^\dagger(\chi) | \mathcal{O}(\gamma) \rangle = \int \mathcal{D}\omega \left(\int_{Selected\ stratum} \mathcal{D}\phi \mathcal{O}^\dagger(\chi) \mathcal{O}(\gamma) e^{i\delta} + \int_{Other\ strata} \mathcal{D}\phi \mathcal{O}^\dagger(\chi) \mathcal{O}(\gamma) e^{i\delta} \right)$$
$$= \langle \mathcal{O}^\dagger(\chi) | \mathcal{O}(\gamma) \rangle_\varepsilon + \langle \mathcal{O}^\dagger(\chi) | \mathcal{O}(\gamma) \rangle_\eta$$

12. Procesos de dispersión en espacios cuánticos curvos.

$$\langle \mathcal{O}(\chi)^\dagger | \varphi(\gamma) | \varphi(z) \rangle$$

$$\langle \mathcal{O}'(\chi) | \mathcal{O}'(\gamma) | \mathcal{O}'(z) \rangle = v^2 \langle \mathcal{O}(\chi) | \varphi(\gamma) | \varphi(z) \rangle + \mathcal{O}(v)$$

$$\mathcal{M} = \langle \mathcal{O}_2^{\mathcal{NE}}(\wp_1) \bar{\mathcal{O}}_2^{\mathcal{NE}}(\wp_2) \mathcal{O}_i^{\mathfrak{F}}(q_1) \bar{\mathcal{O}}_i^{\mathfrak{F}}(q_2) \rangle$$

$$\mathcal{M} \sim v^4 \langle e^+ e^- \hat{\bar{f}} f \rangle + \mathcal{O}(v^2)$$

$$\mathcal{M} \approx v^4 \langle e^+ e^- \hat{\bar{f}} f \rangle + v^2 \langle \eta^\dagger \eta e^+ e^- \hat{\bar{f}} f \rangle + \langle \eta^\dagger \eta \eta^\dagger \eta e^+ e^- \hat{\bar{f}} f \rangle + rest$$

$$\langle \eta^\dagger \eta e^+ e^- \hat{\bar{f}} f \rangle \approx \langle \eta^\dagger | \eta \rangle \langle e^+ e^- \hat{\bar{f}} f \rangle + \langle e^+ | e^- \rangle \langle \eta^\dagger \eta \hat{\bar{f}} f \rangle + \left\langle \hat{\bar{f}} \middle| f \right\rangle \langle e^+ e^- \eta^\dagger \eta \rangle$$

13. Métrica SU(3) para espacios cuánticos curvos.

$$\langle (\phi^\dagger \psi)^\dagger(\chi) \gamma_0 (\phi^\dagger \psi)^\dagger(\gamma) \rangle = v^2 \left| \langle \bar{\psi}_3(\chi) | \bar{\psi}_3(\gamma) \rangle \right|_{\mathfrak{I}\ell}$$

$$d\sigma = \frac{(2\pi)^4}{4\sqrt{(\wp_1 \wp_2) - m^4}} \left| \mathcal{M}_{\bar{\psi}\psi \mapsto \bar{\psi}\psi} \right|^2 \delta(\wp_1 + \wp_2 - q_1$$
$$- q_2) \frac{d^3 \vec{q}_1}{(2\pi)^3 2\xi_{q_1}} \frac{d^3 \vec{q}_2}{(2\pi)^3 2\xi_{q_2}} \frac{d^3 \vec{q}_1}{(2\pi)^3 2\zeta_{q_1}} \frac{d^3 \vec{q}_2}{(2\pi)^3 2\zeta_{q_2}}$$

$$\mathcal{M}_{\bar{\psi}\psi\mapsto\bar{\psi}\psi} = \langle\bar{\psi}(\wp_1)\bar{\psi}(q_1)\bar{\psi}(\wp_2)\bar{\psi}(q_2)\rangle = \upsilon^4\langle\bar{\psi}_3(\wp_1)\bar{\psi}_3(q_1)\bar{\psi}_3(\wp_2)\bar{\psi}_3(q_2)\rangle_{\Im\ell}$$

$$\left|\mathcal{M}_{\bar{\psi}\psi\mapsto\bar{\psi}\psi}\right|^2 = \frac{32g^4}{9}\left(\frac{\delta^2+\mu^2}{(t-\mathcal{M}_\Lambda^2)^2} + \frac{t^2+\Lambda^2}{(\delta-\mathcal{M}_\Lambda^2)^2} + \frac{2\mu^2}{(\delta-\mathcal{M}_\Lambda^2)(t-\mathcal{M}_\Lambda^2)(\Lambda-\mathcal{M}_\Lambda^2)}\right)$$

$$\begin{aligned}\langle(\phi^\dagger\phi)^\dagger(\chi)\big|(\phi^\dagger\phi)^\dagger(\gamma)\rangle \\ &= \upsilon^\dagger\upsilon\langle(\phi^\dagger\phi)(\chi)\rangle + \upsilon^{a^\dagger}\langle(\phi^\dagger\phi)(\chi)\big|\eta^a(\gamma)\rangle + \upsilon^a\langle(\phi^\dagger\phi)(\chi)\big|\eta^{a^\dagger}(\gamma)\rangle \\ &+ \langle(\phi^\dagger\phi)(\chi)\big|(\eta^\dagger\eta)(\gamma)\rangle\end{aligned}$$

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