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# TEORÍA DE CAMPOS: REFORZAMIENTO TEÓRICO – MATEMÁTICO AL MODELO ESTÁNDAR DE PARTÍCULAS, BAJO LA ESTRUCTURA ECUACIONAL DE YANG – MILLS

## FIELD THEORY: THEORETICAL – MATHEMATICAL REINFORCEMENT TO THE STANDARD PARTICLE MODEL, UNDER THE YANG – MILLS EQUATIONAL STRUCTURE

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# Teoría de Campos: Reforzamiento Teórico – Matemático al Modelo Estándar de Partículas, bajo la estructura ecuacional de Yang – Mills

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**RESUMEN**

El presente artículo científico, tiene como propósito, demostrar, la mecánica de partículas (física de partículas elementales) en un campo determinado, sea cual fuere la fuerza fundamental involucrada, bajo la teoría de campo de Yang – Mills, esto es, bajo estándares generales y uniformemente aplicables, es decir, sin perjuicio del campo de que se trate y en consecuencia, el conjunto de partículas susceptibles de interacción, para lo cual, se optimizan los sistemas de referenciación aquí desglosados (verbigracia, desde la óptica del sistema lagrangiano, etc), desde una perspectiva einsteniana, desde el ángulo de percepción de las teorías de gauge y de la estructura de campo de Higgs, así como del modelo estándar de física de partículas, etc. Asimismo, este artículo científico, procura, reforzar la propuesta de solución formulada por este investigador, bajo la siguiente tríada de premisas: **(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, para un campo de Yang-Mills no abeliano, existe un valor positivo mínimo de la energía.

***Palabras clave:*** física de partículas, escala subatómica, campos de yang-mills, teorías de gauge, ecuación de Higgs

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# Field Theory: Theoretical – Mathematical Reinforcement To The Standard Particle Model, Under The Yang – Mills Equational Structure

**ABSTRACT**

The purpose of this scientific article is to demonstrate particle mechanics (elementary particle physics) in a given field, whatever the fundamental force involved, under the Yang-Mills field theory, that is, under general and uniformly applicable standards, that is, without prejudice to the field in question and consequently, the set of particles susceptible to interaction, for which the referential systems broken down here are optimized (e.g., from the perspective of the Lagrangian system, etc.), from an Einsteinian perspective, from the angle of perception of the theories of gauge and the Higgs field structure, as well as the standard model of particle physics, etc. Likewise, this scientific article seeks to reinforce the proposed solution formulated by this researcher, under the following triad of premises: (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, for a non-abelian Yang-Mills field, there is a minimum positive value of energy.

***Keywords*:** particle physics, subatomic scale, Yang-Mills fields, gauge theories, Higgs equation

## INTRODUCCION

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. 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. Por tanto, el presente trabajo, tiene como finalidad, comprobar 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

La teorización desplegada en el presente manuscrito, resulta de la aplicación de una metodología de investigación integral, esto es, bajo un enfoque híbrido, tanto desde el punto de vista cualitativo como en su dimensión cuantitativa. El tipo de investigación que ha sido desarrollado a lo largo del presente Artículo Científico, es esencialmente predictivo, a la luz de la física teórica, más no, acusa carácter empírico o experimental. Por otro lado, las líneas de investigación adoptadas para la formulación del estado del arte, se ajustan al constructivismo. Cabe indicar, que no existe población de estudio en la medida en que el presente artículo científico, no es de carácter sociológico o social, más aun, en mérito a su impacto en la realidad de transformación. Tampoco se han implementado técnicas de recolección de información, tales como encuestas, entrevistas, etc, salvo revisión bibliográfica, a razón del campo de investigación abordado. Adicionalmente a lo antes expuesto, es perciso resaltar, que el material de apoyo es meramente bibliográfico. La técnica metodológica, dada la complejidad de la temática escrutada, es deductiva, pues la teorización en sentido estricto, ha sido desarrollada desde principios y premisas generales que son inherentes a la física de partículas en sentido lato. Finalmente, para efectos de construir y desarrollar las ecuaciones constantes en el presente artículo científico, se ha tomado en consideración el Modelo Estándar de Física de Partículas, muy especialmente, en tratándose de los campos de Yang – Mills, sin perjuicio de los demás sistemas de recalibración deducidos y esbozados a lo largo del presente Artículo Científico.

## RESULTADOS Y DISCUSIÓN

### Análisis Único de Movimiento de Partículas en Campos de Yang – Mills

$$\mathcal{L} = -\frac{1}{4\pi F^{\mu\nu}(x)F_{\nu\mu}(x)F_{\nu\mu}^{\mu\nu}}(x)F_{\mu\nu}^{\nu\mu}(x) \not\equiv \mathcal{L} = -\frac{1}{4\pi F^{\nu\mu}(x)F_{\mu\nu}(x)F_{\mu\nu}^{\nu\mu}}(x)F_{\nu\mu}^{\mu\nu}(x) \not\equiv \mathcal{L}$$
$$= -\frac{1}{4\pi F^{\mu\nu}(x)F_{\mu\nu}(x)F_{\nu\mu}^{\mu\nu}}(x)F_{\mu\nu}^{\nu\mu}(x) \not\equiv \mathcal{L} = -\frac{1}{4\pi F^{\nu\mu}(x)F_{\nu\mu}(x)F_{\mu\nu}^{\nu\mu}}(x)F_{\nu\mu}^{\mu\nu}(x)$$

$$\mathcal{L} = -\frac{1}{4\pi F^{\mu\nu}(y)F_{\nu\mu}(y)F_{\nu\mu}^{\mu\nu}}(y)F_{\mu\nu}^{\nu\mu}(y) \not\equiv \mathcal{L} = -\frac{1}{4\pi F^{\nu\mu}(y)F_{\mu\nu}(y)F_{\mu\nu}^{\nu\mu}}(y)F_{\nu\mu}^{\mu\nu}(y) \not\equiv \mathcal{L}$$
$$= -\frac{1}{4\pi F^{\mu\nu}(y)F_{\mu\nu}(y)F_{\nu\mu}^{\mu\nu}}(y)F_{\mu\nu}^{\nu\mu}(y) \not\equiv \mathcal{L} = -\frac{1}{4\pi F^{\nu\mu}(y)F_{\nu\mu}(y)F_{\mu\nu}^{\nu\mu}}(y)F_{\nu\mu}^{\mu\nu}(y)$$

$$\mathcal{L} = -\frac{1}{4\pi F^{\mu\nu}(z)F_{\nu\mu}(z)F_{\nu\mu}^{\mu\nu}}(y)F_{\mu\nu}^{\nu\mu}(y) \not\equiv \mathcal{L} = -\frac{1}{4\pi F^{\nu\mu}(z)F_{\mu\nu}(z)F_{\mu\nu}^{\nu\mu}}(z)F_{\nu\mu}^{\mu\nu}(z) \not\equiv \mathcal{L}$$
$$= -\frac{1}{4\pi F^{\mu\nu}(z)F_{\mu\nu}(z)F_{\nu\mu}^{\mu\nu}}(y)F_{\mu\nu}^{\nu\mu}(y) \not\equiv \mathcal{L} = -\frac{1}{4\pi F^{\nu\mu}(z)F_{\nu\mu}(z)F_{\mu\nu}^{\nu\mu}}(z)F_{\nu\mu}^{\mu\nu}(z)$$

$$F^{\mu\nu}(x,t)F_{\nu\mu}(x,t)F_{\mu\nu}(x,t)F^{\nu\mu}(x,t)F^{\nu\mu}(x,t)F_{\mu\nu}(x,t)F_{\nu\mu}(x,t)F^{\mu\nu}(x,t)$$
$$+ F^{\mu\nu}(y,t)F_{\nu\mu}(y,t)F_{\mu\nu}(y,t)F^{\nu\mu}(y,t)F^{\nu\mu}(y,t)F_{\mu\nu}(y,t)F_{\nu\mu}(y,t)F^{\mu\nu}(y,t)$$
$$+ F^{\mu\nu}(z,t)F_{\nu\mu}(z,t)F_{\mu\nu}(z,t)F^{\nu\mu}(z,t)F^{\nu\mu}(z,t)F_{\mu\nu}(z,t)F_{\nu\mu}(z,t)F^{\mu\nu}(z,t)$$
$$+ F^{\mu\nu}(x)F_{\nu\mu}(x)F_{\mu\nu}(x)F^{\nu\mu}(x)F^{\nu\mu}(x)F_{\mu\nu}(x)F_{\nu\mu}(x)F^{\mu\nu}(x)$$
$$+ F^{\mu\nu}(y)F_{\nu\mu}(y)F_{\mu\nu}(y)F^{\nu\mu}(y)F^{\nu\mu}(y)F_{\mu\nu}(y)F_{\nu\mu}(y)F^{\mu\nu}(y)$$
$$+ F^{\mu\nu}(z)F_{\nu\mu}(z)F_{\mu\nu}(z)F^{\nu\mu}(z)F^{\nu\mu}(z)F_{\mu\nu}(z)F_{\nu\mu}(z)F^{\mu\nu}(z)$$
$$= \partial^\mu A_\nu(x,t) - \partial^\nu A_\mu(x,t) + \partial^\mu A_\nu(y,t) - \partial^\nu A_\mu(y,t) + \partial^\mu A_\nu(z,t) - \partial^\nu A_\mu(z,t)$$
$$= \partial^\mu A_\nu(x) - \partial^\nu A_\mu(x) + \partial^\mu A_\nu(y) - \partial^\nu A_\mu(y) + \partial^\mu A_\nu(z) - \partial^\nu A_\mu(z)$$

$$F_{ij}(x,t), F^{ji}(x,t), F_j^i F_i^j(x,t), F_{ij}(y,t), F^{ji}(y,t), F_j^i F_i^j(y,t), F_{ij}(z,t), F^{ji}(z,t), F_j^i F_i^j(z,t)$$
$$= -\epsilon^{ijk}\epsilon_{ijk}B^k B_k(x,t) - \epsilon^{ijk}\epsilon_{ijk}B^k B_k(y,t) - \epsilon^{ijk}\epsilon_{ijk}B^k B_k(z,t)$$

$$A^\mu A_\mu A^\nu A_\nu A^\mu A_\nu A^\nu A_\mu A^{\mu\nu} A_{\nu\mu} A^{\nu\mu} A_{\mu\nu}(x) \rightarrow A^\mu A_\mu A^\nu A_\nu A^\mu A_\nu A^\nu A_\mu A^{\mu\nu} A_{\nu\mu} A^{\nu\mu} A_{\mu\nu}(y)$$
$$\rightarrow A^\mu A_\mu A^\nu A_\nu A^\mu A_\nu A^\nu A_\mu A^{\mu\nu} A_{\nu\mu} A^{\nu\mu} A_{\mu\nu}(z) \rightarrow A'_\mu A'_\nu A'_\nu A'_\mu(x) \rightarrow A'_\mu A'_\nu A'_\nu A'_\mu(y)$$
$$\rightarrow A'_\mu A'_\nu A'_\nu A'_\mu(z) = A^\mu A_\mu A^\nu A_\nu A^\mu A_\nu A^\nu A_\mu A^{\mu\nu} A_{\nu\mu} A^{\nu\mu} A_{\mu\nu}(x)$$
$$\rightarrow A^\mu A_\mu A^\nu A_\nu A^\mu A_\nu A^\nu A_\mu A^{\mu\nu} A_{\nu\mu} A^{\nu\mu} A_{\mu\nu}(y)$$
$$\rightarrow A^\mu A_\mu A^\nu A_\nu A^\mu A_\nu A^\nu A_\mu A^{\mu\nu} A_{\nu\mu} A^{\nu\mu} A_{\mu\nu}(z) + \partial^\mu \partial_\nu \partial^\nu \partial_\mu \partial^{\mu\nu} \partial_{\nu\mu} \partial^{\nu\mu} \partial_{\mu\nu} \alpha(x)$$
$$+ \partial^\mu \partial_\nu \partial^\nu \partial_\mu \partial^{\mu\nu} \partial_{\nu\mu} \partial^{\nu\mu} \partial_{\mu\nu}(y) + \partial^\mu \partial_\nu \partial^\nu \partial_\mu \partial^{\mu\nu} \partial_{\nu\mu} \partial^{\nu\mu} \partial_{\mu\nu}(z)$$

$$F^{\mu\nu}F_{\mu\nu}F^{\nu\mu}F_{\nu\mu}F^{\mu\nu}F_{\nu\mu}F^{\nu\mu}F_{\mu\nu}(x) \to F^{\mu\nu}F_{\mu\nu}F^{\nu\mu}F_{\nu\mu}F^{\mu\nu}F_{\nu\mu}F^{\nu\mu}F_{\mu\nu}(y)$$

$$\to F^{\mu\nu}F_{\mu\nu}F^{\nu\mu}F_{\nu\mu}F^{\mu\nu}F_{\nu\mu}F^{\nu\mu}F_{\mu\nu}(z) \to F'_{\mu\nu}F'_{\nu\mu}(x) \to F'_{\mu\nu}F'_{\nu\mu}(y) \to F'_{\mu\nu}F'_{\nu\mu}(z)$$

$$= \partial_\mu \left( A^\mu A_\nu A^\nu A_\mu A^{\mu\nu} A_{\nu\mu} A^{\nu\mu} A_{\mu\nu}(x) + \partial^\mu \partial_\nu \partial^\nu \partial_\mu \partial^{\mu\nu} \partial_{\nu\mu} \partial^{\nu\mu} \partial_{\mu\nu} \alpha(x) \right)$$

$$- \partial_\nu \left( A^\nu A_\mu A^\mu A_\nu A^{\nu\mu} A_{\mu\nu} A^{\mu\nu} A_{\nu\mu}(x) + \partial^\nu \partial_\mu \partial^\mu \partial_\nu \partial^{\nu\mu} \partial_{\mu\nu} \partial^{\mu\nu} \partial_{\nu\mu} \alpha(x) \right)$$

$$= \partial^\mu \partial^\nu A_\mu A_\nu \partial^\nu \partial^\mu A_\nu A_\mu \partial^{\mu\nu} \partial^{\nu\mu} A_{\mu\nu} A_{\nu\mu} \partial^{\nu\mu} \partial^{\mu\nu} A_{\nu\mu} A_{\mu\nu}(x)$$

$$+ \partial^\mu \partial^\nu \partial_\mu \partial_\nu \partial^\nu \partial^\mu \partial_\nu A_\mu \partial^{\mu\nu} \partial^{\nu\mu} \partial_{\mu\nu} \partial_{\nu\mu} \partial^{\nu\mu} \partial^{\mu\nu} \partial_{\nu\mu} \partial_{\mu\nu} \alpha(x)$$

$$= \partial_\mu \left( A^\mu A_\nu A^\nu A_\mu A^{\mu\nu} A_{\nu\mu} A^{\nu\mu} A_{\mu\nu}(y) + \partial^\mu \partial_\nu \partial^\nu \partial_\mu \partial^{\mu\nu} \partial_{\nu\mu} \partial^{\nu\mu} \partial_{\mu\nu} \alpha(y) \right)$$

$$- \partial_\nu \left( A^\nu A_\mu A^\mu A_\nu A^{\nu\mu} A_{\mu\nu} A^{\mu\nu} A_{\nu\mu}(y) + \partial^\nu \partial_\mu \partial^\mu \partial_\nu \partial^{\nu\mu} \partial_{\mu\nu} \partial^{\mu\nu} \partial_{\nu\mu} \alpha(y) \right)$$

$$= \partial^\mu \partial^\nu A_\mu A_\nu \partial^\nu \partial^\mu A_\nu A_\mu \partial^{\mu\nu} \partial^{\nu\mu} A_{\mu\nu} A_{\nu\mu} \partial^{\nu\mu} \partial^{\mu\nu} A_{\nu\mu} A_{\mu\nu}(y)$$

$$+ \partial^\mu \partial^\nu \partial_\mu \partial_\nu \partial^\nu \partial^\mu \partial_\nu A_\mu \partial^{\mu\nu} \partial^{\nu\mu} \partial_{\mu\nu} \partial_{\nu\mu} \partial^{\nu\mu} \partial^{\mu\nu} \partial_{\nu\mu} \partial_{\mu\nu} \alpha(y)$$

$$= \partial_\mu \left( A^\mu A_\nu A^\nu A_\mu A^{\mu\nu} A_{\nu\mu} A^{\nu\mu} A_{\mu\nu}(z) + \partial^\mu \partial_\nu \partial^\nu \partial_\mu \partial^{\mu\nu} \partial_{\nu\mu} \partial^{\nu\mu} \partial_{\mu\nu} \alpha(z) \right)$$

$$- \partial_\nu \left( A^\nu A_\mu A^\mu A_\nu A^{\nu\mu} A_{\mu\nu} A^{\mu\nu} A_{\nu\mu}(z) + \partial^\nu \partial_\mu \partial^\mu \partial_\nu \partial^{\nu\mu} \partial_{\mu\nu} \partial^{\mu\nu} \partial_{\nu\mu} \alpha(z) \right)$$

$$= \partial^\mu \partial^\nu A_\mu A_\nu \partial^\nu \partial^\mu A_\nu A_\mu \partial^{\mu\nu} \partial^{\nu\mu} A_{\mu\nu} A_{\nu\mu} \partial^{\nu\mu} \partial^{\mu\nu} A_{\nu\mu} A_{\mu\nu}(z)$$

$$+ \partial^\mu \partial^\nu \partial_\mu \partial_\nu \partial^\nu \partial^\mu \partial_\nu A_\mu \partial^{\mu\nu} \partial^{\nu\mu} \partial_{\mu\nu} \partial_{\nu\mu} \partial^{\nu\mu} \partial^{\mu\nu} \partial_{\nu\mu} \partial_{\mu\nu} \alpha(z)$$

$$F'_{\mu\nu}F'_{\nu\mu}(x) = \partial^\mu A^\nu \partial_\nu A_\mu \partial^{\mu\nu} A^{\nu\mu} \partial_{\nu\mu} A_{\mu\nu}(x) - \partial^\nu A^\mu \partial_\mu A_\nu \partial^{\nu\mu} A^{\mu\nu} \partial_{\mu\nu} A_{\nu\mu}(x) = F^{\mu\nu}F_{\nu\mu}(x)$$

$$F'_{\mu\nu}F'_{\nu\mu}(y) = \partial^\mu A^\nu \partial_\nu A_\mu \partial^{\mu\nu} A^{\nu\mu} \partial_{\nu\mu} A_{\mu\nu}(y) - \partial^\nu A^\mu \partial_\mu A_\nu \partial^{\nu\mu} A^{\mu\nu} \partial_{\mu\nu} A_{\nu\mu}(y) = F^{\mu\nu}F_{\nu\mu}(y)$$

$$F'_{\mu\nu}F'_{\nu\mu}(z) = \partial^\mu A^\nu \partial_\nu A_\mu \partial^{\mu\nu} A^{\nu\mu} \partial_{\nu\mu} A_{\mu\nu}(z) - \partial^\nu A^\mu \partial_\mu A_\nu \partial^{\nu\mu} A^{\mu\nu} \partial_{\mu\nu} A_{\nu\mu}(z) = F^{\mu\nu}F_{\nu\mu}(z)$$

$$\mathcal{A}[A^\mu \partial_\nu A^\nu \partial_\mu] = \oiiint_{\nu\mu}^{\mu\nu} \mu\nu\nu\mu \, d^4\chi \mathcal{L}[A^\mu \partial_\nu A^\nu \partial_\mu] + \delta\mathcal{A}[A^\mu \partial_\nu A^\nu \partial_\mu] = \delta \oiiint_{\nu\mu}^{\mu\nu} \mu\nu\nu\mu \, d^4\chi \mathcal{L}[A^\mu \partial_\nu A^\nu \partial_\mu]$$

$$= \oiiint_{\nu\mu}^{\mu\nu} \mu\nu\nu\mu \, d^4\chi \delta\mathcal{L}[A^\mu \partial_\nu A^\nu \partial_\mu]$$

$$\delta\mathcal{L}[A^\mu \partial_\nu A^\nu \partial_\mu] = \frac{\partial\mathcal{L}}{\partial A^\mu A_\nu A^\nu A_\mu} \delta A^\mu_\nu A^\nu_\mu + \frac{\partial\mathcal{L}}{\partial(\partial^\mu A_\nu \partial^\nu A_\mu)\delta(\partial^\mu A_\nu \partial^\nu A_\mu)}$$

$$\delta\mathcal{A}[A^\mu \partial_\nu A^\nu \partial_\mu] = \delta \oiiint_{\nu\mu}^{\mu\nu} \mu\nu\nu\mu \, d^4\chi [\frac{\partial\mathcal{L}}{\partial A^\mu A_\nu A^\nu A_\mu} \delta A^\mu_\nu A^\nu_\mu + \frac{\partial\mathcal{L}}{\partial(\partial^\mu A_\nu \partial^\nu A_\mu)\delta(\partial^\mu A_\nu \partial^\nu A_\mu)}]$$

$$\delta[A^\mu \partial_\nu A^\nu \partial_\mu] = \delta \frac{\partial A^\mu A_\nu A^\nu A_\mu}{\partial\chi^\mu \chi_\nu \chi^\nu \chi_\mu} = \frac{\partial}{\partial\chi^\mu \chi_\nu \chi^\nu \chi_\mu} \delta A^\mu_\nu A^\nu_\mu = \partial^\mu \partial_\nu (\delta A^\mu_\nu A^\nu_\mu)$$

$$\frac{\partial \mathcal{L}}{\partial(\partial^\mu A_v \partial^v \partial_\mu)} \delta(\partial^\mu A_v \partial^v \partial_\mu) = \frac{\partial \mathcal{L}}{\partial(\partial^\mu A_v \partial^v A_\mu)} \partial^\mu \partial_v (\delta A_v^\mu A_\mu^v)$$

$$= \partial^\mu \partial_v \partial^\mu \partial_v [\frac{\partial \mathcal{L}}{\partial(\partial^\mu A_v \partial^v A_\mu)} \delta(\partial^\mu A_v \partial^v A_\mu)] - \frac{\partial \mathcal{L}}{\partial(\partial^\mu A_v \partial^v A_\mu)} \delta(\partial^\mu A_v \partial^v A_\mu)$$

$$\delta \mathcal{A}[A^\mu \partial_v A^v \partial_\mu] = \delta \oiiint_{v\mu}^{\mu v} \mu v v \mu \, d^4 \chi [\frac{\partial \mathcal{L}}{\partial A^\mu A_v A^v A_\mu} \delta A_v^\mu A_\mu^v$$

$$- \partial^\mu \partial_v \partial^v \partial_\mu \frac{\partial \mathcal{L}}{\partial(\partial^\mu A_v \partial^v A_\mu) \delta(\partial^v A_\mu \partial^\mu A_v)} \delta A_v^\mu A_\mu^v$$

$$+ \delta \oiiint_{v\mu}^{\mu v} \mu v v \mu \, d^4 \chi \partial^\mu \partial_v \partial^v \partial_\mu [\frac{\partial \mathcal{L}}{\partial(\partial^\mu A_v \partial^v A_\mu) \delta(\partial^v A_\mu \partial^\mu A_v)} \delta A_v^\mu A_\mu^v]$$

$$\frac{\partial \mathcal{L}}{\partial A^\mu A_v A_v^\mu A_\mu^v} = -\frac{1}{4\pi \frac{\partial}{\partial A^\mu A_v A_v^\mu A_\mu^v} [F^\mu F_v F_v^\mu F_\mu^v]}$$

$$= -1$$

$$/4\pi \frac{\partial}{\partial A^\mu A_v A_v^\mu A_\mu^v} ((\partial^\mu A_v(x) - \partial^v A_\mu(x)) (\partial^v A_\mu(x) - \partial^\mu A_v(x)) (\partial^\mu A^v(x)$$

$$- \partial^v A^\mu(x)) (\partial^v A^\mu(x) - \partial^\mu A^v(x)) (\partial_\mu A_v(x) - \partial_v A_\mu(x)) (\partial_v^\mu A_\mu^v (x)$$

$$- \partial_\mu^v A_v^\mu (x)) ({}_v^\mu \partial_\mu^v A (x) - {}_\mu^v \partial_v^\mu A(x))$$

$$+ -1$$

$$/4\pi \frac{\partial}{\partial A^\mu A_v A_v^\mu A_\mu^v} ((\partial^\mu A_v(y) - \partial^v A_\mu(y)) (\partial^v A_\mu(y) - \partial^\mu A_v(y)) (\partial^\mu A^v(y)$$

$$- \partial^v A^\mu(y)) (\partial^v A^\mu(y) - \partial^\mu A^v(y)) (\partial_\mu A_v(y) - \partial_v A_\mu(y)) (\partial_v^\mu A_\mu^v (y)$$

$$- \partial_\mu^v A_v^\mu (y)) ({}_v^\mu \partial_\mu^v A (y) - {}_\mu^v \partial_v^\mu A(y))$$

$$+ -1$$

$$/4\pi \frac{\partial}{\partial A^\mu A_v A_v^\mu A_\mu^v} ((\partial^\mu A_v(z) - \partial^v A_\mu(z)) (\partial^v A_\mu(z) - \partial^\mu A_v(z)) (\partial^\mu A^v(z)$$

$$- \partial^v A^\mu(z)) (\partial^v A^\mu(z) - \partial^\mu A^v(z)) (\partial_\mu A_v(z) - \partial_v A_\mu(z)) (\partial_v^\mu A_\mu^v (z)$$

$$- \partial_\mu^v A_v^\mu (z)) ({}_v^\mu \partial_\mu^v A (z) - {}_\mu^v \partial_v^\mu A(z))$$

$$\partial_i \partial^j \partial_j \partial^i F^{\mu\nu\varphi} F_{\nu\mu\omega}(x)$$

$$= \frac{\frac{\frac{\partial^\theta \partial_\emptyset F_\sigma^\rho \gamma\beta}{\varepsilon\epsilon\vartheta\pi}}{\Delta\nabla}}{\tau} + \prod_\nu^\mu \lambda \coprod_\mu^\nu \lambda H_{iggs}$$

$$- W^\mu W_\nu W^\nu W_\mu W_\nu^\mu W_\mu^\nu {}_\nu^\mu W_\mu^\nu W - \eta^\theta \eta_\beta \eta_{\phi\nu}^{\sigma\mu}{}_\Omega^\alpha \eta / \mathbb{R}^4$$

En la que la constante $H_{iggs}$ es igual a:

$$\mathcal{L}_{SM} = \frac{1}{2\partial_\nu g_\mu^a \partial_\mu g_\nu^b} - g_s f^{abc} \partial_\mu g_\nu^a g_\nu^b g_\nu^c \partial_\nu g_\mu^a g_\mu^b g_\mu^c - \frac{1}{4 g_s^2 f^{abc} f^{ade} g_\mu^b g_\mu^c g_\mu^d g_\mu^d g_\nu^b g_\nu^c g_\nu^d g_\nu^d}$$

$$- \partial_\nu W_\mu^+ \partial_\nu W_\mu^- \partial_\mu W_\nu^+ \partial_\mu W_\nu^- - M^2 W_\mu^+ W_\mu^- W_\nu^+ W_\nu^- - \frac{1}{2\partial_\nu Z_\mu^0 \partial_\mu Z_\nu^0} - \frac{1}{2_\omega^{c^2} M^2 Z_\mu^0 Z_\nu^0}$$

$$- \frac{1}{2\partial_\mu \mathcal{A}_\nu \partial_\nu \mathcal{A}_\mu}$$

$$-igc_\omega \left( \partial_\nu Z_\mu^0 (W_\mu^+ W_\nu^- W_\mu^- W_\nu^+) - Z_\mu^0 Z_\nu^0 (\partial_\nu W_\mu^+ \partial_\nu W_\mu^- \partial_\mu W_\nu^+ \partial_\mu W_\nu^-) \right)$$

$$- igs_\omega \left( \partial_\mu \mathcal{A}_\nu \partial_\nu \mathcal{A}_\mu (W_\mu^+ W_\mu^- W_\nu^+ W_\nu^-) \right.$$

$$\left. - \mathcal{A}_\mu (\partial_\nu W_\mu^+ \partial_\nu W_\mu^- \partial_\mu W_\nu^+ \partial_\mu W_\nu^-) - \mathcal{A}_\nu (\partial_\nu W_\mu^+ \partial_\nu W_\mu^- \partial_\mu W_\nu^+ \partial_\mu W_\nu^-) \right)$$

$$- \frac{1}{2 g^2 W_\mu^+ W_\nu^- W_\mu^- W_\nu^+} + g^2 c_\omega^2 (Z_\mu^0 W_\mu^+ W_\mu^- Z_\nu^0 W_\nu^+ W_\nu^-)$$

$$+ g^2 s_\omega^2 (\mathcal{A}_\mu W_\mu^+ W_\mu^- \mathcal{A}_\nu W_\nu^+ W_\nu^-)$$

$$+ g^2 c_\omega s_\omega (\mathcal{A}_\mu Z_\mu^0 (W_\mu^+ W_\mu^-) \mathcal{A}_\nu Z_\nu^0 (W_\nu^+ W_\nu^-) - 2\mathcal{A}_\mu W_\mu^+ W_\mu^- Z_\mu^0 \mathcal{A}_\nu W_\nu^+ W_\nu^- Z_\nu^0)$$

$$- \frac{1}{2\partial_\mu \mathcal{H} \partial_\nu \mathcal{H}} - 2M^2 \propto_h \mathcal{H}^2 - \partial_\mu \phi^+ \partial_\nu \phi^- \partial_\nu \phi^+ \partial_\nu \phi^- - \frac{1}{2\partial_\mu \phi^0 \partial_\nu \phi^0 \partial_\nu \phi^0 \partial_\nu \phi^0}$$

$$-\beta_h\left(\frac{2M^2}{g^2}+\frac{2M}{g\mathcal{H}}+\frac{1}{2}(\mathcal{H}^2+\phi^0\phi^+\phi^0\phi^-+2\phi^0\phi^+\phi^0\phi^-)\right)+\frac{2M^4}{g^2\propto_h}$$

$$-g\propto_h M(\mathcal{H}^3+\mathcal{H}\phi^0\phi^0+2\mathcal{H}\phi^+\phi^-)-1/8g^2\propto_h(\mathcal{H}^4+(\phi^0)^4+4(\phi^+\phi^-)^2+4(\phi^0)^2\phi^+\phi^-$$

$$+4\mathcal{H}^2\phi^+\phi^-+2(\phi^0)^2\mathcal{H}^2)-gMW_\mu^+W_\mu^-W_v^+W_v^-\mathcal{H}-\frac{\frac{1}{2gM}}{c_\omega^2Z_\mu^0Z_v^0\mathcal{H}}$$

$$-\frac{1}{2ig}\Big(W_\mu^+(\phi^0\partial_\mu\phi^- - \phi^-\partial_\mu\phi^0)-W_\mu^-(\phi^0\partial_\mu\phi^+ - \phi^+\partial_\mu\phi^0)-W_v^+(\phi^0\partial_v\phi^- - \phi^-\partial_v\phi^0)$$

$$-W_v^-(\phi^0\partial_v\phi^+ - \phi^+\partial_v\phi^0)\Big)$$

$$-\frac{1}{2g\left(W_\mu^+(\mathcal{H}\partial_\mu\phi^- - \phi^-\partial_\mu\mathcal{H})W_\mu^-(\mathcal{H}\partial_\mu\phi^+ - \phi^+\partial_\mu\mathcal{H})W_v^+(\mathcal{H}\partial_v\phi^- - \phi^-\partial_v\mathcal{H})W_v^-(\mathcal{H}\partial_v\phi^+ - \phi^+\partial_v\mathcal{H})\right)}$$

$$+\frac{\frac{1}{2g1}}{c_\omega\left(Z_\mu^0(\mathcal{H}\partial_\mu\phi^0-\phi^0\partial_\mu\mathcal{H})Z_v^0(\mathcal{H}\partial_v\phi^0-\phi^0\partial_v\mathcal{H})\right)}+M\left(\frac{1}{c_\omega Z_\mu^0\partial_\mu\phi^0}+W_\mu^+\partial_\mu\phi^-+W_\mu^-\partial_\mu\phi^+\right)$$

$$-\frac{igs_\omega^2}{c_\omega MZ_\mu^0(W^+\phi^- - W^-\phi^+)igs_\omega M\mathcal{A}_\mu(W_\mu^+\phi^-+W_\mu^-\phi^+)}-ig1-\frac{2c_\omega^2}{2c_\omega Z_\mu^0(\phi^+\partial_\mu\phi^- - \phi^-\partial_\mu\phi^+)}$$

$$+igs_\omega\mathcal{A}_\mu(\phi^+\partial_\mu\phi^- - \phi^-\partial_\mu\phi^+)-1/4g^2W_\mu^+W_\mu^-(\mathcal{H}^2+(\phi^0)^2+2\phi^+\phi^-)$$

$$-\frac{\frac{1}{8g^21}}{c_\omega^2Z_\mu^0Z_v^0}$$

$$\mathcal{H}^2+$$

$$\phi^0)^2+2$$

$$\left(\left(\left(\begin{array}{c} 2s_\omega^2-1)^2\phi^+\phi^- - \frac{\frac{1}{2g^2s_\omega^2}}{c_\omega Z_\mu^0\phi^0(W_\mu^+\phi^-+W_\mu^-\phi^+)}-\frac{\frac{1}{2ig^2s_\omega^2}}{c_\omega Z_\mu^0}\mathcal{H}(W_\mu^+\phi^-+W_\mu^-\phi^+)+ \\ \frac{1}{2g^2s_\omega\mathcal{A}_\mu\phi^0(W_\mu^+\phi^-+W_\mu^-\phi^+)}+\frac{1}{2ig^2s_\omega\mathcal{A}_\mu\mathcal{H}(W_\mu^+\phi^-+W_\mu^-\phi^+)}-\frac{g^2s_\omega}{c_\omega(2c_w^2-1)Z_\mu^0\mathcal{A}_\mu\phi^+\phi^-}-g^2s_\omega^2\mathcal{A}_\mu\mathcal{A}_v\phi^+\phi^-+ \\ \frac{1}{2ig_s\lambda_{ij}^a\left(\underset{q\sigma^i}{\rightarrow}\varphi^\mu\underset{q\sigma^j}{\rightarrow}\right)g_\mu^a}\underset{e^\lambda}{-\!\!\rightarrow}(\varphi\partial+m_e^\lambda \end{array}\right)e^\lambda\underset{v^\lambda}{-\!\!\rightarrow}(\varphi\partial+m_v^\lambda\right)v^\lambda\underset{\mu_j^a v^\lambda}{-\!\!\rightarrow\!\!\rightarrow}(\varphi\partial+m_\mu^\lambda\right)-(\mu_j^\lambda$$

$$\underset{d_j^\lambda}{-\!\!\rightarrow})+$$

$$(\varphi\partial + m_d^\lambda)d_j^\lambda$$

$$+ igs_\omega\mathcal{A}_\mu\left(-\left(\underset{e^\lambda}{\rightarrow}\varphi^\mu e^\lambda\right) + \frac{2}{3\left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu\mu_j^\lambda\right)} - \frac{1}{3\left(\underset{d^\lambda}{\rightarrow}\varphi^\mu d^\lambda\right)} + \frac{ig}{4c_\omega Z_\mu^0\left(\underset{v^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5)v^\lambda\right)}\right.$$

$$+\left(\underset{e^\lambda}{\rightarrow}\varphi^\mu(4s_\omega^2 - 1 - \varphi^5)e^\lambda\right) + \left(\underset{d_j^\lambda}{\rightarrow}\varphi^\mu\left(\frac{4}{3s_\omega^2} - 1 - \varphi^5\right)d_j^\lambda\right) + \left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu\left(1 - \frac{8}{3s_\omega^2} + \varphi^5\right)\mu_j^\lambda\right)$$

$$\left. + (\frac{ig}{\sqrt[2]{2}W_\mu^+\left(\underset{v^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5\right)U^{lep}{}_\xi^k e^k}\right) + \left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5)C_{\kappa\lambda}d_j^k\right)$$

$$+ \frac{ig}{\sqrt[2]{2}W_\mu^-\left(\underset{e^{\mathcal{K}}}{\rightarrow}U^{lep\dagger}{}^{\nu}_{\xi}\frac{\frac{\psi\lambda}{\kappa\varphi}}{\rho\varpi} - \triangleq \prod_{\odot\oplus\tau}^{\oplus\odot\gamma}\otimes\frac{\coprod_\nu^\mu ijk}{\otimes\sigma}\Omega\Psi\Phi\Delta(1+\varphi^5)v^\lambda + \underset{d_j^\kappa}{\rightarrow}C_{*}^{\dagger}{}_{\kappa}^{\lambda}\varphi_{\nu\eta}^{\mu\zeta^\eta}(1+\varphi^5)\mu_j^\lambda\right)}$$

$$+ \frac{ig}{2M\sqrt[2]{2}\phi^+\left(-m_c^\kappa\left(\underset{v^\lambda}{\rightarrow}U^{lep}{}_\xi^k e^k(1-\varphi^5)\epsilon^\kappa\right) + m_\mu^\lambda\underset{\mu_j^\lambda}{\rightarrow}U^{lep\dagger}(1+\varphi^5)\varepsilon^\kappa\right)}$$

$$+ \frac{ig}{2M\sqrt[2]{2}\phi^-\left(m_c^\kappa\left(\underset{v^\lambda}{\rightarrow}U^{lep}{}_\xi^k e^k(1-\varphi^5)\epsilon^\kappa\right) \pm m_\mu^\lambda\underset{\mu_j^\lambda}{\rightarrow}U^{lep\dagger}(1+\varphi^5)\varepsilon^\kappa\right)} - \frac{\frac{g}{2m_v^\lambda}}{M}\mathcal{H}\left(\underset{v^\lambda}{\rightarrow}v^\lambda\right)$$

$$-\frac{\dfrac{\frac{g}{2m_c^{\lambda}}}{\dfrac{M\mathcal{H}\left(\underset{e^{\lambda}}{\rightarrow}e^{\lambda}\right)}{1}}}{4\underset{v^{\lambda}}{\rightarrow}M_{\lambda\kappa}^{R}(1-\gamma_5)v^{\kappa}}+\frac{\frac{ig}{2m_v^{\lambda}}}{M\phi^0\left(\underset{v^{\lambda}}{\rightarrow}\gamma^5 v^{\lambda}\right)}-\frac{\frac{ig}{2m_c^{\lambda}}}{M\phi^0\left(\underset{e^{\lambda}}{\rightarrow}\gamma^5 e^{\lambda}\right)}-\frac{1}{4\underset{v^{\kappa}}{\rightarrow}M_{\lambda\kappa}^{R}(1-\gamma_5)\underset{v^{\kappa}}{\rightarrow}}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^+\left(-m_d^{\kappa}\left(\underset{\mu_j^{\lambda}}{\rightarrow}C_{\lambda\kappa}(1-\varphi^5)d_j^{\kappa}\right)+m_d^{\kappa}\left(\underset{\mu_j^{\lambda}}{\rightarrow}C_{\lambda\kappa}(1-\varphi^5)d_j^{\kappa}\right)\right)}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^-\left(m_d^{\lambda}\left(\underset{d_j^{\lambda}}{\rightarrow}C_{\lambda\kappa\wedge\theta*}^{\dagger}(1+\varphi^5)\mu_j^{\kappa}\right)\pm m_d^{\lambda}\left(\underset{d_j^{\lambda}}{\rightarrow}C_{\lambda\kappa\wedge\nabla*}^{\dagger}(1+\varphi^5)\mu_j^{\kappa}\right)\right)}$$

$$-\frac{\frac{g}{2m_\mu^\lambda}}{M\mathcal{H}\left(\underset{\mu_j^\lambda}{\rightarrow}\mu_j^\lambda\right)}-\frac{\frac{g}{2m_d^\lambda}}{M}\mathcal{H}\left(\underset{d_j^\lambda}{\rightarrow}d_j^\lambda\right)+\frac{\frac{ig}{2m_\mu^\lambda}}{M}\phi^0\left(\underset{\mu_j^\lambda}{\rightarrow}\gamma^5\mu_j^\lambda\right)-\frac{\frac{ig}{2m_d^\lambda}}{M}\phi^0\left(\underset{d_j^\lambda}{\rightarrow}\gamma^5 d_j^\lambda\right)$$

$$+\underset{G^a}{\rightarrow}\partial^2G^a+g_sf^{abc}\partial_\mu\underset{G^a}{\rightarrow}G^bg_\mu^c+\underset{\alpha^+}{\rightarrow}(\partial^2-M^2)\alpha^+ +\underset{\alpha^-}{\rightarrow}(\partial^2-M^2)\alpha^-$$

$$+\underset{\alpha^0}{\rightarrow}\left(\partial^2-\frac{M^2}{c_\omega^2}\right)\alpha^0+\underset{b}{\rightarrow}\partial^2 b+igc_\omega W_\mu^+\left(\partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^-}{\rightarrow}-\partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^0}{\rightarrow}\right)$$

$$+igs_wW_\mu^+\left(\partial_\mu\underset{b}{\rightarrow}\alpha^- -\partial_\mu\underset{a}{\rightarrow}b^-\right)+igc_\omega W_\mu^-\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^0}{\rightarrow}-\partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)$$

$$+igs_\omega W_\mu^-\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^0}{\rightarrow}-\partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)+igc_\omega Z_\mu^0\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^-}{\rightarrow}-\partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)$$

$$+igs_\omega\mathcal{A}_\mu\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^-}{\rightarrow}-\partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)-1/2gM(\frac{\underset{\alpha^+}{\rightarrow}\alpha^+\mathcal{H}\hbar\mathbb{R}^4}{h}+\underset{\alpha^-}{\rightarrow}\alpha^-\mathcal{H}+1$$

$$-\frac{2c_{\mathfrak{J}}^2}{2c_\omega igM\left(\underset{\alpha^+}{\rightarrow}a^0\phi^+-\underset{\alpha^-}{\rightarrow}a^0\phi^-\right)}+\frac{1}{2c_\omega igM\left(\underset{\alpha^0}{\rightarrow}a^-\phi^+-\underset{\alpha^0}{\rightarrow}a^+\phi^-\right)}$$

$$+igMs_\omega\left(\underset{\alpha^0}{\rightarrow}a^-\phi^+-\underset{\alpha^0}{\rightarrow}a^+\phi^-\right)+1/2igM\left(\underset{\alpha^+}{\rightarrow}a^+\phi^0-\underset{\alpha^-}{\rightarrow}a^-\phi^0\right)$$

$$\Phi(x)=\begin{pmatrix}\phi^+\\ \phi^0\end{pmatrix}=\frac{1}{\sqrt{2}}\begin{pmatrix}\phi_1+\mathrm{i}\phi_2\\ \phi_3+\mathrm{i}\phi_4\end{pmatrix}$$

$$\mathcal{L}_{SBS}=(\mathcal{D}_\mu\Phi)^\dagger(\mathcal{D}^\mu\Phi)-V(\Phi)$$

$$V(\Phi)=\mu^2\Phi^\dagger\Phi+\lambda(\Phi^\dagger\Phi)^2$$

$$|\Phi|^2 = \Phi^\dagger \Phi = -\frac{\mu^2}{2\lambda} = \frac{\upsilon^2}{2}$$

$$\Phi(x) = \begin{pmatrix} \phi^+ \\ \phi^0 \end{pmatrix} \longrightarrow \frac{1}{\sqrt{2}} \begin{pmatrix} 0 \\ \upsilon \end{pmatrix}$$

$$\Phi(x) = \frac{1}{\sqrt{2}} e^{\mathrm{i}\frac{\vec{\xi}(x)\cdot\vec{\tau}}{\upsilon}} \begin{pmatrix} 0 \\ \upsilon + \mathrm{h}(x) \end{pmatrix}$$

$$U(\xi) = e^{-\mathrm{i}\frac{\vec{\xi}(x)\cdot\vec{\tau}}{\upsilon}}$$

$$\begin{aligned} \Phi' &= U(\xi)\Phi = \tfrac{1}{\sqrt{2}} \begin{pmatrix} 0 \\ \upsilon + \mathrm{h}(x) \end{pmatrix} \\ \left(\frac{\vec{\tau}\,\vec{\mathrm{W}}'_\mu}{2}\right) &= U(\xi)\left(\frac{\vec{\tau}\,\vec{\mathrm{W}}_\mu}{2}\right) U^{-1}(\xi) - \tfrac{\mathrm{i}}{g}(\partial_\mu U(\xi)) U^{-1}(\xi) \\ \mathrm{B}'_\mu &= \mathrm{B}_\mu \end{aligned}$$

$$\mathcal{L} = \mathcal{L}_{bos.} + \mathcal{L}_{ferm.} + \mathcal{L}_{SBS}$$

$$(\mathcal{D}_\mu \Phi)^\dagger (\mathcal{D}^\mu \Phi) = \frac{\upsilon^2}{8}[\mathrm{g}^2(W_{1\mu}^2 + W_{2\mu}^2) + (\mathrm{g}W_{3\mu} - \mathrm{g}' B_\mu)^2]$$

$$\begin{aligned} \mathrm{W}_\mu^\pm &= \tfrac{1}{\sqrt{2}}(\mathrm{W}_\mu^1 \mp \mathrm{W}_\mu^2) \\ \mathrm{Z}_\mu &= \cos\theta_\mathrm{W}\,\mathrm{W}_\mu^3 - \sin\theta_\mathrm{W}\,\mathrm{B}_\mu \\ \mathrm{A}_\mu &= \sin\theta_\mathrm{W}\,\mathrm{W}_\mu^3 + \cos\theta_\mathrm{W}\,\mathrm{B}_\mu \end{aligned}$$

$$\tan\theta_\mathrm{W} \equiv \frac{\mathrm{g}'}{\mathrm{g}}$$

$$\mathrm{M_W} = \tfrac{1}{2}\mathrm{g}\upsilon$$

$$\mathrm{M_Z} = \tfrac{1}{2}\upsilon\sqrt{\mathrm{g}^2 + \mathrm{g}'^2}$$

$$\begin{aligned} g &= \frac{e}{\sin\theta_W} \\ g' &= \frac{e}{\cos\theta_W} \end{aligned}$$

$$m_H^2 = 2\lambda v^2$$

$$\mu \to \nu_\mu \bar{\nu}_e e$$

$$v = (\sqrt{2}G_F)^{-\frac{1}{2}}$$

$$\mathcal{L}_{YW} = \lambda_e \bar{\ell}_L \Phi e_R + \lambda_u \bar{q}_L \tilde{\Phi} u_R + \lambda_d \bar{q}_L \Phi d_R + h.c.$$

$$\begin{aligned} \ell_L &= \begin{pmatrix} e \\ \nu_e \end{pmatrix}_L, \begin{pmatrix} \mu \\ \nu_\mu \end{pmatrix}_L, \begin{pmatrix} \tau \\ \nu_\tau \end{pmatrix}_L \\ q_L &= \begin{pmatrix} u \\ d \end{pmatrix}_L, \begin{pmatrix} c \\ s \end{pmatrix}_L, \begin{pmatrix} t \\ b \end{pmatrix}_L \end{aligned}$$

$$\begin{aligned} \ell'_L &= U(\xi)\ell_L; \qquad & e'_R &= e_R \\ q'_L &= U(\xi)q_L; \qquad & u'_R &= u_R;\ d'_R = d \end{aligned}$$

$$\begin{aligned} m_e &= \lambda_e \frac{v}{\sqrt{2}} \\ m_u &= \lambda_u \frac{v}{\sqrt{2}} \\ m_d &= \lambda_d \frac{v}{\sqrt{2}} \end{aligned}$$

O es igual a:

$$\mathcal{L}_{Higgs} = \overline{\left([\partial_\mu + \frac{1}{2}ig_1 B_\mu + \frac{1}{2}ig_2 \mathbf{W}_\mu]\phi\right)}\left([\partial_\mu + \frac{1}{2}ig_1 B_\mu + \frac{1}{2}ig_2 \mathbf{W}_\mu]\phi\right) - \frac{m_H^2\left(\bar{\phi}\phi - \frac{v^2}{2}\right)^2}{2v^2}$$

$$\mathcal{L}_{SM}(x)$$

$$= -\frac{1}{2\pi\partial^\mu\partial_v\partial^v\partial_\mu\partial_v^\mu\partial_\mu^v g_\mu^a g_a^\mu g_v^b g_b^v} - g_s f^{ab} f_{ab}\partial^\mu\partial_v\partial^v\partial_\mu\partial_v^\mu\partial_\mu^v g_\mu^a g_a^\mu g_v^b g_b^v - \frac{1}{4\pi g_S^2 f^{cd} f_{cd}\partial^\mu\partial_v\partial^v\partial_\mu\partial_v^\mu\partial_\mu^v g_\mu^c g_c^\mu g_v^d g_d^v}$$

$$- \partial^\mu W_\mu\partial^v W_v - M^2 W_\mu^+ W_v^- W_\mu^- W_v^+ W_+^\mu W_-^v W_-^\mu W_+^v - \frac{1}{2\pi\partial^\mu\partial_v\partial^v\partial_\mu\partial_v^\mu\partial_\mu^v Z_\mu^0 Z_v^0 Z_0^\mu Z_0^v} - \frac{1}{2c_m^2 M^2 Z_\mu^0 Z_v^0 Z_0^\mu Z_0^v} - \frac{1}{2\partial^\mu A_v\partial^v A_\mu}$$

$$- igc_w\left(\partial^\mu\partial_v\partial^v\partial_\mu\partial_v^\mu\partial_\mu^v Z_\mu^0 Z_v^0 Z_0^\mu Z_0^v(W_\mu^+ W_v^- W_\mu^- W_v^+)\right) - Z_\mu^0(\partial^\mu\partial_\mu W_\mu^+ W_\mu^- W_+^\mu W_-^\mu) + Z_v^0(\partial^v\partial_v W_v^+ W_v^- W_+^v W_-^v)$$

$$- igS_w(\partial^\mu A_v\partial^v A_\mu(W_\mu^+ W_v^- W_\mu^- W_v^+ W_+^\mu W_-^v W_-^\mu W_+^v) Z_\mu^0 Z_v^0 Z_0^\mu Z_0^v) - A_\mu(\partial^\mu\partial_\mu W_\mu^+ W_\mu^- W_+^\mu W_-^\mu Z_\mu^0 Z_0^\mu)$$

$$+ A_v(\partial^v\partial_v W_v^+ W_v^- W_+^v W_-^v Z_v^0 Z_0^v) - \frac{1}{2g^2\left(\partial^\mu A_v\partial^v A_\mu(W_\mu^+ W_v^- W_\mu^- W_v^+ W_+^\mu W_-^v W_-^\mu W_+^v Z_\mu^0 Z_v^0 Z_0^\mu Z_0^v)\right)}$$

$$+ g^2 c_w^2\left(\partial^\mu A_v\partial^v A_\mu(W_\mu^+ W_v^- W_\mu^- W_v^+ W_+^\mu W_-^v W_-^\mu W_+^v Z_\mu^0 Z_v^0 Z_0^\mu Z_0^v)\right)$$

$$+ g^2 S_w^2\left(\partial^\mu A_v\partial^v A_\mu(W_\mu^+ W_v^- W_\mu^- W_v^+ W_+^\mu W_-^v W_-^\mu W_+^v Z_\mu^0 Z_v^0 Z_0^\mu Z_0^v)\right)$$

$$- g^2 c_w S_w\left(\partial^\mu A_v\partial^v A_\mu(W_\mu^+ W_v^- W_\mu^- W_v^+ W_+^\mu W_-^v W_-^\mu W_+^v Z_\mu^0 Z_v^0 Z_0^\mu Z_0^v)\right)$$

$$- \frac{1}{2\pi\left(\partial H^\mu A H_v H\partial^v H A_\mu(W_\mu^+ W_v^- W_\mu^- W_v^+ W_+^\mu W_-^v W_-^\mu W_+^v Z_\mu^0 Z_v^0 Z_0^\mu Z_0^v H^\mu H_V H_v^\mu H_\mu^v)\right)} + \frac{\frac{\frac{1}{2\pi(2M^2H^2H^3)}}{d^\curlywedge em^C\gamma}}{\frac{GUM_{Scw}^2}{\frac{2M}{\prod_\sigma^\rho\frac{\beta_\eta^\xi}{\frac{h^4}{\hbar^2}}}}} - \frac{2g_c^2 M_S^2}{\Psi\Phi\zeta} - \lambda\partial$$

$$\otimes\frac{\frac{\omega}{\Delta\nabla\theta}}{\frac{\prod_{\triangleq}^{\dagger}\infty ∰_j^i k\left(\frac{\frac{\phi_\mu^+\phi_v^-\phi_\mu^-\phi_v^+}{\phi_+^\mu\phi_-^v\phi_-^\mu\phi_+^v}}{\phi_\mu^0\phi_v^0\phi_0^\mu\phi_0^v}\right)\left(\varphi\psi\omega\lambda_\mu^+\varphi\psi\omega\lambda_v^-\varphi\psi\omega\lambda_\mu^-\varphi\psi\omega\lambda_v^+\frac{2\varphi\psi\omega\lambda^\mu}{\varphi\psi\omega\lambda}_+\varphi\psi\omega\lambda_-^v\varphi\psi\omega\lambda_-^\mu\varphi\psi\omega\lambda_+^v\frac{\frac{1}{2\pi\varphi\psi\omega\lambda}}{\varphi\psi\omega\lambda}{}_\mu^0\varphi\psi\omega\lambda_v^0\varphi\psi\omega\lambda_0^\mu\varphi\psi\omega\lambda_0^v\right)}{2M\sqrt[\phi\varphi\lambda\kappa]{\frac{\frac{\frac{2\xi\eta}{\zeta\epsilon\varepsilon}}{\delta\alpha}}{\frac{o\sigma\rho}{\Psi\Omega}}\mho}}}$$

$$= \mathcal{L}_{Higgs}$$

$$= \left(\partial^\mu\partial_v\,\partial^v\partial_\mu + \frac{1}{2ig_1 B^\mu B_v B^v B_\mu} + \frac{1}{2jg_2 B^\mu B_v B^v B_\mu} + \frac{1}{2ig_1 W^\mu W_v W^v W_\mu} + \frac{1}{2jg_2 W^\mu W_v W^v W_\mu}\right) - m_H^2\phi'\phi - v^2/2v^2/\tau^2$$

$$\partial_i\partial^j\partial_j\partial^i F^{\mu\nu\varphi}F_{\nu\mu\omega}(y)$$

$$= \frac{\frac{\frac{\partial^\theta\partial_\emptyset F_\sigma^\rho\gamma\beta}{\varepsilon\epsilon\vartheta\pi}}{\Delta\nabla}}{\tau} + \prod_v^\mu\lambda\coprod_\mu^v\lambda\,H_{iggs}$$

$$- W^\mu W_v W^v W_\mu W_v^\mu W_\mu^v{}_v^\mu W_\mu^v W - \eta^\theta\eta_\beta\eta_{\phi v}^{\sigma\mu}{}_\Omega^\alpha\eta/\mathbb{R}^4$$

En la que la constante $H_{iggs}$ es igual a:

$$\mathcal{L}_{SM} = \frac{1}{2\partial_v g_\mu^a\partial_\mu g_v^b} - g_s f^{abc}\partial_\mu g_v^a g_v^b g_v^c\partial_v g_\mu^a g_\mu^b g_\mu^c - \frac{1}{4g_S^2 f^{abc} f^{ade} g_\mu^b g_\mu^c g_\mu^d g_\mu^d g_v^b g_v^c g_v^d g_v^d} - \partial_v W_\mu^+\partial_v W_\mu^-\partial_\mu W_v^+\partial_\mu W_v^- - M^2 W_\mu^+ W_\mu^- W_v^+ W_v^-$$

$$- \frac{1}{2\partial_v Z_\mu^0\partial_\mu Z_v^0} - \frac{1}{2c_\omega^{c^2} M^2 Z_\mu^0 Z_v^0} - \frac{1}{2\partial_\mu\mathcal{A}_v\partial_v\mathcal{A}_\mu}$$

$$-igc_\omega\left(\partial_v Z_\mu^0(W_\mu^+W_v^-W_\mu^-W_v^+)-Z_\mu^0Z_v^0(\partial_vW_\mu^+\partial_vW_\mu^-\partial_\mu W_v^+\partial_\mu W_v^-)\right)$$

$$-igs_\omega\left(\partial_\mu\mathcal{A}_v\partial_v\mathcal{A}_\mu(W_\mu^+W_\mu^-W_v^+W_v^-)-\mathcal{A}_\mu(\partial_vW_\mu^+\partial_vW_\mu^-\partial_\mu W_v^+\partial_\mu W_v^-)-\mathcal{A}_v(\partial_vW_\mu^+\partial_vW_\mu^-\partial_\mu W_v^+\partial_\mu W_v^-)\right)$$

$$-\frac{1}{2g^2W_\mu^+W_v^-W_\mu^-W_v^+}+g^2c_\omega^2(Z_\mu^0W_\mu^+W_\mu^-Z_v^0W_v^+W_v^-)$$

$$+g^2s_\omega^2(\mathcal{A}_\mu W_\mu^+W_\mu^-\mathcal{A}_vW_v^+W_v^-)+g^2c_\omega s_\omega(\mathcal{A}_\mu Z_\mu^0(W_\mu^+W_\mu^-)\mathcal{A}_vZ_v^0(W_v^+W_v^-)-2\mathcal{A}_\mu W_\mu^+W_\mu^-Z_\mu^0\mathcal{A}_vW_v^+W_v^-Z_v^0)-\frac{1}{2\partial_\mu\mathcal{H}\partial_v\mathcal{H}}-2M^2\propto_h\mathcal{H}^2$$

$$-\partial_\mu\phi^+\partial_v\phi^-\partial_v\phi^+\partial_v\phi^--\frac{1}{2\partial_\mu\phi^0\partial_v\phi^0\partial_v\phi^0\partial_v\phi^0}$$

$$-\beta_h\left(\frac{2M^2}{g^2}+\frac{2M}{g\mathcal{H}}+\frac{1}{2}(\mathcal{H}^2+\phi^0\phi^+\phi^0\phi^-+2\phi^0\phi^+\phi^0\phi^-)\right)+\frac{2M^4}{g^2\propto_h}-g\propto_h M(\mathcal{H}^3+\mathcal{H}\phi^0\phi^0+2\mathcal{H}\phi^+\phi^-)-1/8g^2\propto_h(\mathcal{H}^4+(\phi^0)^4$$

$$+4(\phi^+\phi^-)^2+4(\phi^0)^2\phi^+\phi^-+4\mathcal{H}^2\phi^+\phi^-+2(\phi^0)^2\mathcal{H}^2)-gMW_\mu^+W_\mu^-W_v^+W_v^-\mathcal{H}-\frac{\frac{1}{2gM}}{c_\omega^2Z_\mu^0Z_v^0\mathcal{H}}$$

$$-\frac{1}{2ig}\left(W_\mu^+(\phi^0\partial_\mu\phi^--\phi^-\partial_\mu\phi^0)-W_\mu^-(\phi^0\partial_\mu\phi^+-\phi^+\partial_\mu\phi^0)-W_v^+(\phi^0\partial_v\phi^--\phi^-\partial_v\phi^0)\right.$$

$$\left.-W_v^-(\phi^0\partial_v\phi^+-\phi^+\partial_v\phi^0)\right)$$

$$-\frac{1}{2g\left(W_\mu^+(\mathcal{H}\partial_\mu\phi^--\phi^-\partial_\mu\mathcal{H})W_\mu^-(\mathcal{H}\partial_\mu\phi^+-\phi^+\partial_\mu\mathcal{H})W_v^+(\mathcal{H}\partial_v\phi^--\phi^-\partial_v\mathcal{H})W_v^-(\mathcal{H}\partial_v\phi^+-\phi^+\partial_v\mathcal{H})\right)}$$

$$+\frac{\frac{1}{2g1}}{c_\omega\left(Z_\mu^0(\mathcal{H}\partial_\mu\phi^0-\phi^0\partial_\mu\mathcal{H})Z_v^0(\mathcal{H}\partial_v\phi^0-\phi^0\partial_v\mathcal{H})\right)}+M\left(\frac{1}{c_\omega Z_\mu^0\partial_\mu\phi^0}+W_\mu^+\partial_\mu\phi^-+W_\mu^-\partial_\mu\phi^+\right)$$

$$-\frac{igs_\omega^2}{c_\omega MZ_\mu^0(W^+\phi^--W^-\phi^+)igs_\omega M\mathcal{A}_\mu(W_\mu^+\phi^-+W_\mu^-\phi^+)}-ig1-\frac{2c_\omega^2}{2c_\omega Z_\mu^0(\phi^+\partial_\mu\phi^--\phi^-\partial_\mu\phi^+)}$$

$$+igs_\omega\mathcal{A}_\mu(\phi^+\partial_\mu\phi^--\phi^-\partial_\mu\phi^+)-1/4g^2W_\mu^+W_\mu^-(\mathcal{H}^2+(\phi^0)^2+2\phi^+\phi^-)$$

$$-\frac{\frac{1}{8g^21}}{c_\omega^2Z_\mu^0Z_v^0}$$

$$\mathcal{H}^2+$$

$$\phi^0)^2+2$$

$$2s_\omega^2-1)^2\phi^+\phi^--\frac{\frac{1}{2g^2s_\omega^2}}{c_\omega Z_\mu^0\phi^0(W_\mu^+\phi^-+W_\mu^-\phi^+)}-\frac{\frac{1}{2ig^2s_\omega^2}}{c_\omega Z_\mu^0}\mathcal{H}(W_\mu^+\phi^-+W_\mu^-\phi^+)+$$

$$\left(\left(\left(\frac{1}{2g^2s_\omega\mathcal{A}_\mu\phi^0(W_\mu^+\phi^-+W_\mu^-\phi^+)}+\frac{1}{2ig^2s_\omega\mathcal{A}_\mu\mathcal{H}(W_\mu^+\phi^-+W_\mu^-\phi^+)}-\frac{g^2s_\omega}{c_\omega(2c_w^2-1)Z_\mu^0\mathcal{A}_\mu\phi^+\phi^-}-g^2s_\omega^2\mathcal{A}_\mu\mathcal{A}_v\phi^+\phi^-+\right)e^\lambda\underset{v^\lambda}{-\!\!\rightarrow}(\varphi\partial+m_v^\lambda\right)v^\lambda\underset{\mu_j^a v^\lambda}{-\!\!\rightarrow\rightarrow}(\varphi\partial+m_\mu^\lambda\right)-(\mu_j^\lambda$$

$$\frac{1}{2ig_s\lambda_{ij}^a\left(\underset{q\sigma^i}{\rightarrow}\varphi^\mu\underset{q\sigma^j}{\rightarrow}\right)g_\mu^a}\underset{e^\lambda}{-\!\!\rightarrow}(\varphi\partial+m_e^\lambda$$

$$\underset{d_j^\lambda}{-\!\!\rightarrow})+$$

$$(\varphi\partial + m_d^\lambda)d_j^\lambda + igs_\omega\mathcal{A}_\mu\left(-\left(\underset{e^\lambda}{\rightarrow}\varphi^\mu e^\lambda\right) + \frac{2}{3\left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu\mu_j^\lambda\right)} - \frac{1}{3\left(\underset{d^\lambda}{\rightarrow}\varphi^\mu d^\lambda\right)} + \frac{ig}{4c_\omega Z_\mu^0\left(\underset{\nu^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5)\nu^\lambda\right)}\right.$$

$$+\left(\underset{e^\lambda}{\rightarrow}\varphi^\mu(4s_\omega^2 - 1 - \varphi^5)e^\lambda\right) + \left(\underset{d_j^\lambda}{\rightarrow}\varphi^\mu\left(\frac{4}{3s_\omega^2} - 1 - \varphi^5\right)d_j^\lambda\right) + \left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu\left(1 - \frac{8}{3s_\omega^2} + \varphi^5\right)\mu_j^\lambda\right)$$

$$\left. + (\frac{ig}{\sqrt[2]{2}W_\mu^+\left(\underset{\nu^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5\right)U^{lep}{}_\xi^k e^k}\right) + \left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5)C_{k\lambda}d_j^k\right)$$

$$+\frac{ig}{\sqrt[2]{2}W_\mu^-\left(\underset{e^{\mathcal{K}}}{\rightarrow}U^{lep^\dagger}\frac{{}^\nu\psi\lambda}{\frac{\kappa\varphi}{{}_\xi\rho\varpi}} - \triangleq \prod_{\odot\oplus\tau}^{\oplus\odot\gamma}\otimes\frac{\coprod_\nu^\mu ijk}{\bigotimes\sigma}\Omega\Psi\Phi\Delta(1+\varphi^5)\nu^\lambda + \underset{d_j^\kappa}{\rightarrow}C_*^\dagger{}_\kappa^\lambda\varphi_{\nu\eta}^{\mu\zeta\eta}(1+\varphi^5)\mu_j^\lambda\right)}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^+\left(-m_c^\kappa\left(\underset{\nu^\lambda}{\rightarrow}U^{lep}{}_\xi^k e^k(1-\varphi^5)\epsilon^\kappa\right) + m_\mu^\lambda\underset{\mu_j^\lambda}{\rightarrow}U^{lep^\dagger}(1+\varphi^5)\varepsilon^\kappa\right)}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^-\left(m_c^\kappa\left(\underset{\nu^\lambda}{\rightarrow}U^{lep}{}_\xi^k e^k(1-\varphi^5)\epsilon^\kappa\right) \pm m_\mu^\lambda\underset{\mu_j^\lambda}{\rightarrow}U^{lep^\dagger}(1+\varphi^5)\varepsilon^\kappa\right)} - \frac{\frac{g}{2m_\nu^\lambda}}{M}\mathcal{H}\left(\underset{\nu^\lambda}{\rightarrow}\nu^\lambda\right)$$

$$-\frac{\frac{\frac{g}{2m_c^\lambda}}{M\mathcal{H}\left(\underset{e^\lambda}{\rightarrow}e^\lambda\right)}}{\frac{1}{4\underset{\nu^\lambda}{\rightarrow}M_{\lambda\kappa}^R(1-\gamma_5)\nu^\kappa}} + \frac{\frac{ig}{2m_\nu^\lambda}}{M\phi^0\left(\underset{\nu^\lambda}{\rightarrow}\gamma^5\nu^\lambda\right)} - \frac{\frac{ig}{2m_c^\lambda}}{M\phi^0\left(\underset{e^\lambda}{\rightarrow}\gamma^5 e^\lambda\right)} - \frac{1}{4\underset{\nu^\kappa}{\rightarrow}M_{\lambda\kappa}^R(1-\gamma_5)\underset{\nu^\kappa}{\rightarrow}}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^+\left(-m_d^\kappa\left(\underset{\mu_j^\lambda}{\rightarrow}C_{\lambda\kappa}(1-\varphi^5)d_j^\kappa\right) + m_d^\kappa\left(\underset{\mu_j^\lambda}{\rightarrow}C_{\lambda\kappa}(1-\varphi^5)d_j^\kappa\right)\right)}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^-\left(m_d^\lambda\left(\underset{d_j^\lambda}{\rightarrow}C_{\lambda\kappa\bigwedge\theta*}^\dagger(1+\varphi^5)\mu_j^\kappa\right) \pm m_d^\lambda\left(\underset{d_j^\lambda}{\rightarrow}C_{\lambda\kappa\bigwedge\nabla*}^\dagger(1+\varphi^5)\mu_j^\kappa\right)\right)} - \frac{\frac{g}{2m_\mu^\lambda}}{M\mathcal{H}\left(\underset{\mu_j^\lambda}{\rightarrow}\mu_j^\lambda\right)}$$

$$-\frac{\frac{g}{2m_d^\lambda}}{M}\mathcal{H}\left(\underset{d_j^\lambda}{\rightarrow}d_j^\lambda\right) + \frac{\frac{ig}{2m_\mu^\lambda}}{M}\phi^0\left(\underset{\mu_j^\lambda}{\rightarrow}\gamma^5\mu_j^\lambda\right) - \frac{\frac{ig}{2m_d^\lambda}}{M}\phi^0\left(\underset{d_j^\lambda}{\rightarrow}\gamma^5 d_j^\lambda\right) + \underset{G^a}{\rightarrow}\partial^2 G^a + g_s f^{abc}\partial_\mu\underset{G^a}{\rightarrow}G^b g_\mu^c$$

$$+\underset{\alpha^+}{\rightarrow}(\partial^2 - M^2)\alpha^+ + \underset{\alpha^-}{\rightarrow}(\partial^2 - M^2)\alpha^- + \underset{\alpha^0}{\rightarrow}\left(\partial^2 - \frac{M^2}{c_\omega^2}\right)\alpha^0 + \underset{b}{\rightarrow}\partial^2 b + igc_\omega W_\mu^+\left(\partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^-}{\rightarrow} - \partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^0}{\rightarrow}\right)$$

$$+igs_w W_\mu^+\left(\partial_\mu\underset{b}{\rightarrow}\alpha^- - \partial_\mu\underset{a}{\rightarrow}b^-\right) + igc_\omega W_\mu^-\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^0}{\rightarrow} - \partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right) + igs_\omega W_\mu^-\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^0}{\rightarrow} - \partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)$$

$$+igc_\omega Z_\mu^0\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^-}{\rightarrow} - \partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right) + igs_\omega\mathcal{A}_\mu\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^-}{\rightarrow} - \partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right) - 1/2gM(\frac{\underset{\alpha^+}{\rightarrow}\alpha^+\mathcal{H}\hbar\mathbb{R}^4}{h} + \underset{\alpha^-}{\rightarrow}\alpha^-\mathcal{H}$$

$$+1 - \frac{2c_{\mathfrak{I}}^2}{2c_\omega igM\left(\underset{\alpha^+}{\rightarrow}\alpha^0\phi^+ - \underset{\alpha^-}{\rightarrow}\alpha^0\phi^-\right)} + \frac{1}{2c_\omega igM\left(\underset{\alpha^0}{\rightarrow}\alpha^-\phi^+ - \underset{\alpha^0}{\rightarrow}\alpha^+\phi^-\right)}$$

$$+igMs_\omega\left(\underset{\alpha^0}{\rightarrow}\alpha^-\phi^+ - \underset{\alpha^0}{\rightarrow}\alpha^+\phi^-\right) + 1/2igM\left(\underset{\alpha^+}{\rightarrow}\alpha^+\phi^0 - \underset{\alpha^-}{\rightarrow}\alpha^-\phi^0\right)$$

$$\Phi(x) = \begin{pmatrix} \phi^+ \\ \phi^0 \end{pmatrix} = \frac{1}{\sqrt{2}} \begin{pmatrix} \phi_1 + \mathrm{i}\phi_2 \\ \phi_3 + \mathrm{i}\phi_4 \end{pmatrix}$$

$$\mathcal{L}_{SBS} = (\mathcal{D}_\mu \Phi)^\dagger (\mathcal{D}^\mu \Phi) - V(\Phi)$$

$$V(\Phi) = \mu^2 \Phi^\dagger \Phi + \lambda (\Phi^\dagger \Phi)^2$$

$$|\Phi|^2 = \Phi^\dagger \Phi = -\frac{\mu^2}{2\lambda} = \frac{v^2}{2}$$

$$\Phi(x) = \begin{pmatrix} \phi^+ \\ \phi^0 \end{pmatrix} \longrightarrow \frac{1}{\sqrt{2}} \begin{pmatrix} 0 \\ v \end{pmatrix}$$

$$\Phi(x) = \frac{1}{\sqrt{2}} e^{\mathrm{i}\frac{\vec{\xi}(x)\cdot\vec{\tau}}{v}} \begin{pmatrix} 0 \\ v + \mathrm{h}(x) \end{pmatrix}$$

$$U(\xi) = e^{-\mathrm{i}\frac{\vec{\xi}(x)\cdot\vec{\tau}}{v}}$$

$$\begin{aligned} \Phi' &= U(\xi)\Phi = \tfrac{1}{\sqrt{2}} \begin{pmatrix} 0 \\ v + \mathrm{h}(x) \end{pmatrix} \\ \left(\frac{\vec{\tau}\,\vec{\mathrm{W}}'_\mu}{2}\right) &= U(\xi) \left(\frac{\vec{\tau}\,\vec{\mathrm{W}}_\mu}{2}\right) U^{-1}(\xi) - \tfrac{\mathrm{i}}{g} (\partial_\mu U(\xi)) U^{-1}(\xi) \\ \mathrm{B}'_\mu &= \mathrm{B}_\mu \end{aligned}$$

$$\mathcal{L} = \mathcal{L}_{bos.} + \mathcal{L}_{ferm.} + \mathcal{L}_{SBS}$$

$$(\mathcal{D}_\mu \Phi)^\dagger (\mathcal{D}^\mu \Phi) = \frac{v^2}{8} [\mathrm{g}^2 (W_{1\mu}^2 + W_{2\mu}^2) + (\mathrm{g} W_{3\mu} - \mathrm{g}' B_\mu)^2]$$

$$\begin{aligned} \mathrm{W}^\pm_\mu &= \tfrac{1}{\sqrt{2}} (\mathrm{W}^1_\mu \mp \mathrm{W}^2_\mu) \\ \mathrm{Z}_\mu &= \cos\theta_\mathrm{W} \mathrm{W}^3_\mu - \sin\theta_\mathrm{W} \mathrm{B}_\mu \\ \mathrm{A}_\mu &= \sin\theta_\mathrm{W} \mathrm{W}^3_\mu + \cos\theta_\mathrm{W} \mathrm{B}_\mu \end{aligned}$$

$$\tan\theta_\mathrm{W} \equiv \frac{\mathrm{g}'}{\mathrm{g}}$$

$$M_W = \frac{1}{2} g v$$

$$M_Z = \frac{1}{2} v \sqrt{g^2 + g'^2}$$

$$g = \frac{e}{\sin\theta_W}$$
$$g' = \frac{e}{\cos\theta_W}$$

$$m_H^2 = 2\lambda v^2$$

$$\mu \to \nu_\mu \bar{\nu}_e e$$

$$v = (\sqrt{2} G_F)^{-\frac{1}{2}}$$

$$\mathcal{L}_{YW} = \lambda_e \bar{\ell}_L \Phi e_R + \lambda_u \bar{q}_L \tilde{\Phi} u_R + \lambda_d \bar{q}_L \Phi d_R + h.c.$$

$$\ell_L = \begin{pmatrix} e \\ \nu_e \end{pmatrix}_L, \begin{pmatrix} \mu \\ \nu_\mu \end{pmatrix}_L, \begin{pmatrix} \tau \\ \nu_\tau \end{pmatrix}_L$$

$$q_L = \begin{pmatrix} u \\ d \end{pmatrix}_L, \begin{pmatrix} c \\ s \end{pmatrix}_L, \begin{pmatrix} t \\ b \end{pmatrix}_L$$

$$\ell'_L = U(\xi)\ell_L; \qquad e'_R = e_R$$
$$q'_L = U(\xi) q_L; \qquad u'_R = u_R;\ d'_R = d$$

$$m_e = \lambda_e \frac{v}{\sqrt{2}}$$
$$m_u = \lambda_u \frac{v}{\sqrt{2}}$$
$$m_d = \lambda_d \frac{v}{\sqrt{2}}$$

O es igual a:

$$\mathcal{L}_{Higgs} = \overline{\left( [\partial_\mu + \frac{1}{2} i g_1 B_\mu + \frac{1}{2} i g_2 \mathbf{W}_\mu]\phi \right)} \left( [\partial_\mu + \frac{1}{2} i g_1 B_\mu + \frac{1}{2} i g_2 \mathbf{W}_\mu]\phi \right) - \frac{m_H^2 \left( \bar{\phi}\phi - \frac{v^2}{2} \right)^2}{2v^2}$$

$\mathcal{L}_{SM}(y)$

$$= -\frac{1}{2\pi\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}g_{\mu}^{a}g_{a}^{\mu}g_{v}^{b}g_{b}^{v}} - g_{s}f^{ab}f_{ab}\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}g_{\mu}^{a}g_{a}^{\mu}g_{v}^{b}g_{b}^{v} - \frac{1}{4\pi g_{S}^{2}f^{cd}f_{cd}\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}g_{\mu}^{c}g_{c}^{\mu}g_{v}^{d}g_{d}^{v}} - \partial^{\mu}W_{\mu}\partial^{v}W_{v}$$

$$- M^{2}W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v} - \frac{1}{2\pi\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}} - \frac{1}{2c_{m}^{2}M^{2}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}} - \frac{1}{2\partial^{\mu}A_{v}\partial^{v}A_{\mu}}$$

$$- igc_{w}\left(\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}\right)\right) - Z_{\mu}^{0}\left(\partial^{\mu}\partial_{\mu}W_{\mu}^{+}W_{\mu}^{-}W_{+}^{\mu}W_{-}^{\mu}\right) + Z_{v}^{0}\left(\partial^{v}\partial_{v}W_{v}^{+}W_{v}^{-}W_{+}^{v}W_{-}^{v}\right)$$

$$- igS_{w}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}\right)Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\right) - A_{\mu}\left(\partial^{\mu}\partial_{\mu}W_{\mu}^{+}W_{\mu}^{-}W_{+}^{\mu}W_{-}^{\mu}Z_{\mu}^{0}Z_{0}^{\mu}\right) + A_{v}\left(\partial^{v}\partial_{v}W_{v}^{+}W_{v}^{-}W_{+}^{v}W_{-}^{v}Z_{v}^{0}Z_{0}^{v}\right)$$

$$- \frac{1}{2g^{2}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\right)\right)} + g^{2}c_{w}^{2}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\right)\right)$$

$$+ g^{2}S_{w}^{2}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\right)\right) - g^{2}c_{w}S_{w}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\right)\right)$$

$$- \frac{1}{2\pi\left(\partial H^{\mu}AH_{v}H\partial^{v}HA_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}H^{\mu}H_{V}H_{v}^{\mu}H_{\mu}^{v}\right)\right)} + \frac{\dfrac{\dfrac{\dfrac{1}{2\pi(2M^{2}H^{2}H^{3})}}{d^{\wedge}em^{C}\gamma}}{GUM_{Scw}^{2}}}{\dfrac{2M}{\dfrac{\beta_{\eta}^{\xi}}{\prod_{\sigma}^{\rho}\dfrac{h^{4}}{\hbar^{2}}}}} - \frac{2g_{c}^{2}M_{S}^{2}}{\Psi\Phi\zeta} - \lambda\partial$$

$$\otimes\frac{\omega}{\Delta\nabla\theta}$$

$$/\prod_{\triangleq}^{\dagger}\infty\oiiint_{j}^{i}k\begin{pmatrix}\dfrac{\dfrac{\phi_{\mu}^{+}\phi_{v}^{-}\phi_{\mu}^{-}\phi_{v}^{+}}{\phi_{+}^{\mu}\phi_{-}^{v}\phi_{-}^{\mu}\phi_{+}^{v}}}{\phi_{\mu}^{0}\phi_{v}^{0}\phi_{0}^{\mu}\phi_{0}^{v}}\end{pmatrix}\left(\varphi\psi\omega\lambda_{\mu}^{+}\varphi\psi\omega\lambda_{v}^{-}\varphi\psi\omega\lambda_{\mu}^{-}\varphi\psi\omega\lambda_{v}^{+}\frac{2\varphi\psi\omega\lambda^{\mu}}{\varphi\psi\omega\lambda}_{+}\varphi\psi\omega\lambda_{-}^{v}\varphi\psi\omega\lambda_{-}^{\mu}\varphi\psi\omega\lambda_{+}^{v}\frac{1/2\pi\varphi\psi\omega\lambda^{0}}{\varphi\psi\omega\lambda}_{\mu}\varphi\psi\omega\lambda_{v}^{0}\varphi\psi\omega\lambda_{0}^{\mu}\varphi\psi\omega\lambda_{0}^{v}\right)$$

$$/2M\sqrt[\phi\varphi\lambda\kappa]{\frac{\dfrac{\dfrac{2\xi\eta}{\zeta\epsilon\varepsilon}}{\delta\alpha}}{o\sigma\rho}/\Psi\Omega\mho = \mathcal{L}_{Higgs} = \left(\partial^{\mu}\partial_{v}\,\partial^{v}\partial_{\mu} + \frac{1}{2ig_{1}B^{\mu}B_{v}B^{v}B_{\mu}} + \frac{1}{2jg_{2}B^{\mu}B_{v}B^{v}B_{\mu}} + \frac{1}{2ig_{1}W^{\mu}W_{v}W^{v}W_{\mu}} + \frac{1}{2jg_{2}W^{\mu}W_{v}W^{v}W_{\mu}}\right) - m_{H}^{2}\phi'\phi - v^{2}/2v^{2}}$$

$$/\tau^{2}$$

$$\partial_{i}\partial^{j}\partial_{j}\partial^{i}F^{\mu v\varphi}F_{v\mu\omega}(z)$$

$$= \frac{\dfrac{\dfrac{\partial^{\theta}\partial_{\emptyset}F_{\sigma}^{\rho}\gamma\beta}{\varepsilon\epsilon\vartheta\pi}}{\Delta\nabla}}{\tau} + \prod_{v}^{\mu}\lambda\coprod_{\mu}^{v}\lambda\,H_{iggs}$$

$$- W^{\mu}W_{v}W^{v}W_{\mu}W_{v}^{\mu}W_{\mu\ v}^{\ v\mu}W_{\ \mu}^{\ v}W - \eta^{\theta}\eta_{\beta}\eta_{\phi v\ \Omega}^{\sigma\mu\ \alpha}\eta/\mathbb{R}^{4}$$

En la que la constante $H_{iggs}$ es igual a:

$$\mathcal{L}_{SM} = \frac{1}{2\partial_{v}g_{\mu}^{a}\partial_{\mu}g_{v}^{b}} - g_{s}f^{abc}\partial_{\mu}g_{v}^{a}g_{v}^{b}g_{v}^{c}\partial_{v}g_{\mu}^{a}g_{\mu}^{b}g_{\mu}^{c} - \frac{1}{4g_{s}^{2}f^{abc}f^{ade}g_{\mu}^{b}g_{\mu}^{c}g_{\mu}^{d}g_{\mu}^{d}g_{v}^{b}g_{v}^{c}g_{v}^{d}g_{v}^{d}} - \partial_{v}W_{\mu}^{+}\partial_{v}W_{\mu}^{-}\partial_{\mu}W_{v}^{+}\partial_{\mu}W_{v}^{-} - M^{2}W_{\mu}^{+}W_{\mu}^{-}W_{v}^{+}W_{v}^{-}$$

$$- \frac{1}{2\partial_{v}Z_{\mu}^{0}\partial_{\mu}Z_{v}^{0}} - \frac{1}{2c_{\omega}^{2}M^{2}Z_{\mu}^{0}Z_{v}^{0}} - \frac{1}{2\partial_{\mu}\mathcal{A}_{v}\partial_{v}\mathcal{A}_{\mu}}$$

$$-igc_{\omega}\left(\partial_{v}Z_{\mu}^{0}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}\right) - Z_{\mu}^{0}Z_{v}^{0}\left(\partial_{v}W_{\mu}^{+}\partial_{v}W_{\mu}^{-}\partial_{\mu}W_{v}^{+}\partial_{\mu}W_{v}^{-}\right)\right)$$

$$- igs_{\omega}\left(\partial_{\mu}\mathcal{A}_{v}\partial_{v}\mathcal{A}_{\mu}\left(W_{\mu}^{+}W_{\mu}^{-}W_{v}^{+}W_{v}^{-}\right) - \mathcal{A}_{\mu}\left(\partial_{v}W_{\mu}^{+}\partial_{v}W_{\mu}^{-}\partial_{\mu}W_{v}^{+}\partial_{\mu}W_{v}^{-}\right) - \mathcal{A}_{v}\left(\partial_{v}W_{\mu}^{+}\partial_{v}W_{\mu}^{-}\partial_{\mu}W_{v}^{+}\partial_{\mu}W_{v}^{-}\right)\right)$$

$$- \frac{1}{2g^{2}W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}} + g^{2}c_{\omega}^{2}\left(Z_{\mu}^{0}W_{\mu}^{+}W_{\mu}^{-}Z_{v}^{0}W_{v}^{+}W_{v}^{-}\right)$$

$$+g^{2}s_{\omega}^{2}\left(\mathcal{A}_{\mu}W_{\mu}^{+}W_{\mu}^{-}\mathcal{A}_{v}W_{v}^{+}W_{v}^{-}\right) + g^{2}c_{\omega}s_{\omega}\left(\mathcal{A}_{\mu}Z_{\mu}^{0}\left(W_{\mu}^{+}W_{\mu}^{-}\right)\mathcal{A}_{v}Z_{v}^{0}\left(W_{v}^{+}W_{v}^{-}\right) - 2\mathcal{A}_{\mu}W_{\mu}^{+}W_{\mu}^{-}Z_{\mu}^{0}\mathcal{A}_{v}W_{v}^{+}W_{v}^{-}Z_{v}^{0}\right) - \frac{1}{2\partial_{\mu}\mathcal{H}\partial_{v}\mathcal{H}} - 2M^{2}\propto_{h}\mathcal{H}^{2}$$

$$- \partial_{\mu}\phi^{+}\partial_{v}\phi^{-}\partial_{v}\phi^{+}\partial_{v}\phi^{-} - \frac{1}{2\partial_{\mu}\phi^{0}\partial_{v}\phi^{0}\partial_{v}\phi^{0}\partial_{v}\phi^{0}}$$

$$-\beta_h\left(\frac{2M^2}{g^2}+\frac{2M}{g\mathcal{H}}+\frac{1}{2}(\mathcal{H}^2+\phi^0\phi^+\phi^0\phi^-+2\phi^0\phi^+\phi^0\phi^-)\right)+\frac{2M^4}{g^2\propto_h}-g\propto_h M(\mathcal{H}^3+\mathcal{H}\phi^0\phi^0+2\mathcal{H}\phi^+\phi^-)-1/8g^2\propto_h(\mathcal{H}^4+(\phi^0)^4$$

$$+4(\phi^+\phi^-)^2+4(\phi^0)^2\phi^+\phi^-+4\mathcal{H}^2\phi^+\phi^-+2(\phi^0)^2\mathcal{H}^2)-gMW_\mu^+W_\mu^-W_v^+W_v^-\mathcal{H}-\frac{\frac{1}{2gM}}{c_\omega^2Z_\mu^0Z_v^0\mathcal{H}}$$

$$-\frac{1}{2ig}\Big(W_\mu^+(\phi^0\partial_\mu\phi^--\phi^-\partial_\mu\phi^0)-W_\mu^-(\phi^0\partial_\mu\phi^+-\phi^+\partial_\mu\phi^0)-W_v^+(\phi^0\partial_v\phi^--\phi^-\partial_v\phi^0)$$

$$-W_v^-(\phi^0\partial_v\phi^+-\phi^+\partial_v\phi^0)\Big)$$

$$-\frac{1}{2g\left(W_\mu^+(\mathcal{H}\partial_\mu\phi^--\phi^-\partial_\mu\mathcal{H})W_\mu^-(\mathcal{H}\partial_\mu\phi^+-\phi^+\partial_\mu\mathcal{H})W_v^+(\mathcal{H}\partial_v\phi^--\phi^-\partial_v\mathcal{H})W_v^-(\mathcal{H}\partial_v\phi^+-\phi^+\partial_v\mathcal{H})\right)}$$

$$+\frac{\frac{1}{2g1}}{c_\omega\left(Z_\mu^0(\mathcal{H}\partial_\mu\phi^0-\phi^0\partial_\mu\mathcal{H})Z_v^0(\mathcal{H}\partial_v\phi^0-\phi^0\partial_v\mathcal{H})\right)}+M\left(\frac{1}{c_\omega Z_\mu^0\partial_\mu\phi^0}+W_\mu^+\partial_\mu\phi^-+W_\mu^-\partial_\mu\phi^+\right)$$

$$-\frac{igs_\omega^2}{c_\omega MZ_\mu^0(W^+\phi^--W^-\phi^+)igs_\omega M\mathcal{A}_\mu(W_\mu^+\phi^-+W_\mu^-\phi^+)}-ig1-\frac{2c_\omega^2}{2c_\omega Z_\mu^0(\phi^+\partial_\mu\phi^--\phi^-\partial_\mu\phi^+)}$$

$$+igs_\omega\mathcal{A}_\mu(\phi^+\partial_\mu\phi^--\phi^-\partial_\mu\phi^+)-1/4g^2W_\mu^+W_\mu^-(\mathcal{H}^2+(\phi^0)^2+2\phi^+\phi^-)$$

$$-\frac{\frac{1}{8g^21}}{\begin{array}{c}c_\omega^2Z_\mu^0Z_v^0\\ \mathcal{H}^2+\\ \phi^0)^2+2\end{array}}$$

$$\left(\left(\left(\begin{array}{c}2s_\omega^2-1)^2\phi^+\phi^--\frac{\frac{1}{2g^2s_\omega^2}}{c_\omega Z_\mu^0\phi^0(W_\mu^+\phi^-+W_\mu^-\phi^+)}-\frac{\frac{1}{2ig^2s_\omega^2}}{c_\omega Z_\mu^0}\mathcal{H}(W_\mu^+\phi^-+W_\mu^-\phi^+)+\\ \frac{1}{2g^2s_\omega\mathcal{A}_\mu\phi^0(W_\mu^+\phi^-+W_\mu^-\phi^+)}+\frac{1}{2ig^2s_\omega\mathcal{A}_\mu\mathcal{H}(W_\mu^+\phi^-+W_\mu^-\phi^+)}-\frac{g^2s_\omega}{c_\omega(2c_w^2-1)Z_\mu^0\mathcal{A}_\mu\phi^+\phi^-}-g^2s_\omega^2\mathcal{A}_\mu\mathcal{A}_v\phi^+\phi^-+\\ \frac{1}{2igs_s\lambda_{ij}^a\left(\underset{q\sigma^i}{\rightarrow}\varphi^\mu\underset{q\sigma^j}{\rightarrow}\right)g_\mu^a}-\underset{e^\lambda}{\rightarrow}(\varphi\partial+m_e^\lambda\end{array}\right)e^\lambda-\underset{v^\lambda}{\rightarrow}(\varphi\partial+m_v^\lambda\right)v^\lambda-\underset{\mu_j^\lambda v^\lambda}{\rightarrow\rightarrow}(\varphi\partial+m_\mu^\lambda\right)-(\mu_j^\lambda$$

$$-\underset{d_j^\lambda}{\rightarrow})+$$

$$(\varphi\partial+m_d^\lambda)d_j^\lambda+igs_\omega\mathcal{A}_\mu\Bigg(-\left(\underset{e^\lambda}{\rightarrow}\varphi^\mu e^\lambda\right)+\frac{2}{3\left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu\mu_j^\lambda\right)}-\frac{1}{3\left(\underset{d^\lambda}{\rightarrow}\varphi^\mu d^\lambda\right)}+\frac{ig}{4c_\omega Z_\mu^0\left(\underset{v^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5)v^\lambda\right)}$$

$$+\left(\underset{e^\lambda}{\rightarrow}\varphi^\mu(4s_\omega^2-1-\varphi^5)e^\lambda\right)+\left(\underset{d_j^\lambda}{\rightarrow}\varphi^\mu\left(\frac{4}{3s_\omega^2}-1-\varphi^5\right)d_j^\lambda\right)+\left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu\left(1-\frac{8}{3s_\omega^2}+\varphi^5\right)\mu_j^\lambda\right)$$

$$+\left(\frac{ig}{\sqrt[2]{2}W_\mu^+\left(\underset{v^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5)\right)U^{lep}{}_\xi^k e^k}\right)+\left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5)c_{\kappa\lambda}d_j^k\right)$$

$$+\frac{ig}{\sqrt[2]{2}W_\mu^-\left(\underset{e^\mathcal{K}}{\rightarrow}U^{lep^\dagger}\frac{{}^v\psi\lambda}{\kappa\varphi}{}_\xi\rho\varpi-\triangleq\prod\nolimits_{\odot\oplus}^{\oplus\odot}{}_\tau^\gamma\otimes\frac{\coprod_v^\mu ijk}{\bigotimes\sigma}\Omega\Psi\Phi\Delta(1+\varphi^5)v^\lambda+\underset{d_j^\kappa}{\rightarrow}C_{*\kappa}^{\dagger\lambda}\varphi_{v\eta}^{\mu\zeta\eta}(1+\varphi^5)\mu_j^\lambda\right)}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^+\left(-m_c^\kappa\left(\underset{v^\lambda}{\rightarrow}U^{lep}{}_\xi^k e^k(1-\varphi^5)\epsilon^\kappa\right)+m_\mu^\lambda\underset{\mu_j^\lambda}{\rightarrow}U^{lep^\dagger}(1+\varphi^5)\epsilon^\kappa\right)}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^-\left(m_c^\kappa\left(\underset{v^\lambda}{\rightarrow}U^{lep}{}_\xi^k e^k(1-\varphi^5)\epsilon^\kappa\right)\pm m_\mu^\lambda\underset{\mu_j^\lambda}{\rightarrow}U^{lep^\dagger}(1+\varphi^5)\epsilon^\kappa\right)}-\frac{\frac{g}{2m_v^\lambda}}{M}\mathcal{H}\left(\underset{v^\lambda}{\rightarrow}v^\lambda\right)$$

$$-\frac{\frac{\frac{g}{2m_c^\lambda}}{M\mathcal{H}\left(\underset{e^\lambda}{\rightarrow} e^\lambda\right)}}{\frac{1}{4\underset{v^\lambda}{\rightarrow} M_{\lambda\kappa}^R(1-\gamma_5)v^\kappa}}+\frac{\frac{ig}{2m_v^\lambda}}{M\phi^0\left(\underset{v^\lambda}{\rightarrow}\gamma^5 v^\lambda\right)}-\frac{\frac{ig}{2m_c^\lambda}}{M\phi^0\left(\underset{e^\lambda}{\rightarrow}\gamma^5 e^\lambda\right)}-\frac{1}{4\underset{v^\kappa}{\rightarrow} M_{\lambda\kappa}^R(1-\gamma_5)\underset{v^\kappa}{\rightarrow}}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^+\left(-m_d^\kappa\left(\underset{\mu_j^\lambda}{\rightarrow} C_{\lambda\kappa}(1-\varphi^5)d_j^\kappa\right)+m_d^\kappa\left(\underset{\mu_j^\lambda}{\rightarrow} C_{\lambda\kappa}(1-\varphi^5)d_j^\kappa\right)\right)}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^-\left(m_d^\lambda\left(\underset{d_j^\lambda}{\rightarrow} C_{\lambda\kappa\wedge\theta*}^\dagger(1+\varphi^5)\mu_j^\kappa\right)\pm m_d^\lambda\left(\underset{d_j^\lambda}{\rightarrow} C_{\lambda\kappa\wedge\nabla*}^\dagger(1+\varphi^5)\mu_j^\kappa\right)\right)}-\frac{\frac{g}{2m_\mu^\lambda}}{M\mathcal{H}\left(\underset{\mu_j^\lambda}{\rightarrow}\mu_j^\lambda\right)}$$

$$-\frac{\frac{g}{2m_d^\lambda}}{M}\mathcal{H}\left(\underset{d_j^\lambda}{\rightarrow} d_j^\lambda\right)+\frac{\frac{ig}{2m_\mu^\lambda}}{M}\phi^0\left(\underset{\mu_j^\lambda}{\rightarrow}\gamma^5\mu_j^\lambda\right)-\frac{\frac{ig}{2m_d^\lambda}}{M}\phi^0\left(\underset{d_j^\lambda}{\rightarrow}\gamma^5 d_j^\lambda\right)+\underset{G^a}{\rightarrow}\partial^2 G^a+g_s f^{abc}\partial_\mu\underset{G^a}{\rightarrow}G^b g_\mu^c$$

$$+\underset{\alpha^+}{\rightarrow}(\partial^2-M^2)\alpha^++\underset{\alpha^-}{\rightarrow}(\partial^2-M^2)\alpha^-+\underset{\alpha^0}{\rightarrow}\left(\partial^2-\frac{M^2}{c_\omega^2}\right)\alpha^0+\underset{b}{\rightarrow}\partial^2 b+igc_\omega W_\mu^+\left(\partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^-}{\rightarrow}-\partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^0}{\rightarrow}\right)$$

$$+igs_w W_\mu^+\left(\partial_\mu\underset{b}{\rightarrow}\alpha^--\partial_\mu\underset{a}{\rightarrow}b^-\right)+igc_\omega W_\mu^-\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^0}{\rightarrow}-\partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)+igs_\omega W_\mu^-\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^0}{\rightarrow}-\partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)$$

$$+igc_\omega Z_\mu^0\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^-}{\rightarrow}-\partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)+igs_\omega\mathcal{A}_\mu\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^-}{\rightarrow}-\partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)-1/2gM(\frac{\underset{\alpha^+}{\rightarrow}\alpha^+\mathcal{H}\hbar\mathbb{R}^4}{h}+\underset{\alpha^-}{\rightarrow}\alpha^-\mathcal{H}$$

$$+1-\frac{2c_{\Im}^2}{2c_\omega igM\left(\underset{\alpha^+}{\rightarrow}a^0\phi^+-\underset{\alpha^-}{\rightarrow}a^0\phi^-\right)}+\frac{1}{2c_\omega igM\left(\underset{\alpha^0}{\rightarrow}a^-\phi^+-\underset{\alpha^0}{\rightarrow}a^+\phi^-\right)}$$

$$+igMs_\omega\left(\underset{\alpha^0}{\rightarrow}a^-\phi^+-\underset{\alpha^0}{\rightarrow}a^+\phi^-\right)+1/2igM\left(\underset{\alpha^+}{\rightarrow}a^+\phi^0-\underset{\alpha^-}{\rightarrow}a^-\phi^0\right)$$

$$\Phi(x)=\begin{pmatrix}\phi^+\\ \phi^0\end{pmatrix}=\frac{1}{\sqrt{2}}\begin{pmatrix}\phi_1+\mathrm{i}\phi_2\\ \phi_3+\mathrm{i}\phi_4\end{pmatrix}$$

$$\mathcal{L}_{SBS}=(\mathcal{D}_\mu\Phi)^\dagger(\mathcal{D}^\mu\Phi)-V(\Phi)$$

$$V(\Phi)=\mu^2\Phi^\dagger\Phi+\lambda(\Phi^\dagger\Phi)^2$$

$$|\Phi|^2=\Phi^\dagger\Phi=-\frac{\mu^2}{2\lambda}=\frac{v^2}{2}$$

$$\Phi(x)=\begin{pmatrix}\phi^+\\ \phi^0\end{pmatrix}\longrightarrow\frac{1}{\sqrt{2}}\begin{pmatrix}0\\ v\end{pmatrix}$$

$$\Phi(x)=\frac{1}{\sqrt{2}}e^{\mathrm{i}\frac{\vec{\xi}(x)\cdot\vec{\tau}}{v}}\begin{pmatrix}0\\ v+\mathrm{h}(x)\end{pmatrix}$$

$$U(\xi) = e^{-\mathrm{i}\frac{\vec{\xi}(x)\cdot\vec{\tau}}{v}}$$

$$\begin{aligned}\Phi' &= U(\xi)\Phi = \tfrac{1}{\sqrt{2}}\begin{pmatrix}0\\ v+\mathrm{h}(x)\end{pmatrix}\\ \left(\frac{\vec{\tau}\,\vec{\mathrm{W}}'_\mu}{2}\right) &= U(\xi)\left(\frac{\vec{\tau}\,\vec{\mathrm{W}}_\mu}{2}\right)U^{-1}(\xi) - \tfrac{\mathrm{i}}{g}(\partial_\mu U(\xi))U^{-1}(\xi)\\ \mathrm{B}'_\mu &= \mathrm{B}_\mu\end{aligned}$$

$$\mathcal{L} = \mathcal{L}_{bos.} + \mathcal{L}_{ferm.} + \mathcal{L}_{SBS}$$

$$(\mathcal{D}_\mu\Phi)^\dagger(\mathcal{D}^\mu\Phi) = \frac{v^2}{8}[\mathrm{g}^2(W_{1\mu}^2 + W_{2\mu}^2) + (\mathrm{g}W_{3\mu} - \mathrm{g}'B_\mu)^2]$$

$$\begin{aligned}\mathrm{W}_\mu^\pm &= \tfrac{1}{\sqrt{2}}(\mathrm{W}_\mu^1 \mp \mathrm{W}_\mu^2)\\ \mathrm{Z}_\mu &= \cos\theta_\mathrm{W}\mathrm{W}_\mu^3 - \sin\theta_\mathrm{W}\mathrm{B}_\mu\\ \mathrm{A}_\mu &= \sin\theta_\mathrm{W}\mathrm{W}_\mu^3 + \cos\theta_\mathrm{W}\mathrm{B}_\mu\end{aligned}$$

$$\tan\theta_\mathrm{W} \equiv \frac{\mathrm{g}'}{\mathrm{g}}$$

$$\mathrm{M_W} = \tfrac{1}{2}\mathrm{g}v$$

$$\mathrm{M_Z} = \tfrac{1}{2}v\sqrt{\mathrm{g}^2 + \mathrm{g}'^2}$$

$$\begin{aligned}\mathrm{g} &= \frac{e}{\sin\theta_\mathrm{W}}\\ \mathrm{g}' &= \frac{e}{\cos\theta_\mathrm{W}}\end{aligned}$$

$$\mathrm{m_H^2} = 2\lambda v^2$$

$$\mu \to \nu_\mu\bar{\nu}_\mathrm{e}\mathrm{e}$$

$$v = (\sqrt{2}\mathrm{G_F})^{-\frac{1}{2}}$$

$$\mathcal{L}_{YW} = \lambda_\mathrm{e}\bar{\ell}_L\Phi\mathrm{e}_R + \lambda_\mathrm{u}\bar{\mathrm{q}}_L\tilde{\Phi}\mathrm{u}_R + \lambda_\mathrm{d}\bar{\mathrm{q}}_L\Phi\mathrm{d}_R + \mathrm{h.c.}$$

$$
\begin{aligned}
\ell_L &= \begin{pmatrix} \mathrm{e} \\ \nu_{\mathrm{e}} \end{pmatrix}_L, \begin{pmatrix} \mu \\ \nu_\mu \end{pmatrix}_L, \begin{pmatrix} \tau \\ \nu_\tau \end{pmatrix}_L \\
\mathrm{q}_L &= \begin{pmatrix} \mathrm{u} \\ \mathrm{d} \end{pmatrix}_L, \begin{pmatrix} \mathrm{c} \\ \mathrm{s} \end{pmatrix}_L, \begin{pmatrix} \mathrm{t} \\ \mathrm{b} \end{pmatrix}_L
\end{aligned}
$$

$$
\begin{aligned}
\ell'_L = U(\xi)\ell_L; &\qquad \mathrm{e}'_R = \mathrm{e}_R \\
\mathrm{q}'_L = U(\xi)q_L; &\qquad \mathrm{u}'_R = \mathrm{u}_R;\ \mathrm{d}'_R = \mathrm{d}
\end{aligned}
$$

$$
\begin{aligned}
\mathrm{m}_{\mathrm{e}} &= \lambda_{\mathrm{e}} \frac{v}{\sqrt{2}} \\
\mathrm{m}_{\mathrm{u}} &= \lambda_{\mathrm{u}} \frac{v}{\sqrt{2}} \\
\mathrm{m}_{\mathrm{d}} &= \lambda_{\mathrm{d}} \frac{v}{\sqrt{2}}
\end{aligned}
$$

O es igual a:

$$
\mathcal{L}_{Higgs} = \overline{\left([\partial_\mu + \frac{1}{2}ig_1 B_\mu + \frac{1}{2}ig_2 \mathbf{W}_\mu]\phi\right)}\left([\partial_\mu + \frac{1}{2}ig_1 B_\mu + \frac{1}{2}ig_2 \mathbf{W}_\mu]\phi\right) - \frac{m_H^2\left(\bar{\phi}\phi - \frac{v^2}{2}\right)^2}{2v^2}
$$

$$
\begin{aligned}
&\mathcal{L}_{SM}(z)\\
&= -\frac{1}{2\pi\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}g_{\mu}^{a}g_{a}^{\mu}g_{v}^{b}g_{b}^{v}} - g_{s}f^{ab}f_{ab}\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}g_{\mu}^{a}g_{a}^{\mu}g_{v}^{b}g_{b}^{v} - \frac{1}{4\pi g_{S}^{2}f^{cd}f_{cd}\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}g_{\mu}^{c}g_{c}^{\mu}g_{v}^{d}g_{d}^{v}}\\
&-\partial^{\mu}W_{\mu}\partial^{v}W_{v} - M^{2}W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v} - \frac{1}{2\pi\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}} - \frac{1}{2c_{m}^{2}M^{2}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}} - \frac{1}{2\partial^{\mu}A_{v}\partial^{v}A_{\mu}}\\
&-igc_{w}\left(\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}\right)\right) - Z_{\mu}^{0}\left(\partial^{\mu}\partial_{\mu}W_{\mu}^{+}W_{\mu}^{-}W_{+}^{\mu}W_{-}^{\mu}\right) + Z_{v}^{0}\left(\partial^{v}\partial_{v}W_{v}^{+}W_{v}^{-}W_{+}^{v}W_{-}^{v}\right)\\
&-igS_{w}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}\right)Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\right) - A_{\mu}\left(\partial^{\mu}\partial_{\mu}W_{\mu}^{+}W_{\mu}^{-}W_{+}^{\mu}W_{-}^{\mu}Z_{\mu}^{0}Z_{0}^{\mu}\right)\\
&+A_{v}\left(\partial^{v}\partial_{v}W_{v}^{+}W_{v}^{-}W_{+}^{v}W_{-}^{v}Z_{v}^{0}Z_{0}^{v}\right) - \frac{1}{2g^{2}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\right)\right)}\\
&+g^{2}c_{w}^{2}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\right)\right)\\
&+g^{2}S_{w}^{2}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\right)\right)\\
&-g^{2}c_{w}S_{w}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\right)\right)\\
&-\frac{1}{2\pi\left(\partial H^{\mu}AH_{v}H\partial^{v}HA_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}H^{\mu}H_{V}H_{v}^{\mu}H_{\mu}^{v}\right)\right)} + \frac{\dfrac{\dfrac{1}{2\pi(2M^{2}H^{2}H^{3})}}{\dfrac{d^{\lambda}em^{C}\gamma}{GUM_{Scw}^{2}}}}{\dfrac{\dfrac{2M}{\beta_{\eta}^{\xi}}}{\prod_{\sigma}^{\rho}\dfrac{h^{4}}{\hbar^{2}}}} - \frac{2g_{c}^{2}M_{S}^{2}}{\Psi\Phi\zeta} - \lambda\partial\\
&\otimes\frac{\omega}{\Delta\nabla\theta}\\
&/\prod_{\triangleq}^{\dagger}\infty\oiiint_{j}^{i}k\left(\frac{\dfrac{\phi_{\mu}^{+}\phi_{v}^{-}\phi_{\mu}^{-}\phi_{v}^{+}}{\phi_{+}^{\mu}\phi_{-}^{v}\phi_{-}^{\mu}\phi_{+}^{v}}}{\phi_{\mu}^{0}\phi_{v}^{0}\phi_{0}^{\mu}\phi_{0}^{v}}\right)\left(\varphi\psi\omega\lambda_{\mu}^{+}\varphi\psi\omega\lambda_{v}^{-}\varphi\psi\omega\lambda_{\mu}^{-}\varphi\psi\omega\lambda_{v}^{+}\frac{2\varphi\psi\omega\lambda^{\mu}}{\varphi\psi\omega\lambda}_{+}\varphi\psi\omega\lambda_{-}^{v}\varphi\psi\omega\lambda_{-}^{\mu}\varphi\psi\omega\lambda_{+}^{v}\frac{1/2\pi\varphi\psi\omega\lambda^{0}}{\varphi\psi\omega\lambda}_{\mu}\varphi\psi\omega\lambda_{v}^{0}\varphi\psi\omega\lambda_{0}^{\mu}\varphi\psi\omega\lambda_{0}^{v}\right)\\
&/2M\sqrt[\phi\varphi\lambda\kappa]{\frac{\dfrac{2\xi\eta}{\zeta\epsilon\varepsilon}}{\dfrac{\delta\alpha}{o\sigma\rho}}/\Psi\Omega\mho} = \mathcal{L}_{Higgs}\\
&=\left(\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu} + \frac{1}{2ig_{1}B^{\mu}B_{v}B^{v}B_{\mu}} + \frac{1}{2jg_{2}B^{\mu}B_{v}B^{v}B_{\mu}} + \frac{1}{2ig_{1}W^{\mu}W_{v}W^{v}W_{\mu}} + \frac{1}{2jg_{2}W^{\mu}W_{v}W^{v}W_{\mu}}\right) - m_{H}^{2}\phi'\phi - v^{2}/2v^{2}/\tau^{2}
\end{aligned}
$$

$$
\begin{aligned}
\mathcal{H}_{c} &\equiv \frac{1}{2\pi\prod_{i}^{k}(x) + \prod_{k}^{i}(x)\partial^{i}\partial_{k}A^{k}A_{i}(x) + \dfrac{1}{4\pi F^{ki}(x)F_{ik}(x)}}\\
&= H_{c}\oiiint_{i}^{k}d^{3}\chi\left[\frac{1}{2\pi\prod_{i}^{k}(x) + \prod_{k}^{i}(x)\partial^{i}\partial_{k}A^{k}A_{i}(x) + \dfrac{1}{4\pi F^{ki}(x)F_{ik}(x)}}\right]\\
&= H^{\rho}H_{c}H^{c}H_{\rho}H_{c}^{\rho}H_{\rho}^{c}\varrho \equiv \oiiint_{i}^{k}\frac{d^{3}\chi\lambda}{\hbar}\underset{[\lambda\Phi\triangleq]}{\mho\Omega\mathbb{R}^{4}}/G_{\varepsilon}R_{e}
\end{aligned}
$$

Donde:

$$G_{\varepsilon} = \mathrm{G}_{\mu\nu} = \frac{8\pi \mathrm{G}}{\mathrm{c}^4} T_{\mu\nu}$$

$$R_e = R_{\mu\nu} - \frac{1}{2} R\, g_{\mu\nu} + \Lambda\, g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$\mathcal{H}_c \equiv \frac{1}{2\pi \prod_i^k(y) + \prod_k^i(y)\partial^i\partial_k\, A^k A_i(y) + \frac{1}{4F^{ki}(y)F_{ik}(y)}}$$

$$= H_c \oiiint_i^k d^3\chi\left[\frac{1}{2\pi \prod_i^k(y) + \prod_k^i(y)\partial^i\partial_k\, A^k A_i(y) + \frac{1}{4\pi F^{ki}(y)F_{ik}(y)}}\right]$$

$$= H^{\rho} H_c H^c H_{\rho} H_c^{\rho} H_{\rho}^{c} \varrho \equiv \oiiint_i^k \frac{d^3\chi\lambda}{\hbar} \mho\Omega\mathbb{R}^4 / G_{\varepsilon} R_e \quad [\lambda\Phi \triangleq]$$

Donde:


$$G_{\varepsilon} = \mathrm{G}_{\mu\nu} = \frac{8\pi \mathrm{G}}{\mathrm{c}^4} T_{\mu\nu}$$

$$R_e = R_{\mu\nu} - \frac{1}{2} R\, g_{\mu\nu} + \Lambda\, g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$\mathcal{H}_c \equiv \frac{1}{2\pi \prod_i^k(z) + \prod_k^i(z)\partial^i\partial_k A^k A_i(z) + \frac{1}{4\pi F^{ki}(z)F_{ik}(z)}}$$

$$= H_c \oiiint_i^k d^3\chi[\frac{1}{2\pi \prod_i^k(z) + \prod_k^i(z)\partial^i\partial_k A^k A_i(z) + \frac{1}{4\pi F^{ki}(z)F_{ik}(z)}}]$$

$$= H^\rho H_c H^c H_\rho H_c^\rho H_\rho^c \varrho \equiv \oiiint_i^k \frac{d^3\chi\lambda}{\hbar} \mho\Omega\mathbb{R}^4/G_\varepsilon R_e$$

$$[\lambda\Phi \triangleq]$$

Donde:

$$G_\varepsilon = \quad G_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$R_e = \quad R_{\mu\nu} - \frac{1}{2} R\, g_{\mu\nu} + \Lambda\, g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$\{B(x,t), C(x,t)/\Phi\Psi\kappa\varphi\theta$$

$$= \prod\nolimits_{v}^{\mu}(x,t)\lambda\phi \frac{\oint_\sigma^\varphi d^3z[\delta_v^\mu B(x,t)\lambda\phi/\delta_v^\mu A_{\mu v}(x,t)\lambda\phi}{\delta_v^\mu C(x,t)\lambda\phi}$$

$$/\delta \prod\nolimits_{\mu}^{v}(x,t)\lambda\phi - \frac{\oint_\sigma^\varphi d^3z[\delta_\mu^v B(x,t)\lambda\phi/\delta_\mu^v C(z,t)\lambda\phi}{\delta_\mu^v A_{v\mu}(x,t)\lambda\phi} /\delta \prod\nolimits_{v\mu}^{\mu v}(x,t)\lambda\phi$$

$$\{B(y,t), C(y,t)/\Phi\Psi\kappa\varphi\theta$$

$$= \prod\nolimits_{v}^{\mu}(y,t)\lambda\phi \frac{\oint_\sigma^\varphi d^3z[\delta_v^\mu B(y,t)\lambda\phi/\delta_v^\mu A_{\mu v}(y,t)\lambda\phi}{\delta_v^\mu C(y,t)\lambda\phi}$$

$$/\delta \prod\nolimits_{\mu}^{v}(y,t)\lambda\phi - \frac{\oint_\sigma^\varphi d^3z[\delta_\mu^v B(y,t)\lambda\phi/\delta_\mu^v C(y,t)\lambda\phi}{\delta_\mu^v A_{v\mu}(y,t)\lambda\phi} /\delta \prod\nolimits_{v\mu}^{\mu v}(y,t)\lambda\phi$$

$$\{B(z,t),C(z,t)/\Phi\Psi\kappa\varphi\theta$$

$$= \prod\nolimits_{v}^{\mu}(z,t)\lambda\phi\frac{\oint_{\sigma}^{\varphi} d^3z[\delta_v^\mu B(z,t)\lambda\phi/\delta_v^\mu A_{\mu v}(z,t)\lambda\phi}{\delta_v^\mu C(z,t)\lambda\phi}$$

$$/\delta\prod\nolimits_{\mu}^{v}(z,t)\lambda\phi - \frac{\oint_{\sigma}^{\varphi} d^3z[\delta_\mu^v B(z,t)\lambda\phi/\delta_\mu^v C(z,t)\lambda\phi}{\delta_\mu^v A_{v\mu}(z,t)\lambda\phi}/\delta\prod\nolimits_{v\mu}^{\mu v}(z,t)\lambda\phi$$

$$\{F(x),G(x)\}_{D\bowtie}$$

$$=\divideontimes\{F(x),G(x)\}\oplus$$

$$-\coprod_{\varphi}^{\gamma}\psi\prod_{\gamma}^{\varphi}\lambda$$

$$\approxeq\frac{\oiiint_{v}^{\mu}\frac{\zeta}{\beta}d^3\mu v^3\,\mu v_3\mu v^d\mu v_d v\mu^3 v\mu_3 v\mu^d v\mu_d\phi^\mu\phi_v\phi^v\phi_\mu\varphi^v\varphi_\mu\varphi^\mu\varphi_v\phi^{\mu v}\phi_{v\mu}\phi^{v\mu}\phi_{\mu v}\varphi^{\mu v}\varphi_{v\mu}\varphi^{v\mu}\varphi_{\mu v}C^{-1\pi}_{\mu v v c^{-i\omega t}mc^4_\hbar}}{\alpha\beta/h\mho\Omega\oint\frac{\dagger}{\pi}/\Delta\nabla\otimes\boxtimes\ltimes\rtimes\leftthreetimes\rightthreetimes}$$

$$\{F(y),G(y)\}_{D\bowtie}$$

$$=\divideontimes\{F(y),G(y)\}\oplus$$

$$-\coprod_{\varphi}^{\gamma}\psi\prod_{\gamma}^{\varphi}\lambda$$

$$\approxeq\frac{\oiiint_{v}^{\mu}\frac{\zeta}{\beta}d^3\mu v^3\,\mu v_3\mu v^d\mu v_d v\mu^3 v\mu_3 v\mu^d v\mu_d\phi^\mu\phi_v\phi^v\phi_\mu\varphi^v\varphi_\mu\varphi^\mu\varphi_v\phi^{\mu v}\phi_{v\mu}\phi^{v\mu}\phi_{\mu v}\varphi^{\mu v}\varphi_{v\mu}\varphi^{v\mu}\varphi_{\mu v}C^{-1\pi}_{\mu v v c^{-i\omega t}mc^4_\hbar}}{\alpha\beta/h\mho\Omega\oint\frac{\dagger}{\pi}/\Delta\nabla\otimes\boxtimes\ltimes\rtimes\leftthreetimes\rightthreetimes}$$

$$\{F(z),G(z)\}_{D\bowtie}$$

$$=\divideontimes\{F(z),G(z)\}\oplus$$

$$-\coprod_{\varphi}^{\gamma}\psi\prod_{\gamma}^{\varphi}\lambda$$

$$\approxeq\frac{\oiiint_{v}^{\mu}\frac{\zeta}{\beta}d^3\mu v^3\,\mu v_3\mu v^d\mu v_d v\mu^3 v\mu_3 v\mu^d v\mu_d\phi^\mu\phi_v\phi^v\phi_\mu\varphi^v\varphi_\mu\varphi^\mu\varphi_v\phi^{\mu v}\phi_{v\mu}\phi^{v\mu}\phi_{\mu v}\varphi^{\mu v}\varphi_{v\mu}\varphi^{v\mu}\varphi_{\mu v}C^{-1\pi}_{\mu v v c^{-i\omega t}mc^4_\hbar}}{\alpha\beta/h\mho\Omega\oint\frac{\dagger}{\pi}/\Delta\nabla\otimes\boxtimes\ltimes\rtimes\leftthreetimes\rightthreetimes}$$

$$\mathcal{L} = -\frac{1}{4\pi f^{ab}(x)t_{ab}(x)f_{ab}t^{ab}f_{ba}^{ab}}(x)t_{ba}^{ab}(x)f_{ab}^{ba}(x)t_{ab}^{ba}(x) \neq \mathcal{L}$$

$$= -\frac{1}{4\pi f^{ba}(x)t_{ba}(x)f_{ba}t^{ba}f_{ab}^{ba}}(x)t_{ab}^{ba}(x)f_{ba}^{ab}(x)t_{ba}^{ab}(x)$$

$$\mathcal{L} = -\frac{1}{4\pi f^{ab}(y)t_{ab}(y)f_{ab}t^{ab}f_{ba}^{ab}}(y)t_{ba}^{ab}(y)f_{ab}^{ba}(y)t_{ab}^{ba}(y) \neq \mathcal{L}$$
$$= -\frac{1}{4\pi f^{ba}(y)t_{ba}(y)f_{ba}t^{ba}f_{ab}^{ba}}(y)t_{ab}^{ba}(y)f_{ba}^{ab}(y)t_{ba}^{ab}(y)$$

$$\mathcal{L} = -\frac{1}{4\pi f^{ab}(z)t_{ab}(z)f_{ab}t^{ab}f_{ba}^{ab}}(z)t_{ba}^{ab}(z)f_{ab}^{ba}(z)t_{ab}^{ba}(z) \neq \mathcal{L}$$
$$= -\frac{1}{4\pi f^{ba}(z)t_{ba}(z)f_{ba}t^{ba}f_{ab}^{ba}}(z)t_{ab}^{ba}(z)f_{ba}^{ab}(z)t_{ba}^{ab}(z)$$

$$f^{ab}(x,t)t_{ba}(x,t)f_{ab}(x,t)t^{ba}(x,t)f^{ba}(x,t)t_{ab}(x,t)f_{ba}(x,t)t^{ab}(x,t)$$
$$+ f^{ab}(y,t)t_{ba}(y,t)f_{ab}(y,t)t^{ba}(y,t)f^{ba}(y,t)t_{ab}(y,t)f_{ba}(y,t)t^{ab}(y,t)$$
$$+ f^{ab}(x)t_{ba}(x)f_{ab}(x)t^{ba}(x)f^{ba}(x)t_{ab}(x)f_{ba}(x)t^{ab}(x)$$
$$+ f^{ab}(y)t_{ba}(y)f_{ab}(y)t^{ba}(y)f^{ba}(y)t_{ab}(y)f_{ba}(y)t^{ab}(y)$$
$$+ f^{ab}(z)t_{ba}(z)f_{ab}(z)t^{ba}(z)f^{ba}(z)t_{ab}(z)f_{ba}(z)t^{ab}(z)$$
$$= \partial^a A_b(x,t) - \partial^b A_a(x,t) + \partial^a A_b(y,t) - \partial^b A_a(y,t) + \partial^a A_b(z,t) - \partial^b A_a(z,t)$$
$$= \partial^a A_b(x) - \partial^b A_a(x) + \partial^a A_b(y) - \partial^a A_b(y) + \partial^a A_b(z) - \partial^b A_a(z)$$

$$f_{ij}(x,k), t^{ji}(x,k), f^{ij}(x,k)t_{ji}(x,k), f_{ji}(x,k), t^{ij}(x,k), f^{ji}(x,k)t_{ij}(x,k) + f_j^i t_i^j(x,k), f_i^j t_j^i\ (x,k)$$
$$+ f_{ij}(y,k), t^{ji}(y,k), f^{ij}(y,k)t_{ji}(y,k), f_{ji}(y,k), t^{ij}(y,k), f^{ji}(y,k)t_{ij}(y,k) + f_j^i t_i^j(y,k), f_i^j t_j^i\ (y,k)$$
$$+ f_{ij}(z,k), t^{ji}(z,k), f^{ij}(z,k)t_{ji}(z,k), f_{ji}(z,k), t^{ij}(z,k), f^{ji}(z,k)t_{ij}(z,k) + f_j^i t_i^j(z,k), f_i^j t_j^i\ (z,k)$$
$$= -\epsilon^{ijk}\epsilon_{ijk}B^k B_k(x,k) - \epsilon^{ijk}\epsilon_{ijk}B^k B_k(y,k) - \epsilon^{ijk}\epsilon_{ijk}B^k B_k(z,k)$$

$$A^a A_a A^b A_b A^a A_b A^b A_a A^{ab} A_{ba} A^{ba} A_{ab}(x) \rightarrow A^a A_a A^b A_b A^a A_b A^b A_a A^{ab} A_{ba} A^{ba} A_{ab}(y)$$
$$\rightarrow A^a A_a A^b A_b A^a A_b A^b A_a A^{ab} A_{ba} A^{ba} A_{ab}(z) \rightarrow A'_a A'_b A'_b A'_a(x) \rightarrow A'_a A'_b A'_b A'_a(y)$$
$$\rightarrow A'_a A'_b A'_b A'_a(z) = A^a A_a A^b A_b A^a A_b A^b A_a A^{ab} A_{ba} A^{ba} A_{ab}(x)$$
$$\rightarrow A^a A_a A^b A_b A^a A_b A^b A_a A^{ab} A_{ba} A^{ba} A_{ab}(y)$$
$$\rightarrow A^a A_a A^b A_b A^a A_b A^b A_a A^{ab} A_{ba} A^{ba} A_{ab}(z) + \partial^a \partial_b \partial^b \partial_a \partial^{ab} \partial_{ba} \partial^{ba} \partial_{ab} \alpha(x)$$
$$+ \partial^a \partial_b \partial^b \partial_a \partial^{ab} \partial_{ba} \partial^{ba} \partial_{ab} \alpha(y) + \partial^a \partial_b \partial^b \partial_a \partial^{ab} \partial_{ba} \partial^{ba} \partial_{ab} \alpha(z)$$

$$f^{ab}t_{ba}f^{ba}t_{ab}f^{ab}t_{ab}f^{ba}t_{ba}(x) \rightarrow f^{ab}t_{ba}f^{ba}t_{ab}f^{ab}t_{ab}f^{ba}t_{ba}(y)$$
$$\rightarrow f^{ab}t_{ba}f^{ba}t_{ab}f^{ab}t_{ab}f^{ba}t_{ba}(z) \rightarrow f'_{ab}t'_{ba}f'_{ba}t'_{ab}(x) \rightarrow f'_{ab}t'_{ba}f'_{ba}t'_{ab}(y)$$
$$\rightarrow f'_{ab}t'_{ba}f'_{ba}t'_{ab}(z)$$
$$= \partial_a \left(A^aA_bA^bA_aA^{ab}A_{ba}A^{ba}A_{ab}(x) + \partial^a\partial_b\partial^b\partial_a\partial^{ab}\partial_{ba}\partial^{ba}\partial_{ab}\alpha(x)\right)$$
$$- \partial_b \left(A^bA_aA^aA_bA^{ba}A_{ab}A^{ab}A_{ba}(x) + \partial^b\partial_a\partial^a\partial_b\partial^{ba}\partial_{ab}\partial^{ab}\partial_{ba}\alpha(x)\right)$$
$$= \partial^a\partial^bA_aA_b\partial^b\partial^aA_bA_a\partial^{ab}\partial^{ba}A_{ab}A_{ba}\partial^{ba}\partial^{ab}A_{ba}A_{ab}(x)$$
$$+ \partial^a\partial^b\partial_a\partial_b\partial^b\partial^a\partial_bA_a\partial^{ab}\partial^{ba}\partial_{ab}\partial_{ba}\partial^{ba}\partial^{ab}\partial_{ba}\partial_{ab}\alpha(x)$$
$$= \partial_a \left(A^aA_bA^bA_aA^{ab}A_{ba}A^{ba}A_{ab}(y) + \partial^a\partial_b\partial^b\partial_a\partial^{ab}\partial_{ba}\partial^{ba}\partial_{ab}\alpha(y)\right)$$
$$- \partial_b \left(A^bA_aA^aA_bA^{ba}A_{ab}A^{ab}A_{ba}(y) + \partial^b\partial_a\partial^a\partial_b\partial^{ba}\partial_{ab}\partial^{ab}\partial_{ba}\alpha(y)\right)$$
$$= \partial^a\partial^bA_aA_b\partial^b\partial^aA_bA_a\partial^{ab}\partial^{ba}A_{ab}A_{ba}\partial^{ba}\partial^{ab}A_{ba}A_{ab}(y)$$
$$+ \partial^a\partial^b\partial_a\partial_b\partial^b\partial^a\partial_bA_a\partial^{ab}\partial^{ba}\partial_{ab}\partial_{ba}\partial^{ba}\partial^{ab}\partial_{ba}\partial_{ab}\alpha(y)$$
$$= \partial_a \left(A^aA_bA^bA_aA^{ab}A_{ba}A^{ba}A_{ab}(z) + \partial^a\partial_b\partial^b\partial_a\partial^{ab}\partial_{ba}\partial^{ba}\partial_{ab}\alpha(z)\right)$$
$$- \partial_b \left(A^bA_aA^aA_bA^{ba}A_{ab}A^{ab}A_{ba}(z) + \partial^b\partial_a\partial^a\partial_b\partial^{ba}\partial_{ab}\partial^{ab}\partial_{ba}\alpha(z)\right)$$
$$= \partial^a\partial^bA_aA_b\partial^b\partial^aA_bA_a\partial^{ab}\partial^{ba}A_{ab}A_{ba}\partial^{ba}\partial^{ab}A_{ba}A_{ab}(z)$$
$$+ \partial^a\partial^b\partial_a\partial_b\partial^b\partial^a\partial_bA_a\partial^{ab}\partial^{ba}\partial_{ab}\partial_{ba}\partial^{ba}\partial^{ab}\partial_{ba}\partial_{ab}\alpha(z)$$

$$f'_{ab}t'_{ba}f'_{ba}t'_{ab}(x) = \partial^aA^b\partial_bA_a\partial^{ab}A^{ba}\partial_{ba}A_{ab}(x) - \partial^bA^a\partial_aA_b\partial^{ba}A^{ab}\partial_{ab}A_{ba}(x)$$
$$= f^{ab}t_{ba}f^{ba}t_{ab}\,(x)$$

$$f'_{ab}t'_{ba}f'_{ba}t'_{ab}(y) = \partial^aA^b\partial_bA_a\partial^{ab}A^{ba}\partial_{ba}A_{ab}(y) - \partial^bA^a\partial_aA_b\partial^{ba}A^{ab}\partial_{ab}A_{ba}(y)$$
$$= f^{ab}t_{ba}f^{ba}t_{ab}\,(y)$$

$$f'_{ab}t'_{ba}f'_{ba}t'_{ab}(z) = \partial^aA^b\partial_bA_a\partial^{ab}A^{ba}\partial_{ba}A_{ab}(z) - \partial^bA^a\partial_aA_b\partial^{ba}A^{ab}\partial_{ab}A_{ba}(z)$$
$$= f^{ab}t_{ba}f^{ba}t_{ab}\,(z)$$

$$\mathcal{A}[A^a\partial_bA^b\partial_a] = \oiiint_{ba}^{ab} abba\, d^4\chi\mathcal{L}[A^a\partial_bA^b\partial_a] + \delta\mathcal{A}[A^a\partial_bA^b\partial_a] = \delta \oiiint_{ba}^{ab} abba\, d^4\chi\mathcal{L}[A^a\partial_bA^b\partial_a]$$
$$= \oiiint_{ba}^{ab} abba\, d^4\chi\delta\mathcal{L}[A^a\partial_bA^b\partial_a]$$

$$\delta\mathcal{L}[A^a\partial_bA^b\partial_a] = \frac{\partial\mathcal{L}}{\partial A^aA_bA^bA_a}\delta A_b^aA_a^b + \frac{\partial\mathcal{L}}{\partial(\partial^aA_b\partial^bA_a)\delta(\partial^aA_b\partial^bA_a)}$$

$$\delta\mathcal{A}[A^a\partial_bA^b\partial_a] = \delta \oiiint_{ba}^{ab} abba\, d^4\chi[\frac{\partial\mathcal{L}}{\partial A^aA_bA^bA_a}\delta A_b^aA_a^b + \frac{\partial\mathcal{L}}{\partial(\partial^aA_b\partial^bA_a)\delta(\partial^aA_b\partial^bA_a)}]$$

$$\delta[A^a\partial_b A^b\partial_a] = \delta\frac{\partial A^a A_b A^b A_a}{\partial\chi^a\chi_b\chi^b\chi_a} = \frac{\partial}{\partial\chi^a\chi_b\chi^b\chi_a}\,\delta A^a_b A^b_a = \partial^a\partial_b(\delta A^a_b A^b_a)$$

$$\frac{\partial\mathcal{L}}{\partial(\partial^a A_b\partial^a\partial_b)}\delta(\partial^a A_b\partial^b\partial_a) = \frac{\partial\mathcal{L}}{\partial(\partial^a A_b\partial^b A_a)}\partial^a\partial_b(\delta A^a_b A^b_a)$$

$$= \partial^a\partial_b\partial^a\partial_b[\frac{\partial\mathcal{L}}{\partial(\partial^a A_b\partial^b A_a)}\delta(\partial^a A_b\partial^b A_a)] - \frac{\partial\mathcal{L}}{\partial(\partial^a A_b\partial^b A_a)}\delta(\partial^a A_b\partial^b A_a)$$

$$\delta\mathcal{A}[A^a\partial_b A^b\partial_a] = \delta\oiiint_{ba}^{ab} abba\, d^4\chi[\frac{\partial\mathcal{L}}{\partial A^a A_b A^b A_a}\delta A^a_b A^b_a$$

$$-\partial^a\partial_b\partial^b\partial_a\frac{\partial\mathcal{L}}{\partial(\partial^a A_b\partial^b A_a)\delta(\partial^b A_a\partial^a A_b)}\delta A^a_b A^b_a$$

$$+\ \delta\oiiint_{ba}^{ab} abba\, d^4\chi\partial^a\partial_b\partial^b\partial_a[\frac{\partial\mathcal{L}}{\partial(\partial^a A_b\partial^b A_a)\delta(\partial^b A_a\partial^a A_b)}\delta A^a_b A^b_a]$$

$$\frac{\partial\mathcal{L}}{\partial A^a A_b A^a_b A^b_a} = -\frac{1}{4\pi\frac{\partial}{\partial A^a A_b A^a_b A^b_a}[f^a t_b f^a_b t^b_a t^a f_b t^a_b f^b_a]}$$

$$= -1$$

$$/4\pi\frac{\partial}{\partial A^a A_b A^a_b A^b_a}(\left(\partial^a A_b(x) - \partial^b A_a(x)\right)\left(\partial^b A_a(x) - \partial^a A_b(x)\right)\left(\partial^a A^b(x)\right.$$

$$\left.-\partial^b A^a(x)\right)\left(\partial^b A^a(x) - \partial^a A^b(x)\right)\left(\partial_a A_b(x) - \partial_b A_a(x)\right)\left(\partial^a_b A^b_a(x)\right.$$

$$\left.-\ \partial^b_a A^a_b(x)\right)\left({}^a_b\partial^b_a A(x) - {}^b_a\partial^a_b A(x)\right)$$

$$+ -1$$

$$/4\pi\frac{\partial}{\partial A^a A_b A^a_b A^b_a}(\left(\partial^a A_b(y) - \partial^b A_a(y)\right)\left(\partial^b A_a(y) - \partial^a A_b(y)\right)\left(\partial^a A^b(y)\right.$$

$$\left.-\partial^b A^a(y)\right)\left(\partial^b A^a(y) - \partial^a A^b(y)\right)\left(\partial_a A_b(y) - \partial_b A_a(y)\right)\left(\partial^a_b A^b_a(y)\right.$$

$$\left.-\ \partial^b_a A^a_b(y)\right)\left({}^a_b\partial^b_a A(y) - {}^b_a\partial^a_b A(y)\right)$$

$$+ -1$$

$$/4\pi\frac{\partial}{\partial A^a A_b A^a_b A^b_a}(\left(\partial^a A_b(z) - \partial^b A_a(z)\right)\left(\partial^b A_a(z) - \partial^a A_b(z)\right)\left(\partial^a A^b(z)\right.$$

$$\left.-\partial^b A^a(z)\right)\left(\partial^b A^a(z) - \partial^a A^b(z)\right)\left(\partial_a A_b(z) - \partial_b A_a(z)\right)\left(\partial^a_b A^b_a(z)\right.$$

$$\left.-\ \partial^b_a A^a_b(z)\right)\left({}^a_b\partial^b_a A(z) - {}^b_a\partial^a_b A(z)\right)$$

$$\partial_i \partial^j \partial_j \partial^i f^{ab\varphi} t_{ba\omega} t^{ab\varphi} f_{ba\omega}(x)$$

$$= \frac{\frac{\partial^{\theta} \partial_{\emptyset} F_{\sigma}^{\rho} \gamma \beta}{\varepsilon \epsilon \vartheta \pi}}{\frac{\Delta \nabla}{\tau}} + \prod_{b}^{a} \lambda \coprod_{a}^{b} \lambda H_{iggs}$$

$$- W^a W_b W^b W_a W_b^a W_a^b {}_b^a W_a^b W - \eta^{\theta} \eta_{\beta} \eta_{\phi v \Omega}^{\sigma \mu \alpha} \eta / \mathbb{R}^4$$

En la que la constante $H_{iggs}$ es igual a:

$$\mathcal{L}_{SM} = \frac{1}{2\partial_v g_\mu^a \partial_\mu g_v^b} - g_s f^{abc} \partial_\mu g_v^a g_v^b g_v^c \partial_v g_\mu^a g_\mu^b g_\mu^c - \frac{1}{4 g_s^2 f^{abc} f^{ade} g_\mu^b g_\mu^c g_\mu^d g_\mu^d g_v^b g_v^c g_v^d g_v^d} - \partial_v W_\mu^+ \partial_v W_\mu^- \partial_\mu W_v^+ \partial_\mu W_v^- - M^2 W_\mu^+ W_\mu^- W_v^+ W_v^-$$

$$- \frac{1}{2\partial_v Z_\mu^0 \partial_\mu Z_v^0} - \frac{1}{2 c_\omega^{2} M^2 Z_\mu^0 Z_v^0} - \frac{1}{2\partial_\mu \mathcal{A}_v \partial_v \mathcal{A}_\mu}$$

$$-igc_\omega \left( \partial_v Z_\mu^0 (W_\mu^+ W_v^- W_\mu^- W_v^+) - Z_\mu^0 Z_v^0 (\partial_v W_\mu^+ \partial_v W_\mu^- \partial_\mu W_v^+ \partial_\mu W_v^-) \right)$$

$$- igs_\omega \left( \partial_\mu \mathcal{A}_v \partial_v \mathcal{A}_\mu (W_\mu^+ W_\mu^- W_v^+ W_v^-) - \mathcal{A}_\mu (\partial_v W_\mu^+ \partial_v W_\mu^- \partial_\mu W_v^+ \partial_\mu W_v^-) - \mathcal{A}_v (\partial_v W_\mu^+ \partial_v W_\mu^- \partial_\mu W_v^+ \partial_\mu W_v^-) \right)$$

$$- \frac{1}{2 g^2 W_\mu^+ W_v^- W_\mu^- W_v^+} + g^2 c_\omega^2 (Z_\mu^0 W_\mu^+ W_\mu^- Z_v^0 W_v^+ W_v^-)$$

$$+ g^2 s_\omega^2 (\mathcal{A}_\mu W_\mu^+ W_\mu^- \mathcal{A}_v W_v^+ W_v^-) + g^2 c_\omega s_\omega (\mathcal{A}_\mu Z_\mu^0 (W_\mu^+ W_\mu^-) \mathcal{A}_v Z_v^0 (W_v^+ W_v^-) - 2\mathcal{A}_\mu W_\mu^+ W_\mu^- Z_\mu^0 \mathcal{A}_v W_v^+ W_v^- Z_v^0) - \frac{1}{2\partial_\mu \mathcal{H} \partial_v \mathcal{H}} - 2M^2 \propto_h \mathcal{H}^2$$

$$- \partial_\mu \phi^+ \partial_v \phi^- \partial_v \phi^+ \partial_\mu \phi^- - \frac{1}{2\partial_\mu \phi^0 \partial_v \phi^0 \partial_v \phi^0 \partial_\mu \phi^0}$$

$$-\beta_h \left( \frac{2M^2}{g^2} + \frac{2M}{g\mathcal{H}} + \frac{1}{2} (\mathcal{H}^2 + \phi^0 \phi^+ \phi^0 \phi^- + 2\phi^0 \phi^+ \phi^0 \phi^-) \right) + \frac{2M^4}{g^2 \propto_h} - g \propto_h M(\mathcal{H}^3 + \mathcal{H}\phi^0\phi^0 + 2\mathcal{H}\phi^+\phi^-) - 1/8 g^2 \propto_h (\mathcal{H}^4 + (\phi^0)^4$$

$$+ 4(\phi^+\phi^-)^2 + 4(\phi^0)^2 \phi^+ \phi^- + 4\mathcal{H}^2 \phi^+ \phi^- + 2(\phi^0)^2 \mathcal{H}^2) - gMW_\mu^+ W_\mu^- W_v^+ W_v^- \mathcal{H} - \frac{\frac{1}{2gM}}{c_\omega^2 Z_\mu^0 Z_v^0 \mathcal{H}}$$

$$- \frac{1}{2ig} \left( W_\mu^+ (\phi^0 \partial_\mu \phi^- - \phi^- \partial_\mu \phi^0) - W_\mu^- (\phi^0 \partial_\mu \phi^+ - \phi^+ \partial_\mu \phi^0) - W_v^+ (\phi^0 \partial_v \phi^- - \phi^- \partial_v \phi^0) \right.$$

$$\left. - W_v^- (\phi^0 \partial_v \phi^+ - \phi^+ \partial_v \phi^0) \right)$$

$$- \frac{1}{2g \left( W_\mu^+ (\mathcal{H} \partial_\mu \phi^- - \phi^- \partial_\mu \mathcal{H}) W_\mu^- (\mathcal{H} \partial_\mu \phi^+ - \phi^+ \partial_\mu \mathcal{H}) W_v^+ (\mathcal{H} \partial_v \phi^- - \phi^- \partial_v \mathcal{H}) W_v^- (\mathcal{H} \partial_v \phi^+ - \phi^+ \partial_v \mathcal{H}) \right)}$$

$$+ \frac{\frac{1}{2g1}}{c_\omega \left( Z_\mu^0 (\mathcal{H} \partial_\mu \phi^0 - \phi^0 \partial_\mu \mathcal{H}) Z_v^0 (\mathcal{H} \partial_v \phi^0 - \phi^0 \partial_v \mathcal{H}) \right)} + M \left( \frac{1}{c_\omega Z_\mu^0 \partial_\mu \phi^0} + W_\mu^+ \partial_\mu \phi^- + W_\mu^- \partial_\mu \phi^+ \right)$$

$$- \frac{igs_\omega^2}{c_\omega M Z_\mu^0 (W^+ \phi^- - W^- \phi^+) igs_\omega M \mathcal{A}_\mu (W_\mu^+ \phi^- + W_\mu^- \phi^+)} - ig1 - \frac{2c_\omega^2}{2c_\omega Z_\mu^0 (\phi^+ \partial_\mu \phi^- - \phi^- \partial_\mu \phi^+)}$$

$$+ igs_\omega \mathcal{A}_\mu (\phi^+ \partial_\mu \phi^- - \phi^- \partial_\mu \phi^+) - 1/4 g^2 W_\mu^+ W_\mu^- (\mathcal{H}^2 + (\phi^0)^2 + 2\phi^+ \phi^-)$$

$$- \frac{\frac{\frac{1}{8g^2 1}}{c_\omega^2 Z_\mu^0 Z_v^0}}{\left( \left( \left( \begin{matrix} \mathcal{H}^2 + \\ \phi^0)^2 + 2 \\ 2s_\omega^2 - 1)^2 \phi^+ \phi^- - \frac{\frac{1}{2g^2 s_\omega^2}}{c_\omega Z_\mu^0 \phi^0 (W_\mu^+ \phi^- + W_\mu^- \phi^+)} - \frac{\frac{1}{2ig^2 s_\omega^2}}{c_\omega Z_\mu^0} \mathcal{H} (W_\mu^+ \phi^- + W_\mu^- \phi^+) + \\ \frac{1}{2g^2 s_\omega \mathcal{A}_\mu \phi^0 (W_\mu^+ \phi^- + W_\mu^- \phi^+)} + \frac{1}{2ig^2 s_\omega \mathcal{A}_\mu \mathcal{H} (W_\mu^+ \phi^- + W_\mu^- \phi^+)} - \frac{g^2 s_\omega}{c_\omega (2c_w^2 - 1) Z_\mu^0 \mathcal{A}_\mu \phi^+ \phi^-} - g^2 s_\omega^2 \mathcal{A}_\mu \mathcal{A}_v \phi^+ \phi^- + \\ \frac{1}{2ig_s \lambda_{ij}^a \left( \underset{q\sigma^i}{\longrightarrow} \varphi^\mu \underset{q\sigma^j}{\longrightarrow} \right) g_\mu^a} - \underset{e^\lambda}{\longrightarrow} (\varphi \partial + m_e^\lambda \end{matrix} \right) e^\lambda - \underset{v^\lambda}{\longrightarrow} (\varphi \partial + m_v^\lambda \right) v^\lambda - \underset{\mu_j^a v^\lambda}{\longrightarrow\longrightarrow} (\varphi \partial + m_\mu^\lambda \right) - (\mu_j^\lambda}$$

$$- \underset{d_j^\lambda}{\longrightarrow}) +$$

$$(\varphi\partial + m_d^\lambda)d_j^\lambda + igs_\omega\mathcal{A}_\mu\Bigg(-\left(\underset{e^\lambda}{\rightarrow}\varphi^\mu e^\lambda\right) + \frac{2}{3\left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu\mu_j^\lambda\right)} - \frac{1}{3\left(\underset{d^\lambda}{\rightarrow}\varphi^\mu d^\lambda\right)} + \frac{ig}{4c_\omega Z_\mu^0\left(\underset{v^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5)v^\lambda\right)}$$

$$+\left(\underset{e^\lambda}{\rightarrow}\varphi^\mu(4s_\omega^2 - 1 - \varphi^5)e^\lambda\right) + \left(\underset{d_j^\lambda}{\rightarrow}\varphi^\mu\left(\frac{4}{3s_\omega^2} - 1 - \varphi^5\right)d_j^\lambda\right) + \left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu\left(1 - \frac{8}{3s_\omega^2} + \varphi^5\right)\mu_j^\lambda\right)$$

$$+\left(\frac{ig}{\sqrt[2]{2}W_\mu^+\left(\underset{v^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5)\,U^{lep}{}_\xi^k e^k\right)}\right) + \left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5)C_{k\lambda}d_j^k\right)$$

$$+\frac{ig}{\sqrt[2]{2}W_\mu^-\left(\underset{e^{\mathcal{K}}}{\rightarrow}U^{lep^\dagger}\frac{{}^\nu\psi\lambda}{\kappa\varphi}{}_\xi\rho\varpi - \triangleq \prod_{\odot\oplus\tau}^{\oplus\odot\gamma}\otimes\frac{\coprod_\nu^\mu ijk}{\bigotimes\sigma}\Omega\Psi\Phi\Delta(1+\varphi^5)v^\lambda + \underset{d_j^\kappa}{\rightarrow}C_{*\kappa}^{\dagger\lambda}\varphi_{\nu\eta}^{\mu\zeta\eta}(1+\varphi^5)\mu_j^\lambda\right)}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^+\left(-m_c^\kappa\left(\underset{v^\lambda}{\rightarrow}U^{lep}{}_\xi^k e^k(1-\varphi^5)\epsilon^\kappa\right) + m_\mu^\lambda\underset{\mu_j^\lambda}{\rightarrow}U^{lep^\dagger}(1+\varphi^5)\varepsilon^\kappa\right)}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^-\left(m_c^\kappa\left(\underset{v^\lambda}{\rightarrow}U^{lep}{}_\xi^k e^k(1-\varphi^5)\epsilon^\kappa\right) \pm m_\mu^\lambda\underset{\mu_j^\lambda}{\rightarrow}U^{lep^\dagger}(1+\varphi^5)\varepsilon^\kappa\right)} - \frac{\frac{g}{2m_v^\lambda}}{M}\mathcal{H}\left(\underset{v^\lambda}{\rightarrow}v^\lambda\right)$$

$$-\frac{\frac{\frac{g}{2m_c^\lambda}}{M\mathcal{H}\left(\underset{e^\lambda}{\rightarrow}e^\lambda\right)}}{\frac{1}{4\underset{v^\lambda}{\rightarrow}M_{\lambda\kappa}^R(1-\gamma_5)v^\kappa}} + \frac{\frac{ig}{2m_v^\lambda}}{M\phi^0\left(\underset{v^\lambda}{\rightarrow}\gamma^5 v^\lambda\right)} - \frac{\frac{ig}{2m_c^\lambda}}{M\phi^0\left(\underset{e^\lambda}{\rightarrow}\gamma^5 e^\lambda\right)} - \frac{1}{4\underset{v^\kappa}{\rightarrow}M_{\lambda\kappa}^R(1-\gamma_5)\underset{v^\kappa}{\rightarrow}}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^+\left(-m_d^\kappa\left(\underset{\mu_j^\lambda}{\rightarrow}C_{\lambda\kappa}(1-\varphi^5)d_j^\kappa\right) + m_d^\kappa\left(\underset{\mu_j^\lambda}{\rightarrow}C_{\lambda\kappa}(1-\varphi^5)d_j^\kappa\right)\right)}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^-\left(m_d^\lambda\left(\underset{d_j^\lambda}{\rightarrow}C_{\lambda\kappa\bigwedge\theta*}^\dagger(1+\varphi^5)\mu_j^\kappa\right) \pm m_d^\lambda\left(\underset{d_j^\lambda}{\rightarrow}C_{\lambda\kappa\bigwedge\nabla*}^\dagger(1+\varphi^5)\mu_j^\kappa\right)\right)} - \frac{\frac{g}{2m_\mu^\lambda}}{M\mathcal{H}\left(\underset{\mu_j^\lambda}{\rightarrow}\mu_j^\lambda\right)}$$

$$-\frac{\frac{g}{2m_d^\lambda}}{M}\mathcal{H}\left(\underset{d_j^\lambda}{\rightarrow}d_j^\lambda\right) + \frac{\frac{ig}{2m_\mu^\lambda}}{M}\phi^0\left(\underset{\mu_j^\lambda}{\rightarrow}\gamma^5\mu_j^\lambda\right) - \frac{\frac{ig}{2m_d^\lambda}}{M}\phi^0\left(\underset{d_j^\lambda}{\rightarrow}\gamma^5 d_j^\lambda\right) + \underset{G^a}{\rightarrow}\partial^2 G^a + g_s f^{abc}\partial_\mu\underset{G^a}{\rightarrow}G^b g_\mu^c$$

$$+\underset{\alpha^+}{\rightarrow}(\partial^2 - M^2)\alpha^+ + \underset{\alpha^-}{\rightarrow}(\partial^2 - M^2)\alpha^- + \underset{\alpha^0}{\rightarrow}\left(\partial^2 - \frac{M^2}{c_\omega^2}\right)\alpha^0 + \underset{b}{\rightarrow}\partial^2 b + igc_\omega W_\mu^+\left(\partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^-}{\rightarrow} - \partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^0}{\rightarrow}\right)$$

$$+igs_w W_\mu^+\left(\partial_\mu\underset{b}{\rightarrow}\alpha^- - \partial_\mu\underset{a}{\rightarrow}b^-\right) + igc_\omega W_\mu^-\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^0}{\rightarrow} - \partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right) + igs_\omega W_\mu^-\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^0}{\rightarrow} - \partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)$$

$$+igc_\omega Z_\mu^0\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^-}{\rightarrow} - \partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right) + igs_\omega\mathcal{A}_\mu\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^-}{\rightarrow} - \partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right) - 1/2gM\left(\frac{\underset{\alpha^+}{\rightarrow}\alpha^+\mathcal{H}\hbar\mathbb{R}^4}{h} + \underset{\alpha^-}{\rightarrow}\alpha^-\mathcal{H}\right.$$

$$+1 - \frac{2c_{\mathfrak{J}}^2}{2c_\omega igM\left(\underset{\alpha^+}{\rightarrow}\alpha^0\phi^+ - \underset{\alpha^-}{\rightarrow}\alpha^0\phi^-\right)} + \frac{1}{2c_\omega igM\left(\underset{\alpha^0}{\rightarrow}\alpha^-\phi^+ - \underset{\alpha^0}{\rightarrow}\alpha^+\phi^-\right)}$$

$$+igMs_\omega\left(\underset{\alpha^0}{\rightarrow}\alpha^-\phi^+ - \underset{\alpha^0}{\rightarrow}\alpha^+\phi^-\right) + 1/2igM\left(\underset{\alpha^+}{\rightarrow}\alpha^+\phi^0 - \underset{\alpha^-}{\rightarrow}\alpha^-\phi^0\right)$$

$$\Phi(x) = \begin{pmatrix} \phi^+ \\ \phi^0 \end{pmatrix} = \frac{1}{\sqrt{2}} \begin{pmatrix} \phi_1 + \mathrm{i}\phi_2 \\ \phi_3 + \mathrm{i}\phi_4 \end{pmatrix}$$

$$\mathcal{L}_{SBS} = (\mathcal{D}_\mu \Phi)^\dagger (\mathcal{D}^\mu \Phi) - V(\Phi)$$

$$V(\Phi) = \mu^2 \Phi^\dagger \Phi + \lambda (\Phi^\dagger \Phi)^2$$

$$|\Phi|^2 = \Phi^\dagger \Phi = -\frac{\mu^2}{2\lambda} = \frac{v^2}{2}$$

$$\Phi(x) = \begin{pmatrix} \phi^+ \\ \phi^0 \end{pmatrix} \longrightarrow \frac{1}{\sqrt{2}} \begin{pmatrix} 0 \\ v \end{pmatrix}$$

$$\Phi(x) = \frac{1}{\sqrt{2}} e^{\mathrm{i} \frac{\vec{\xi}(x) \cdot \vec{\tau}}{v}} \begin{pmatrix} 0 \\ v + \mathrm{h}(x) \end{pmatrix}$$

$$U(\xi) = e^{-\mathrm{i} \frac{\vec{\xi}(x) \cdot \vec{\tau}}{v}}$$

$$\begin{aligned} \Phi' &= U(\xi)\Phi = \tfrac{1}{\sqrt{2}} \begin{pmatrix} 0 \\ v + \mathrm{h}(x) \end{pmatrix} \\ \left( \frac{\vec{\tau}\, \vec{\mathrm{W}}'_\mu}{2} \right) &= U(\xi) \left( \frac{\vec{\tau}\, \vec{\mathrm{W}}_\mu}{2} \right) U^{-1}(\xi) - \tfrac{\mathrm{i}}{g} (\partial_\mu U(\xi)) U^{-1}(\xi) \\ \mathrm{B}'_\mu &= \mathrm{B}_\mu \end{aligned}$$

$$\mathcal{L} = \mathcal{L}_{bos.} + \mathcal{L}_{ferm.} + \mathcal{L}_{SBS}$$

$$(\mathcal{D}_\mu \Phi)^\dagger (\mathcal{D}^\mu \Phi) = \frac{v^2}{8} [\mathrm{g}^2 (W_{1\mu}^2 + W_{2\mu}^2) + (\mathrm{g} W_{3\mu} - \mathrm{g}' B_\mu)^2]$$

$$\begin{aligned} \mathrm{W}^\pm_\mu &= \tfrac{1}{\sqrt{2}} (\mathrm{W}^1_\mu \mp \mathrm{W}^2_\mu) \\ \mathrm{Z}_\mu &= \cos\theta_\mathrm{W} \mathrm{W}^3_\mu - \sin\theta_\mathrm{W} \mathrm{B}_\mu \\ \mathrm{A}_\mu &= \sin\theta_\mathrm{W} \mathrm{W}^3_\mu + \cos\theta_\mathrm{W} \mathrm{B}_\mu \end{aligned}$$

$$\tan\theta_\mathrm{W} \equiv \frac{\mathrm{g}'}{\mathrm{g}}$$

$$
\begin{aligned}
\mathrm{M_W} &= \tfrac{1}{2}\mathrm{g}\upsilon \\
\mathrm{M_Z} &= \tfrac{1}{2}\upsilon\sqrt{\mathrm{g}^2 + \mathrm{g}'^2}
\end{aligned}
$$

$$
\begin{aligned}
\mathrm{g} &= \frac{e}{\sin\theta_{\mathrm{W}}} \\
\mathrm{g}' &= \frac{e}{\cos\theta_{\mathrm{W}}}
\end{aligned}
$$

$$\mathrm{m}_{\mathrm{H}}^2 = 2\lambda\upsilon^2$$

$$\mu \to \nu_\mu \bar{\nu}_{\mathrm{e}} \mathrm{e}$$

$$\upsilon = (\sqrt{2}\mathrm{G_F})^{-\frac{1}{2}}$$

$$\mathcal{L}_{YW} = \lambda_{\mathrm{e}} \bar{\ell}_L \Phi \mathrm{e}_R + \lambda_{\mathrm{u}} \bar{\mathrm{q}}_L \tilde{\Phi} \mathrm{u}_R + \lambda_{\mathrm{d}} \bar{\mathrm{q}}_L \Phi \mathrm{d}_R + \mathrm{h.c.}$$

$$
\begin{aligned}
\ell_L &= \begin{pmatrix} \mathrm{e} \\ \nu_{\mathrm{e}} \end{pmatrix}_L, \begin{pmatrix} \mu \\ \nu_\mu \end{pmatrix}_L, \begin{pmatrix} \tau \\ \nu_\tau \end{pmatrix}_L \\
\mathrm{q}_L &= \begin{pmatrix} \mathrm{u} \\ \mathrm{d} \end{pmatrix}_L, \begin{pmatrix} \mathrm{c} \\ \mathrm{s} \end{pmatrix}_L, \begin{pmatrix} \mathrm{t} \\ \mathrm{b} \end{pmatrix}_L
\end{aligned}
$$

$$
\begin{aligned}
\ell'_L &= U(\xi)\ell_L; \qquad & \mathrm{e}'_R &= \mathrm{e}_R \\
\mathrm{q}'_L &= U(\xi)q_L; \qquad & \mathrm{u}'_R &= \mathrm{u}_R;\ \mathrm{d}'_R = \mathrm{d}
\end{aligned}
$$

$$
\begin{aligned}
\mathrm{m_e} &= \lambda_{\mathrm{e}} \frac{\upsilon}{\sqrt{2}} \\
\mathrm{m_u} &= \lambda_{\mathrm{u}} \frac{\upsilon}{\sqrt{2}} \\
\mathrm{m_d} &= \lambda_{\mathrm{d}} \frac{\upsilon}{\sqrt{2}}
\end{aligned}
$$

O es igual a:

$$\mathcal{L}_{Higgs} = \overline{\left([\partial_\mu + \frac{1}{2} i g_1 B_\mu + \frac{1}{2} i g_2 \mathbf{W}_\mu]\phi\right)} \left([\partial_\mu + \frac{1}{2} i g_1 B_\mu + \frac{1}{2} i g_2 \mathbf{W}_\mu]\phi\right) - \frac{m_H^2 \left(\bar{\phi}\phi - \frac{v^2}{2}\right)^2}{2v^2}$$

$$\mathcal{L}_{SM}(x) \equiv (a,b) \simeq (b,a)$$

$$= -\frac{1}{2\pi\partial^\mu\partial_\nu\partial^\nu\partial_\mu\partial_\nu^\mu\partial_\mu^\nu g_\mu^a g_a^\mu g_\nu^b g_b^\nu} - g_s f^{ab} f_{ab}\partial^\mu\partial_\nu\partial^\nu\partial_\mu\partial_\nu^\mu\partial_\mu^\nu g_\mu^a g_a^\mu g_\nu^b g_b^\nu - \frac{1}{4\pi g_S^2 f^{cd} f_{cd}\partial^\mu\partial_\nu\partial^\nu\partial_\mu\partial_\nu^\mu\partial_\mu^\nu g_\mu^c g_c^\mu g_\nu^d g_d^\nu} - \partial^\mu W_\mu \partial^\nu W_\nu$$

$$- M^2 W_\mu^+ W_\nu^- W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu - \frac{1}{2\pi\partial^\mu\partial_\nu\partial^\nu\partial_\mu\partial_\nu^\mu\partial_\mu^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu} - \frac{1}{2c_m^2 M^2 Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu} - \frac{1}{2\partial^\mu A_\nu \partial^\nu A_\mu}$$

$$- igc_w\left(\partial^\mu\partial_\nu\partial^\nu\partial_\mu\partial_\nu^\mu\partial_\mu^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu (W_\mu^+ W_\nu^- W_\mu^- W_\nu^+)\right) - Z_\mu^0(\partial^\mu\partial_\mu W_\mu^+ W_\mu^- W_+^\mu W_-^\mu) + Z_\nu^0(\partial^\nu\partial_\nu W_\nu^+ W_\nu^- W_+^\nu W_-^\nu)$$

$$- igS_w(\partial^\mu A_\nu \partial^\nu A_\mu(W_\mu^+ W_\nu^- W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu) Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu) - A_\mu(\partial^\mu\partial_\mu W_\mu^+ W_\mu^- W_+^\mu W_-^\mu Z_\mu^0 Z_0^\mu) + A_\nu\,(\partial^\nu\partial_\nu W_\nu^+ W_\nu^- W_+^\nu W_-^\nu Z_\nu^0 Z_0^\nu)$$

$$- \frac{1}{2g^2\left(\partial^\mu A_\nu \partial^\nu A_\mu(W_\mu^+ W_\nu^- W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu)\right)} + g^2 c_w^2\left(\partial^\mu A_\nu \partial^\nu A_\mu(W_\mu^+ W_\nu^- W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu)\right)$$

$$+ g^2 S_w^2\left(\partial^\mu A_\nu \partial^\nu A_\mu(W_\mu^+ W_\nu^- W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu)\right) - g^2 c_w S_w\left(\partial^\mu A_\nu \partial^\nu A_\mu(W_\mu^+ W_\nu^- W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu)\right)$$

$$- \frac{1}{2\pi\left(\partial H^\mu A H_\nu H \partial^\nu H A_\mu(W_\mu^+ W_\nu^- W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu H^\mu H_\nu H_\nu^\mu H_\mu^\nu)\right)} + \frac{\frac{\frac{\frac{1}{2\pi(2M^2H^2H^3)}}{d^\wedge em^C\gamma}}{GUM_{Scw}^2}}{\frac{2M}{\frac{\beta_\eta^\xi}{\prod_\sigma^\rho \frac{h^4}{\hbar^2}}}} - \frac{2g_c^2 M_S^2}{\Psi\Phi\zeta} - \lambda\partial$$

$$\otimes \frac{\omega}{\Delta\nabla\theta}$$

$$/\prod_{\triangleq}^{\dagger}\infty\oiiint_j^i k\begin{pmatrix}\frac{\frac{\phi_\mu^+\phi_\nu^-\phi_\mu^-\phi_\nu^+}{\phi_+^\mu\phi_-^\nu\phi_-^\mu\phi_+^\nu}}{\phi_\mu^0\phi_\nu^0\phi_0^\mu\phi_0^\nu}\end{pmatrix}(\varphi\psi\omega\lambda_\mu^+\varphi\psi\omega\lambda_\nu^-\varphi\psi\omega\lambda_\mu^-\varphi\psi\omega\lambda_\nu^+\frac{2\varphi\psi\omega\lambda^\mu}{\varphi\psi\omega\lambda}{}_+\varphi\psi\omega\lambda_-^\nu\varphi\psi\omega\lambda_-^\mu\varphi\psi\omega\lambda_+^\nu\frac{1/2\pi\varphi\psi\omega\lambda^0}{\varphi\psi\omega\lambda}{}_\mu\varphi\psi\omega\lambda_\nu^0\varphi\psi\omega\lambda_0^\mu\varphi\psi\omega\lambda_0^\nu)$$

$$/2M\sqrt[\phi\varphi\lambda\kappa]{\frac{\frac{\frac{2\xi\eta}{\zeta\epsilon\varepsilon}}{\delta\alpha}}{o\sigma\rho}/\Psi\Omega\mho = \mathcal{L}_{Higgs} = \left(\partial^\mu\partial_\nu\,\partial^\nu\partial_\mu + \frac{1}{2ig_1 B^\mu B_\nu B^\nu B_\mu} + \frac{1}{2jg_2 B^\mu B_\nu B^\nu B_\mu} + \frac{1}{2ig_1 W^\mu W_\nu W^\nu W_\mu} + \frac{1}{2jg_2 W^\mu W_\nu W^\nu W_\mu}\right) - m_H^2\phi'\phi - v^2/2v^2}$$

$$/\tau^2$$

$$\partial_i\partial^j\partial_j\partial^i f^{ab\varphi}t_{ba\omega}t^{ab\varphi}f_{ba\omega}(y)$$

$$= \frac{\frac{\frac{\partial^\theta\partial_\emptyset F_\sigma^\rho\gamma\beta}{\varepsilon\epsilon\vartheta\pi}}{\Delta\nabla}}{\tau} + \prod_b^a \lambda \coprod_a^b \lambda\, H_{iggs}$$

$$- W^a W_b W^b W_a W_b^a W_a{}^b{}_b^a W^b_a W - \eta^\theta\eta_\beta\eta_{\phi\nu}^{\sigma\mu}{}_\Omega^\alpha\eta/\mathbb{R}^4$$

En la que la constante $H_{iggs}$ es igual a:

$$\mathcal{L}_{SM} = \frac{1}{2\partial_\nu g_\mu^a \partial_\mu g_\nu^b} - g_s f^{abc}\partial_\mu g_\nu^a g_\nu^b g_\nu^c \partial_\nu g_\mu^a g_\mu^b g_\mu^c - \frac{1}{4g_s^2 f^{abc} f^{ade} g_\mu^b g_\mu^c g_\mu^d g_\mu^d g_\nu^b g_\nu^c g_\nu^d g_\nu^d} - \partial_\nu W_\mu^+ \partial_\nu W_\mu^- \partial_\mu W_\nu^+ \partial_\mu W_\nu^- - M^2 W_\mu^+ W_\mu^- W_\nu^+ W_\nu^-$$

$$- \frac{1}{2\partial_\nu Z_\mu^0 \partial_\mu Z_\nu^0} - \frac{1}{2_\omega^{c^2} M^2 Z_\mu^0 Z_\nu^0} - \frac{1}{2\partial_\mu \mathcal{A}_\nu \partial_\nu \mathcal{A}_\mu}$$

$$-igc_\omega\left(\partial_\nu Z_\mu^0(W_\mu^+ W_\nu^- W_\mu^- W_\nu^+) - Z_\mu^0 Z_\nu^0(\partial_\nu W_\mu^+ \partial_\nu W_\mu^- \partial_\mu W_\nu^+ \partial_\mu W_\nu^-)\right)$$

$$- igs_\omega\left(\partial_\mu \mathcal{A}_\nu \partial_\nu \mathcal{A}_\mu(W_\mu^+ W_\mu^- W_\nu^+ W_\nu^-) - \mathcal{A}_\mu(\partial_\nu W_\mu^+ \partial_\nu W_\mu^- \partial_\mu W_\nu^+ \partial_\mu W_\nu^-) - \mathcal{A}_\nu(\partial_\nu W_\mu^+ \partial_\nu W_\mu^- \partial_\mu W_\nu^+ \partial_\mu W_\nu^-)\right)$$

$$- \frac{1}{2g^2 W_\mu^+ W_\nu^- W_\mu^- W_\nu^+} + g^2 c_\omega^2(Z_\mu^0 W_\mu^+ W_\mu^- Z_\nu^0 W_\nu^+ W_\nu^-)$$

$$+g^2 s_\omega^2(\mathcal{A}_\mu W_\mu^+ W_\mu^- \mathcal{A}_\nu W_\nu^+ W_\nu^-) + g^2 c_\omega s_\omega(\mathcal{A}_\mu Z_\mu^0(W_\mu^+ W_\mu^-)\mathcal{A}_\nu Z_\nu^0(W_\nu^+ W_\nu^-) - 2\mathcal{A}_\mu W_\mu^+ W_\mu^- Z_\mu^0 \mathcal{A}_\nu W_\nu^+ W_\nu^- Z_\nu^0) - \frac{1}{2\partial_\mu \mathcal{H} \partial_\nu \mathcal{H}} - 2M^2 \propto_h \mathcal{H}^2$$

$$- \partial_\mu \phi^+ \partial_\nu \phi^- \partial_\nu \phi^+ \partial_\nu \phi^- - \frac{1}{2\partial_\mu \phi^0 \partial_\nu \phi^0 \partial_\nu \phi^0 \partial_\nu \phi^0}$$

$$-\beta_h\left(\frac{2M^2}{g^2}+\frac{2M}{g\mathcal{H}}+\frac{1}{2}(\mathcal{H}^2+\phi^0\phi^+\phi^0\phi^-+2\phi^0\phi^+\phi^0\phi^-)\right)+\frac{2M^4}{g^2\propto_h}-g\propto_h M(\mathcal{H}^3+\mathcal{H}\phi^0\phi^0+2\mathcal{H}\phi^+\phi^-)-1/8g^2\propto_h(\mathcal{H}^4+(\phi^0)^4$$

$$+4(\phi^+\phi^-)^2+4(\phi^0)^2\phi^+\phi^-+4\mathcal{H}^2\phi^+\phi^-+2(\phi^0)^2\mathcal{H}^2)-gMW_\mu^+W_\mu^-W_v^+W_v^-\mathcal{H}-\frac{\frac{1}{2gM}}{c_\omega^2Z_\mu^0Z_v^0\mathcal{H}}$$

$$-\frac{1}{2ig}\Big(W_\mu^+(\phi^0\partial_\mu\phi^--\phi^-\partial_\mu\phi^0)-W_\mu^-(\phi^0\partial_\mu\phi^+-\phi^+\partial_\mu\phi^0)-W_v^+(\phi^0\partial_v\phi^--\phi^-\partial_v\phi^0)$$

$$-W_v^-(\phi^0\partial_v\phi^+-\phi^+\partial_v\phi^0)\Big)$$

$$-\frac{1}{2g\left(W_\mu^+(\mathcal{H}\partial_\mu\phi^--\phi^-\partial_\mu\mathcal{H})W_\mu^-(\mathcal{H}\partial_\mu\phi^+-\phi^+\partial_\mu\mathcal{H})W_v^+(\mathcal{H}\partial_v\phi^--\phi^-\partial_v\mathcal{H})W_v^-(\mathcal{H}\partial_v\phi^+-\phi^+\partial_v\mathcal{H})\right)}$$

$$+\frac{\frac{1}{2g1}}{c_\omega\left(Z_\mu^0(\mathcal{H}\partial_\mu\phi^0-\phi^0\partial_\mu\mathcal{H})Z_v^0(\mathcal{H}\partial_v\phi^0-\phi^0\partial_v\mathcal{H})\right)}+M\left(\frac{1}{c_\omega Z_\mu^0\partial_\mu\phi^0}+W_\mu^+\partial_\mu\phi^-+W_\mu^-\partial_\mu\phi^+\right)$$

$$-\frac{igs_\omega^2}{c_\omega MZ_\mu^0(W^+\phi^--W^-\phi^+)igs_\omega M\mathcal{A}_\mu(W_\mu^+\phi^-+W_\mu^-\phi^+)}-ig1-\frac{2c_\omega^2}{2c_\omega Z_\mu^0(\phi^+\partial_\mu\phi^--\phi^-\partial_\mu\phi^+)}$$

$$+igs_\omega\mathcal{A}_\mu(\phi^+\partial_\mu\phi^--\phi^-\partial_\mu\phi^+)-1/4g^2W_\mu^+W_\mu^-(\mathcal{H}^2+(\phi^0)^2+2\phi^+\phi^-)$$

$$-\frac{\frac{1}{8g^21}}{c_\omega^2Z_\mu^0Z_v^0}$$

$$\mathcal{H}^2+$$

$$\phi^0)^2+2$$

$$\left(\left(\left(\begin{matrix}2s_\omega^2-1)^2\phi^+\phi^--\frac{\frac{1}{2g^2s_\omega^2}}{c_\omega Z_\mu^0\phi^0(W_\mu^+\phi^-+W_\mu^-\phi^+)}-\frac{\frac{1}{2ig^2s_\omega^2}}{c_\omega Z_\mu^0}\mathcal{H}(W_\mu^+\phi^-+W_\mu^-\phi^+)+\\ \frac{1}{2g^2s_\omega\mathcal{A}_\mu\phi^0(W_\mu^+\phi^-+W_\mu^-\phi^+)}+\frac{1}{2ig^2s_\omega\mathcal{A}_\mu\mathcal{H}(W_\mu^+\phi^-+W_\mu^-\phi^+)}-\frac{g^2s_\omega}{c_\omega(2c_w^2-1)Z_\mu^0\mathcal{A}_\mu\phi^+\phi^-}-g^2s_\omega^2\mathcal{A}_\mu\mathcal{A}_v\phi^+\phi^-+\\ \frac{1}{2igs_s\lambda_{ij}^a\left(\underset{q\sigma^i}{\rightarrow}\varphi^\mu\underset{q\sigma^j}{\rightarrow}\right)g_\mu^a}-\underset{e^\lambda}{\rightarrow}(\varphi\partial+m_e^\lambda\end{matrix}\right)e^\lambda-\underset{v^\lambda}{\rightarrow}(\varphi\partial+m_v^\lambda\right)v^\lambda-\underset{\mu_j^a v^\lambda}{\rightarrow\rightarrow}(\varphi\partial+m_\mu^\lambda\right)-(\mu_j^\lambda$$

$$-\underset{d_j^\lambda}{\rightarrow})+$$

$$(\varphi\partial+m_d^\lambda)d_j^\lambda+igs_\omega\mathcal{A}_\mu\left(-\left(\underset{e^\lambda}{\rightarrow}\varphi^\mu e^\lambda\right)+\frac{2}{3\left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu\mu_j^\lambda\right)}-\frac{1}{3\left(\underset{d^\lambda}{\rightarrow}\varphi^\mu d^\lambda\right)}+\frac{ig}{4c_\omega Z_\mu^0\left(\underset{v^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5)v^\lambda\right)}\right.$$

$$+\left(\underset{e^\lambda}{\rightarrow}\varphi^\mu(4s_\omega^2-1-\varphi^5)e^\lambda\right)+\left(\underset{d_j^\lambda}{\rightarrow}\varphi^\mu\left(\frac{4}{3s_\omega^2}-1-\varphi^5\right)d_j^\lambda\right)+\left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu\left(1-\frac{8}{3s_\omega^2}+\varphi^5\right)\mu_j^\lambda\right)$$

$$+\left(\frac{ig}{\sqrt[2]{2}W_\mu^+\left(\underset{v^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5)\right)U^{lep}{}_\xi^k e^k}\right)+\left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5)C_{k\lambda}d_j^k\right)$$

$$+\frac{ig}{\sqrt[2]{2}W_\mu^-\left(\underset{e^\mathcal{K}}{\rightarrow}U^{lep^\dagger}\,{}^{v}_{\xi}\frac{\overline{\psi\lambda}\,\kappa\varphi}{\rho\varpi}-\triangleq\prod_{\odot\oplus\tau}^{\oplus\odot\gamma}\otimes\frac{\coprod_v^\mu ijk}{\bigotimes\sigma}\Omega\Psi\Phi\Delta(1+\varphi^5)v^\lambda+\underset{d_j^\kappa}{\rightarrow}C_{*\ \kappa}^{\dagger\ \lambda}\varphi_{v\eta}^{\mu\zeta\eta}(1+\varphi^5)\mu_j^\lambda\right)}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^+\left(-m_c^\kappa\left(\underset{v^\lambda}{\rightarrow}U^{lep}{}_\xi^k e^k(1-\varphi^5)\epsilon^\kappa\right)+m_\mu^\lambda\underset{\mu_j^\lambda}{\rightarrow}U^{lep^\dagger}(1+\varphi^5)\varepsilon^\kappa\right)}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^-\left(m_c^\kappa\left(\underset{v^\lambda}{\rightarrow}U^{lep}{}_\xi^k e^k(1-\varphi^5)\epsilon^\kappa\right)\pm m_\mu^\lambda\underset{\mu_j^\lambda}{\rightarrow}U^{lep^\dagger}(1+\varphi^5)\varepsilon^\kappa\right)}-\frac{\frac{g}{2m_v^\lambda}}{M}\mathcal{H}\left(\underset{v^\lambda}{\rightarrow}v^\lambda\right)$$

$$-\frac{\frac{\frac{g}{2m_c^\lambda}}{M\mathcal{H}\left(\underset{e^\lambda}{\rightarrow} e^\lambda\right)}}{\frac{1}{4\underset{v^\lambda}{\rightarrow} M_{\lambda\kappa}^R\left(1-\gamma_5\right)v^\kappa}}+\frac{\frac{ig}{2m_v^\lambda}}{M\phi^0\left(\underset{v^\lambda}{\rightarrow}\gamma^5 v^\lambda\right)}-\frac{\frac{ig}{2m_c^\lambda}}{M\phi^0\left(\underset{e^\lambda}{\rightarrow}\gamma^5 e^\lambda\right)}-\frac{1}{4\underset{v^\kappa}{\rightarrow} M_{\lambda\kappa}^R\left(1-\gamma_5\right)\underset{v^\kappa}{\rightarrow}}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^+\left(-m_d^\kappa\left(\underset{\mu_j^\lambda}{\rightarrow} C_{\lambda\kappa}\left(1-\varphi^5\right)d_j^\kappa\right)+m_d^\kappa\left(\underset{\mu_j^\lambda}{\rightarrow} C_{\lambda\kappa}\left(1-\varphi^5\right)d_j^\kappa\right)\right)}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^-\left(m_d^\lambda\left(\underset{d_j^\lambda}{\rightarrow} C_{\lambda\kappa\wedge\theta*}^\dagger\left(1+\varphi^5\right)\mu_j^\kappa\right)\pm m_d^\lambda\left(\underset{d_j^\lambda}{\rightarrow} C_{\lambda\kappa\wedge\nabla*}^\dagger\left(1+\varphi^5\right)\mu_j^\kappa\right)\right)}-\frac{\frac{g}{2m_\mu^\lambda}}{M\mathcal{H}\left(\underset{\mu_j^\lambda}{\rightarrow}\mu_j^\lambda\right)}$$

$$-\frac{\frac{g}{2m_d^\lambda}}{M}\mathcal{H}\left(\underset{d_j^\lambda}{\rightarrow} d_j^\lambda\right)+\frac{\frac{ig}{2m_\mu^\lambda}}{M}\phi^0\left(\underset{\mu_j^\lambda}{\rightarrow}\gamma^5\mu_j^\lambda\right)-\frac{\frac{ig}{2m_d^\lambda}}{M}\phi^0\left(\underset{d_j^\lambda}{\rightarrow}\gamma^5 d_j^\lambda\right)+\underset{G^a}{\rightarrow}\partial^2 G^a+g_s f^{abc}\partial_\mu\underset{G^a}{\rightarrow}G^b g_\mu^c$$

$$+\underset{\alpha^+}{\rightarrow}\left(\partial^2-M^2\right)\alpha^+ +\underset{\alpha^-}{\rightarrow}\left(\partial^2-M^2\right)\alpha^- +\underset{\alpha^0}{\rightarrow}\left(\partial^2-\frac{M^2}{c_\omega^2}\right)\alpha^0+\underset{b}{\rightarrow}\partial^2 b+igc_\omega W_\mu^+\left(\partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^-}{\rightarrow}-\partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^0}{\rightarrow}\right)$$

$$+igs_w W_\mu^+\left(\partial_\mu\underset{b}{\rightarrow}\alpha^- -\partial_\mu\underset{a}{\rightarrow}b^-\right)+igc_\omega W_\mu^-\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^0}{\rightarrow}-\partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)+igs_\omega W_\mu^-\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^0}{\rightarrow}-\partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)$$

$$+igc_\omega Z_\mu^0\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^-}{\rightarrow}-\partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)+igs_\omega\mathcal{A}_\mu\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^-}{\rightarrow}-\partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)-1/2gM(\frac{\underset{\alpha^+}{\rightarrow}\alpha^+\mathcal{H}\hbar\mathbb{R}^4}{h}+\underset{\alpha^-}{\rightarrow}\alpha^-\mathcal{H}$$

$$+1-\frac{2c_{\Im}^2}{2c_\omega igM\left(\underset{\alpha^+}{\rightarrow}a^0\phi^+-\underset{\alpha^-}{\rightarrow}a^0\phi^-\right)}+\frac{1}{2c_\omega igM\left(\underset{\alpha^0}{\rightarrow}a^-\phi^+-\underset{\alpha^0}{\rightarrow}a^+\phi^-\right)}$$

$$+igMs_\omega\left(\underset{\alpha^0}{\rightarrow}a^-\phi^+-\underset{\alpha^0}{\rightarrow}a^+\phi^-\right)+1/2igM\left(\underset{\alpha^+}{\rightarrow}a^+\phi^0-\underset{\alpha^-}{\rightarrow}a^-\phi^0\right)$$

$$\Phi(x)=\begin{pmatrix}\phi^+\\ \phi^0\end{pmatrix}=\frac{1}{\sqrt{2}}\begin{pmatrix}\phi_1+\mathrm{i}\phi_2\\ \phi_3+\mathrm{i}\phi_4\end{pmatrix}$$

$$\mathcal{L}_{SBS}=(\mathcal{D}_\mu\Phi)^\dagger(\mathcal{D}^\mu\Phi)-V(\Phi)$$

$$V(\Phi)=\mu^2\Phi^\dagger\Phi+\lambda(\Phi^\dagger\Phi)^2$$

$$|\Phi|^2=\Phi^\dagger\Phi=-\frac{\mu^2}{2\lambda}=\frac{v^2}{2}$$

$$\Phi(x)=\begin{pmatrix}\phi^+\\ \phi^0\end{pmatrix}\longrightarrow\frac{1}{\sqrt{2}}\begin{pmatrix}0\\ v\end{pmatrix}$$

$$\Phi(x)=\frac{1}{\sqrt{2}}e^{\mathrm{i}\frac{\vec{\xi}(x)\cdot\vec{\tau}}{v}}\begin{pmatrix}0\\ v+\mathrm{h}(x)\end{pmatrix}$$

$$U(\xi) = e^{-\mathrm{i}\frac{\vec{\xi}(x)\cdot\vec{\tau}}{v}}$$

$$\begin{aligned}
\Phi' &= U(\xi)\Phi = \tfrac{1}{\sqrt{2}}\begin{pmatrix} 0 \\ v + \mathrm{h}(x) \end{pmatrix} \\
\left(\frac{\vec{\tau}\,\vec{\mathrm{W}}'_\mu}{2}\right) &= U(\xi)\left(\frac{\vec{\tau}\,\vec{\mathrm{W}}_\mu}{2}\right)U^{-1}(\xi) - \tfrac{\mathrm{i}}{g}(\partial_\mu U(\xi))U^{-1}(\xi) \\
\mathrm{B}'_\mu &= \mathrm{B}_\mu
\end{aligned}$$

$$\mathcal{L} = \mathcal{L}_{bos.} + \mathcal{L}_{ferm.} + \mathcal{L}_{SBS}$$

$$(\mathcal{D}_\mu\Phi)^\dagger(\mathcal{D}^\mu\Phi) = \frac{v^2}{8}[\mathrm{g}^2(W_{1\mu}^2 + W_{2\mu}^2) + (\mathrm{g}W_{3\mu} - \mathrm{g}'B_\mu)^2]$$

$$\begin{aligned}
\mathrm{W}_\mu^\pm &= \tfrac{1}{\sqrt{2}}(\mathrm{W}_\mu^1 \mp \mathrm{W}_\mu^2) \\
\mathrm{Z}_\mu &= \cos\theta_\mathrm{W}\mathrm{W}_\mu^3 - \sin\theta_\mathrm{W}\mathrm{B}_\mu \\
\mathrm{A}_\mu &= \sin\theta_\mathrm{W}\mathrm{W}_\mu^3 + \cos\theta_\mathrm{W}\mathrm{B}_\mu
\end{aligned}$$

$$\tan\theta_\mathrm{W} \equiv \frac{\mathrm{g}'}{\mathrm{g}}$$

$$\mathrm{M_W} = \tfrac{1}{2}\mathrm{g}v$$

$$\mathrm{M_Z} = \tfrac{1}{2}v\sqrt{\mathrm{g}^2 + \mathrm{g}'^2}$$

$$\begin{aligned}
\mathrm{g} &= \frac{e}{\sin\theta_\mathrm{W}} \\
\mathrm{g}' &= \frac{e}{\cos\theta_\mathrm{W}}
\end{aligned}$$

$$\mathrm{m_H^2} = 2\lambda v^2$$

$$\mu \to \nu_\mu \bar{\nu}_\mathrm{e}\mathrm{e}$$

$$v = (\sqrt{2}\mathrm{G_F})^{-\frac{1}{2}}$$

$$\mathcal{L}_{YW} = \lambda_\mathrm{e}\bar{\ell}_L\Phi\mathrm{e}_R + \lambda_\mathrm{u}\bar{\mathrm{q}}_L\tilde{\Phi}\mathrm{u}_R + \lambda_\mathrm{d}\bar{\mathrm{q}}_L\Phi\mathrm{d}_R + \mathrm{h.c.}$$

$$\ell_L = \begin{pmatrix} e \\ \nu_e \end{pmatrix}_L, \begin{pmatrix} \mu \\ \nu_\mu \end{pmatrix}_L, \begin{pmatrix} \tau \\ \nu_\tau \end{pmatrix}_L$$

$$q_L = \begin{pmatrix} u \\ d \end{pmatrix}_L, \begin{pmatrix} c \\ s \end{pmatrix}_L, \begin{pmatrix} t \\ b \end{pmatrix}_L$$

$$\ell'_L = U(\xi)\ell_L; \qquad e'_R = e_R$$
$$q'_L = U(\xi)q_L; \qquad u'_R = u_R;\ d'_R = d$$

$$m_e = \lambda_e \frac{v}{\sqrt{2}}$$
$$m_u = \lambda_u \frac{v}{\sqrt{2}}$$
$$m_d = \lambda_d \frac{v}{\sqrt{2}}$$

O es igual a:

$$\mathcal{L}_{Higgs} = \overline{\left([\partial_\mu + \frac{1}{2}ig_1 B_\mu + \frac{1}{2}ig_2 \mathbf{W}_\mu]\phi\right)}\left([\partial_\mu + \frac{1}{2}ig_1 B_\mu + \frac{1}{2}ig_2 \mathbf{W}_\mu]\phi\right) - \frac{m_H^2\left(\bar{\phi}\phi - \frac{v^2}{2}\right)^2}{2v^2}$$

$$\mathcal{L}_{SM}(y) \equiv (a,b) \simeq (b,a)$$

$$= -\frac{1}{2\pi\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}g_{\mu}^{a}g_{a}^{\mu}g_{v}^{b}g_{b}^{v}} - g_{s}f^{ab}f_{ab}\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}g_{\mu}^{a}g_{a}^{\mu}g_{v}^{b}g_{b}^{v} - \frac{1}{4\pi g_{S}^{2}f^{cd}f_{cd}\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}g_{\mu}^{c}g_{c}^{\mu}g_{v}^{d}g_{d}^{v}} - \partial^{\mu}W_{\mu}\partial^{v}W_{v}$$

$$- M^{2}W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v} - \frac{1}{2\pi\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}} - \frac{1}{2c_{m}^{2}M^{2}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}} - \frac{1}{2\partial^{\mu}A_{v}\partial^{v}A_{\mu}}$$

$$- igc_{w}\left(\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}\right)\right) - Z_{\mu}^{0}\left(\partial^{\mu}\partial_{\mu}W_{\mu}^{+}W_{\mu}^{-}W_{+}^{\mu}W_{-}^{\mu}\right) + Z_{v}^{0}\left(\partial^{v}\partial_{v}W_{v}^{+}W_{v}^{-}W_{+}^{v}W_{-}^{v}\right)$$

$$- igS_{w}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}\right)Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\right) - A_{\mu}\left(\partial^{\mu}\partial_{\mu}W_{\mu}^{+}W_{\mu}^{-}W_{+}^{\mu}W_{-}^{\mu}Z_{\mu}^{0}Z_{0}^{\mu}\right) + A_{v}\left(\partial^{v}\partial_{v}W_{v}^{+}W_{v}^{-}W_{+}^{v}W_{-}^{v}Z_{v}^{0}Z_{0}^{v}\right)$$

$$- \frac{1}{2g^{2}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\right)\right)} + g^{2}c_{w}^{2}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\right)\right)$$

$$+ g^{2}S_{w}^{2}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\right)\right) - g^{2}c_{w}S_{w}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}\right)\right)$$

$$- \frac{1}{2\pi\left(\partial H^{\mu}AH_{v}H\partial^{v}HA_{\mu}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}H^{\mu}H_{v}H_{v}^{\mu}H_{\mu}^{v}\right)\right)} + \frac{\frac{\frac{1}{2\pi(2M^{2}H^{2}H^{3})}}{\frac{d^{\wedge}em^{C}\gamma}{GUM_{Scw}^{2}}}}{\frac{\frac{2M}{\beta_{\eta}^{\xi}}}{\prod_{\sigma}^{\rho}\frac{h^{4}}{\hbar^{2}}}} - \frac{2g_{c}^{2}M_{S}^{2}}{\Psi\Phi\zeta} - \lambda\partial$$

$$\otimes \frac{\dfrac{\frac{\omega}{\Delta\nabla\theta}}{\prod_{\triangleq}^{\dagger}\infty\oiiint_{j}^{i}k\left(\dfrac{\frac{\phi_{\mu}^{+}\phi_{v}^{-}\phi_{\mu}^{-}\phi_{v}^{+}}{\phi_{+}^{\mu}\phi_{-}^{v}\phi_{-}^{\mu}\phi_{+}^{v}}}{\phi_{\mu}^{0}\phi_{v}^{0}\phi_{0}^{\mu}\phi_{0}^{v}}\right)\left(\varphi\psi\omega\lambda_{\mu}^{+}\varphi\psi\omega\lambda_{v}^{-}\varphi\psi\omega\lambda_{\mu}^{-}\varphi\psi\omega\lambda_{v}^{+}\frac{2\varphi\psi\omega\lambda^{\mu}}{\varphi\psi\omega\lambda}_{+}\varphi\psi\omega\lambda_{-}^{v}\varphi\psi\omega\lambda_{-}^{\mu}\varphi\psi\omega\lambda_{+}^{v}\frac{\frac{1}{2\pi\varphi\psi\omega\lambda}}{\varphi\psi\omega\lambda}_{\mu}^{0}\varphi\psi\omega\lambda_{v}^{0}\varphi\psi\omega\lambda_{0}^{\mu}\varphi\psi\omega\lambda_{0}^{v}\right)}{2M\sqrt[\phi\varphi\lambda\kappa]{\dfrac{\frac{\frac{2\xi\eta}{\zeta\epsilon\varepsilon}}{\frac{\delta\alpha}{o\sigma\rho}}}{\Psi\Omega}}\mho = \mathcal{L}_{Higgs} = \left(\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu} + \frac{1}{2ig_{1}B^{\mu}B_{v}B^{v}B_{\mu}} + \frac{1}{2jg_{2}B^{\mu}B_{v}B^{v}B_{\mu}} + \frac{1}{2ig_{1}W^{\mu}W_{v}W^{v}W_{\mu}} + \frac{1}{2jg_{2}W^{\mu}W_{v}W^{v}W_{\mu}}\right) - m_{H}^{2}\phi'\phi - \frac{v^{2}}{2v^{2}}}$$

$$/\tau^{2}$$

$$\partial_{i}\partial^{j}\partial_{j}\partial^{i}f^{ab\varphi}t_{ba\omega}t^{ab\varphi}f_{ba\omega}(z)$$

$$= \frac{\frac{\frac{\partial^{\theta}\partial_{\emptyset}F_{\sigma}^{\rho}\gamma\beta}{\varepsilon\epsilon\vartheta\pi}}{\Delta\nabla}}{\tau} + \prod_{b}^{a}\lambda\coprod_{a}^{b}\lambda\,H_{iggs}$$

$$- W^{a}W_{b}W^{b}W_{a}W_{b}^{a}W_{a}^{b}{}_{b}^{a}W_{a}^{b}W - \eta^{\theta}\eta_{\beta}\eta_{\phi v}^{\sigma\mu}{}_{\Omega}^{\alpha}\eta/\mathbb{R}^{4}$$

En la que la constante $H_{iggs}$ es igual a:

$$\mathcal{L}_{SM} = \frac{1}{2\partial_{v}g_{\mu}^{a}\partial_{\mu}g_{v}^{b}} - g_{s}f^{abc}\partial_{\mu}g_{v}^{a}g_{v}^{b}g_{v}^{c}\partial_{v}g_{\mu}^{a}g_{\mu}^{b}g_{\mu}^{c} - \frac{1}{4g_{s}^{2}f^{abc}f^{ade}g_{\mu}^{b}g_{\mu}^{c}g_{\mu}^{d}g_{\mu}^{d}g_{v}^{b}g_{v}^{c}g_{v}^{d}g_{v}^{d}} - \partial_{v}W_{\mu}^{+}\partial_{v}W_{\mu}^{-}\partial_{\mu}W_{v}^{+}\partial_{\mu}W_{v}^{-} - M^{2}W_{\mu}^{+}W_{\mu}^{-}W_{v}^{+}W_{v}^{-}$$

$$- \frac{1}{2\partial_{v}Z_{\mu}^{0}\partial_{\mu}Z_{v}^{0}} - \frac{1}{2c_{\omega}^{2}M^{2}Z_{\mu}^{0}Z_{v}^{0}} - \frac{1}{2\partial_{\mu}\mathcal{A}_{v}\partial_{v}\mathcal{A}_{\mu}}$$

$$-igc_{\omega}\left(\partial_{v}Z_{\mu}^{0}\left(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}\right) - Z_{\mu}^{0}Z_{v}^{0}\left(\partial_{v}W_{\mu}^{+}\partial_{v}W_{\mu}^{-}\partial_{\mu}W_{v}^{+}\partial_{\mu}W_{v}^{-}\right)\right)$$

$$- igs_{\omega}\left(\partial_{\mu}\mathcal{A}_{v}\partial_{v}\mathcal{A}_{\mu}\left(W_{\mu}^{+}W_{\mu}^{-}W_{v}^{+}W_{v}^{-}\right) - \mathcal{A}_{\mu}\left(\partial_{v}W_{\mu}^{+}\partial_{v}W_{\mu}^{-}\partial_{\mu}W_{v}^{+}\partial_{\mu}W_{v}^{-}\right) - \mathcal{A}_{v}\left(\partial_{v}W_{\mu}^{+}\partial_{v}W_{\mu}^{-}\partial_{\mu}W_{v}^{+}\partial_{\mu}W_{v}^{-}\right)\right)$$

$$- \frac{1}{2g^{2}W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}} + g^{2}c_{\omega}^{2}\left(Z_{\mu}^{0}W_{\mu}^{+}W_{\mu}^{-}Z_{v}^{0}W_{v}^{+}W_{v}^{-}\right)$$

$$+g^{2}s_{\omega}^{2}\left(\mathcal{A}_{\mu}W_{\mu}^{+}W_{\mu}^{-}\mathcal{A}_{v}W_{v}^{+}W_{v}^{-}\right) + g^{2}c_{\omega}s_{\omega}\left(\mathcal{A}_{\mu}Z_{\mu}^{0}\left(W_{\mu}^{+}W_{\mu}^{-}\right)\mathcal{A}_{v}Z_{v}^{0}\left(W_{v}^{+}W_{v}^{-}\right) - 2\mathcal{A}_{\mu}W_{\mu}^{+}W_{\mu}^{-}Z_{\mu}^{0}\mathcal{A}_{v}W_{v}^{+}W_{v}^{-}Z_{v}^{0}\right) - \frac{1}{2\partial_{\mu}\mathcal{H}\partial_{v}\mathcal{H}} - 2M^{2}\propto_{h}\mathcal{H}^{2}$$

$$- \partial_{\mu}\phi^{+}\partial_{v}\phi^{-}\partial_{v}\phi^{+}\partial_{v}\phi^{-} - \frac{1}{2\partial_{\mu}\phi^{0}\partial_{v}\phi^{0}\partial_{v}\phi^{0}\partial_{v}\phi^{0}}$$

$$-\beta_h\left(\frac{2M^2}{g^2}+\frac{2M}{g\mathcal{H}}+\frac{1}{2}(\mathcal{H}^2+\phi^0\phi^+\phi^0\phi^-+2\phi^0\phi^+\phi^0\phi^-)\right)+\frac{2M^4}{g^2\propto_h}-g\propto_h M(\mathcal{H}^3+\mathcal{H}\phi^0\phi^0+2\mathcal{H}\phi^+\phi^-)-1/8g^2\propto_h(\mathcal{H}^4+(\phi^0)^4$$

$$+4(\phi^+\phi^-)^2+4(\phi^0)^2\phi^+\phi^-+4\mathcal{H}^2\phi^+\phi^-+2(\phi^0)^2\mathcal{H}^2)-gMW_\mu^+W_\mu^-W_v^+W_v^-\mathcal{H}-\frac{\frac{1}{2gM}}{c_\omega^2Z_\mu^0Z_v^0\mathcal{H}}$$

$$-\frac{1}{2ig}\left(W_\mu^+(\phi^0\partial_\mu\phi^--\phi^-\partial_\mu\phi^0)-W_\mu^-(\phi^0\partial_\mu\phi^+-\phi^+\partial_\mu\phi^0)-W_v^+(\phi^0\partial_v\phi^--\phi^-\partial_v\phi^0)\right.$$

$$\left.-W_v^-(\phi^0\partial_v\phi^+-\phi^+\partial_v\phi^0)\right)$$

$$-\frac{1}{2g\left(W_\mu^+(\mathcal{H}\partial_\mu\phi^--\phi^-\partial_\mu\mathcal{H})W_\mu^-(\mathcal{H}\partial_\mu\phi^+-\phi^+\partial_\mu\mathcal{H})W_v^+(\mathcal{H}\partial_v\phi^--\phi^-\partial_v\mathcal{H})W_v^-(\mathcal{H}\partial_v\phi^+-\phi^+\partial_v\mathcal{H})\right)}$$

$$+\frac{\frac{1}{2g1}}{c_\omega\left(Z_\mu^0(\mathcal{H}\partial_\mu\phi^0-\phi^0\partial_\mu\mathcal{H})Z_v^0(\mathcal{H}\partial_v\phi^0-\phi^0\partial_v\mathcal{H})\right)}+M\left(\frac{1}{c_\omega Z_\mu^0\partial_\mu\phi^0}+W_\mu^+\partial_\mu\phi^-+W_\mu^-\partial_\mu\phi^+\right)$$

$$-\frac{igs_\omega^2}{c_\omega MZ_\mu^0(W^+\phi^--W^-\phi^+)igs_\omega M\mathcal{A}_\mu(W_\mu^+\phi^-+W_\mu^-\phi^+)}-ig1-\frac{2c_\omega^2}{2c_\omega Z_\mu^0(\phi^+\partial_\mu\phi^--\phi^-\partial_\mu\phi^+)}$$

$$+igs_\omega\mathcal{A}_\mu(\phi^+\partial_\mu\phi^--\phi^-\partial_\mu\phi^+)-1/4g^2W_\mu^+W_\mu^-(\mathcal{H}^2+(\phi^0)^2+2\phi^+\phi^-)$$

$$-\frac{\frac{1}{8g^21}}{\begin{array}{c}c_\omega^2Z_\mu^0Z_v^0\\ \mathcal{H}^2+\\ \phi^0)^2+2\end{array}}$$

$$\left(\left(\left(\left(\begin{array}{c}2s_\omega^2-1)^2\phi^+\phi^--\frac{\frac{1}{2g^2s_\omega^2}}{c_\omega Z_\mu^0\phi^0(W_\mu^+\phi^-+W_\mu^-\phi^+)}-\frac{\frac{1}{2ig^2s_\omega^2}}{c_\omega Z_\mu^0}\mathcal{H}(W_\mu^+\phi^-+W_\mu^-\phi^+)+\\ \frac{1}{2g^2s_\omega\mathcal{A}_\mu\phi^0(W_\mu^+\phi^-+W_\mu^-\phi^+)}+\frac{1}{2ig^2s_\omega\mathcal{A}_\mu\mathcal{H}(W_\mu^+\phi^-+W_\mu^-\phi^+)}-\frac{g^2s_\omega}{c_\omega(2c_w^2-1)Z_\mu^0\mathcal{A}_\mu\phi^+\phi^-}-g^2s_\omega^2\mathcal{A}_\mu\mathcal{A}_v\phi^+\phi^-+\\ \frac{1}{2ig_s\lambda_{ij}^a\left(\underset{q\sigma^i}{\rightarrow}\varphi^\mu\underset{q\sigma^j}{\rightarrow}\right)g_\mu^a}-\underset{e^\lambda}{\rightarrow}(\varphi\partial+m_e^\lambda\end{array}\right)e^\lambda-\underset{v^\lambda}{\rightarrow}(\varphi\partial+m_v^\lambda\right)v^\lambda-\underset{\mu_j^\lambda v^\lambda}{\rightarrow\rightarrow}(\varphi\partial+m_\mu^\lambda\right)-(\mu_j^\lambda$$

$$-\underset{d_j^\lambda}{\rightarrow})+$$

$$(\varphi\partial+m_d^\lambda)d_j^\lambda+igs_\omega\mathcal{A}_\mu\left(-\left(\underset{e^\lambda}{\rightarrow}\varphi^\mu e^\lambda\right)+\frac{2}{3\left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu\mu_j^\lambda\right)}-\frac{1}{3\left(\underset{d^\lambda}{\rightarrow}\varphi^\mu d^\lambda\right)}+\frac{ig}{4c_\omega Z_\mu^0\left(\underset{v^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5)v^\lambda\right)}\right.$$

$$+\left(\underset{e^\lambda}{\rightarrow}\varphi^\mu(4s_\omega^2-1-\varphi^5)e^\lambda\right)+\left(\underset{d_j^\lambda}{\rightarrow}\varphi^\mu\left(\frac{4}{3s_\omega^2}-1-\varphi^5\right)d_j^\lambda\right)+\left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu\left(1-\frac{8}{3s_\omega^2}+\varphi^5\right)\mu_j^\lambda\right)$$

$$+\left(\frac{ig}{\sqrt[2]{2}W_\mu^+\left(\underset{v^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5)\right)U^{lep}{}_\xi^k e^k}\right)+\left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5)c_{\kappa\lambda}d_j^k\right)$$

$$+\frac{ig}{\sqrt[2]{2}W_\mu^-\left(\underset{e^{\mathcal{K}}}{\rightarrow}U^{lep\dagger}\frac{{}^v\frac{\psi\lambda}{\kappa\varphi}}{{}_\xi\rho\varpi}-\triangleq\prod_{\odot\oplus\tau}^{\oplus\odot\gamma}\otimes\frac{\coprod_v^\mu ijk}{\bigotimes\sigma}\Omega\Psi\Phi\Delta(1+\varphi^5)v^\lambda+\underset{d_j^\kappa}{\rightarrow}C_{*\;\kappa}^{\dagger\;\lambda}\varphi_{v\eta}^{\mu\zeta\eta}(1+\varphi^5)\mu_j^\lambda\right)}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^+\left(-m_c^\kappa\left(\underset{v^\lambda}{\rightarrow}U^{lep}{}_\xi^k e^k(1-\varphi^5)\epsilon^\kappa\right)+m_\mu^\lambda\underset{\mu_j^\lambda}{\rightarrow}U^{lep\dagger}(1+\varphi^5)\varepsilon^\kappa\right)}$$

$$+\frac{ig}{2M\sqrt[2]{2}\phi^-\left(m_c^\kappa\left(\underset{v^\lambda}{\rightarrow}U^{lep}{}_\xi^k e^k(1-\varphi^5)\epsilon^\kappa\right)\pm m_\mu^\lambda\underset{\mu_j^\lambda}{\rightarrow}U^{lep\dagger}(1+\varphi^5)\varepsilon^\kappa\right)}-\frac{\frac{g}{2m_v^\lambda}}{M}\mathcal{H}\left(\underset{v^\lambda}{\rightarrow}v^\lambda\right)$$

$$
-\frac{\frac{\frac{g}{2m_c^\lambda}}{M\mathcal{H}\left(\underset{e^\lambda}{\rightarrow} e^\lambda\right)}}{4\underset{v^\lambda}{\rightarrow} M^R_{\lambda\kappa}\left(1-\gamma_5\right)v^\kappa}+\frac{\frac{ig}{2m_\nu^\lambda}}{M\phi^0\left(\underset{v^\lambda}{\rightarrow}\gamma^5 v^\lambda\right)}-\frac{\frac{ig}{2m_c^\lambda}}{M\phi^0\left(\underset{e^\lambda}{\rightarrow}\gamma^5 e^\lambda\right)}-\frac{1}{4\underset{v^\kappa}{\rightarrow} M^R_{\lambda\kappa}\left(1-\gamma_5\right)\underset{v^\kappa}{\rightarrow}}
$$

$$
+\frac{ig}{2M\sqrt[2]{2}\phi^+\left(-m_d^\kappa\left(\underset{\mu_j^\lambda}{\rightarrow} C_{\lambda\kappa}\left(1-\varphi^5\right)d_j^\kappa\right)+m_d^\kappa\left(\underset{\mu_j^\lambda}{\rightarrow} C_{\lambda\kappa}\left(1-\varphi^5\right)d_j^\kappa\right)\right)}
$$

$$
+\frac{ig}{2M\sqrt[2]{2}\phi^-\left(m_d^\lambda\left(\underset{d_j^\lambda}{\rightarrow} C^\dagger_{\lambda\kappa\bigwedge\theta*}\left(1+\varphi^5\right)\mu_j^\kappa\right)\pm m_d^\lambda\left(\underset{d_j^\lambda}{\rightarrow} C^\dagger_{\lambda\kappa\bigwedge\nabla*}\left(1+\varphi^5\right)\mu_j^\kappa\right)\right)}-\frac{\frac{g}{2m_\mu^\lambda}}{M\mathcal{H}\left(\underset{\mu_j^\lambda}{\rightarrow}\mu_j^\lambda\right)}
$$

$$
-\frac{\frac{g}{2m_d^\lambda}}{M}\mathcal{H}\left(\underset{d_j^\lambda}{\rightarrow} d_j^\lambda\right)+\frac{\frac{ig}{2m_\mu^\lambda}}{M}\phi^0\left(\underset{\mu_j^\lambda}{\rightarrow}\gamma^5\mu_j^\lambda\right)-\frac{\frac{ig}{2m_d^\lambda}}{M}\phi^0\left(\underset{d_j^\lambda}{\rightarrow}\gamma^5 d_j^\lambda\right)+\underset{G^a}{\rightarrow}\partial^2 G^a+g_s f^{abc}\partial_\mu\underset{G^a}{\rightarrow} G^b g_\mu^c
$$

$$
+\underset{\alpha^+}{\rightarrow}\left(\partial^2-M^2\right)\alpha^+ +\underset{\alpha^-}{\rightarrow}\left(\partial^2-M^2\right)\alpha^- +\underset{\alpha^0}{\rightarrow}\left(\partial^2-\frac{M^2}{c_\omega^2}\right)\alpha^0+\underset{b}{\rightarrow}\partial^2 b+igc_\omega W_\mu^+\left(\partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^-}{\rightarrow}-\partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^0}{\rightarrow}\right)
$$

$$
+igs_w W_\mu^+\left(\partial_\mu\underset{b}{\rightarrow}\alpha^- -\partial_\mu\underset{a}{\rightarrow} b^-\right)+igc_\omega W_\mu^-\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^0}{\rightarrow}-\partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)+igs_\omega W_\mu^-\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^0}{\rightarrow}-\partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)
$$

$$
+igc_\omega Z_\mu^0\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^-}{\rightarrow}-\partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)+igs_\omega\mathcal{A}_\mu\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^-}{\rightarrow}-\partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)-1/2gM(\frac{\underset{\alpha^+}{\rightarrow}\alpha^+\mathcal{H}\hbar\mathbb{R}^4}{h}+\underset{\alpha^-}{\rightarrow}\alpha^-\mathcal{H}
$$

$$
+1-\frac{2c_{\mathfrak{I}}^2}{2c_\omega igM\left(\underset{\alpha^+}{\rightarrow} a^0\phi^+ -\underset{\alpha^-}{\rightarrow} a^0\phi^-\right)}+\frac{1}{2c_\omega igM\left(\underset{\alpha^0}{\rightarrow} a^-\phi^+ -\underset{\alpha^0}{\rightarrow} a^+\phi^-\right)}
$$

$$
+igMs_\omega\left(\underset{\alpha^0}{\rightarrow} a^-\phi^+ -\underset{\alpha^0}{\rightarrow} a^+\phi^-\right)+1/2igM\left(\underset{\alpha^+}{\rightarrow} a^+\phi^0-\underset{\alpha^-}{\rightarrow} a^-\phi^0\right)
$$

$$
\Phi(x)=\begin{pmatrix}\phi^+\\ \phi^0\end{pmatrix}=\frac{1}{\sqrt{2}}\begin{pmatrix}\phi_1+\mathrm{i}\phi_2\\ \phi_3+\mathrm{i}\phi_4\end{pmatrix}
$$

$$
\mathcal{L}_{SBS}=(\mathcal{D}_\mu\Phi)^\dagger(\mathcal{D}^\mu\Phi)-V(\Phi)
$$

$$
V(\Phi)=\mu^2\Phi^\dagger\Phi+\lambda(\Phi^\dagger\Phi)^2
$$

$$
|\Phi|^2=\Phi^\dagger\Phi=-\frac{\mu^2}{2\lambda}=\frac{v^2}{2}
$$

$$
\Phi(x)=\begin{pmatrix}\phi^+\\ \phi^0\end{pmatrix}\longrightarrow\frac{1}{\sqrt{2}}\begin{pmatrix}0\\ v\end{pmatrix}
$$

$$
\Phi(x)=\frac{1}{\sqrt{2}}e^{\mathrm{i}\frac{\vec{\xi}(x)\cdot\vec{\tau}}{v}}\begin{pmatrix}0\\ v+\mathrm{h}(x)\end{pmatrix}
$$

$$U(\xi) = e^{-\mathrm{i}\frac{\vec{\xi}(x)\cdot\vec{\tau}}{v}}$$

$$\begin{aligned}
\Phi' &= U(\xi)\Phi = \frac{1}{\sqrt{2}}\begin{pmatrix} 0 \\ v + \mathrm{h}(x) \end{pmatrix} \\
\left(\frac{\vec{\tau}\,\vec{\mathrm{W}}'_\mu}{2}\right) &= U(\xi)\left(\frac{\vec{\tau}\,\vec{\mathrm{W}}_\mu}{2}\right)U^{-1}(\xi) - \frac{\mathrm{i}}{g}(\partial_\mu U(\xi))U^{-1}(\xi) \\
\mathrm{B}'_\mu &= \mathrm{B}_\mu
\end{aligned}$$

$$\mathcal{L} = \mathcal{L}_{bos.} + \mathcal{L}_{ferm.} + \mathcal{L}_{SBS}$$

$$(\mathcal{D}_\mu\Phi)^\dagger(\mathcal{D}^\mu\Phi) = \frac{v^2}{8}[\mathrm{g}^2(W_{1\mu}^2 + W_{2\mu}^2) + (\mathrm{g}W_{3\mu} - \mathrm{g}'B_\mu)^2]$$

$$\begin{aligned}
\mathrm{W}_\mu^\pm &= \frac{1}{\sqrt{2}}(\mathrm{W}_\mu^1 \mp \mathrm{W}_\mu^2) \\
\mathrm{Z}_\mu &= \cos\theta_\mathrm{W}\mathrm{W}_\mu^3 - \sin\theta_\mathrm{W}\mathrm{B}_\mu \\
\mathrm{A}_\mu &= \sin\theta_\mathrm{W}\mathrm{W}_\mu^3 + \cos\theta_\mathrm{W}\mathrm{B}_\mu
\end{aligned}$$

$$\tan\theta_\mathrm{W} \equiv \frac{\mathrm{g}'}{\mathrm{g}}$$

$$\mathrm{M_W} = \frac{1}{2}\mathrm{g}v$$

$$\mathrm{M_Z} = \frac{1}{2}v\sqrt{\mathrm{g}^2 + \mathrm{g}'^2}$$

$$\begin{aligned}
\mathrm{g} &= \frac{e}{\sin\theta_\mathrm{W}} \\
\mathrm{g}' &= \frac{e}{\cos\theta_\mathrm{W}}
\end{aligned}$$

$$\mathrm{m_H^2} = 2\lambda v^2$$

$$\mu \to \nu_\mu\bar{\nu}_\mathrm{e}\mathrm{e}$$

$$v = (\sqrt{2}\mathrm{G_F})^{-\frac{1}{2}}$$

$$\mathcal{L}_{YW} = \lambda_\mathrm{e}\bar{\ell}_L\Phi\mathrm{e}_R + \lambda_\mathrm{u}\bar{\mathrm{q}}_L\tilde{\Phi}\mathrm{u}_R + \lambda_\mathrm{d}\bar{\mathrm{q}}_L\Phi\mathrm{d}_R + \mathrm{h.c.}$$

$$\ell_L = \begin{pmatrix} \mathrm{e} \\ \nu_{\mathrm{e}} \end{pmatrix}_L, \begin{pmatrix} \mu \\ \nu_\mu \end{pmatrix}_L, \begin{pmatrix} \tau \\ \nu_\tau \end{pmatrix}_L$$

$$\mathrm{q}_L = \begin{pmatrix} \mathrm{u} \\ \mathrm{d} \end{pmatrix}_L, \begin{pmatrix} \mathrm{c} \\ \mathrm{s} \end{pmatrix}_L, \begin{pmatrix} \mathrm{t} \\ \mathrm{b} \end{pmatrix}_L$$

$$\ell'_L = U(\xi)\ell_L; \qquad \mathrm{e}'_R = \mathrm{e}_R$$
$$\mathrm{q}'_L = U(\xi)q_L; \qquad \mathrm{u}'_R = \mathrm{u}_R;\ \mathrm{d}'_R = \mathrm{d}$$

$$\mathrm{m_e} = \lambda_{\mathrm{e}} \frac{v}{\sqrt{2}}$$
$$\mathrm{m_u} = \lambda_{\mathrm{u}} \frac{v}{\sqrt{2}}$$
$$\mathrm{m_d} = \lambda_{\mathrm{d}} \frac{v}{\sqrt{2}}$$

O es igual a:

$$\mathcal{L}_{Higgs} = \overline{\left([\partial_\mu + \frac{1}{2}ig_1 B_\mu + \frac{1}{2}ig_2 \mathbf{W}_\mu]\phi\right)}\left([\partial_\mu + \frac{1}{2}ig_1 B_\mu + \frac{1}{2}ig_2 \mathbf{W}_\mu]\phi\right) - \frac{m_H^2\left(\bar{\phi}\phi - \frac{v^2}{2}\right)^2}{2v^2}$$

$$\mathcal{L}_{SM}(z) \equiv (a,b) \simeq (b,a)$$

$$= -\frac{1}{2\pi\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}g_{\mu}^{a}g_{a}^{\mu}g_{v}^{b}g_{b}^{v}} - g_{s}f^{ab}f_{ab}\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}g_{\mu}^{a}g_{a}^{\mu}g_{v}^{b}g_{b}^{v} - \frac{1}{4\pi g_{S}^{2}f^{cd}f_{cd}\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}g_{\mu}^{c}g_{c}^{\mu}g_{v}^{d}g_{d}^{v}}$$

$$-\partial^{\mu}W_{\mu}\partial^{v}W_{v} - M^{2}W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v} - \frac{1}{2\pi\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}} - \frac{1}{2c_{m}^{2}M^{2}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}} - \frac{1}{2\partial^{\mu}A_{v}\partial^{v}A_{\mu}}$$

$$-igc_{w}\left(\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu}\partial_{v}^{\mu}\partial_{\mu}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+})\right) - Z_{\mu}^{0}(\partial^{\mu}\partial_{\mu}W_{\mu}^{+}W_{\mu}^{-}W_{+}^{\mu}W_{-}^{\mu}) + Z_{v}^{0}(\partial^{v}\partial_{v}W_{v}^{+}W_{v}^{-}W_{+}^{v}W_{-}^{v})$$

$$-igS_{w}(\partial^{\mu}A_{v}\partial^{v}A_{\mu}(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v})Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}) - A_{\mu}(\partial^{\mu}\partial_{\mu}W_{\mu}^{+}W_{\mu}^{-}W_{+}^{\mu}W_{-}^{\mu}Z_{\mu}^{0}Z_{0}^{\mu})$$

$$+A_{v}(\partial^{v}\partial_{v}W_{v}^{+}W_{v}^{-}W_{+}^{v}W_{-}^{v}Z_{v}^{0}Z_{0}^{v}) - \frac{1}{2g^{2}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v})\right)}$$

$$+g^{2}c_{w}^{2}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v})\right)$$

$$+g^{2}S_{w}^{2}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v})\right)$$

$$-g^{2}c_{w}S_{w}\left(\partial^{\mu}A_{v}\partial^{v}A_{\mu}(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v})\right)$$

$$-\frac{1}{2\pi\left(\partial H^{\mu}AH_{v}H\partial^{v}HA_{\mu}(W_{\mu}^{+}W_{v}^{-}W_{\mu}^{-}W_{v}^{+}W_{+}^{\mu}W_{-}^{v}W_{-}^{\mu}W_{+}^{v}Z_{\mu}^{0}Z_{v}^{0}Z_{0}^{\mu}Z_{0}^{v}H^{\mu}H_{V}H_{v}^{\mu}H_{\mu}^{v})\right)} + \frac{\frac{\frac{1}{2\pi(2M^{2}H^{2}H^{3})}}{\frac{d^{\wedge}em^{C}\gamma}{GUM_{Scw}^{2}}}}{\frac{2M}{\frac{\beta_{\eta}^{\xi}}{\prod_{\sigma}^{\rho}\frac{h^{4}}{\hbar^{2}}}}} - \frac{2g_{c}^{2}M_{S}^{2}}{\Psi\Phi\zeta} - \lambda\partial$$

$$\otimes\frac{\omega}{\Delta\nabla\theta}$$

$$/\prod_{\triangleq}^{\dagger}\infty\oiiint_{j}^{i}k\left(\frac{\frac{\phi_{\mu}^{+}\phi_{v}^{-}\phi_{\mu}^{-}\phi_{v}^{+}}{\phi_{+}^{\mu}\phi_{-}^{v}\phi_{-}^{\mu}\phi_{+}^{v}}}{\phi_{\mu}^{0}\phi_{v}^{0}\phi_{0}^{\mu}\phi_{0}^{v}}\right)(\varphi\psi\omega\lambda_{\mu}^{+}\varphi\psi\omega\lambda_{v}^{-}\varphi\psi\omega\lambda_{\mu}^{-}\varphi\psi\omega\lambda_{v}^{+}\frac{2\varphi\psi\omega\lambda^{\mu}}{\varphi\psi\omega\lambda}_{+}\varphi\psi\omega\lambda_{-}^{v}\varphi\psi\omega\lambda_{-}^{\mu}\varphi\psi\omega\lambda_{+}^{v}\frac{1/2\pi\varphi\psi\omega\lambda^{0}}{\varphi\psi\omega\lambda}_{\mu}\varphi\psi\omega\lambda_{v}^{0}\varphi\psi\omega\lambda_{0}^{\mu}\varphi\psi\omega\lambda_{0}^{v})$$

$$/2M\sqrt[\phi\varphi\lambda\kappa]{\frac{\frac{2\xi\eta}{\zeta\epsilon\varepsilon}}{\frac{\delta\alpha}{o\sigma\rho}}}/\Psi\Omega\mho = \mathcal{L}_{Higgs}$$

$$= \left(\partial^{\mu}\partial_{v}\partial^{v}\partial_{\mu} + \frac{1}{2ig_{1}B^{\mu}B_{v}B^{v}B_{\mu}} + \frac{1}{2jg_{2}B^{\mu}B_{v}B^{v}B_{\mu}} + \frac{1}{2ig_{1}W^{\mu}W_{v}W^{v}W_{\mu}} + \frac{1}{2jg_{2}W^{\mu}W_{v}W^{v}W_{\mu}}\right) - m_{H}^{2}\phi^{'}\phi - \frac{v^{2}}{2v^{2}}/\tau^{2}$$

$$\mathcal{H}_{ab} \equiv \frac{1}{2\pi\prod_{i}^{k}(x) + \prod_{k}^{i}(x)\partial^{i}\partial_{k}A^{k}A_{i}(x) + \frac{1}{4\pi F^{ki}(x)F_{ik}(x)}}$$

$$= H_{ab}\oiiint_{i}^{k}d^{3}\chi\left[\frac{1}{2\pi\prod_{i}^{k}(x) + \prod_{k}^{i}(x)\partial^{i}\partial_{k}A^{k}A_{i}(x) + \frac{1}{4\pi F^{ki}(x)F_{ik}(x)}}\right]$$

$$= H^{\rho}H_{c}H^{c}H_{\rho}H_{c}^{\rho}H_{\rho}^{c}\varrho \equiv \oiiint_{i}^{k}\frac{d^{3}\chi\lambda}{\hbar}\underset{[\lambda\Phi\triangleq]}{\mho\Omega\mathbb{R}^{4}}/G_{\varepsilon}R_{e}$$

Donde:

$$G_{\mathcal{E}} = \quad G_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$R_e = \quad R_{\mu\nu} - \frac{1}{2} R\, g_{\mu\nu} + \Lambda\, g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$\mathcal{H}_{ab} \equiv \frac{1}{2\pi \prod_i^k(y) + \prod_k^i(y)\partial^i\partial_k\, A^k A_i(y) + \frac{1}{4F^{ki}(y)F_{ik}(y)}}$$

$$= H_{ab} \oiiint_i^k d^3\chi[\frac{1}{2\pi \prod_i^k(y) + \prod_k^i(y)\partial^i\partial_k\, A^k A_i(y) + \frac{1}{4\pi F^{ki}(y)F_{ik}(y)}}]$$

$$= H^\rho H_c H^c H_\rho H_c^\rho H_\rho^c \varrho \equiv \oiiint_i^k \frac{d^3\chi\lambda}{\hbar} \mho\Omega\mathbb{R}^4/G_{\mathcal{E}} R_e \quad [\lambda\Phi \triangleq]$$

Donde:

$$G_{\mathcal{E}} = \quad G_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$R_e = \quad R_{\mu\nu} - \frac{1}{2} R\, g_{\mu\nu} + \Lambda\, g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$\mathcal{H}_{ab} \equiv \frac{1}{2\pi \prod_i^k(z) + \prod_k^i(z)\partial^i\partial_k A^k A_i(z) + \frac{1}{4\pi F^{ki}(z)F_{ik}(z)}}$$

$$= H_{ab} \oiiint_i^k d^3\chi[\frac{1}{2\pi \prod_i^k(z) + \prod_k^i(z)\partial^i\partial_k A^k A_i(z) + \frac{1}{4\pi F^{ki}(z)F_{ik}(z)}}]$$

$$= H^\rho H_c H^c H_\rho H_c^\rho H_\rho^c \varrho \equiv \oiiint_i^k \frac{d^3\chi\lambda}{\hbar} \mho\Omega\mathbb{R}^4/G_\varepsilon R_e \quad [\lambda\Phi \triangleq]$$

Donde:

$$G_\varepsilon = \quad G_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$R_e = \quad R_{\mu\nu} - \frac{1}{2} R\, g_{\mu\nu} + \Lambda\, g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$\mathcal{H}_{ba} \equiv \frac{1}{2\pi \prod_i^k(x) + \prod_k^i(x)\partial^i\partial_k A^k A_i(x) + \frac{1}{4\pi F^{ki}(x)F_{ik}(x)}}$$

$$= H_{ba} \oiiint_i^k d^3\chi[\frac{1}{2\pi \prod_i^k(x) + \prod_k^i(x)\partial^i\partial_k A^k A_i(x) + \frac{1}{4\pi F^{ki}(x)F_{ik}(x)}}]$$

$$= H^\rho H_c H^c H_\rho H_c^\rho H_\rho^c \varrho \equiv \oiiint_i^k \frac{d^3\chi\lambda}{\hbar} \mho\Omega\mathbb{R}^4/G_\varepsilon R_e \quad [\lambda\Phi \triangleq]$$

Donde:

$$G_\varepsilon = \quad G_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$R_{\mu\nu} - \frac{1}{2} R\, g_{\mu\nu} + \Lambda\, g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$R_e =$$

$$\mathcal{H}_{ba} \equiv \frac{1}{2\pi \prod_i^k(y) + \prod_k^i(y)\partial^i\partial_k\, A^k A_i(y) + \frac{1}{4F^{ki}(y)F_{ik}(y)}}$$

$$= H_{ba} \oiiint_i^k d^3\chi[\frac{1}{2\pi \prod_i^k(y) + \prod_k^i(y)\partial^i\partial_k\, A^k A_i(y) + \frac{1}{4\pi F^{ki}(y)F_{ik}(y)}}]$$

$$= H^\rho H_c H^c H_\rho H_c^\rho H_\rho^c \varrho \equiv \oiiint_i^k \frac{d^3\chi\lambda}{\hbar} \mho\Omega\mathbb{R}^4/G_\varepsilon R_e \quad [\lambda\Phi \triangleq]$$

Donde:

$$G_\varepsilon = \quad \mathrm{G}_{\mu\nu} = \frac{8\pi\mathrm{G}}{\mathrm{c}^4} T_{\mu\nu}$$

$$R_{\mu\nu} - \frac{1}{2} R\, g_{\mu\nu} + \Lambda\, g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$R_e =$$

$$\mathcal{H}_{ba} \equiv \frac{1}{2\pi \prod_i^k(z) + \prod_k^i(z)\partial^i\partial_k\, A^k A_i(z) + \frac{1}{4\pi F^{ki}(z)F_{ik}(z)}}$$

$$= H_{ba} \oiiint_i^k d^3\chi[\frac{1}{2\pi \prod_i^k(z) + \prod_k^i(z)\partial^i\partial_k\, A^k A_i(z) + \frac{1}{4\pi F^{ki}(z)F_{ik}(z)}}]$$

$$= H^\rho H_c H^c H_\rho H_c^\rho H_\rho^c \varrho \equiv \oiiint_i^k \frac{d^3\chi\lambda}{\hbar} \mho\Omega\mathbb{R}^4/G_\varepsilon R_e \quad [\lambda\Phi \triangleq]$$

Donde:

$$G_{\mathcal{E}} = \mathrm{G}_{\mu\nu} = \frac{8\pi \mathrm{G}}{\mathrm{c}^4} T_{\mu\nu}$$

$$R_e = R_{\mu\nu} - \frac{1}{2} R\, g_{\mu\nu} + \Lambda\, g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$\{B(x,k), C(x,k)/\Phi\Psi\kappa\varphi\theta$$
$$= \delta \prod\nolimits_b^a (x,k)\lambda\phi \frac{\oint_\sigma^\varphi d^3z[\delta_b^a B(x,k)\lambda\phi/\delta_b^a A_{ab}(x,k)\lambda\phi}{\delta_b^a C(x,k)\lambda\phi}$$
$$/\delta \prod\nolimits_a^b (x,k)\lambda\phi \frac{\oint_\sigma^\varphi d^3z[\delta_a^b B(x,k)\lambda\phi/\delta_a^b C(x,k)\lambda\phi}{\delta_a^b A_{ba}(x,k)\lambda\phi} /\delta \prod\nolimits_{ba}^{ab} (x,k)\,\lambda\phi$$

$$\{B(y,k), C(y,k)/\Phi\Psi\kappa\varphi\theta$$
$$= \delta \prod\nolimits_b^a (y,k)\lambda\phi \frac{\oint_\sigma^\varphi d^3z[\delta_b^a B(y,k)\lambda\phi/\delta_b^a A_{ab}(y,k)\lambda\phi}{\delta_b^a C(y,k)\lambda\phi}$$
$$/\delta \prod\nolimits_a^b (y,k)\lambda\phi \frac{\oint_\sigma^\varphi d^3z[\delta_a^b B(y,k)\lambda\phi/\delta_a^b C(y,k)\lambda\phi}{\delta_a^b A_{ba}(y,k)\lambda\phi} /\delta \prod\nolimits_{ba}^{ab} (y,k)\,\lambda\phi$$

$$\{B(z,k), C(z,k)/\Phi\Psi\kappa\varphi\theta$$
$$= \delta \prod\nolimits_b^a (z,k)\lambda\phi \frac{\oint_\sigma^\varphi d^3z[\delta_b^a B(z,k)\lambda\phi/\delta_b^a A_{ab}(z,k)\lambda\phi}{\delta_b^a C(z,k)\lambda\phi}$$
$$/\delta \prod\nolimits_a^b (z,k)\lambda\phi \frac{\oint_\sigma^\varphi d^3z[\delta_a^b B(z,k)\lambda\phi/\delta_a^b C(z,k)\lambda\phi}{\delta_a^b A_{ba}(z,k)\lambda\phi} /\delta \prod\nolimits_{ba}^{ab} (z,k)\,\lambda\phi$$

$$\{F(x), G(x)\}_{D\bowtie} =\circledast \{F(x), G(x)\} \oplus$$
$$- \coprod_\varphi^\gamma \psi \prod_\gamma^\varphi \lambda$$
$$\approxeq \frac{\oiiint_\upsilon^\mu \frac{\zeta}{\beta} d^3ab^3\, ab_3 ab^d ab_d ba^3 ba_3 ba^d ba_d \phi^a \phi_b \phi^b \phi_a \varphi^b \varphi_a \varphi^a \varphi_b \phi^{ab} \phi_{ba} \phi^{ba} \phi_{ab} \varphi^{ab} \varphi_{ba} \varphi^{ba} \varphi_{ab} C_{abbac^{-i\omega t} mc_\hbar^4}^{-1\pi}}{\alpha\beta/h\mho\Omega\oint \frac{\dagger}{\pi}/\Delta\nabla \otimes \boxtimes \ltimes \rtimes \curlywedge \curlyvee}$$

$$\{F(y),G(y)\}_{D\bowtie} =\circledast \{F(y),G(y)\}\oplus -\coprod_{\varphi}^{\gamma}\psi\prod_{\gamma}^{\varphi}\lambda \approxeq \frac{\oiiint_{v}^{\mu}\frac{\zeta}{\beta}d^3ab^3\,ab_3ab^dab_dba^3ba_3ba^dba_d\phi^a\phi_b\phi^b\phi_a\varphi^b\varphi_a\varphi^a\varphi_b\phi^{ab}\phi_{ba}\phi^{ba}\phi_{ab}\varphi^{ab}\varphi_{ba}\varphi^{ba}\varphi_{ab}C_{abbac^{-\iota\omega t}mc_{\hbar}^4}^{-1\pi}}{\alpha\beta/h\mho\Omega\oint\frac{\dagger}{\pi}/\Delta\nabla\otimes\boxtimes\ltimes\rtimes\leftthreetimes\rightthreetimes}$$

$$\{F(z),G(z)\}_{D\bowtie} =\circledast \{F(z),G(z)\}\oplus -\coprod_{\varphi}^{\gamma}\psi\prod_{\gamma}^{\varphi}\lambda \approxeq \frac{\oiiint_{v}^{\mu}\frac{\zeta}{\beta}d^3ab^3\,ab_3ab^dab_dba^3ba_3ba^dba_d\phi^a\phi_b\phi^b\phi_a\varphi^b\varphi_a\varphi^a\varphi_b\phi^{ab}\phi_{ba}\phi^{ba}\phi_{ab}\varphi^{ab}\varphi_{ba}\varphi^{ba}\varphi_{ab}C_{abbac^{-\iota\omega t}mc_{\hbar}^4}^{-1\pi}}{\alpha\beta/h\mho\Omega\oint\frac{\dagger}{\pi}/\Delta\nabla\otimes\boxtimes\ltimes\rtimes\leftthreetimes\rightthreetimes}$$

$$A=(v_Le_Lv_Re_Rv'_Le'_Lv'_Re'_R)\sigma^\mu\sigma^v\sigma_v^\mu\sigma_\mu^v i\partial^\mu j\partial^\mu k\partial^\mu i\partial^v j\partial^v k\partial^v ijk\partial_v^\mu ijk\partial_\mu^v\left(\frac{v'_L}{e'_L}\right)\left(\frac{v_L}{e_L}\right)\left(\frac{v'_R}{e'_R}\right)\left(\frac{v_R}{e_R}\right)+$$
$$e'_R\sigma^\mu\sigma^v\sigma_v^\mu\sigma_\mu^v i\partial^\mu j\partial^\mu k\partial^\mu i\partial^v j\partial^v k\partial^v ijk\partial_v^\mu ijk\partial_\mu^v e_R+v'_R\sigma^\mu\sigma^v\sigma_v^\mu\sigma_\mu^v i\partial^\mu j\partial^\mu k\partial^\mu i\partial^v j\partial^v k\partial^v ijk\partial_v^\mu ijk\partial_\mu^v v_R+$$
$$e'_L\sigma^\mu\sigma^v\sigma_v^\mu\sigma_\mu^v i\partial^\mu j\partial^\mu k\partial^\mu i\partial^v j\partial^v k\partial^v ijk\partial_v^\mu ijk\partial_\mu^v e_L+v'_L\sigma^\mu\sigma^v\sigma_v^\mu\sigma_\mu^v i\partial^\mu j\partial^\mu k\partial^\mu i\partial^v j\partial^v k\partial^v ijk\partial_v^\mu ijk\partial_\mu^v v_L+$$
$$e'_R\sigma^\mu\sigma^v\sigma_v^\mu\sigma_\mu^v i\partial^\mu j\partial^\mu k\partial^\mu i\partial^v j\partial^v k\partial^v ijk\partial_v^\mu ijk\partial_\mu^v e_R+v'_R\sigma^\mu\sigma^v\sigma_v^\mu\sigma_\mu^v i\partial^\mu j\partial^\mu k\partial^\mu i\partial^v j\partial^v k\partial^v ijk\partial_v^\mu ijk\partial_\mu^v v_R+$$
$$e'_L\sigma^\mu\sigma^v\sigma_v^\mu\sigma_\mu^v i\partial^\mu j\partial^\mu k\partial^\mu i\partial^v j\partial^v k\partial^v ijk\partial_v^\mu ijk\partial_\mu^v e_L+$$
$$v'_L\sigma^\mu\sigma^v\sigma_v^\mu\sigma_\mu^v i\partial^\mu j\partial^\mu k\partial^\mu i\partial^v j\partial^v k\partial^v ijk\partial_v^\mu ijk\partial_\mu^v v_L(u_Ld_Lu_Rd_Ru'_Ld'_Lu'_Rd'_R)\sigma^\mu\sigma^v\sigma_v^\mu\sigma_\mu^v i\partial^\mu j\partial^\mu k\partial^\mu i\partial^v j\partial^v k\partial^v ijk\partial_v^\mu ijk\partial_\mu^v\left(\frac{u'_L}{d'_L}\right)\left(\frac{u_L}{d_L}\right)\left(\frac{u'_R}{d'_R}\right)\left(\frac{u_R}{d_R}\right)$$
$$u'_R\sigma^\mu\sigma^v\sigma_v^\mu\sigma_\mu^v i\partial^\mu j\partial^\mu k\partial^\mu i\partial^v j\partial^v k\partial^v ijk\partial_v^\mu ijk\partial_\mu^v u_R+d'_R\sigma^\mu\sigma^v\sigma_v^\mu\sigma_\mu^v i\partial^\mu j\partial^\mu k\partial^\mu i\partial^v j\partial^v k\partial^v ijk\partial_v^\mu ijk\partial_\mu^v d_R+$$
$$u'_L\sigma^\mu\sigma^v\sigma_v^\mu\sigma_\mu^v i\partial^\mu j\partial^\mu k\partial^\mu i\partial^v j\partial^v k\partial^v ijk\partial_v^\mu ijk\partial_\mu^v u_L+d'_L\sigma^\mu\sigma^v\sigma_v^\mu\sigma_\mu^v i\partial^\mu j\partial^\mu k\partial^\mu i\partial^v j\partial^v k\partial^v ijk\partial_v^\mu ijk\partial_\mu^v d_L\pm\frac{1}{4\pi B^{\mu v}B_{\mu v}B^{v\mu}B_{v\mu}}\pm$$
$$\frac{1}{8\pi tr(W^{\mu v}W_{\mu v}W^{v\mu}W_{v\mu})}-\frac{\frac{e\sqrt{2}}{v\sqrt{2}}}{e,v,e',v'\left[=(v'_Le'_Lv'_Re'_R)\phi M^ee_R+\phi'^{M'^e}e'_R+\phi M^vv_R+\phi'^{M'^v}v'_R+\phi M^ee_L+\phi'^{M'^e}e'_L+\phi M^vv_L+\phi'^{M'^v}v'_L\left(\frac{v'_L}{e'_L}\right)\left(\frac{v_L}{e_L}\right)\left(\frac{v'_R}{e'_R}\right)\left(\frac{v_R}{e_R}\right)\right]}+$$
$$\frac{\frac{u\sqrt{2}}{d\sqrt{2}}}{u,d,u',d'\left[=(u'_Ld'_Lu'_Rd'_R)\phi M^uu_R+\phi'^{M'^u}u'_R+\phi M^dd_R+\phi'^{M'^d}d'_R+\phi M^uu_L+\phi'^{M'^u}u'_L+\phi M^dd_L+\phi'^{M'^d}d'_L\left(\frac{u'_L}{d'_L}\right)\left(\frac{u_L}{d_L}\right)\left(\frac{u'_R}{d'_R}\right)\left(\frac{u_R}{d_R}\right)\right]}/\tau^2=$$
$$\xi_{\lambda\Omega\psi}^{\sigma\varsigma\zeta}\Sigma\iiiint\text{ħȸꞪӜƷҖДҞɥӁƸ}\varsigma\pi mc\mathbb{R}^4$$

## CONCLUSIONES

En mérito al análisis de campo antes descrito – marco praxeológico (campos de gauge), bajo el marco metodológico de las teorías 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 campo de Yang-Mills no abeliano, en efecto existe un valor positivo mínimo de energía, calculado a través de la siguiente constante universal

$$\mu := \inf \mathrm{Spec}(\hat{H})\backslash 0 > 0 = \xi_{\lambda\Omega\psi}^{\sigma\varsigma\zeta}\Sigma\iiiint\text{ħȸꞪӜƷҖДҞɥӁƸ}\varsigma\pi mc\mathbb{R}^4$$

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 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 $\Delta$; **(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.**

**Formalización matemática relativa a agujeros negros cuánticos en espacios curvos y teoría cuántica de campos curvos.**

**1. Teorema de Helmholtz - condición Hessiana - Galileón vectorial - tensor doble dual de Riemann.**

$$
\begin{aligned}
\mathrm{A}_\mu = \mathcal{A}_\mu + \partial_\mu \varpi, \mathcal{H}^{\mu\nu} \equiv \frac{\partial^2 \mathcal{L}}{\partial(\partial_0 \mathcal{A}_\mu)(\partial_0 \mathcal{A}_\nu)}, \delta \\
&= \int \left[ -\frac{1}{4}\mathcal{F}_{\mu\nu}\mathcal{F}^{\mu\nu} + \frac{1}{2}m^2\mathrm{A}^2 + \sum_{\eta=2}^{6} \mathcal{L}_{\mathrm{N,A}}^{Gal} \right] d^4\chi \, , \mathcal{L}_{2,\mathrm{A}}^{Gal} = f_2(\mathrm{A}_\mu, \mathcal{F}_{\mu\nu}, \tilde{\mathcal{F}}_{\mu\nu}), \mathcal{L}_{3,\mathrm{A}}^{Gal} \\
&= f_2(\mathrm{A}^2)\delta_\mu^\mu, \mathcal{L}_{4,\mathrm{A}}^{Gal} = f_4(\mathrm{A}^2)\left[ \left(\delta_\mu^\mu\right)^2 - \delta_\rho^\sigma \delta_\sigma^\rho \right], \mathcal{L}_{5,\mathrm{A}}^{Gal} \\
&= f_5(\mathrm{A}^2)\left[ \left(\delta_\mu^\mu\right)^3 - 3\delta_\mu^\mu \delta_\rho^\sigma \delta_\sigma^\rho + 2\delta_\rho^\sigma \delta_\sigma^\gamma \delta_\gamma^\rho \right] + g_5(\mathrm{A}^2)\tilde{\mathcal{F}}^{\alpha\mu}\tilde{\mathcal{F}}_\mu^\beta \delta_{\alpha\beta}, \mathcal{L}_{6,\mathrm{A}}^{Gal} \\
&= g_6(\mathrm{A}^2)\tilde{\mathcal{F}}^{\alpha\beta}\tilde{\mathcal{F}}^{\mu\nu}\delta_{\alpha\mu}\delta_{\beta\nu}, \delta = \int d^4\chi \sqrt{-g}\left( \mathcal{F} + \sum_{i=2}^{6} \mathcal{L}_i \right), \mathcal{L}_2 \\
&= \mathfrak{G}_2(\chi, \mathcal{F}_{\mu\nu}, \tilde{\mathcal{F}}_{\mu\nu}), \mathcal{L}_3 = \mathfrak{G}_3(\chi)\nabla_\mu \mathrm{A}^\mu, \mathcal{L}_4 \\
&= \mathfrak{G}_4(\chi)\mathcal{R} + \mathfrak{G}_{4,\chi}(\chi)\left[ \left(\nabla_\mu \mathrm{A}^\mu\right)^2 - \nabla_\mu \mathrm{A}_\nu \nabla^\nu \mathrm{A}^\mu \right], \mathcal{L}_5 \\
&= \mathfrak{G}_5(\chi)\mathfrak{G}_{\mu\nu}\nabla^\nu \mathrm{A}^\mu \\
&- \frac{1}{6}\mathfrak{G}_{5,\chi}(\chi)\left[ \left(\nabla_\mu \mathrm{A}^\mu\right)^3 - 3\nabla_\mu \mathrm{A}^\mu \nabla_\rho \mathrm{A}_\sigma \nabla^\sigma \mathrm{A}^\rho + 2\nabla_\rho \mathrm{A}_\sigma \nabla^\nu \mathrm{A}^\rho \mathrm{A}^\sigma \nabla_\nu \right] \\
&+ g_5(\chi)\tilde{\mathcal{F}}^{\alpha\mu}\tilde{\mathcal{F}}_\mu^\beta \nabla_\alpha \mathrm{A}_\beta, \mathcal{L}_6 \\
&= \mathfrak{G}_6(\chi)\mathcal{L}^{\mu\nu\alpha\beta}\nabla_\mu \mathrm{A}_\nu \nabla_\alpha \mathrm{A}_\beta + \frac{1}{2}\mathfrak{G}_{6,\chi}(\chi)\tilde{\mathcal{F}}^{\alpha\beta}\tilde{\mathcal{F}}^{\mu\nu}\nabla_\alpha \mathrm{A}_\mu \nabla_\beta \mathrm{A}_\nu, \mathcal{L}^{\mu\nu\alpha\beta} \\
&\equiv \frac{1}{4}\varepsilon^{\mu\nu\rho\sigma}\varepsilon^{\alpha\beta\gamma\delta}\mathcal{R}_{\rho\sigma\gamma\delta}
\end{aligned}
$$

**1.2. Teoría de coordenadas.**

$$g = -f(r)dt \otimes dt + \hbar^{-1}(r)dr \otimes dr + r^2 d\theta \otimes d\theta + r^2 sin^2\theta d\phi \otimes d\phi$$

**1.3. Solución de Reissner-Nordström y acoplamientos.**

$$
\begin{aligned}
\mathfrak{G}_4 = \frac{m_\rho^2 \nabla_\beta \mathcal{F}^{\alpha\beta} m_\rho^2}{2}\mathfrak{G}_{\mu\nu}, \frac{1}{2}\left( \mathcal{F}_{\mu\alpha}\mathcal{F}_\nu^\alpha - \frac{1}{4}g_{\mu\nu}\mathcal{F}_{\alpha\beta}\mathcal{F}^{\alpha\beta} \right), \mathcal{F}_{01} = \partial_0 \mathrm{A}_1 - \partial_1 \mathrm{A}_0 = -\mathrm{A}_0' \\
&= \mathcal{F}_{10} - \frac{\hbar}{fr}\mathrm{A}_0' + \frac{\hbar f \mathrm{A}_0'}{4f^2} - \frac{\hbar' \mathrm{A}_0'}{4f} - \frac{\hbar \mathrm{A}_0''}{2f} + \frac{m_\rho^2}{2r^2}f - \frac{m_\rho^2 f \hbar}{2r^2} - \frac{1}{4}\hbar \mathrm{A}_0'^2 - \frac{m_\rho^2 f \hbar'}{2r} \\
&+ \frac{m_\rho^2}{2r^2} - \frac{m_\rho^2}{2\hbar r^2} + \frac{\mathrm{A}_0'^2}{4f} + \frac{m_\rho^2 f'}{2fr} - \frac{m_\rho^2 r \hbar'}{4} - \frac{\hbar r^2 \mathrm{A}_0'^2}{4f} + \frac{m_\rho^2 \hbar f' r}{4f} - \frac{m_\rho^2 \hbar f'^2 r^2}{8f^2} \\
&+ \frac{m_\rho^2 f' \hbar' r^2}{8f} + \frac{m_\rho^2 \hbar f'' r^2}{4f} \int \left( 1 - \frac{2\mathcal{M}}{r} - \frac{Q^2}{2m_\rho^2 r^2} \right) d\hbar
\end{aligned}
$$

$$\frac{\mu^2 \mathrm{A}^2 \nabla_\beta \mathcal{F}^{\alpha\beta} m_\rho^2}{2} \mathfrak{G}_{\mu\nu}$$

$$= \frac{1}{2}\left(\frac{1}{4} g_{\mu\nu}\mathcal{F}_{\alpha\beta}\mathcal{F}^{\alpha\beta} - \mathcal{F}_{\mu\alpha}\mathcal{F}_\nu^\alpha\right) + \frac{1}{2}\mu^2 \mathrm{A}_\mu \mathrm{A}_\nu + \frac{\frac{1}{2}\mu^2 \chi g_{\mu\nu}\mu^2}{f}\mathrm{A}_0 - \frac{\hbar}{rf}\mathrm{A}_0'$$

$$- \frac{\hbar}{2f}\mathrm{A}_0'' - \frac{\hbar'}{4f}\mathrm{A}_0' + \frac{\hbar f'}{4f^2 \mathrm{A}_0'} - \frac{\mu^2 \mathrm{A}_1 \hbar\, m_\rho^2 f}{2r^2} - \frac{m_\rho^2 f \hbar}{2r^2} - \frac{m_\rho^2 f \hbar'}{2r} - \frac{1}{4}\hbar \mathrm{A}_0'^2$$

$$- \frac{1}{4}\mu^2 \mathrm{A}_0^2 - \frac{1}{4}\mu^2 f\hbar \mathrm{A}_1^2 - \frac{m_\rho^2 f}{2r^2} + \frac{m_\rho^2}{f\hbar} + \frac{m_\rho^2 f \hbar'}{2r} + \frac{1}{4}\hbar \mathrm{A}_0'^2 - \frac{1}{4}\mu^2 \mathrm{A}_0^2 - \frac{1}{2}\mu f \hbar \mathrm{A}_1^2$$

$$+ \frac{m_\rho^2 \hbar f' r}{4f} - \frac{m_\rho^2 \hbar f'^2 r^2}{8f^2} + \frac{1}{4}\, m_\rho^2 \hbar' r + \frac{m_\rho^2 f' \hbar' r^2}{8f} - \frac{\hbar r^2}{4f}\mathrm{A}_0'^2 + \frac{m_\rho^2 \hbar f'' r^2}{4f}$$

$$- \frac{\mu^2 r^2}{4f}\mathrm{A}_0^2 + \frac{1}{4}\mu^2 \hbar r^2 \mathrm{A}_1^2$$

$$- \frac{1}{2}\mu^2 \mathrm{A}_0 \mathrm{A}_1\, m_\rho^2 \left(f'\hbar - \frac{f\hbar'}{\hbar^2}\right.$$

$$= \left.\frac{\mu^2 \mathrm{A}_0^2 r}{\hbar^2}\right) \lim_{r\to\infty}\left(f'\hbar - \frac{f\hbar'}{\hbar^2}\right) \lim_{r\to\infty}\left(\frac{\mu^2 \mathrm{A}_0^2 r(r)}{m_\rho^2 \hbar^2}\right) - \hbar\left(\frac{\mathrm{A}_0''}{2} + \frac{\mathrm{A}_0'}{r}\right) + \frac{\mu^2 \mathrm{A}_0^2 \mathrm{A}_0'}{4\, m_\rho^2 f}$$

$$+ c_1 \frac{\mu^2 \mathrm{A}_0 e^{-\sqrt{2\mu r}}}{r} c_2 \frac{\mu^2 \mathrm{A}_1 e^{\sqrt{2\mu r}}}{r}$$

$$
\begin{aligned}
\frac{m_\rho^2}{2}\mathfrak{G}_{\mu\nu} = \frac{1}{2}\left[\mathcal{F}_{\mu\alpha}\mathcal{F}_\nu^\alpha - \frac{\mathcal{F}^2}{4}g_{\mu\nu}\right]& \\
&- \frac{1}{4}\left[\frac{1}{2}g_{\mu\nu}(\nabla_\alpha \mathrm{A}^\alpha)^2 - 2\mathrm{A}_\mu\nabla_\nu\nabla_\alpha\mathrm{A}^\alpha - 2\nabla_\alpha\mathrm{A}_\mu\nabla_\nu\mathrm{A}^\alpha + \frac{1}{2}g_{\mu\nu}\nabla_\alpha\mathrm{A}_\beta\nabla^\beta\mathrm{A}^\alpha\right. \\
&+ \nabla_\alpha\left(\mathrm{A}_\mu\nabla^\alpha\mathrm{A}_\nu + \mathrm{A}_\mu\nabla_\nu\mathrm{A}^\alpha - \mathrm{A}^\alpha\nabla_\mu\mathrm{A}_\nu\right) + g_{\mu\nu}\mathrm{A}_\beta\nabla^\beta\nabla^\alpha\mathrm{A}_\alpha \\
&\left.- \frac{1}{2}\left(\mathrm{A}_\mu\mathrm{A}_\nu\mathcal{R} - \mathrm{A}^2\mathfrak{G}_{\mu\nu} - g_{\mu\nu}\boxdot\mathrm{A}^2 + \nabla_\mu\nabla_\nu\mathrm{A}^2\right)\right]\nabla_\beta\mathcal{F}^{\alpha\beta} - \frac{1}{2}\mathfrak{G}^{\beta\alpha}\mathrm{A}_\beta \\
&- 2\mathrm{A}_0 f(-1 + \hbar + r\hbar') \\
&+ r\left[\mathrm{A}_0'\left(\hbar r f' - f(4\hbar + r\hbar)\right) - 2f\hbar r\mathrm{A}_0''\right]\mathrm{A}_1\hbar\left(f(\hbar - 1) + \hbar r f'\right) - 2\hbar r^2\mathrm{A}_0'^2 \\
&+ \mathrm{A}_0^2(-1 + \hbar + r\hbar') \\
&- f\left[\mathrm{A}_1\hbar^2(\mathrm{A}_1 + 4r\mathrm{A}_1') + 4m_\rho^2(r\hbar' - 1)\right. \\
&\left.+ \hbar\left(4m_\rho^2 + \mathrm{A}_1^2(1 + 3r\hbar')\right)\right]4\mathrm{A}_0\mathrm{A}_0' f\hbar r + \mathrm{A}_0^2[f(\hbar - 1) - \hbar r f'] \\
&+ f\left[f\left(-4m_\rho^2 + \left(4m_\rho^2 + \mathrm{A}_1^2\right)\hbar + 3\mathrm{A}_1^2\hbar^2\right)\right. \\
&\left.+ \hbar r\left(2r\mathrm{A}_0'^2 + \left(4m_\rho^2 - 3\mathrm{A}_1^2\hbar\right)f'\right)\right]4\mathrm{A}_0 f\left[-2\hbar f' r\mathrm{A}_0'\right. \\
&\left.+ f\left(r\mathrm{A}_0'\hbar' + 2\hbar(\mathrm{A}_0' + r\mathrm{A}_0'')\right)\right] \\
&+ \mathrm{A}_0^2\left[3\hbar f'^2 r + 2f^2\hbar' - f\left(rf'\hbar' + 2\hbar(f' + rf'')\right)\right] \\
&+ f\left[4\mathrm{A}_1 f\hbar^2\mathrm{A}_1'(2f + rf')\right. \\
&\left.+ 4m_\rho^2\left(-\hbar r f'^2 + 2f^2\hbar' + f\left(rf'\hbar' + 2\hbar(f' + rf'')\right)\right)\right] \\
&+ \mathrm{A}_1^2\hbar\left[-\hbar r f'^2 + 6f^2\hbar' + f\left(2rf'\hbar' + 2\hbar(f' + rf'')\right)\right]\mathrm{A}_0\mathrm{A}_1[f(\hbar - 1) \\
&+ \hbar r f'] \int \mathcal{C} - 2\mathcal{M}/r\hbar r^2\mathrm{A}_0'^2 - 4\mathfrak{G}_{4,\chi}(-1 + \hbar + r\hbar) \\
&+ 4f\left[\mathfrak{G}_{4,\chi}\mathrm{A}_1\hbar^2(\mathrm{A}_1 + 2r\mathrm{A}_1') + \mathfrak{G}_4(r\hbar' - 1)\right. \\
&\left.+ \hbar\left(\mathfrak{G}_4 + 2\mathfrak{G}_{4,\chi}\mathrm{A}_1^2 r\hbar'\right)\right] \int 4f^2\left[-\mathfrak{G}_4 + \left(\mathfrak{G}_4 - \mathfrak{G}_{4,\chi}\mathrm{A}_1^2\right)\hbar + 2\mathfrak{G}_{4,\chi}\mathrm{A}_1^2\hbar^2\right] \\
&- 4\mathfrak{G}_{4,\chi}\mathrm{A}_0^2\hbar f' r + f\hbar r\left[8\mathfrak{G}_{4,\chi}\mathrm{A}_0\mathrm{A}_0' + r\mathrm{A}_0'^2 + 4\left(\mathfrak{G}_4 + 2\mathfrak{G}_{4,\chi}\mathrm{A}_1^2\hbar\right)f'\right]
\end{aligned}
$$

$$
\mathrm{A}_1 = \pm\sqrt{\frac{r^2(\mathrm{A}_0\mathrm{A}_0' f - fr\mathrm{A}_0'^2 + \mathrm{A}_0^2 f')}{f}}\sqrt{2\mathcal{P}(\mathcal{M}\mathcal{P} + \mathcal{Q})r + \frac{\mathcal{Q}^2}{r - 2\mathcal{M}}}
$$

$$\sqrt{-2\chi_c\left(1-\frac{2\mathcal{M}}{r}\right)+\frac{\left(\mathcal{P}+\frac{\mathcal{Q}}{r}\right)}{r}-2\mathcal{M}\sqrt{\mathcal{Q}^2+\frac{2\mathcal{P}(\mathcal{M}\mathcal{P}+\mathcal{Q})r}{r}-2\mathcal{M}\left\{\left[f\left(\mathfrak{G}_{4,\chi}-\mathfrak{G}_{4,\chi}\hbar\right.\right.\right.}}$$
$$\left.\left.+\,\mathfrak{G}_{4,\chi,\chi}\mathrm{A}_1^2\hbar^2\right)+2\mathfrak{G}_{4,\chi,\chi}\mathrm{A}_0\frac{\hbar}{f}\mathrm{A}_0'r\right]$$
$$-\frac{\hbar}{f}\left[\mathfrak{G}_{4,\chi,\chi}\mathrm{A}_0^2+f\left(\mathfrak{G}_{4,\chi}-\mathfrak{G}_{4,\chi,\chi}\mathrm{A}_1^2\hbar\right)\right]rf'\right\}\pm 2m_\rho^2 r\,/2m_\rho^2(r^2-2\mathcal{M}r)$$
$$+\,\mathcal{Q}^2\left[m_\rho^2(\mathcal{P}^2-2\chi_c)r^2+2m_\rho^2(\mathcal{P}\mathcal{Q}+2\mathcal{M}\chi_c)r+\mathcal{Q}^2\left(m_\rho^2-\chi_c\right)\right]^{\frac{1}{2}}1$$
$$/2fr^2\left\{-m_\rho^2(-1+rf'+f)-r^2\mathrm{A}_0'^2\right\}$$
$$+\frac{1}{4r^2}\mathfrak{G}_{5,\chi,\chi}\alpha_1^2\{2f[\mathrm{A}_0\mathrm{A}_1\mathrm{A}_0'+(\mathrm{A}_0^2-\mathrm{A}_1^2f^2)\mathrm{A}_1']+\mathrm{A}_1(\mathrm{A}_0^2-\mathrm{A}_1^2f^2)f'\}f$$
$$/2r\left\{m_\rho^2(-1+rf'+f)+r^2\mathrm{A}_0'^2\right\}$$
$$+\,1/4r^2\mathfrak{G}_{5,\chi,\chi}\alpha_1^3f^2[2\mathrm{A}_0\mathrm{A}_0'f+(-\mathrm{A}_0^2-\mathrm{A}_1^2f^2)f']-2r\mathrm{A}_0'^2+m_\rho^2(2f'+rf'')$$

$$\mathrm{A}_0=\mathcal{P}+\frac{\mathcal{Q}}{r}\left\{\mathfrak{G}_{4,\chi,\chi}\mathrm{A}_1^2\hbar^2f'r+f\left[\mathfrak{G}_{4,\chi}+\hbar\left(-\mathfrak{G}_{4,\chi,\chi}+\mathfrak{G}_{4,\chi,\chi}\mathrm{A}_1^2\hbar\right)r\hbar'\right]\right\}$$
$$+\frac{r}{8}\left[\mathrm{A}_0'^2\left(\hbar f'r-f(4\hbar+r\hbar')\right)-2f\hbar r\mathrm{A}_0''\right]\mathrm{A}_0r+\frac{1}{2}\mathrm{A}_0''r^2$$
$$+\,\mathfrak{G}_{5,\chi,\chi}\mathrm{A}_0\mathrm{A}_1^2(f\mathrm{A}_1'+\mathrm{A}_1f')$$
$$+\frac{1}{f}\mathfrak{G}_{5,\chi}\mathrm{A}_0(-(-1+f)f\mathrm{A}_1'+\mathrm{A}_1(1-2f)f')\mathfrak{G}_{5,\chi}\left(\mathrm{A}_0^2(f-1)\frac{f'}{f^2}\right.$$
$$\left.-\frac{2\mathrm{A}_0(f-1)\mathrm{A}_0'}{f}+\mathrm{A}_1^2(1-3f)f'\right)$$
$$+\,\mathfrak{G}_{5,\chi,\chi}\mathrm{A}_1^2(2\mathrm{A}_0\mathrm{A}_0'f+(\mathrm{A}_1^2f^2-\mathrm{A}_0^2)f')(\chi_c+\mathrm{A}_0^2-3\chi_cf)(\mathrm{A}_0^2-2\chi_cf)(\mathrm{A}_0\mathrm{A}_0'$$
$$-\,\chi_cf')$$

$$f'=-\frac{4f}{r}+\frac{\mathcal{Q}^2}{\chi_cr^3}+\frac{2\mathcal{P}\mathcal{Q}}{\chi_cr^2}+\frac{2\mathcal{P}^2}{\chi_cr}+4f^3+\frac{r^4f'\mathcal{Q}^2r}{\chi_c}+\frac{2\mathcal{P}\mathcal{Q}r^2}{\chi_c}+\frac{\frac{2\mathcal{P}^2r^3}{\chi_c}(r^4f)'\mathcal{Q}^2r}{\chi_c}+\frac{2\mathcal{P}\mathcal{Q}r^2}{\chi_c}$$
$$+\frac{2\mathcal{P}^2r^3}{\chi_c}r^4f\frac{\mathcal{Q}^2r^2}{2\chi_c}+\frac{2\mathcal{P}\mathcal{Q}r^2}{3\chi_c}\frac{\mathcal{P}^2r^4}{2\chi_c}+\mathcal{C}f\frac{1}{\chi_c}\left(\mathcal{P}+\frac{\mathcal{Q}}{r}\right)^2+\frac{\mathcal{C}}{r^4}$$

$$\mathrm{A}_\eta=\pm\frac{2m_\rho^2\sqrt{2\left(2\mathcal{M}^2m_\rho^2-\mathcal{Q}\right)r^2}}{\mathcal{Q}\left[2m_\rho^2r^2(2\mathcal{M}-r)-\mathcal{Q}^2\right]}\sqrt{\frac{r(\mathcal{P}^2r+4\mathcal{M}\chi_c-2r\chi_c)}{r}}-2\mathcal{M}m_\rho^2/2\,f(rf''+2f')$$
$$-\frac{\chi_c}{4}rf'^2-\chi_cff'f''\mathfrak{G}_6(rf''+2f')-\frac{rf'^2}{2rf}$$
$$-\frac{1}{r}[2ff''+(f'^2-2ff'')+f'^2/f]\mathfrak{G}_6+2\chi_c(f-1)f'^2\mathfrak{G}_{6,\chi}$$

**1.4. Agujeros negros cuánticos EGB en espacios curvos.**

$$\delta = \frac{1}{32\pi}\int d^4\sqrt{-g}[\mathcal{R} + \alpha\mathcal{L}_{\mathfrak{GB}}], \mathcal{L}_{\mathfrak{GB}}$$
$$= \mathcal{R}^2 - 4\mathcal{R}_{\mu\nu}\mathcal{R}^{\mu\nu} + \mathcal{R}_{\mu\nu\alpha\beta}\mathcal{R}^{\mu\nu\alpha\beta}2\alpha\left[\mathcal{R}\mathcal{R}_{\alpha\beta} - 2\mathcal{R}_{\alpha\sigma}\mathcal{R}^{\sigma}_{\beta} + \mathcal{R}^{\sigma\delta\epsilon}_{\alpha}\mathcal{R}_{\beta\sigma\delta\epsilon}\right]$$
$$-\frac{1}{2}\alpha g_{\alpha\beta}\mathcal{L}_{\mathfrak{GB}} + \mathcal{R}_{\alpha\beta} - \frac{1}{2}g_{\alpha\beta}\mathcal{R} = \mathcal{T}_{\alpha\beta}, \mathcal{T}^{\beta}_{\alpha}$$
$$= \rho(r)\varphi\left[\mathrm{B}(r)\delta^{\beta}_{\alpha} - \frac{\{1 + 3\mathrm{B}(r)\}r_{\alpha}r^{\beta}}{r_{\eta}r^{\eta}}\right], \langle\mathcal{T}^{\beta}_{\alpha}\rangle = -\rho(r)\frac{\varphi}{3}, \delta^{\beta}_{\alpha}$$
$$= -\rho(r)\delta^{\beta}_{\alpha}, \langle r_{\alpha}r^{\beta}\rangle$$
$$= \frac{1}{3}\delta^{\beta}_{\alpha}r_{\eta}r^{\eta}\int \omega_{\varrho}\rho\int \mathrm{B}(r) - 3\omega_{\varrho} + \frac{1}{6\omega_{\varrho}}\int \mathcal{T}^{\theta}_{\theta}\,\mathcal{T}^{\phi}_{\phi} - \frac{1}{2}\rho(3\omega_{\varrho} + 1)$$

$$ds^2 = -f(r)dt^2 + \frac{1}{f(r)dr^2} + r^2(d\theta^2 + sin^2\theta d\phi^2), \langle\mathcal{T}^{r}_{r}\rangle$$
$$= \frac{f'}{f} + f - \frac{1}{r^2} - \alpha\left[2ff' - \frac{2f'}{r^3} - f^2 - 2f + \frac{1}{r^4}\right], \langle\mathcal{T}^{\theta}_{\theta}\mathcal{T}^{\phi}_{\phi}\rangle$$
$$= \frac{f''}{2} + \frac{f'}{r}$$
$$-\frac{\alpha}{2}\left[2ff'' - 2f' + \frac{2f'^2}{r^2} + 4f' + 2f^2 - \frac{4ff'}{r^3} + 2f^2 - 4f + \frac{2}{r^4}\right], \rho$$
$$= \frac{f'}{f} + f - \frac{1}{r^2} - \alpha\left[2ff' - \frac{2f'}{r^3} - f^2 - 2f + \frac{1}{r^4}\right] - \frac{\rho(3\omega_{\varrho} + 1)}{2}$$
$$= \frac{f''}{2} + \frac{f'}{r}$$
$$-\frac{\alpha}{2}\left[2ff'' - 2f'' + \frac{2f'^2}{r^2} + 4f' + 2f^2 - \frac{4ff'}{r^3} + 2f^2 - 4f + \frac{2}{r^4}\right][r^2f']'$$
$$+ (3\omega_{\varrho} + 1)[r(f-1)]'$$
$$-\alpha\left\{2[(f-1)f']' + (3\omega_{\varrho} - 1)\left(\frac{f^2}{r}\right)' - (6\omega_{\varrho} - 2)\left(\frac{f}{r}\right)' - 3\omega_{\varrho} - 1/r^2\right\}$$

$$f_{\pm}(r) = 1 + \frac{r^2}{2\alpha}\left[1 \pm \sqrt{1 + \frac{16\alpha\mathcal{M}}{r^3} + 16\alpha\Gamma/r^{3\omega_{\varrho}+3}}\right]\int 1 - \frac{2\mathcal{M}}{r} + \frac{2\mathfrak{C}}{r^{3\omega_{\varrho}+1}} + \frac{r^2}{\alpha}\int 1 + \frac{2\mathcal{M}}{r}$$
$$-\frac{2\mathfrak{C}}{r^{3\omega_{\varrho}+1}} - \frac{r^2}{\alpha}$$

### 1.5. Horizonte de eventos de un agujero negro cuántico en espacios curvos.

$$2\alpha\tau_{\hbar}^{3\omega_{\varrho}/2} + \tau_{\hbar}^{(3\omega_{\varrho}+4)/2} - \sqrt{\tau_{\hbar}^{3\omega_{\varrho}+4} + 16\alpha\tau_{\hbar}^{3\omega_{\varrho}+1} + 16\alpha\Gamma\tau_{\hbar}}, \boldsymbol{\alpha}(\boldsymbol{\Gamma}, \tau_{\hbar})$$
$$= \mathbf{2}\tau_{\hbar} - \tau_{\hbar}^{2}$$
$$+ 2\Gamma$$
$$/\tau_{\hbar}^{3\omega_{\varrho}-1} \int dc\, c_e(\tau_{\hbar}) \left(1 - \tau_{\hbar}\tau_{\hbar}^{3\omega_{\varrho}}/3\omega_{\varrho} - 1\right)^{3\omega_{\varrho}} \int 18\omega_{\varrho}^{2} - 1$$
$$\equiv c_c\alpha_c(c_c, \tau_e)\left[\tau_{\hbar}^{3\omega_{\varrho}}\left(\tau_{\hbar}^{3} + 2\alpha\right) + 2c\alpha\left(1 - 3\omega_{\varrho}\right)\right.$$
$$\left. - \tau_{\hbar}^{(3\omega_{\varrho}+3)/2}\sqrt{\tau_{\hbar}^{3\omega_{\varrho}}\left(\tau_{\hbar}^{3} + 16\alpha\right) + 16c\alpha}\right] \otimes 1$$
$$/\alpha\tau_{\hbar}^{(3\omega_{\varrho}+1)/2}\sqrt{\tau_{\hbar}^{3\omega_{\varrho}}\left(\tau_{\hbar}^{3} + 16\alpha\right) + 16c\alpha}$$

## 1.6. Perturbaciones escalares de un agujero negro cuántico EGB.

$$1/\sqrt{-g}\partial_{\mu}\left(\sqrt{-g}g^{\mu\nu}\partial_{\nu}\right)\phi \int \frac{e^{-i\omega\tau}\mathcal{Y}(\theta,\phi)\xi(r)}{r} dr_{\circledast} \frac{dr}{f(r)} d^{2}\xi(r)/dr_{\circledast}^{2}$$
$$+ [\omega^{2} - \mathcal{V}_{\mathbb{E}}(r)]\xi(r), \mathcal{V}_{\mathbb{E}}(r)$$
$$= f(r)\left[\frac{\ell(\ell+1)}{r^{2}} + \frac{f'^{(r)}}{r}\right]1$$
$$/\sqrt{-g}\partial_{\mu}\left(\sqrt{-g}\mathfrak{F}_{\beta\gamma}g^{\beta\nu}g^{\gamma\mu}\right)\Lambda_{\phi}\xi(r)\sin(\omega t)\sin\theta\, d\mathcal{P}_{\ell}(\cos\theta)/d\theta, \mathcal{V}_{\mathbb{EM}}(r)$$
$$= f(r)[\ell(\ell+1)/r^{2}]$$

$$\omega^{2} = \left[\mathcal{V}_{0} + (-2\mathcal{V}_{0}'')^{1/2}\Lambda\right] - i\hat{\alpha}(-2\mathcal{V}_{0}'')^{1/2}[1 + \overline{\Omega}]$$

$$\Omega = \sqrt{f(r_0)/r_0^{2}}, \Lambda = \sqrt{f(r_0)/2r_0^{2}\left(2f(r_0) - r_0 f''(r_0)\right)}$$

## 1.7. Agujeros negros cuánticos en espacios curvos (métrica).

### 1.7.1. Modelo Ashtekar-Pawlowski-Singh.

$$ds_{\mathcal{APS}}^{2} = -d\tau^{2} + \alpha(\tau)^{2}d\tilde{r}^{2} + \alpha(\tau)^{2}\tilde{r}^{2}d\Omega_{2}^{2}, \mathcal{H}^{2} \triangleq \left(\frac{\dot{\alpha}}{\alpha}\right)^{2} = \frac{16\pi\mathfrak{G}\rho}{3}(1 - \rho/\rho_c)$$

### 1.7.2. Modelo Oppenheimer-Snyder.

$$ds_{qOS}^{2} = -\left(1 - \mathcal{F}(r)\right)dt^{2} + \frac{dr^{2}}{1} - \mathfrak{G}(r) + r^{2}d\Omega_{2}^{2}, ds_{qOS}^{2}$$
$$= -\left(1 - \frac{2\mathcal{M}}{r} + \frac{\alpha\mathcal{M}^{2}}{r^{4}}\right)dt^{2} + \left(1 - \frac{2\mathcal{M}}{r} + \frac{\alpha\mathcal{M}^{2}}{r^{4}}\right)dr^{2} + r^{2}d\Omega_{2}^{2}, r_{\beta}$$
$$= \left(\frac{\alpha\mathcal{M}}{2}\right)^{\frac{1}{3}}, r_{\pm} = \zeta\left(1 \pm \sqrt{2\zeta - 1}\right)\sqrt{\alpha}/\sqrt{(1+\zeta)(1+\zeta)^{3}}$$

### 1.7.3. Algoritmo Newman-Janis.

$$ds_{eff}^2 = -\Delta(r) - \frac{\alpha^2 sin^2\theta}{\rho^2} dt^2 + \frac{\rho^2}{\Delta(r)} dr^2 + \rho^2 d\theta^2 + (r^2+\alpha^2)sin^2\theta - \frac{\Delta(r)\alpha^2 sin^4\theta}{\rho^2} d\phi^2 - \frac{2\alpha sin^2\theta\left(\alpha^2+r^2-\Delta(r)\right)}{\rho^2} dtd\phi, \Delta(r) = r^2+\alpha^2-2\mathcal{M}r+\frac{\alpha\mathcal{M}^2}{r^2}, \rho^2 = r^2+\alpha^2\,cos^2\theta, \Delta(r) = \Delta_{Kerr}(r)+\frac{\alpha\mathcal{M}^2}{r^2}$$

### 1.7.4. Formalismo Jacobi – Hamilton y métrica de Kerr.

$$2\partial_t\delta = -g^{\mu\nu}\partial_{\chi^\mu}\delta\partial_{\chi^\nu}\delta, \delta = \frac{1}{2}m_\rho^2\tau - \mathbb{E}t + \mathcal{L}\phi + A_r(r) + A_\theta(\theta), \rho^2\dot{t} = r^2 + \frac{\alpha^2}{A_r(r)(\mathbb{E}(r^2+\alpha^2)-\alpha\mathcal{L})} + \alpha(\mathcal{L}-\alpha\mathfrak{E}\,sin^2\theta), \rho^2\dot{r} = \pm\sqrt{\mathcal{R}(r)}, \rho^2\dot{\theta} = \pm\sqrt{\Theta(\theta)}, \rho^2\dot{\phi} = \frac{\alpha}{\Delta(r)(\mathbb{E}(r^2+\alpha^2)-\alpha\mathcal{L})} + (\mathcal{L}\,csc^2\theta - \alpha\mathfrak{E}), \mathcal{R}(r) = \left((r^2+\alpha^2)\mathbb{E}-\alpha\mathcal{L}\right)^2 - \Delta(r)(\mathcal{Z}+(\mathcal{L}-\alpha\mathfrak{E})^2), \Theta(\theta) = \mathcal{Z} + cos^2\theta(\alpha^2\mathbb{E}^2 - \mathcal{L}^2csc^2\theta), \mathcal{R}(r) = \mathcal{R}_{Kerr}(r) - \frac{\alpha(\mathcal{Z}+(\mathcal{L}-\alpha\mathfrak{E})^2)\mathcal{M}^2}{r^2}, \mathcal{V}^{eff}(r) = \mathcal{V}_{Kerr}^{eff}(r) + \alpha(\mathcal{Z}+(\mathcal{L}-\alpha\mathfrak{E})^2)\mathcal{M}^2/2r^6$$

$$\xi(r_\rho) = \xi_{Kerr}(r_\rho) + \frac{2\alpha\mathcal{M}^2 r_\rho\left(\Delta_{Kerr}(r_\rho)+r_\rho\Gamma\right)}{\alpha\Gamma\left(\alpha\mathcal{M}^2-r_\rho^3\Gamma\right)}, \eta(r_\rho) = \eta_{Kerr}(r_\rho) + 4\alpha\mathcal{M}^2r_\rho^3 / \Gamma^2\left(\alpha\mathcal{M}^2-\Gamma r_\rho^3\right)^2\left[2\Gamma r_\rho^3(\mathcal{M}-\Gamma) - \alpha\mathcal{M}^3 + r_\rho^2(\mathcal{M}-2\Gamma)\left[\mathcal{M}\left(\alpha\mathcal{M}-3r_\rho^2\Gamma\right)+\Gamma r_\rho^3\right]/\alpha^2\right]$$

$$\boldsymbol{\chi}(r_\rho) = -\lim_{\substack{r\to\infty\\ \theta\to\theta_0}} r^2\sin\theta\, d\phi/dr, \boldsymbol{\gamma}(r_\rho) = -\lim_{\substack{r\to\infty\\ \theta\to\theta_0}} r^2\, d\theta/dr$$

$$\boldsymbol{\chi}(r_\rho) = -\xi(r_\rho), \boldsymbol{\gamma}(r_\rho) = \pm\sqrt{\eta(r_\rho)}, \boldsymbol{\chi}(r_\rho) = \chi_{Kerr}(r_\rho) - \frac{2\alpha\mathcal{M}^2 r_\rho\left(\Delta_{Kerr}(r_\rho)+r_\rho\Gamma\right)}{\alpha\Gamma\left(\alpha\mathcal{M}^2-r_\rho^3\Gamma\right)}, \boldsymbol{\gamma}(r_\rho) = \gamma_{Kerr}(r_\rho) \pm \frac{2\alpha\mathcal{M}^2r_\rho^3}{\Gamma^2\sqrt{\eta_{Kerr}(r_\rho)}\left(\alpha\mathcal{M}^2-\Gamma r_\rho^3\right)^2}\left[\frac{r_\rho^2(\mathcal{M}-2\Gamma)\left[\mathcal{M}\left(\alpha\mathcal{M}-3r_\rho^2\Gamma\right)+\Gamma r_\rho^3\right]}{\alpha^2} + 2\Gamma r_\rho^3(\mathcal{M}-\Gamma) - \alpha\mathcal{M}^3\right]$$

### 1.7.5. Método Kumar-Ghosh.

$$A_{sh} = 2\int_{r_-}^{r_+} d\chi^r\gamma(r)\,\partial_r\chi(r), \theta_d = \frac{2}{d}\sqrt{\frac{A_{sh}}{\pi}}$$

## 2. Campos cuánticos gravitacionales en espacios curvos (gravedad cuántica).

$$
\begin{aligned}
\mathfrak{G} = &-\frac{1}{2}\left(g_{\mu\nu}\mathcal{F} + \mathcal{F}_{\mu\alpha}\mathcal{F}_{\nu}^{\alpha}\right) - \frac{1}{2}g_{\mu\nu}\mathfrak{G}_2 - \frac{1}{2}\mathfrak{G}_{2,\chi}\mathrm{A}_{\mu}\mathrm{A}_{\nu} - \frac{1}{2}\mathfrak{G}_{2,\mathcal{F}}\mathcal{F}_{\mu\alpha}\mathcal{F}_{\nu}^{\alpha} \\
&+ \mathfrak{G}_{2,\mathcal{Y}}\left(2\mathrm{A}^{\sigma}\mathrm{A}_{\mu}\mathcal{F}_{\alpha}^{\nu}\mathcal{F}_{\sigma\alpha} - \mathrm{A}^{\alpha}\mathrm{A}^{\beta}\mathcal{F}_{\beta\nu}\mathcal{F}_{\mu\alpha}\right) \\
&+ \mathfrak{G}_{3,\chi}\left[-\frac{1}{2\mathrm{A}_{\mu}\mathrm{A}_{\nu}\nabla_{\alpha}\mathrm{A}^{\alpha}} + \mathrm{A}^{\alpha}\left(\mathrm{A}_{\mu}\nabla_{\nu}\mathrm{A}_{\alpha} - \frac{1}{2}g_{\mu\nu}\mathrm{A}^{\beta}\nabla_{\alpha}\mathrm{A}_{\beta}\right)\right] + \mathfrak{G}_4\mathfrak{G}_{\mu\nu} \\
&+ \mathfrak{G}_{4,\chi}\left[\frac{1}{2}g_{\mu\nu}(\nabla_{\alpha}\mathrm{A}^{\alpha})^2 - \frac{1}{2}g_{\mu\nu}\nabla_{\alpha}\mathrm{A}_{\beta}\nabla^{\beta}\mathrm{A}^{\alpha} - 2\mathrm{A}_{\mu}\nabla_{\nu}\nabla_{\alpha}\mathrm{A}^{\alpha} + g_{\mu\nu}\mathrm{A}_{\beta}\nabla^{\beta}\nabla^{\alpha}\mathrm{A}_{\alpha}\right. \\
&+ \nabla_{\alpha}\left(\mathrm{A}_{\mu}\nabla^{\alpha}\mathrm{A}_{\nu} + \mathrm{A}_{\mu}\nabla_{\nu}\mathrm{A}^{\alpha} - \mathrm{A}^{\alpha}\nabla_{\mu}\mathrm{A}_{\nu}\right) - 2\nabla_{\alpha}\mathrm{A}_{\mu}\nabla_{\nu}\mathrm{A}^{\alpha} \\
&\left.-\frac{1}{2}\left(\mathcal{R}\mathrm{A}_{\mu}\mathrm{A}_{\nu} + \nabla_{\mu}\nabla_{\nu}\mathrm{A}^2 - g_{\mu\nu}\boxdot\mathrm{A}^2\right)\right] \\
&+ \mathfrak{G}_{4,\chi,\chi}\left[\frac{1}{4}\nabla_{\mu}\mathrm{A}^2\nabla_{\nu}\mathrm{A}^2 - \frac{1}{4}g_{\mu\nu}\nabla^{\alpha}\mathrm{A}^2\nabla_{\alpha}\mathrm{A}^2 + \mathrm{A}_{\mu}\nabla_{\nu}\mathrm{A}^2\nabla_{\alpha}\mathrm{A}^{\alpha}\right. \\
&\left.-\frac{1}{2}g_{\mu\nu}\mathrm{A}^{\beta}\nabla_{\beta}\mathrm{A}^2\nabla_{\alpha}\mathrm{A}^{\alpha} - \frac{1}{2}\nabla_{\alpha}\mathrm{A}^2\left(\mathrm{A}_{\mu}\nabla^{\alpha}\mathrm{A}_{\nu} + \mathrm{A}_{\mu}\nabla_{\nu}\mathrm{A}^{\alpha} - \mathrm{A}^{\alpha}\nabla_{\mu}\mathrm{A}_{\nu}\right)\right]
\end{aligned}
$$

$$
\begin{aligned}
\mathfrak{G} = &\nabla_{\beta}\mathcal{F}^{\alpha\beta} - \mathfrak{G}_{2,\chi}\mathrm{A}^{\alpha} + \nabla_{\beta}\mathfrak{G}_{2,\mathcal{F}}\mathcal{F}^{\beta\alpha} + \mathfrak{G}_{2,\mathcal{F}}\nabla_{\beta}\mathcal{F}^{\beta\alpha} - 4\nabla_{\beta}\mathfrak{G}_{2,\mathcal{Y}}\mathrm{A}^{\nu}\mathrm{A}^{\beta}\mathcal{F}_{\nu}^{\alpha} \\
&- 2\mathfrak{G}_{2,\mathcal{Y}}\left[\mathrm{A}_{\mu}\mathcal{F}_{\mu\lambda}\mathcal{F}^{\alpha\lambda} + 2\left(\nabla_{\beta}\mathrm{A}^{\nu}\right)\mathrm{A}^{\beta}\mathcal{F}_{\nu}^{\alpha} - 2\mathrm{A}^{\nu}\nabla_{\beta}\mathrm{A}^{\beta}\mathcal{F}_{\nu}^{\alpha} - 2\mathrm{A}^{\nu}\mathrm{A}^{\beta}\nabla_{\beta}\mathcal{F}_{\nu}^{\alpha}\right] \\
&+ \mathfrak{G}_{3,\chi}\left(\frac{1}{2}\nabla^{\alpha}\mathrm{A}^2 - \mathrm{A}^{\alpha}\nabla_{\mu}\mathrm{A}^{\mu}\right) + 2\mathfrak{G}_{4,\chi}\mathfrak{G}^{\beta\alpha}\mathrm{A}_{\beta} \\
&- \mathfrak{G}_{4,\chi,\chi}\left[\mathrm{A}^{\alpha}\left(\nabla_{\mu}\mathrm{A}^{\mu}\right)^2 - \mathrm{A}^{\alpha}\nabla_{\mu}\mathrm{A}_{\nu}\nabla^{\nu}\mathrm{A}^{\mu} - \nabla_{\beta}\mathrm{A}^2\left(g^{\alpha\beta}\nabla_{\mu}\mathrm{A}^{\mu} - \nabla^{\alpha}\mathrm{A}^{\beta}\right)\right] \\
&+ \mathfrak{G}_{5,\chi}\left[\frac{1}{2}\nabla_{\beta}\mathrm{A}^2\mathfrak{G}^{\beta\alpha} - \mathrm{A}^{\alpha}\mathfrak{G}_{\mu\nu}\nabla^{\mu}\mathrm{A}^{\nu} + \frac{1}{2}\nabla_{\mu}\mathrm{A}^{\mu}\nabla^{\alpha}\nabla_{\beta}\mathrm{A}^{\beta} - \nabla_{\beta}\left(\nabla_{\mu}\mathrm{A}^{\mu}\nabla^{\alpha}\mathrm{A}^{\beta}\right)\right. \\
&\left.-\frac{1}{2}\nabla^{\alpha}\left(\nabla_{\rho}\mathrm{A}_{\sigma}\nabla^{\sigma}\mathrm{A}^{\rho}\right)\right] \\
&+ \mathfrak{G}_{5,\chi,\chi}\left\{\frac{1}{6}\mathrm{A}^{\alpha}\left[\left(\nabla_{\mu}\mathrm{A}^{\mu}\right)^3 - 3\nabla_{\mu}\mathrm{A}^{\mu}\nabla_{\rho}\mathrm{A}_{\sigma}\nabla^{\sigma}\mathrm{A}^{\rho} + 2\nabla_{\rho}\mathrm{A}_{\sigma}\nabla^{\nu}\mathrm{A}^{\rho}\nabla^{\sigma}\mathrm{A}_{\nu}\right]\right. \\
&-\frac{1}{4}\left[\nabla^{\alpha}\mathrm{A}^2\left(\nabla_{\mu}\mathrm{A}^{\mu}\right)^2 + \nabla^{\alpha}\mathrm{A}^2\nabla_{\rho}\mathrm{A}_{\sigma}\nabla^{\sigma}\mathrm{A}^{\rho} + 2\nabla_{\beta}\mathrm{A}^2\nabla_{\mu}\mathrm{A}^{\mu}\nabla^{\alpha}\mathrm{A}^{\beta}\right. \\
&\left.\left.- 2\nabla_{\beta}\mathrm{A}^2\nabla^{\nu}\mathrm{A}^{\beta}\nabla^{\alpha}\mathrm{A}_{\nu} + 4\mathrm{A}^2\nabla_{\beta}\left(\nabla^{\nu}\mathrm{A}^{\beta}\nabla^{\alpha}\mathrm{A}_{\nu}\right)\right]\right\} \\
&+ g_5\left[\nabla_{\beta}\tilde{\mathcal{F}}^{\beta\mu}\tilde{\mathcal{F}}_{\mu}^{\alpha} + \tilde{\mathcal{F}}^{\beta\mu}\nabla_{\beta}\tilde{\mathcal{F}}_{\mu}^{\alpha} - 2\nabla_{\beta}\tilde{\mathcal{F}}_{\mu}^{\sigma}\varepsilon^{\lambda\mu\alpha\beta}\nabla_{\lambda}\mathrm{A}_{\sigma} - 2\tilde{\mathcal{F}}_{\mu}^{\sigma}\varepsilon^{\lambda\mu\alpha\beta}\nabla_{\beta}\nabla_{\lambda}\mathrm{A}_{\sigma}\right] \\
&+ g_{5,\chi}\left[\mathrm{A}^{\alpha}\tilde{\mathcal{F}}^{\gamma\mu}\tilde{\mathcal{F}}_{\mu}^{\beta}\nabla_{\lambda}\mathrm{A}_{\beta} + \mathrm{A}_{\beta}\tilde{\mathcal{F}}_{\mu}^{\sigma}\varepsilon^{\lambda\mu\alpha\beta}\nabla_{\lambda}\mathrm{A}_{\sigma} - \frac{1}{2}\nabla_{\beta}\mathrm{A}^2\tilde{\mathcal{F}}^{\beta\mu}\tilde{\mathcal{F}}_{\mu}^{\alpha}\right] \\
&- 2\mathfrak{G}_6\left[\nabla_{\beta}\mathcal{L}^{\beta\alpha\gamma\sigma}\nabla_{\gamma}\mathrm{A}_{\sigma} + \mathcal{L}^{\beta\alpha\gamma\sigma}\nabla_{\beta}\nabla_{\gamma}\mathrm{A}_{\sigma}\right] \\
&+ \mathfrak{G}_{6,\chi}\left[\nabla_{\beta}\mathrm{A}^2\mathcal{L}^{\beta\alpha\gamma\sigma}\nabla_{\gamma}\mathrm{A}_{\sigma} - \varepsilon^{\gamma\sigma\beta\alpha}\nabla_{\beta}\tilde{\mathcal{F}}^{\mu\nu}\nabla_{\gamma}\mathrm{A}_{\mu}\nabla_{\sigma}\mathrm{A}_{\nu}\right. \\
&- \varepsilon^{\gamma\sigma\beta\alpha}\tilde{\mathcal{F}}^{\mu\nu}\left(\nabla_{\beta}\nabla_{\gamma}\mathrm{A}_{\mu}\right)\nabla_{\sigma}\mathrm{A}_{\nu} - \varepsilon^{\gamma\sigma\beta\alpha}\nabla_{\beta}\tilde{\mathcal{F}}^{\mu\nu}\nabla_{\gamma}\mathrm{A}_{\mu}\nabla_{\beta}\nabla_{\sigma}\mathrm{A}_{\nu} \\
&- \mathrm{A}^{\alpha}\mathcal{L}^{\mu\nu\gamma\beta}\nabla_{\mu}\mathrm{A}_{\nu}\nabla_{\gamma}\mathrm{A}_{\beta} - \nabla_{\beta}\tilde{\mathcal{F}}^{\mu\nu}\varepsilon^{\gamma\sigma\beta\alpha}\nabla_{\mu}\mathrm{A}_{\gamma}\nabla_{\nu}\mathrm{A}_{\sigma} - \tilde{\mathcal{F}}^{\mu\nu}\varepsilon^{\gamma\sigma\beta\alpha}\left(\nabla_{\beta}\nabla_{\mu}\mathrm{A}_{\gamma}\right)\nabla_{\nu}\mathrm{A}_{\sigma} \\
&- \tilde{\mathcal{F}}^{\mu\nu}\varepsilon^{\gamma\sigma\beta\alpha}\nabla_{\mu}\mathrm{A}_{\gamma}\nabla_{\beta}\nabla_{\nu}\mathrm{A}_{\sigma} - \nabla_{\beta}\tilde{\mathcal{F}}^{\gamma\beta}\tilde{\mathcal{F}}^{\mu}\nabla_{\gamma}\mathrm{A}_{\mu} - \tilde{\mathcal{F}}^{\gamma\beta}\nabla_{\beta}\mathcal{F}^{\mu\alpha}\nabla_{\gamma}\mathrm{A}_{\mu} \\
&\left.- \tilde{\mathcal{F}}^{\gamma\beta}\tilde{\mathcal{F}}^{\mu\alpha}\nabla_{\beta}\nabla_{\gamma}\mathrm{A}_{\mu}\right] \\
&+ \frac{\mathfrak{G}_{6,\chi,\chi}}{2}\left[\nabla_{\beta}\mathrm{A}^2\varepsilon^{\gamma\sigma\beta\alpha}\tilde{\mathcal{F}}^{\mu\nu}\nabla_{\gamma}\mathrm{A}_{\mu}\nabla_{\sigma}\mathrm{A}_{\nu} - \mathrm{A}^{\alpha}\tilde{\mathcal{F}}^{\gamma\beta}\tilde{\mathcal{F}}^{\mu\nu}\nabla_{\gamma}\mathrm{A}_{\mu}\nabla_{\beta}\mathrm{A}_{\nu}\right. \\
&\left.+ \nabla_{\beta}\mathrm{A}^2\tilde{\mathcal{F}}^{\mu\nu}\varepsilon^{\gamma\sigma\beta\alpha}\nabla_{\mu}\mathrm{A}_{\gamma}\nabla_{\nu}\mathrm{A}_{\sigma} + \nabla_{\beta}\mathrm{A}^2\tilde{\mathcal{F}}^{\gamma\beta}\tilde{\mathcal{F}}^{\mu\alpha}\nabla_{\gamma}\mathrm{A}_{\mu}\right]
\end{aligned}
$$

**3. Decoherencia cuántica en espacios curvos.**

$$|\psi(t_\eta)\rangle = \sum_{\chi_\eta} \Pi_{\chi_\eta} \mathcal{U}_{\eta,\eta-1} \otimes \sum_{\chi_1} \Pi_{\chi_1} \mathcal{U}_{1,0} \sum_{\chi_0} \Pi_{\chi_0} |\psi(t_0)\rangle \equiv \sum_{\chi} |\psi(\chi)\rangle , \mathfrak{D}(\chi,\gamma)$$
$$\equiv \langle\psi(\chi)|\psi(\gamma)\rangle, \epsilon(\chi,\gamma) \equiv \frac{|\mathfrak{D}(\chi,\gamma)|}{\sqrt{\mathfrak{D}(\chi,\chi)\mathfrak{D}(\gamma,\gamma)}}, \epsilon$$
$$\equiv \frac{1}{\mathfrak{M}^{2\mathfrak{L}-1}} - \mathfrak{M}^{\mathfrak{L}} \sum_{\chi \neq \gamma} |\epsilon(\chi,\gamma)| , \rho(z)$$
$$\equiv \sum_{\chi(z),\gamma(z)} \mathfrak{D}(\chi,\gamma) \langle\psi(t_0)|\mathcal{U}^\dagger_{2,0}\Pi_{\chi_4}\mathcal{U}^\dagger_{7,2}\Pi_{\chi_3}\mathcal{U}_{7,2}\Pi_{\chi_4}\mathcal{U}_{2,0}|\psi(t_0)\rangle, \rho_{cl}(z)$$
$$\equiv \sum_{\chi(z)} \mathfrak{D}(\chi,\chi) , \Delta_\Gamma(\rho|\rho_{cl}) \equiv \frac{1}{2} \sum_{z\in\mathbb{Z}_\mathcal{T}} |\rho(z) - \rho_{cl}(z)| \in [0,1], \Delta_\Gamma(\rho|\rho_{cl})$$
$$= \frac{1}{2} \sum_{z\in\mathbb{Z}_\mathcal{T}} \left| \sum_{\chi(z)\neq\gamma(z)} \mathfrak{D}(\chi,\gamma) \right| \Delta_{\mathcal{L}}^{max} \equiv \max_{\mathcal{T}\cap\{\tau_\eta\}\neq\emptyset} \Delta_\Gamma(\rho|\rho_{cl})$$

$$\mathcal{H} = \mathcal{H}_\mathrm{A} + \mathcal{H}_\mathrm{B} + \lambda\mathcal{H}_\mathcal{J}, \mathcal{P}_m$$
$$= \sum_{\chi,\chi'} \delta_{m,\chi+\chi'} \Pi_{\chi,\chi'} \int \mathcal{H}_\mathcal{M} \equiv \mathcal{P}_m \mathcal{H} \mathcal{P}_m = \sum_{\chi,\gamma} \Pi_{\chi,m-\chi} \mathcal{H} \Pi_{\gamma,m-\gamma} , \mathcal{H}_0$$
$$= \begin{pmatrix} \mathcal{H}_{--} & \mathcal{H}_{-0} & \mathcal{H}_{-+} \\ \mathcal{H}_{0-} & \mathcal{H}_{00} & \mathcal{H}_{0+} \\ \mathcal{H}_{+-} & \mathcal{H}_{+0} & \mathcal{H}_{++} \end{pmatrix}$$

$$\frac{1}{\mathcal{V}_\pm \left(\frac{\pi\lambda\mathcal{V}_\pm}{2\Delta\xi}\right)^2}, \tau = \frac{\Delta\xi}{4\pi\lambda^2\mathcal{V}_\pm}, |\psi(t_0)\rangle$$
$$= \sqrt{\rho_-(0)}|\psi_-\rangle + \sqrt{\rho_0(0)}|\psi_0\rangle$$
$$+ \sqrt{\rho_+(0)} \Big| \psi_+\rangle\langle\psi(\chi)|\psi(\gamma)\rangle \sim \frac{1}{\mathcal{D}} \sum_i c_i^{\circledast}(\chi) c_i^{\circledast}(\gamma) \sim 1/\sqrt{\mathfrak{D}}$$

## 4. Partícula Cosmológica (comportamiento en espacios cuánticos curvos).

$$|\psi\rangle = \sum |c_{mn}| e^{i\varphi mn} \big| m\rangle_\rho |\eta\rangle_\delta, \phi_\mathcal{T} \equiv \frac{\dfrac{\dfrac{\partial\phi_{\mathcal{PT}}}{\partial\eta} \partial \left(\dfrac{\partial\varphi_{mn}}{\partial m}\right)}{\partial\eta} \dfrac{\partial\phi_{\delta\mathcal{T}}}{\partial m} \otimes \dfrac{\partial\phi_{\delta\mathcal{T}}}{\partial\omega_0} \partial\omega_0}{\partial m} = \frac{\tau_g \partial\omega_0}{\partial m}, \phi_\mathcal{T}$$
$$= \frac{\partial\phi_{\mathcal{PT}}}{\partial\eta} = -\frac{\tau_g \partial\omega_0}{\partial m}$$

$$\int \phi(t)dt = \frac{2}{\Gamma}\Delta/1 + (2\Delta/\Gamma)^2\ \sigma_0/\mathrm{A} \int \mathrm{N}_\epsilon^\delta(t)dt \int \phi_\mathcal{T}(t)dt = \mathcal{C}_{\tau_\mathcal{T}}, \delta\omega_{\mathcal{AC}}$$
$$= \frac{2\Omega^2}{\Gamma^2}\Delta/1 + \left(\frac{2\Delta}{\Gamma}\right)^2 = -\frac{\mathcal{I}}{\mathcal{I}_{sat}}\Delta/1 + \left(\frac{2\Delta}{\Gamma}\right)^2 \int \phi_\mathcal{T}(t)dt$$
$$= -\tau_g \int \frac{\delta\omega_{\mathcal{AC}}}{\mathrm{N}_\rho} dt = \frac{\hbar\omega_\rho}{\mathrm{A}\mathcal{I}_{sat}}\Delta/1 + \left(\frac{2\Delta}{\Gamma}\right)^2 \tau_g\sigma_0/\mathrm{A}\Gamma\ \omega_\rho/\omega_0\ \Delta/1$$
$$+ \left(\frac{2\Delta}{\Gamma}\right)^2 \tau_g\ \mathfrak{C}\ \omega_\rho/\omega_0\tau_g$$

## 5. Comportamiento de la luz en espacios cuánticos curvos.

$$dr' = dr(1 - r_\delta/r)^{-1/2} = ds\, sin\, \theta, r d\varphi = ds\, cos\, \theta, r\frac{d\varphi}{dr}$$
$$= (1 - r_\delta/r)^{-1/2}\, cot\, \theta, \eta_i r_i\, cos\, \theta_i = \eta r\, cos\, \theta = q, \frac{d\varphi}{dr}$$
$$= \frac{q}{r}\, 1/\sqrt{\eta^2 r^2 - q^2}\left(1 - \frac{r_\delta}{r}\right)^{-\frac{1}{2}}, \eta(r) = \left(1 - \frac{r_\delta}{r}\right)^{-\frac{1}{2}}, \frac{d\varphi}{dr}$$
$$= 1/r^2[r^3 - q^2(r - r_\delta)/q^2 r^2(r - r_\delta)]^{-1/2}\left(1 - \frac{r_\delta}{r}\right)^{-\frac{1}{2}}, \frac{d\varphi}{dr}$$
$$= 1/r^2[r^3 - q^2(r - r_\delta)/q^2 r^3]^{-1/2}\left(1 - \frac{r_\delta}{r}\right)^{-\frac{1}{2}}$$

$$\varphi_{ij} = \int_{r_i}^{r_j} d\varphi = \int_{r_i}^{r_j} \frac{d\ell}{r}$$
$$= \int_{r_i}^{r_j} \frac{dr'}{r\tan\theta} = \int_{r_i}^{r_j} \frac{dr\eta_0 r_0}{r\sqrt{\eta^2 r^2 - \eta_0^2 r_0^2}}\left(1 - \frac{r_\delta}{r}\right)^{-\frac{1}{2}} 2\eta(r_i)\sqrt{\frac{r_0(r_i - r_\delta)}{r_i Q}}\mathcal{F}(z_i, \kappa)$$
$$- 2\eta(r_j)\sqrt{\frac{r_0(r_j - r_\delta)}{r_j Q}}\mathcal{F}(z_j, \kappa)$$

$$\Delta\alpha^{(\mathcal{MMA})} = \alpha_\alpha - \alpha_v$$
$$= (\varphi_{0\mathcal{M}} + \varphi_{0\mathbb{E}})$$
$$- \left[\arccos\left(\frac{r_0}{r_\mathcal{M}}\right) + \arccos\left(\frac{r_0}{r_\mathfrak{E}}\right)\right]\left[4\eta_0\sqrt{r_0 - \frac{r_\delta}{Q}}\mathcal{F}\left(\frac{\pi}{2}, \kappa\right)\right.$$
$$\left. - 2\eta(r_\mathcal{M})\sqrt{\frac{r_0(r_\mathcal{M} - r_\delta)}{r_\mathcal{M} Q}}\mathcal{F}(z(r_\mathcal{M}), \kappa) - 2\eta(r_\mathfrak{E})\sqrt{\frac{r_0(r_\mathbb{E} - r_\delta)}{r_\mathfrak{E} Q}}\mathcal{F}(z(r_\mathbb{E}), \kappa)\right]$$
$$- \left[\arccos\left(\frac{r_0}{r_\mathcal{M}}\right) + \arccos\left(\frac{r_0}{r_\mathfrak{E}}\right)\right], \Delta\alpha^{(\mathcal{PPN})}$$
$$= (1 + \gamma)\frac{\mathfrak{G}\mathcal{M}_\delta}{r_0 c^2(\cos\beta - \cos\delta)}, \Delta\alpha^{(Einstein)} = \frac{2r_\delta}{r_0}, \Delta\alpha^{(Darwin)}$$
$$= 4\sqrt{\frac{r_0}{Q}}\left[\mathcal{F}\left(\frac{\pi}{2}, \kappa\right) - \mathcal{F}(z_\infty, \kappa)\right] - \varpi$$

$$\sin^2 z = 2r_0 r_\delta + \frac{r(r_\delta - r_0 + Q)}{r(3r_\delta - r_0 + Q)}, \kappa^2$$
$$= 3r_\delta - r_0 + \frac{Q}{2Q}, \sin z_\infty^2 = r_\delta - r_0 + +Q/3r_\delta - r_0 + Q$$

$$\Delta\alpha^{(\mathcal{MMA})} = \left[4\eta_0\sqrt{r_0 - \frac{r_\delta}{Q}}\mathcal{F}\left(\frac{\pi}{2},\kappa\right) - 2\eta(r_{\mathfrak{E}})\sqrt{\frac{r_0(r_{\mathbb{E}} - r_\delta)}{r_{\mathfrak{E}}Q}}\mathcal{F}(z(r_{\mathbb{E}}),\kappa) - 2\sqrt{\frac{r_0}{Q}}\mathcal{F}(z_\infty,\kappa)\right] - \left[\arccos\left(\frac{r_0}{r_{\mathfrak{E}}}\right) + \frac{\pi}{2}\right]$$

### 5.1. Métrica Shapiro.

$$\Delta t = 2\left[(t_{0\mathcal{M}} + t_{0\mathfrak{E}}) - \frac{1}{c}\left(\sqrt{r_{\mathcal{M}}^2 - r_0^2} + \sqrt{r_{\mathfrak{E}}^2 - r_0^2}\right)\right], t_{ij}^{(\mathfrak{GR})}$$

$$= \sqrt{\frac{r_j^2 - r_i^2}{c}} + \frac{r_\delta}{c}\log\left(r_j + \sqrt{\frac{r_j^2 - r_i^2}{c}}/r_i\right) + \frac{r_\delta}{2c}\sqrt{r_j - \frac{r_i}{r_j}} + r_i, t_{ij}^{(\mathcal{MMA})}$$

$$= \int_{r_i}^{r_j}\frac{\eta ds}{c} = \int_{r_i}^{r_j}\frac{\eta dr'}{c\sqrt{1-\cos^2\theta}} = \prod\frac{1}{c}\int_{r_i}^{r_j} dr\,\eta^2 r/\sqrt{\eta^2 r^2 - \eta_0^2 r_0^2}\left(1 - \frac{r_\delta}{r}\right)^{-\frac{1}{2}}$$

## 6. Ondas cuánticas no markovianas en espacios curvos.

### 6.1. Hamiltoniano Weisskopf-Wigner.

$$\frac{\hat{\mathcal{H}}}{\hbar} = \Delta\sum_{j=1}^{4}\hat{\alpha}_j^\dagger\hat{\alpha}_i^\star - \mathcal{J}\sum_{j=-\infty}^{\infty}(\hat{\alpha}_j^\dagger\hat{\alpha}_{i+1}^\star\hat{\alpha}_j^\star\hat{\alpha}_i^\dagger) + g\sum_{j=1}^{4}\hat{\alpha}_j^\dagger\hat{\beta}_j^\dagger + \hat{\alpha}_j^\star\hat{\beta}_j^\star)$$

$$\Big|\psi(t)\rangle = \mathrm{A}(t)\hat{\alpha}_1^\dagger\hat{\alpha}_2^\star|0\rangle + \sum_{j<j'}\mathrm{B}_{j,j'}(t)\left(1/\sqrt{2}\hat{\beta}_j^\dagger\hat{\beta}_i^\star\right)|0\rangle + \sum_{j,j'}\mathcal{C}_{j,j'}(t)\hat{\alpha}_j^\dagger\hat{\beta}_j^\dagger|0\rangle$$

$$f(t) = -\frac{1}{2\pi i}\int_{-\infty+i0^+}^{+\infty+i0^+}\tilde{f}(\omega)e^{-i\omega t}d\omega, |\psi_\sigma(t)\rangle$$

$$= \frac{\alpha_\sigma(t)}{\sqrt{2}(\hat{\alpha}_1^\dagger + \sigma\hat{\alpha}_2^\dagger)|0\rangle} + \sum_{j=2}^{\infty}\beta_{\sigma,j}(t)/\sqrt{2}(\hat{\beta}_{3-j}^\dagger + \sigma\hat{\beta}_j^\dagger)|0\rangle$$

$$\tilde{\alpha}_\sigma(\omega) = \frac{\left(-\omega - \Delta - \sigma g^2 + \sigma g^2\frac{\sqrt{\omega-\sigma}}{\sqrt{\omega+\sigma}}\right)^{-1}(\sigma+1)e^{i\sigma t}}{4\sqrt{\pi}g^2 t^{\frac{3}{2}}g^2(\sigma - i)e^{-i\sigma t}}/4\sqrt{\pi}(g^2 - 1 + \sigma\Delta)^2 t^{\frac{3}{2}}$$

$$|\tilde{\psi}(\omega)\rangle = \tilde{\mathrm{A}}(\omega)\hat{\alpha}_1^\dagger\hat{\alpha}_2^\star|0\rangle + \sum_{\rho<q}\hat{\mathrm{B}}_{p,q'}(\omega)\hat{\beta}_\rho^\dagger\hat{\beta}_q^\dagger|0\rangle + \sum_q\hat{\mathrm{B}}_{q,q'}(\omega)\left(\frac{1}{\sqrt{2}}\hat{\beta}_q^\dagger\hat{\beta}_q^\dagger\right)|0\rangle + \sum_{j,q}\hat{\mathcal{C}}_{j,q'}(\omega)\,\hat{\alpha}_j^\dagger\hat{\beta}_q^\dagger|0\rangle$$

$$\widehat{\mathrm{A}} = \frac{1}{\omega - 2\Delta} + \frac{gd}{\omega - 2\Delta} \int_{-\frac{\pi}{d}}^{\frac{\pi}{d}} \frac{\left(e^{-\frac{iqd}{2}}\tilde{\mathcal{C}}_{2,q} + e^{\frac{iqd}{2}}\tilde{\mathcal{C}}_{1,q}\right) dq}{2\pi} \widetilde{\mathrm{B}}_{\rho<q}$$

$$= \frac{g}{\omega} - \omega_\rho - \omega_q \sum_{j=1}^{4} e^{i\rho d\left(\frac{3}{2}-j\right)} \tilde{\mathcal{C}}_{j,q} + e^{iqd\left(\frac{3}{2}-j\right)} \tilde{\mathcal{C}}_{j,\rho} \widetilde{\mathrm{B}}_{q,q}$$

$$= \sqrt{2g}/\omega - 2\omega_q \sum_{j=1}^{4} e^{iqd\left(\frac{3}{2}-j\right)} \tilde{\mathcal{C}}_{j,q}$$

$$\mathcal{C}(\omega, z) = \sum_{j=-\infty}^{\infty} \tilde{\mathcal{C}}_{1,j}(\omega) z^{1-j} \, \mathcal{C}\left(\omega, e^{iqd}\right) = e^{-\frac{iqd}{2}} \tilde{\mathcal{C}}_{1,q}(\omega), \mathcal{C}_\sigma(\omega, z)$$

$$= \frac{1}{2}\left(\mathcal{C}(\omega, z) + \frac{\sigma}{z}\mathcal{C}(\omega, z^{-1})\right), \mathcal{C}_\sigma(\omega, z)$$

$$= g\left(\frac{1}{z} + \sigma\right) \tilde{\alpha}_\sigma(\delta\omega) \left(\frac{1}{2} + \frac{g\tilde{\mathcal{C}}_{1,2}(\omega)}{\omega} - 2\Delta\right.$$

$$\left. + \mathrm{g} \oint z' + \sigma/1 + 2\delta\omega\, z' + z'^2 \int \mathcal{C}_\sigma(\omega, z') dz' / 2\pi i \right)$$

## 6.2. Incrementales.

$$\delta\mathcal{C}_\sigma(z) = \left(2g\tilde{\mathcal{C}}_{1,1}\sigma - 1\right) z$$
$$+ \sigma/z \sqrt{\delta\omega - \sigma}/\sqrt{\delta\omega + \sigma}$$
$$/g^3([g^{-2}(\delta\omega - \Delta) - \sigma]^2 - \delta\omega - \sigma/\delta\omega + \sigma)(g^{-2}(z + 1/z/2 + \Delta) + 2\sigma z/z$$
$$- \sigma)$$

$$\delta^2\mathcal{C}_\sigma(z) = -2\sigma\left(2g\tilde{\mathcal{C}}_{1,1}\sigma - 1\right)\sqrt{\delta\omega - \sigma/}\sqrt{\delta\omega + \sigma}(z + \sigma)^2/z(z - \sigma)$$
$$/g^3([g^{-2}(\delta\omega - \Delta) - \sigma]^2 \delta\omega - \sigma/\delta\omega + \sigma)([g^{-2}(z + 1/z/2 + \Delta) + \sigma]^2$$
$$- (z + \sigma)^2/(z + \sigma)^2)$$

## 6.3. Función Φ.

$$\Phi(z) = -\mathcal{K}(\kappa^{-1}) sg\eta\mathcal{R}e\omega$$
$$/2\pi\sqrt{\kappa}\left(\frac{z^{-1} - z}{1 - \zeta(z)} + \frac{z + 1}{z - 1}(1 + \omega) + 2z - 1/z + 1\zeta^{-1}(-1) - z^2 - 6z\right.$$
$$\left. + 1/z^2 + 1\zeta^{-1}(z)\right)$$
$$- 2sg\eta\mathcal{R}e\omega$$
$$/\pi i\kappa\left(\mathcal{K}(\kappa^{-1})\mathfrak{E}(x; \kappa) - \kappa^2\mathbb{E}(\kappa^{-1})\mathcal{F}(x; \kappa) - (1 - \kappa^2)\mathcal{K}(\kappa^{-1})\mathcal{F}(x; \kappa)\right)$$

## 6.4. Integrales elípticas.

$$\mathcal{F}(x; \kappa) = \int_0^\chi \frac{dt}{\sqrt{1 - t^2}\sqrt{1 - \kappa^2 t^2}}, \mathfrak{E}(x; \kappa) = \int_0^\chi \frac{dt}{\sqrt{1 - \kappa^2 t^2}\sqrt{1 - t^2}} dt$$

### 6.5. Excentricidad.

$$\kappa = \omega^2 + \frac{-2\omega\sqrt{\omega-2}\sqrt{\omega+2}}{2} sgn\mathcal{J}m\omega = \begin{cases} +1 if\ \mathcal{J}m\omega > 0 \vee (\mathcal{J}m\omega = 0 \wedge \mathcal{R}e\omega < 2) \\ -1\ \doteq \end{cases}$$

$$\chi = \frac{\kappa^{-\frac{1}{2}} sgn\mathcal{J}m\omega}{\sqrt{-\kappa - \zeta^{-1}(-1)\frac{z+1}{z-1}}\sqrt{\zeta^{-1}(z) - \frac{\zeta(1)}{\zeta^{-1}(z)} - \zeta(-1)}}$$

$$\sqrt{\zeta^{-1}(-1) - \zeta(-1)/\zeta^{-1}(z) - \zeta(-1)\,\zeta^{-1}(z) - \zeta^{-1}(1)/\zeta^{-1}(-1) - \zeta^{-1}(1)}$$

$$sgn\mathcal{R}e\omega = \begin{cases} +1\ if\ \mathcal{R}e\omega \geqslant 0 \\ -1 \propto \end{cases}$$

### 6.6. Función Racional.

$$\begin{aligned} r_\sigma(z) = \frac{\sigma}{4}\left(\delta\mathcal{C}_\sigma(z) + \frac{\sigma}{z}\delta\mathcal{C}_\sigma\left(\frac{1}{z}\right)\right)\sqrt{\delta\omega+\sigma/}\sqrt{\delta\omega-\sigma}[g^{-2}(\delta\omega-\Delta)-\sigma] \\ + \left(2g\tilde{\mathcal{C}}_{1,1}\sigma - 1\right)\sum_{i=1}^{4}\alpha_\sigma(z_{\sigma i})(\sigma + z^{-1})\, z_{\sigma i}\left(\frac{1}{1+\delta\omega z_{\sigma i} + z_{\sigma i}^2}\right. \\ \left. - \frac{1}{(1-z_{\sigma i}z)(1-z_{\sigma i}z^{-1})}\right)(z_{\sigma i}^2 + 2\Delta z_{\sigma i} + 1)(z_{\sigma i} - \sigma)4g^2 z_{\sigma i}, \alpha_\sigma(z) \\ = \left(2\sigma(2\Phi(z)+1)\right)\sqrt{\delta\omega-\sigma/}\sqrt{\delta\omega+\sigma} \\ - [g^{-2}(\delta\omega-\Delta)-\sigma](1-z^{-2}) \\ /2g^3([g^{-2}(\delta\omega-\Delta)-\sigma]^2\delta\omega-\sigma/\delta\omega+\sigma)(g^{-2}(1-z^{-2})+4/(\sigma-z)^2) \end{aligned}$$

### 6.7. Amplitudes especiales.

$$2g\tilde{\mathcal{C}}_{1,1} = \frac{\sum_{\sigma,i}\sigma\alpha_\sigma(z_{\sigma i})}{\sum_{\sigma,i}\alpha_0(z_{\sigma i}), 2g\tilde{\mathcal{C}}_{1,2}} = \omega - \frac{2\Delta}{2\mathrm{g}}\left(\sum\nolimits_{\sigma,i}\sigma\alpha_\sigma(z_{\sigma i})\right)^2 - \frac{\left(\sum_{\sigma,i}\alpha_\sigma(z_{\sigma i})\right)^2}{\sum_{\sigma,i}\sigma\alpha_\sigma(z_{\sigma i})} - 1$$

### 6.8. Estructura Analítica.

$$\delta^2\mathcal{C}_\sigma(z) = \delta\mathcal{C}_\sigma(z) - \sigma z^{-1}\delta\mathcal{C}_\sigma(z^{-1}), \mathcal{C}_\sigma(z) = \frac{1}{2}\delta^2\mathcal{C}_\sigma(z)\left(\Phi(z)+\frac{1}{2}\right) - \frac{1}{2}\delta\mathcal{C}_\sigma(z) + \frac{1}{2}r_\sigma(z)$$

### 6.9. Análisis espectral.

$$\widetilde{\mathbf{A}}(\boldsymbol{\omega}) = \left(\sum\nolimits_{\sigma,i}\sigma\alpha_\sigma(\omega, z_{\sigma i})\right)^{\mathbf{2}} - \frac{\left(\sum_{\sigma,i}\alpha_\sigma(\omega, z_{\sigma i})\right)^{\mathbf{2}}}{\mathbf{2}\boldsymbol{g}}\sum\nolimits_{\sigma,i}\alpha_\sigma(\omega, z_{\sigma i}) \sim \frac{e^{\mp 2it}}{t}\log^2(t)$$

$$\hat{\alpha}_1^\dagger\hat{\alpha}_2^\dagger|0\rangle(1+\Delta)\Gamma\frac{1}{\sqrt{2}}(\hat{\alpha}_1^\dagger - \hat{\alpha}_2^\dagger)|0\rangle(1+\Delta)\Gamma|0\rangle(1-\Delta)\Gamma\frac{1}{\sqrt{2}}(\hat{\alpha}_1^\dagger + \hat{\alpha}_2^\dagger)|0\rangle(1-\Delta)\Gamma|0\rangle$$

### 6.9. Límite Markoviano.

$$\dot{\rho} = -i\left[\sum_{j=1}^{4} \Delta\hat{\alpha}_j^{\dagger}\hat{\alpha}_j^{\star}, \rho\right]$$
$$+ \sum_{\nu=1}^{4} \frac{\Gamma_\nu}{2}\left(2\hat{O}_\nu\rho\tilde{O}_\nu^{\dagger} - \rho\tilde{O}_\nu^{\dagger}\hat{O}_\nu - \tilde{O}_\nu^{\dagger}\hat{O}_\nu\rho\right)Tr\left(\hat{\alpha}_1^{\dagger}\hat{\alpha}_1 + \hat{\alpha}_2^{\dagger}\hat{\alpha}_2 - 2\hat{\alpha}_1^{\dagger}\hat{\alpha}_2^{\dagger}\hat{\alpha}_1\hat{\alpha}_2\right)\rho$$
$$= 1 - \Delta\,/1 + \Delta\, e^{-(1-\Delta)\Gamma t} + 1 + \Delta\,/1 - \Delta e^{-(1+\Delta)\Gamma t} - 2\;1 + \Delta^2\,/1 - \Delta^2 e^{-2\Gamma t}$$

## 6.10. Amplitudes de campo en espacios curvos.

$$\boldsymbol{\omega}\tilde{\mathrm{A}} - 1 = 2\Delta\tilde{\mathrm{A}} + g\sum_{q}\left(e^{iq\chi_1}\tilde{\mathfrak{C}}_{2,q} + e^{iq\chi_2}\tilde{\mathfrak{C}}_{1,q}\right)\omega\tilde{\mathrm{B}}_{\rho,q}$$
$$= \left(\omega_\rho + \omega_q\right)\tilde{\mathrm{B}}_{\rho,q}$$
$$+ g\sum_{j=1}^{4}\left(e^{-i\rho\chi_j}\tilde{\mathfrak{C}}_{j,q} + e^{-iq\chi_j}\tilde{\mathfrak{C}}_{j,\rho}\right)\omega\tilde{\mathrm{B}}_{q,q}$$
$$= 2\omega_q\tilde{\mathrm{B}}_{q,q} + \sqrt{2g}\sum_{j=1}^{4} e^{-iq\chi_j}\tilde{\mathfrak{C}}_{j,q}\omega\tilde{\mathfrak{C}}_{j,q} = \left(\Delta + \omega_q\right)\tilde{\mathfrak{C}}_{j,q} + g e^{iq\chi_j}\,\tilde{\mathrm{A}}$$
$$+ g\left(\sum_{\rho<q} e^{i\rho\chi_j}\tilde{\mathrm{B}}_{\rho,q} + \sum_{q<\rho} e^{i\rho\chi_j}\tilde{\mathrm{B}}_{q,\rho} + \sqrt{2}\, e^{iq\chi_j}\tilde{\mathrm{B}}_{q,q}\right)$$

$$\left(\omega - \Delta - \omega_q\right)\tilde{\mathfrak{C}}_{j,q}$$
$$= \frac{g e^{iq\chi_j}}{\omega - 2\Delta} + g^2\sum_{\rho} e^{i(\rho\chi_1 + q\chi_j)}\,\tilde{\mathfrak{C}}_{2,\rho} + \frac{e^{i(\rho\chi_2 + q\chi_j)}\tilde{\mathfrak{C}}_{1,\rho}}{\omega - 2\Delta}$$
$$+ \mathrm{g}^2\sum_{\rho}\sum_{j'=1}^{4} e^{i\rho\left(\chi_j - \chi_{j'}\right)}\tilde{\mathfrak{C}}_{j',q} + e^{i\left(\rho\chi_j - q\chi_{j'}\right)}\tilde{\mathfrak{C}}_{j',\rho}/\omega - \omega_\rho - \omega_q$$

$$\left(\omega - \Delta - \omega_q\right)\tilde{\mathfrak{C}}^{\circledast}_{\div j,q}$$
$$= \frac{g e^{iq\chi_j}}{\omega - 2\Delta} + g^2\sum_{\rho} e^{i(\rho\chi_1 + q\chi_j)}\,\tilde{\mathfrak{C}}^{\circledast}_{\div 1,\rho} + \frac{e^{i(\rho\chi_2 + q\chi_j)}\tilde{\mathfrak{C}}^{\circledast}_{\div 2,\rho}}{\omega - 2\Delta}$$
$$+ \mathrm{g}^2\sum_{\rho}\sum_{j'=1}^{4} e^{i\rho\left(\chi_j - \chi_{j'}\right)}\tilde{\mathfrak{C}}^{\circledast}_{\div j,q} + e^{i\left(\rho\chi_j - q\chi_{j'}\right)}\tilde{\mathfrak{C}}^{\circledast}_{\div j,\rho}/\omega - \omega_\rho - \omega_q$$

$$(\delta\omega - \Delta)\mathcal{C}(\omega, z)$$
$$= \frac{g}{z}/\omega - 2\Delta$$
$$+ \frac{g^2}{z}$$
$$/2\pi i\oint\{2\mathfrak{C}(\omega', z)/\omega - 2\Delta + 2\,z\mathfrak{C}(\omega, z) + \mathfrak{C}(\omega, 1/z)/z' + (z + z')\mathfrak{C}(\omega, z')/1$$
$$+ 2\delta\omega z' + z'^2\}\,dz'$$

## 6.11. Incrementales complementarios.

$$\mathfrak{C}_{\sigma}^{\boxed{1}}(z) = \frac{\nu_{-,\sigma}(z)}{\nu_{+,\sigma}(z)\mathfrak{C}_{\sigma}^{\boxed{0}}(z)} - 2\nu_{-,\sigma}(z)\zeta(z) + \frac{\sigma}{\zeta(z)} - \zeta^{-1}(z) \bigotimes \begin{cases} \mathfrak{C}_{\sigma}^{\boxed{0}}(\zeta(z)) \therefore |z| < 1 \\ \mathfrak{C}_{\sigma}^{\boxed{1}}(\zeta(z)) \therefore |z| > 1 \end{cases}$$

$$\nu_{\pm,\sigma}(z) = \frac{1}{z} + \frac{\sigma}{g^{-2}(\delta\omega - \Delta)} \pm \sigma\sqrt{\delta\omega - \sigma/}\sqrt{\delta\omega + \sigma} - \sigma$$

$$\begin{aligned} \delta\mathfrak{C}_{\sigma}(z) = \mathfrak{C}_{\sigma}^{\boxed{1}}(z) - \mathfrak{C}_{\sigma}^{\boxed{0}}(z)\delta^{2}\mathfrak{C}_{\sigma}(z) = \mathfrak{C}_{\sigma}^{\boxed{0}}(z) - \mathfrak{C}_{\sigma}^{\boxed{2}}(z), \delta\mathfrak{C}_{\sigma} = \mathfrak{C}_{\sigma}^{\boxed{1}} - \mathfrak{C}_{\sigma}^{\boxed{0}}\overrightarrow{\zeta(\mathbb{S}^{1})}\mathfrak{C}_{\sigma}^{\boxed{0}} - \mathfrak{C}_{\sigma}^{\boxed{1}} \\ = -\delta\mathfrak{C}_{\sigma}, \delta\mathfrak{C}_{\sigma} \\ = \mathfrak{C}_{\sigma}^{\boxed{1}} - \mathfrak{C}_{\sigma}^{\boxed{0}}\overrightarrow{\zeta^{-1}(\mathbb{S}^{1})}\mathfrak{C}_{\sigma}^{\boxed{2}} - \mathfrak{C}_{\sigma}^{\boxed{1}}4\zeta(z) + \frac{\sigma}{\zeta(z)} - \zeta^{-1}(z)\frac{z+\sigma}{z-z^{-1}} \\ + \left(\nu_{+,\sigma}^{-1}(\zeta(z)) - \nu_{-,\sigma}^{-1}(\zeta(z))\right)\left(\nu_{+,\sigma}^{-1}(z) - \nu_{-,\sigma}^{-1}(z)\right), \nu_{+,\sigma}^{-1}(z) - \nu_{-,\sigma}^{-1}(z) \\ = \frac{2\sigma}{\sigma + z^{-1}}\sqrt{\delta\omega - \sigma/}\sqrt{\delta\omega + \sigma} \end{aligned}$$

$$\begin{aligned} \delta\mathfrak{C}_{\sigma}(z)\nu_{+,\sigma}\frac{(\zeta(z))}{\nu_{-,\sigma}(z)\nu_{-\delta l(z),\sigma}(\zeta(z))} \\ = \frac{2\sigma}{\sigma} + z^{-1}\sqrt{\delta\omega - \sigma/}\sqrt{\delta\omega + \sigma}\mathfrak{C}_{\sigma}(z) - 2\,\zeta(z) + \frac{\sigma}{\zeta(z)} - \zeta^{-1}(z)\mathfrak{C}_{\sigma}(\zeta(z)) \end{aligned}$$

$$\begin{aligned} \delta\mathfrak{C}_{\sigma}(1/z) = \sigma z\frac{\nu_{+\delta l(z),\sigma}(\zeta(z))}{\nu_{-\delta l(z),\sigma}(\zeta(z))\delta\mathfrak{C}_{\sigma}(z)}, \delta\mathfrak{C}_{\sigma}(\zeta(z)) \\ = \delta l(z)\sqrt{\delta\omega - \sigma/}\sqrt{\delta\omega + \sigma}\nu_{+\delta l(z),\sigma}(\zeta(z))/\nu_{-\delta l(z),\sigma}(z)z + \sigma/z - \sigma\delta\mathfrak{C}_{\sigma}(z) \end{aligned}$$

$$\begin{aligned} \mathcal{P}_{inv}\{f_{\sigma}\}(z) = \frac{1}{2}\left(f_{\sigma}(z) + \frac{\sigma}{z}\nu_{-\delta l(z),\sigma}(\zeta(z))/\nu_{+\delta l(z),\sigma}(\zeta(z))f_{\sigma}(z^{-1})\right), \mathcal{P}_{\zeta}\{f_{\sigma}\}(z) \\ = \frac{1}{2}\Big(f_{\sigma}(z) + \delta l(z)\sqrt{\delta\omega - \sigma/}\sqrt{\delta\omega + \sigma}\nu_{-,\sigma}(\zeta(z))/\nu_{+\delta l(z),\sigma}(\zeta(z))z - \sigma/z \\ + \sigma f_{\sigma}(\zeta(z))\Big) \end{aligned}$$

$$\begin{aligned} \mathfrak{C}_{\sigma}(z) = \sigma z^{-1}\frac{g(1 + 2g\tilde{C}_{1,2})}{\omega} - 2\Delta + \mathrm{g}\ 1 - 2\sigma(\omega - \Delta) + 2g\tilde{C}_{1,1}(\omega - 2\Delta) \\ + \frac{2g\tilde{C}_{1,2}(1 - \sigma\omega)}{z^{2}(\omega - 2\Delta)} + \mathcal{O}(z^{-3}) \end{aligned}$$

$$\delta\mathfrak{C}_{\sigma}(z) = 16g^{3}z^{-3}(2g\tilde{C}_{1,1}\sigma - 1) + \mathcal{O}(z^{-4}) = 16g^{3}\sigma z^{2}(2g\tilde{C}_{1,1}\sigma - 1) + \mathcal{O}(z^{3})$$

### 6.12. Análisis Complementario de Función Φ.

$$\Phi(z) = \frac{z+1}{z-1}\left(\frac{1}{4} + \oint z' - 1/z'/1 + 2\delta\omega z' + z'^{2}\sqrt{\delta\omega' + 1/}\sqrt{\delta\omega' - 1}\Phi(z')dz'/2\pi i\right)$$

$$\Phi(z) = -\Phi\left(\frac{1}{z}\right) = \Phi(z) = \delta l(z)(\Phi(\zeta(z)) + \frac{1}{2}), \Phi(z) = 1/4\frac{z+1}{z-1} + \mathcal{O}(|z|^{-1}), \Phi_\zeta(z)$$
$$= -1/2 + 1 + \sum_{\eta=1}^{\infty} \frac{\alpha_\eta z^\eta}{4(1-z)\sqrt{\delta\omega - \frac{1}{\delta\omega} + 1}} \forall |z| < 1/|\zeta(\pm 1)|, \Phi_\zeta(z)$$
$$= 1 + \sum_{\eta=1}^{\infty} \alpha_\eta \zeta(z)^\eta / 4(1-\zeta(z))\frac{z+1}{z-1} \forall z \in \mathbb{R}^4$$

$$\Phi(z) = \Phi_\zeta(z) \forall |z| < \min\{|\zeta(1)|^{-1} |\zeta(-1)|^{-1}\} \Phi'^{(z)}$$
$$\propto (z - z_0)(z - z_0^{-1})(z - \zeta(z_0))(z - \zeta^{-1}(z_0))$$
$$/(\delta\omega^2 - 1)z^2(z-1)^2\sqrt{\delta\omega - 1/\sqrt{\delta\omega + 1}}$$

$$\omega + z_0 + \frac{z_0^{-1}}{2} = \frac{\omega}{2} - \omega + 2/2\sqrt{1 - 2\omega/\omega + 1 + \kappa \bigotimes \left(1 - \frac{\mathfrak{E}(\kappa^{-1})}{\mathcal{K}(\kappa^{-1})}\right)}, \mathcal{R}e\delta\{\Phi(z), z = 1\}$$
$$= \sqrt{\omega(2+\omega)\kappa^{-1}/\pi}\mathcal{K}(\kappa^{-1})$$

$$\Phi(\omega, z) = \Phi(-\omega, -z)$$
$$+ \delta g\eta\mathcal{R}e\omega 2\omega(z^2 + \omega z + 1)\mathcal{K}(\kappa^{-1}(\omega))/\pi(z^2 - 1)\sqrt{\kappa(\omega)}\sqrt{\delta\omega + 1}\sqrt{\delta\omega - 1}$$

$$\xi = \zeta(z) - \frac{\zeta(-1)}{1} - \zeta(-1)\zeta(z)\sqrt{\chi(0^+)^2\zeta(z) - \frac{\zeta^{-1}(-1)}{\zeta(-1)} - \zeta(z)} \bigotimes \sqrt{\chi(0^+)^{-2}\zeta^{-1}(z) - \frac{\zeta(-1)}{\zeta^{-1}(-1)} - \zeta^{-1}(z)}$$

$$\Phi_+(z) = -\frac{\mathcal{K}(\kappa)\sqrt{\kappa}\delta g\eta\mathcal{R}e\omega}{2\pi}\left(z^{-1} - z/1 - \zeta(z) + \frac{z+1}{z-1}(1+\omega) + 2\frac{z-1}{z+1}\zeta(-1) - z^2\right.$$
$$\left. - 6z + 1/z^2 - 1\zeta^{-1}(z)\right)$$
$$+ \xi\frac{2\kappa\delta g\eta\mathcal{R}e\omega}{\pi i}(\mathcal{K}(\kappa)\mathfrak{E}(\chi^{-1};\kappa^{-1}) - \kappa^{-2}\mathfrak{E}(\kappa)\mathcal{F}(\chi^{-1};\kappa^{-1})$$
$$- (1-\kappa^{-2})\mathcal{K}(\kappa)\,\mathcal{F}(\chi^{-1};\kappa^{-1}))$$

$$\Phi_-(\omega, z) = \Phi_+(-\omega, -z)$$
$$+ \delta g\eta\mathcal{R}e\omega 2\omega\sqrt{\kappa\omega}(z^2 + \omega z + 1)\mathcal{K}(\kappa(\omega))/\pi(z^2 - 1)\sqrt{\delta\omega + 1}\sqrt{\delta\omega - 1}$$

$$\delta l(z)\Phi(\omega, z) = \frac{1}{4}$$
$$+ \frac{i}{\pi}\log\left(\delta l(z)\frac{z-1}{z+1}\right)$$
$$+ \frac{i}{\pi}\frac{z(z^2+1)}{(z^2-1)^2}\omega\log\omega + 4i + \frac{(\pi - 6i\log 2)(z + z^{-1})}{2\pi(z - z^{-1})^2\omega}$$
$$+ \frac{4 - (z + z^{-1}) + (z + z^{-1})^2 - \frac{1}{4}(z + z^{-1})^3}{\pi i(z + z^{-1})^4}\omega^2\log\omega + \mathcal{O}(\omega^2)$$

$$\Phi(\omega,z)=\frac{2}{\pi}\arctan\left(1+\sqrt{2}\sqrt{3-2\sqrt{2}-z/}\sqrt{3+2\sqrt{2}-z}\right)-\frac{1}{2}$$
$$+\frac{z(1+z)}{\sqrt{3-2\sqrt{2}-z}\sqrt{3+2\sqrt{2}-z}}\frac{\omega+2}{2\pi}$$
$$+\frac{z(z+1)\sqrt{3-2\sqrt{2}-z}\sqrt{3+2\sqrt{2}-z}}{32\pi(z-1)^4}\left(\frac{1}{2}+i\pi\right.$$
$$\left.+4\log 2-\frac{16z(1-4z+z^2)}{(1-6z+z^2)^2}-\log(\omega+2)\right)(\omega+2)^2$$

$$\Phi(\omega,z)=\frac{2z\log(\omega-2/32\ )}{\pi(1-z)\sqrt{z+2\sqrt{2}+3}\sqrt{z-2\sqrt{2}+3}}$$
$$+\frac{2}{\pi}\arctan\left(\sqrt{2}-1\frac{\sqrt{z-2\sqrt{2}+3}}{\sqrt{z+2\sqrt{2}+3}}\right)-\frac{1}{2}-\frac{(z+1)^2\log(\omega-2/32\ )}{z^2+6z+1}$$
$$-\frac{\frac{4z}{(z+1)^2}}{\sqrt{z-2\sqrt{2}+3}\sqrt{z+2\sqrt{2}+3}}\frac{z(\omega-2)}{2\pi(z-1)}$$
$$+\left(\frac{(z^4+4z^3+36z^2+8z+1)\log(\omega-2/32\ )}{\sqrt{z-2\sqrt{2}+3}\sqrt{z+2\sqrt{2}+3}}\right.$$
$$\left.+\frac{2(z^4+8z^3+36z^2+8z+1)}{(z+1)^4\sqrt{z-2\sqrt{2}+3}\sqrt{z+2\sqrt{2}+3}}\right)\frac{z(\omega-2)^2}{64\pi(z-1)}$$

### 6.13. Análisis Complementario – Función Racional.

$$r_\sigma(1/z)=r_\sigma(z)\sigma z, r_\sigma\big(\zeta(z)\big)=-\frac{1+\frac{\sigma}{\zeta(z)}}{1+\frac{\sigma}{z}}r_\sigma(z)+\gamma_\sigma(z),\gamma_\sigma(z)$$
$$=\frac{\delta^2\mathfrak{C}_\sigma(z)-2\delta\mathfrak{C}_\sigma(z)}{\zeta(z)+\sigma}\left(\frac{\delta\omega-\sigma}{1+\frac{\sigma}{z}}+\zeta(z)-\frac{\zeta^{-1}(z)}{2\nu_{-,\sigma}(z)}\right)$$

$$\mathcal{P}_{inv}\{f_\sigma\}(z)=\frac{\left(f_\sigma(z)+\frac{\sigma}{z}f_\sigma\left(\frac{1}{z}\right)\right)}{2},\mathcal{P}_\zeta\{f_\sigma\}(z)$$
$$=\frac{f_\sigma(z)}{2}-\frac{1}{2}\frac{1+\sigma/z}{1+\sigma/\big(\zeta(z)\big)}\Big(f_\sigma\big(\zeta(z)\big)-\gamma_\sigma(z)\Big)$$

$$r_\sigma(z)=2\sigma g\frac{1+2g\tilde{\mathcal{C}}_{1,2}}{(\omega-2\Delta)z}+2g\frac{1+2g\tilde{\mathcal{C}}_{1,1}(\omega-2\Delta)-2\sigma(\omega-\Delta)+2g\tilde{\mathcal{C}}_{1,2}(1-\sigma\omega)}{(\omega-2\Delta)z^2}$$
$$+\mathcal{O}(1/z^3)g\sigma 1+\frac{2g\tilde{\mathcal{C}}_{1,1}}{\omega}-2\Delta=\big(2g\tilde{\mathcal{C}}_{1,1}-\sigma\big)\sum_{i=1}^{4}\alpha_0(z_{\sigma i})$$

### 6.14. Simetrías.

$$\mathcal{R} = \left\{ \frac{\mathcal{P}(z)}{\mathcal{Q}(z)} \middle| \mathcal{P}, \mathcal{Q} \in \mathbb{C}[z] \right\}, \mathcal{A} = \mathcal{R}\langle 1, \zeta, \delta l, \delta l \zeta \rangle, \alpha(z) = \begin{cases} r_1(z) + \dfrac{r_2(z)\sqrt{\delta\omega - 1}}{\sqrt{\delta\omega + 1}} \therefore |z| < 1 \\ r_3(z) + \dfrac{r_4(z)\sqrt{\delta\omega - 1}}{\sqrt{\delta\omega + 1}} \therefore |z| > 1 \end{cases}$$

$$\begin{aligned} f_1 \sim f_2 \Leftrightarrow \exists \alpha, \alpha^{-1} \in \mathcal{A} | f_1 - \alpha f_2 \in \mathcal{A}, \mathfrak{C}_\sigma(z) \sim \Phi(z) \\ \sim \mathcal{K}(\kappa^{-1})\mathfrak{E}(\chi(z), \kappa) - \kappa^2 \mathbb{E}(\kappa^{-1})\mathfrak{F}(\chi(z), \kappa) \\ - (1 - \kappa^2)\mathcal{K}(\kappa^{-1})\mathfrak{F}(\chi(z), \kappa), [\mathfrak{C}_\sigma(z)] = [\mathfrak{C}_\sigma(\zeta(z))] \end{aligned}$$

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**FE DE ERRATAS – 08 de enero del 2025**

En todas las ecuaciones contenidas en todos los artículos publicados por este autor, hasta la actualidad (08 de enero del 2025), en tanto corresponda por rigor matemático, se incorporará cualquiera de los siguientes formatos de fracción, verbigracia $\frac{\square}{\square}\ {}^{\square}\!/_{\square}\ \square/\square\ \tfrac{\square}{\square}$.

**APÉNDICE B.**

Modelo Einstein – Yang – Mills para espacios cuánticos curvos – Gravedad Cuántica. Formalización Matemática.

$$\begin{cases} \mathcal{R}_{\mu\nu} = 2 < \mathcal{F}_{\mu\beta}, \mathcal{F}_{\beta}^{\mu} > -\frac{1}{2} \bigotimes g_{\mu\nu} \langle \mathcal{F}_{\alpha\beta}, \mathcal{F}^{\alpha\beta} \rangle \\ 0 = \nabla_{\alpha}\mathcal{F}^{\alpha\beta} + \left[\mathrm{A}_{\alpha}, \mathcal{F}^{\alpha\beta}\right] \\ \mathcal{F}_{\alpha\beta} = \nabla_{\alpha}\mathrm{A}_{\beta} - \nabla_{\beta}\mathrm{A}_{\alpha} + \left[\mathrm{A}_{\alpha}, \mathrm{A}_{\beta}\right] \\ \nabla^{\alpha}\mathrm{A}_{\alpha} = 0 \end{cases}$$

$$\hbar_{\mu\nu} = g_{\mu\nu} - m_{\mu\nu}, \hbar^{\mu\nu} = m^{\mu\mu'} m^{\nu\nu'} \hbar_{\mu'\nu'}, \mathcal{H}^{\mu\nu} = g^{\mu\nu} - m^{\mu\nu}$$

$$\nabla^{(m)}_{\frac{\partial}{\partial\chi^{\mu}}} \frac{\partial}{\partial\chi^{\nu}} \mathcal{Z} = \mathfrak{Z} \coloneqq \left\{\mathcal{Z}_{\alpha\beta}, \delta, \partial_{\alpha} \middle| \alpha, \beta \in \{0,3\}\right\} \mathcal{L}_{\mathbb{Z}^{\mathbb{I}}}\mathcal{T} \coloneqq \mathcal{L}_{\mathbb{Z}^{\iota}1} \bigotimes \mathcal{L}_{\mathbb{Z}^{\iota}\kappa}\mathcal{T}\, |\partial\kappa|^2 \coloneqq \left|\nabla^{(m)}\kappa\right|^2$$

$$\coloneqq \xi^{\alpha\beta}\zeta^{\mu\nu}\nabla^{(m)}_{\frac{\partial}{\partial\chi^{\mu}}}\kappa_{\alpha} \bigotimes \nabla^{(m)}_{\frac{\partial}{\partial\chi^{\nu}}}\kappa_{\beta}, |\partial\kappa|^2 = \left|\nabla^{(m)}_{\tau}\kappa\right|^2 + \left|\nabla^{(m)}_{\chi^1}\kappa\right|^2 \bigotimes \left|\nabla^{(m)}_{\chi^{\eta}}\kappa\right|^2$$

$$= \sum_{\alpha,\beta\in\{\tau,\chi^1,\chi^{\eta}\}} \left|\partial_{\alpha}\kappa_{\beta}\right|^2$$

$$r \coloneqq \sqrt{(\chi^1)^2 + (\chi^2)^2 + (\chi^{\eta})^2}$$

$$\bar{\hbar}^{1}_{ij}$$

$$:= \bar{g}_{ij} - \left(1 + \chi\left(\frac{r}{t}\right) \bigotimes \frac{\mathcal{M}}{r}\right) \delta_{ij}\delta_{\mu\nu} \sum_{\mu=0}^{\eta} \left|\nabla^{(m)}\left(\mathcal{L}_{\mathbb{Z}^{\mathbb{I}}}\mathrm{A}_{\mu}\right)(t,\chi)\right| + \sum_{\mu,\nu=0}^{\eta} \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\mathbb{I}}}\hbar^{1}_{\mu\nu}(t,\chi)\right|$$

$$\boxtimes\ \mathbb{C}(\kappa) \bigoplus \mathbb{C}(\eta) \bigoplus \frac{\epsilon}{(1+t+|r-t|^{1-\epsilon})(1+|r-t|)^{1+\gamma}} \sum_{\mu=0}^{\eta} \left|\mathcal{L}_{\mathbb{Z}^{\mathbb{I}}}\mathrm{A}_{\mu}(t,\chi)\right|$$

$$+ \sum_{\mu,\nu=0}^{\eta} \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\mathbb{I}}}\hbar^{1}_{\mu\nu}(t,\chi)\right|$$

$$\boxplus\ \mathbb{C}(\kappa) \bigoplus \mathbb{C}(\eta) \bigoplus \mathbb{C}(\varphi) \bigoplus \mathbb{C}(\psi) \bigoplus \mathbb{C}(\phi) \bigoplus \frac{\epsilon}{(1+t+|r-t|^{1-\epsilon})(1+|r-t|)^{\gamma}}$$

$$+ \sum_{\mu,\nu=0}^{\eta} \left|\mathcal{L}_{\mathbb{Z}^{\mathbb{I}}}\mathcal{R}_{\mu\nu}(t,\chi)\right| \boxtimes\ \mathbb{C}(\kappa) \bigoplus \mathbb{C}(\eta) \bigoplus \frac{\epsilon}{(1+t+|r-t|^{1-\epsilon})(1+|r-t|)^{1+\gamma}}$$

$$\boxplus\ \mathbb{C}(\kappa) \bigoplus \mathbb{C}(\eta) \bigoplus \mathbb{C}(\varphi) \bigoplus \mathbb{C}(\psi) \bigoplus \mathbb{C}(\phi) \bigoplus \frac{\epsilon}{(1+t+|r-t|^{1-\epsilon})(1+|r-t|)^{\gamma}}$$

$$\bar{\varepsilon}_{\zeta} := \sum_{|\mathcal{I}|\leq|\zeta|} \left( \sum_{i=1}^{\eta} \left\| (1+r)^{\frac{1}{2}+\gamma+|\mathcal{I}|} \widehat{\mathcal{D}}\left(\widehat{\mathcal{D}}^{\mathcal{I}}\widehat{\Lambda}\right) \right\|_{\langle\sigma^{2}\rho(\Gamma)\mathrm{e}^{-\mathrm{i}\omega\mathrm{t}}\rangle^{2}} + \left\| (1+r)^{\frac{1}{2}+\gamma+|\mathcal{I}|} \widehat{\mathcal{D}}\left(\widehat{\mathcal{D}}^{\mathcal{I}}\widehat{\hbar}^{-1}\right) \right\|_{\langle\sigma^{2}\rho(\Gamma)\mathrm{e}^{-\mathrm{i}\omega\mathrm{t}}\rangle^{2}} \right)$$

$$:= \sum_{|\mathcal{I}|\leq|\zeta|} \left( \sum_{i=1}^{\eta} \left\| (1+r)^{\frac{1}{2}+\gamma+|\mathcal{I}|} \widehat{\mathcal{D}}\left(\widehat{\mathcal{D}}^{\mathcal{I}}\widehat{\Lambda}\right) \right\|_{\langle\sigma^{2}\rho(\Gamma)\mathrm{e}^{-\mathrm{i}\omega\mathrm{t}}\rangle^{2}} \right.$$

$$+ \left\| (1+r)^{\frac{1}{2}+\gamma+|\mathcal{I}|} \widehat{\mathcal{D}}\left(\widehat{\mathcal{D}}^{\mathcal{I}}\widehat{\Lambda}_{i}\right) \right\|_{\langle\sigma^{2}\rho(\Gamma)\mathrm{e}^{-\mathrm{i}\omega\mathrm{t}}\rangle^{2}}$$

$$\left. + \sum_{i,j=1}^{\eta} \left\| (1+r)^{\frac{1}{2}+\gamma+|\mathcal{I}|} \widehat{\mathcal{D}}\left(\widehat{\mathcal{D}}^{\mathcal{I}}\widehat{\hbar}^{1}_{ij}\right) \right\|_{\langle\sigma^{2}\rho(\Gamma)\rangle^{2}} \right) \mathcal{R} + \hat{\kappa}^{i}_{i}\,\hat{\kappa}^{j}_{j} - \hat{\kappa}^{ij}\hat{\kappa}_{ij}$$

$$= \frac{4}{(\varsigma-1)\langle\hat{\varepsilon}^{ij}\hat{\varepsilon}_{ij}\rangle} + \langle\overline{\mathcal{D}}_{i}\widehat{\Lambda}_{j} - \overline{\mathcal{D}}_{j}\widehat{\Lambda}_{i} + \left[\widehat{\Lambda}_{i}\widehat{\Lambda}_{j}\right]\widehat{\mathcal{D}}^{i}\widehat{\Lambda}^{j} - \widehat{\mathcal{D}}^{j}\widehat{\Lambda}^{i} + \left[\widehat{\Lambda}^{i}\widehat{\Lambda}^{j}\right]\rangle\overline{\mathcal{D}}_{i}\hat{\kappa}^{i}_{j} - \overline{\mathcal{D}}_{j}\hat{\kappa}^{j}_{i}$$

$$= \langle\hat{\varepsilon}_{i}\overline{\mathcal{D}}_{j}\widehat{\Lambda}^{i} - \hat{\varepsilon}_{j}\overline{\mathcal{D}}_{i}\widehat{\Lambda}^{j} + \left[\widehat{\Lambda}_{j}\widehat{\Lambda}^{i}\right]\rangle$$

$$\bar{\varepsilon}_{\zeta}(t) := \sum_{|\mathcal{I}|\leq|\zeta|} \left\| \omega^{\frac{1}{2}}\nabla^{(m)}\left(\mathcal{L}_{\mathbb{Z}^{\mathbb{I}}}\Lambda(t)\right) \right\|_{\langle\sigma^{2}\rho^{2}(\Xi^{\Psi}_{t})\rangle} + \left\| \omega^{\frac{1}{2}}\nabla^{(m)}\left(\mathcal{L}_{\mathbb{Z}^{\mathbb{I}}}\hbar^{1}(t)\right) \right\|_{\langle\sigma^{2}\rho^{2}(\Xi^{\Psi}_{t}\mathrm{e}^{-\mathrm{i}\omega\mathrm{t}})\rangle} (1+t)^{\delta}$$

$$:= \prod_{l=1}^{m} \left[ \prod_{|\mathcal{J}_{l}|\cong|\mathfrak{J}_{l}|} \mathfrak{Q}^{\mathcal{J}_{l}}_{1}\left(\mathcal{L}_{\mathbb{Z}^{\mathcal{J}_{l}}}\kappa^{(l)}\right) \bigotimes \left( \sum_{\eta=0}^{\infty} \mathfrak{P}^{\mathcal{J}_{l}}_{\eta}\left(\mathcal{L}_{\mathbb{Z}^{\mathcal{J}_{l}}}\kappa^{(l)}\right) \right) \right]$$

$$\mathcal{H}^{\mu\nu} = -\hbar^{\mu\nu} + \mathcal{O}^{\mu\nu}(\hbar^2) g^{\lambda\mu}\nabla^{(m)}_{\lambda}\nabla^{(m)}_{\mu}\Lambda_{\sigma}$$

$$= \left(\nabla^{(m)}_{\sigma}\hbar^{\alpha\mu}\right) \bigodot \left(\nabla^{(m)}_{\alpha}\hbar^{\alpha\mu}\right) \bigodot \left(\nabla^{(m)}_{\alpha}\Lambda_{\mu}\right)$$

$$+\frac{1}{2}\left(\nabla^{(m)\mu}\hbar^{\nu}_{\sigma} + \nabla^{(m)}_{\sigma}\hbar^{\nu\mu} - \nabla^{(m)\nu}\hbar^{\mu}_{\sigma}\right) \odot \left(\nabla^{(m)}_{\mu}\Lambda_{\nu} - \nabla^{(m)}_{\nu}\Lambda_{\mu}\right)$$

$$+\frac{1}{2}\left(\nabla^{(m)\mu}\hbar^{\nu}_{\sigma} + \nabla^{(m)}_{\sigma}\hbar^{\nu\mu} - \nabla^{(m)\nu}\hbar^{\mu}_{\sigma}\right)[\Lambda_{\mu}\Lambda_{\nu}]$$

$$-\left(\left[\Lambda_{\mu}\nabla^{(m)\mu}\Lambda_{\sigma}\right] + \left[\mathrm{A}^{\mu},\nabla^{(m)}_{\mu}\Lambda_{\sigma} - \nabla^{(m)}_{\sigma}\Lambda_{\mu}\right] + \left[\Lambda^{\mu}[\Lambda_{\mu}\Lambda_{\sigma}]\right]\right)$$

$$+\mathcal{O}\left(\hbar \circledast \nabla^{(m)}\hbar \bigotimes \nabla^{(m)}\Lambda\right) + \mathcal{O}\left(\hbar \circledast \nabla^{(m)}\hbar \bigotimes \nabla^{(m)}\Lambda^2\right)$$

$$+\mathcal{O}\left(\hbar \circledast \nabla^{(m)}\Lambda \bigotimes \nabla^{(m)}\Lambda\right) + \mathcal{O}\left(\hbar \circledast \nabla^{(m)}\Lambda^3\right) g^{\alpha\beta}\nabla^{(m)}_{\alpha}\nabla^{(m)}_{\beta}\hbar_{\mu\nu}$$

$$= \rho\left(\nabla^{(m)}_{\mu}\hbar^{\mu\nu}\nabla^{(m)}_{\nu}\hbar^{\nu\mu}\right) \bigodot \mathcal{Q}_{\mu\nu}\left(\nabla^{(m)}\hbar\right) \bigodot \mathcal{O}_{\mu\nu}\left(\hbar \bigotimes \left(\nabla^{(m)}\hbar\right)^2\right)$$

$$-4\left\langle \nabla^{(m)}_{\mu}\Lambda_{\beta} - \nabla^{(m)}_{\beta}\Lambda_{\mu} + \nabla^{(m)}_{\nu}\Lambda^{\beta} - \nabla^{(m)\beta}\Lambda_{\nu}\right\rangle$$

$$+m_{\mu\nu} \bigotimes \left\langle \nabla^{(m)}_{\alpha}\Lambda_{\beta} - \nabla^{(m)}_{\beta}\Lambda_{\alpha} + \nabla^{(m)}_{\alpha}\Lambda^{\beta} - \nabla^{(m)\beta}\Lambda^{\alpha}\right\rangle$$

$$-4 \bigotimes \left\langle \nabla^{(m)}_{\mu}\Lambda_{\beta} - \nabla^{(m)}_{\beta}\Lambda_{\mu}[\Lambda_{\nu}\Lambda^{\beta}]\right\rangle + \left\langle [\Lambda_{\mu}\Lambda_{\beta}]\nabla^{(m)}_{\nu}\Lambda^{\beta} - \nabla^{(m)\beta}\Lambda_{\nu}\right\rangle$$

$$+m_{\mu\nu} \bigotimes \left\langle \nabla^{(m)}_{\alpha}\Lambda_{\beta} - \nabla^{(m)}_{\beta}\Lambda_{\alpha}[\Lambda^{\alpha}\Lambda^{\beta}]\right\rangle + \left\langle \Lambda_{\alpha}\Lambda_{\beta}\nabla^{(m)\alpha}\Lambda^{\beta} - \nabla^{(m)\beta}\Lambda^{\alpha}\right\rangle$$

$$+\mathcal{O}\left(\hbar \bigotimes \left(\nabla^{(m)}\Lambda\right)^2\right) + \mathcal{O}\left(\hbar \bigotimes \Lambda^2 \circledast \nabla^{(m)}\Lambda\right)$$

$$+\mathcal{O}\left(\hbar \bigotimes \Lambda^4\right)\rho\left(\nabla^{(m)}_{\mu}\hbar\nabla^{(m)}_{\nu}\hbar\right)$$

$$:= \frac{1}{4}m^{\alpha\alpha'}\nabla^{(m)}_{\mu}\hbar_{\alpha\alpha'}m^{\beta\beta'}\nabla^{(m)}_{\nu}\hbar_{\beta\beta'} - \frac{1}{2}m^{\alpha\alpha'}m^{\beta\beta'}\nabla^{(m)}_{\mu}\hbar_{\alpha\beta}\nabla^{(m)}_{\nu}\hbar_{\alpha'\beta'}\mathcal{Q}_{\mu\nu}\left(\nabla^{(m)}\hbar\right)$$

$$:= \nabla^{(m)}_{\alpha}\hbar_{\beta\mu}m^{\alpha\alpha'}m^{\beta\beta'}\nabla^{(m)}_{\alpha'}\hbar_{\beta'\nu} - m^{\alpha\alpha'}m^{\beta\beta'}\left(\partial_{\alpha}\hbar_{\beta\mu}\partial_{\beta'}\hbar_{\alpha'\nu} - \nabla^{(m)}_{\beta'}\hbar_{\beta\mu}\nabla^{(m)}_{\alpha}\hbar_{\alpha'\nu}\right)$$

$$+m^{\alpha\alpha'}m^{\beta\beta'}\left(\nabla^{(m)}_{\mu}\hbar_{\alpha'\beta'}\nabla^{(m)}_{\alpha}\hbar_{\beta\nu} - \nabla^{(m)}_{\alpha}\hbar_{\alpha'\beta'}\nabla^{(m)}_{\mu}\hbar_{\beta\nu}\right)$$

$$+m^{\alpha\alpha'}m^{\beta\beta'}\left(\nabla^{(m)}_{\nu}\hbar_{\alpha'\beta'}\nabla^{(m)}_{\alpha}\hbar_{\beta\mu} - \nabla^{(m)}_{\alpha}\hbar_{\alpha'\beta'}\nabla^{(m)}_{\nu}\hbar_{\beta\mu}\right)$$

$$+\frac{1}{2}m^{\alpha\alpha'}m^{\beta\beta'}\left(\nabla^{(m)}_{\beta'}\hbar_{\alpha\alpha'}\nabla^{(m)}_{\mu}\hbar_{\beta\nu} - \nabla^{(m)}_{\mu}\hbar_{\alpha\alpha'}\nabla^{(m)}_{\beta'}\hbar_{\beta\nu}\right)$$

$$+\frac{1}{2}m^{\alpha\alpha'}m^{\beta\beta'}\left(\nabla^{(m)}_{\beta'}\hbar_{\alpha\alpha'}\nabla^{(m)}_{\nu}\hbar_{\beta\mu} - \nabla^{(m)}_{\nu}\hbar_{\alpha\alpha'}\nabla^{(m)}_{\beta'}\hbar_{\beta\mu}\right) g^{\lambda\mu}\nabla^{(m)}_{\lambda}\nabla^{(m)}_{\mu}\Lambda_{\underline{\mathcal{L}}}$$

$$= \nabla^{(m)} \hbar \bigotimes \nabla^{(m)} \Lambda + \Lambda \bigotimes \nabla^{(m)} \Lambda + \nabla^{(m)} \hbar \bigotimes \Lambda^2 + \Lambda^3$$

$$+ \mathcal{O}\left(\hbar \bigotimes \nabla^{(m)} \hbar \circledast \nabla^{(m)} \Lambda\right) + \mathcal{O}\left(\hbar \bigotimes \Lambda \circledast \nabla^{(m)} \Lambda\right)$$

$$+ \mathrm{O}\left(\hbar \bigotimes \nabla^{(m)} \hbar \bigotimes \Lambda^2\right) + \mathrm{O}\left(\hbar \bigotimes \Lambda^3\right) + \Lambda_{\mathcal{L}} \bigotimes \nabla^{(m)} \Lambda$$

$$+ \Lambda_{\epsilon_\alpha} g^{\alpha\beta} \nabla_\alpha^{(m)} \nabla_\beta^{(m)} \hbar^1_{\underline{\mathcal{LL}}}$$

$$= \nabla_\hbar^{(m)} + \hbar\left(\nabla^{(m)} \hbar\right)^2 + \nabla^{(m)} \Lambda + \Lambda^2 \bigotimes \nabla^{(m)} \Lambda + \Lambda^4 + \mathcal{O}\left(\hbar \bigotimes \left(\nabla^{(m)} \Lambda\right)^2\right)$$

$$+ \mathcal{O}\left(\hbar \bigotimes \Lambda^4\right) + \left(\nabla^{(m)} \hbar_{\tau\mathcal{U}}\right)^2 + \left(\nabla^{(m)} \Lambda_{\epsilon_\alpha}\right)^2 + g^{\alpha\beta} \nabla_\alpha^{(m)} \nabla_\beta^{(m)} \hbar^0 g^{\lambda\mu} \nabla_\lambda^{(m)} \nabla_\mu^{(m)} \Lambda_\tau$$

$$= \nabla_\hbar^{(m)} \bigotimes \nabla^{(m)} \Lambda + \nabla_\hbar^{(m)} \bigotimes \nabla^{(m)} \Lambda + \Lambda \bigotimes \nabla^{(m)} \Lambda + \nabla_\hbar^{(m)} \bigotimes \Lambda^2 + \Lambda^3$$

$$+ \mathcal{O}\left(\hbar \bigotimes \nabla_\hbar^{(m)} \bigotimes \nabla^{(m)} \Lambda\right) + \mathcal{O}\left(\hbar \bigotimes \Lambda \bigotimes \nabla^{(m)} \Lambda\right)$$

$$+ \mathcal{O}\left(\hbar \bigotimes \nabla_\hbar^{(m)} \bigotimes \Lambda^2\right) + \mathrm{O}\left(\hbar \bigotimes \Lambda^3\right) g^{\alpha\beta} \nabla_\alpha^{(m)} \nabla_\beta^{(m)} \hbar^1_{\underline{\tau\mathcal{U}}}$$

$$= \nabla_\hbar^{(m)} + \hbar\left(\nabla^{(m)} \hbar\right)^2 + \nabla^{(m)} \Lambda + \Lambda^2 \bigotimes \nabla^{(m)} \Lambda + \Lambda^4 + \mathcal{O}\left(\hbar \bigotimes \left(\nabla^{(m)} \Lambda\right)^2\right)$$

$$+ \mathcal{O}\left(\hbar \bigotimes \Lambda^2 \bigotimes \nabla^{(m)} \Lambda\right) + \mathrm{O}\left(\hbar \bigotimes \Lambda^4\right) + g^{\alpha\beta} \nabla_\alpha^{(m)} \nabla_\beta^{(m)} \hbar_0$$

$$\mathcal{L} = \partial_t + \partial_r = \partial_t + \frac{\chi^\iota}{r}\partial_\iota, \underline{\mathcal{L}} = \partial_t - \partial_r = \partial_t - \frac{\chi^\iota}{r}\partial_\iota \left|\nabla^{(m)}\Lambda_{\mathcal{L}}\right|^\dagger$$

$$\sim \left|\nabla^{(m)}\Lambda\right|^{\circledcirc} + \mathcal{O}|\hbar| \bigotimes \left|\nabla^{(m)}\Lambda\right|\left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\mathcal{J}}}\Lambda_{\mathcal{L}}\right|$$

$$\simeq \sum_{|\mathcal{J}|\leq|\zeta|} \left|\nabla^{(m)}(\mathcal{L}_{\mathbb{Z}^{\mathcal{J}}}\Lambda)\right|^\star$$

$$+ \sum_{|\kappa|^{\blacksquare}+|\mathrm{M}|^\ddagger} \mathcal{O}\left((\mathcal{L}_{\mathbb{Z}^\kappa}\hbar) \bigotimes \nabla^{(m)}(\mathcal{L}_{\mathbb{Z}^{\mathcal{M}}}\Lambda)\right)^\perp \left|\nabla^{(m)}(\mathcal{L}_{\mathbb{Z}^{\mathcal{J}}}\Lambda_\mu)\right|^2$$

$$\coloneqq \xi^{\alpha\beta} \langle\nabla_\beta^{(m)}(\mathcal{L}_{\mathbb{Z}^{\mathcal{J}}}\Lambda_\mu)\nabla_\alpha^{(m)}(\mathcal{L}_{\mathbb{Z}^{\mathcal{J}}}\Lambda_\mu)\rangle \left|\nabla^{(m)}\mathcal{H}_{\tau\mathcal{L}}\right|$$

$$\cong \left[\nabla^{(m)}\mathcal{H}\right] + \mathcal{O}\left(|\mathcal{H}| \bigotimes \left|\nabla^{(m)}\mathcal{H}\right|\right) \left|\nabla^{(m)}\hbar_{\tau\mathcal{L}}\right|$$

$$\cong \left[\nabla^{(m)}\hbar\right] + \mathcal{O}\left(|\hbar| \bigotimes \left|\nabla^{(m)}\hbar\right|\right) \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\mathcal{J}}}\mathcal{H}_{\tau\mathcal{L}}\right|$$

$$\cong \sum_{|\kappa|\leq|\zeta|} \left|\nabla^{(m)}(\mathcal{L}_{\mathbb{Z}^\kappa}\hbar)\right| + \sum_{|\kappa|^{\blacksquare}+|\mathrm{M}|^\ddagger} \mathcal{O}\left((\mathcal{L}_{\mathbb{Z}^\kappa}\mathcal{H}) \bigotimes \nabla^{(m)}(\mathcal{L}_{\mathbb{Z}^{\mathcal{M}}}\mathcal{H})\right)^\perp \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\mathcal{J}}}\hbar_{\tau\mathcal{L}}\right|$$

$$\cong \sum_{|\kappa|\leq|\zeta|} \left|\nabla^{(m)}(\mathcal{L}_{\mathbb{Z}^\kappa}\hbar)\right| + \sum_{|\kappa|^{\blacksquare}+|\mathrm{M}|^\ddagger} \mathcal{O}\left((\mathcal{L}_{\mathbb{Z}^\kappa}\hbar) \bigotimes \nabla^{(m)}(\mathcal{L}_{\mathbb{Z}^{\mathcal{M}}}\hbar)\right)^\perp$$

$$\int_{\zeta_{\tau_2}^{\varsigma}}^{\square} \left|\nabla^{(m)}\phi_\mathcal{V}\right|^2 \bigotimes \omega(q) \bigotimes d^3\chi + \int_{\mathfrak{N}_{\tau_2}^{\varsigma_1}}^{\square} \mathfrak{T}_{\hat{\mathfrak{L}}t}^{(g)}(\phi_\mathcal{V}) \bigotimes \omega(q) \bigotimes dv_\eta^{(m)}$$

$$+ \int_{\tau_2}^{\varsigma_1} \int_{\zeta_\tau^\varsigma}^{\square} \left|\nabla^{(m)}\phi_\mathcal{V}\right|^2 \bigotimes \frac{\widehat{\omega}(q)}{(1+|q|)} \bigotimes d^3\chi \bigotimes d\tau$$

$$\sim \int_{\mathfrak{N}_{\tau_1}^{\varsigma}}^{\square} \left|\nabla^{(m)}\phi_\mathcal{V}\right|^2 \bigotimes \omega(q) \bigotimes d^3\chi + \int_{\tau_2}^{\varsigma_1} \int_{\zeta_\tau^\varsigma}^{\square} \frac{1+\tau}{\epsilon}$$

$$\boxtimes \left|g^{\mu\alpha}\nabla_\mu^{(m)}\nabla_\alpha^{(m)}\phi_\mathcal{V}\right|^2 \bigotimes \omega(q) \bigotimes d^3\chi \bigotimes d\tau$$

$$+ \int_{\tau_1}^{\varsigma_2} \int_{\zeta_\tau^\varsigma}^{\square} \mathbb{C}(q_0) \bigotimes \mathbb{C}(\delta) \bigotimes \mathbb{C}(\gamma) \bigotimes \mathbb{C}(\psi) \bigotimes \mathbb{C}(\varphi) \bigotimes \mathbb{C}(\phi) \bigotimes \mathbb{E}(4)$$

$$\bigotimes \frac{\epsilon}{(1+\tau)} \bigotimes \left|\nabla^{(m)}\phi_\mathcal{V}\right|^2 \bigotimes \omega(q) \bigotimes d^3\chi \bigotimes d\tau$$

$$\int_{\zeta_{\tau_2}^{\varsigma}}^{\square} \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\mathcal{I}}}\Lambda_{\epsilon_\alpha}\right|^2 \bigotimes \omega(q) \bigotimes d^3\chi \simeq \int_{\zeta_{\tau_1}^{\varsigma}}^{\square} \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\mathcal{I}}}\Lambda_{\epsilon_\alpha}\right|^2 \bigotimes \omega(q) \bigotimes d^3\chi$$

$$+\sum_{|\mathcal{I}|\leq|\zeta|}\int_{\tau_1}^{\varsigma_2}\left[\int_{\zeta_\tau^\varsigma}^{\square}\left[\mathcal{O}\left(\begin{array}{c}\mathbb{C}(q_0)\bigotimes\mathbb{C}(\delta)\bigotimes\mathbb{C}(\gamma)\bigotimes\mathbb{C}(\psi)\bigotimes\mathbb{C}(\varphi)\bigotimes\mathbb{C}(\phi)\\ \bigotimes\mathbb{C}(\mathcal{I})\bigotimes\mathbb{E}\left(\left|\frac{|\mathbb{I}|}{2}\right|+\triangleq\right)\bigotimes\frac{\epsilon\otimes\left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^\kappa}\hbar\right|^2}{(1+\tau+|q|)}\end{array}\right)\right.\right.$$

$$\left.\left.+\mathcal{O}\left(\begin{array}{c}\mathbb{C}(q_0)\bigotimes\mathbb{C}(\delta)\bigotimes\mathbb{C}(\gamma)\bigotimes\mathbb{C}(\psi)\bigotimes\mathbb{C}(\varphi)\bigotimes\mathbb{C}(\phi)\\ \bigotimes\mathbb{C}(\mathcal{I})\bigotimes\mathbb{E}\left(\left|\frac{|\mathbb{I}|}{2}\right|+\triangleq\right)\bigotimes\frac{\epsilon\otimes\left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^\kappa}\hbar\right|^2}{(1+\tau+|q|)}\end{array}\right)\right]\bigotimes\omega(q)\bigotimes d^3\chi\right]\bigotimes d\tau$$

$$+\int_{\tau_1}^{\varsigma_2}\int_{\zeta_\tau^\varsigma}^{\square}\left[\mathbb{C}(q_0)\bigotimes\mathbb{C}(\delta)\bigotimes\mathbb{C}(\gamma)\bigotimes\mathbb{C}(\psi)\bigotimes\mathbb{C}(\varphi)\bigotimes\mathbb{C}(\phi)\bigotimes\mathbb{C}(\mathcal{I})\bigotimes\mathbb{E}\left(\left|\frac{|\mathbb{I}|}{2}\right|+\right.\right.$$

$$\left.\left.\triangleq\right)\bigotimes\frac{\epsilon}{(1+\tau+|q|)^{1-c(\gamma)\otimes\mathbb{C}(\delta)\otimes\mathbb{C}(\gamma)\otimes\mathbb{C}(\psi)\otimes\mathbb{C}(\varphi)\otimes\mathbb{C}(\phi)\otimes\mathbb{C}(\mathcal{I})\otimes\epsilon\left(\left|\frac{|\mathbb{I}|}{2}\right|+\triangleq\right)\otimes\mathfrak{E}}\otimes(1+|q|)^2\boxed{\sum_{|\kappa|^{\blacksquare}+|\mathrm{M}|^{\ddagger}-\mathbb{I}}\left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^\kappa}\Lambda\right|^2\bigotimes\omega(q)\bigotimes d^3\chi\bigotimes d\tau}}\right]$$

$$+\int_{\tau_1}^{\varsigma_2}\int_{\zeta_\tau^\varsigma}^{\square}\sum_{|\mathcal{I}|\leq|\zeta|}\left[\left(\mathbb{C}(q_0)\bigotimes\mathbb{C}(\mathcal{I})\bigotimes\mathbb{E}\left(\left|\frac{|\mathbb{I}|}{2}\right|+\right.\right.\right.$$

$$\left.\left.\left.\triangleq\right)\bigotimes\frac{\epsilon\otimes\left|\mathcal{L}_{\mathbb{Z}^\kappa}\mathcal{H}_{\mathcal{L}\mathcal{L}}\right|^2}{(1+\tau+|q|)^{1-2\delta}\otimes(1+|q|)^{2\gamma-4\delta}}\right)\right]\bigotimes\omega(q)\bigotimes d^3\chi\bigotimes d\tau$$

$$+\mathbb{C}(q_0)\bigotimes\mathbb{C}(\delta)\bigotimes\mathbb{C}(\gamma)\bigotimes\mathbb{C}(\psi)\bigotimes\mathbb{C}(\varphi)\bigotimes\mathbb{C}(\phi)\bigotimes\mathbb{C}(\mathcal{I})\bigotimes\left(\left|\frac{|\mathbb{I}|}{2}\right|+\right.$$

$$\left.\triangleq\right)\mathbb{E}\bigotimes\frac{\epsilon^4}{(1+\tau+|q|)^{1-c(\gamma)\otimes\mathbb{C}(\delta)\otimes\mathbb{C}(\gamma)\otimes\mathbb{C}(\psi)\otimes\mathbb{C}(\varphi)\otimes\mathbb{C}(\phi)\otimes\mathbb{C}(\mathcal{I})\otimes\epsilon\left(\left|\frac{|\mathbb{I}|}{2}\right|+\triangleq\right)\otimes\mathfrak{E}}\otimes(1+|q|)^2\boxed{\sum_{|\kappa|^{\blacksquare}+|\mathrm{M}|^{\ddagger}-\mathbb{I}}\left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^\kappa}\Lambda\right|^2\bigotimes\omega(q)\bigotimes d^3\chi\bigotimes d\tau}}$$

$$\left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\mathcal{J}}}\Lambda_{\epsilon_\alpha}\right|$$

$$\cong \frac{1}{(1+\tau+|q|)(1+|q|)^{2\gamma-4\delta}} \bigotimes \left[\sum_{|\mathcal{J}|\leq|\zeta|+2} \int_{\zeta_{\tau_1}^{\varsigma}}^{\square} \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\mathcal{J}}}\Lambda_{\epsilon_\alpha}\right|^2 \bigotimes \omega(q) \bigotimes d^3\chi\right]$$

$$+ \sum_{|\kappa|\leq|\mathbb{I}|} \int_{\tau_1}^{\tau} \left[\int_{\zeta_\tau^{\varsigma}}^{\square} \left[\mathcal{O}\left(\mathbb{C}(q_0) \bigotimes \mathbb{C}(\delta) \bigotimes \mathbb{C}(\gamma) \bigotimes \mathbb{C}(\psi) \bigotimes \mathbb{C}(\varphi) \bigotimes \mathbb{C}(\phi) \bigotimes \mathbb{C}(\mathcal{J}) \bigotimes \mathbb{E}\left(\left\lfloor\frac{|\mathbb{I}|}{2}\right\rfloor + \right.\right.\right.\right.$$

$$\left.\triangleq\right) \bigotimes \frac{\epsilon \otimes \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\kappa}}\Lambda\right|^2}{(1+\tau+|q|)}\Bigg)$$

$$+ \mathcal{O}\left(\mathbb{C}(q_0) \bigotimes \mathbb{C}(\delta) \bigotimes \mathbb{C}(\gamma) \bigotimes \mathbb{C}(\psi) \bigotimes \mathbb{C}(\varphi) \bigotimes \mathbb{C}(\phi) \bigotimes \mathbb{C}(\mathcal{J}) \bigotimes \mathbb{E}\left(\left\lfloor\frac{|\mathbb{I}|}{2}\right\rfloor + \right.\right.$$

$$\left.\left.\left.\left.\triangleq\right) \bigotimes \frac{\epsilon \otimes \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\kappa}}\Lambda\right|^2}{(1+\tau+|q|)}\right)\right] \bigotimes \omega(q) \bigotimes d^3\chi\right] \bigotimes d\tau$$

$$+ \int_{\tau_1}^{\tau} \int_{\zeta_\tau^{\varsigma}}^{\square} \left[\mathbb{C}(q_0) \bigotimes \mathbb{C}(\delta) \bigotimes \mathbb{C}(\gamma) \bigotimes \mathbb{C}(\psi) \bigotimes \mathbb{C}(\varphi) \bigotimes \mathbb{C}(\phi) \bigotimes \mathbb{C}(\mathcal{J}) \bigotimes \mathbb{E}\left(\left\lfloor\frac{|\mathbb{I}|}{2}\right\rfloor + \right.\right.$$

$$\left.\left.\triangleq\right) \bigotimes \frac{\epsilon^4}{(1+\tau+|q|)^{1-c(\gamma)\otimes\mathbb{C}(\delta)\otimes\mathbb{C}(\gamma)\otimes\mathbb{C}(\psi)\otimes\mathbb{C}(\varphi)\otimes\mathbb{C}(\phi)\otimes\mathbb{C}(\mathcal{J})\otimes\epsilon\left(\left\lfloor\frac{|\mathbb{I}|}{2}\right\rfloor+\triangleq\right)\otimes\mathfrak{E}} \otimes (1+|q|)^2} \sum_{|\kappa|^{\blacksquare}+|\mathrm{M}|^{\ddagger}-\mathbb{I}} \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\kappa}}\Lambda\right|^2 \bigotimes \omega(q) \bigotimes d^3\chi \bigotimes d\tau\right]$$

$$+\int_{\tau_1}^{\tau}\int_{\zeta_\tau^\varsigma}^{\square}\sum_{|\kappa|\leq|\mathbb{I}|}\left[\left(\mathbb{C}(q_0)\bigotimes\mathbb{C}(\mathcal{J})\bigotimes\mathbb{E}\left(\left\lfloor\frac{|\mathbb{I}|}{2}\right\rfloor+\right.\right.\right.$$

$$\left.\left.\left.\triangleq\right)\bigotimes\frac{\epsilon\otimes|\mathcal{L}_{\mathbb{Z}^\kappa}\mathcal{H}_{\mathcal{L}\mathcal{L}}|^2}{(1+\tau+|q|)^{1-2\delta}\otimes(1+|q|)^{2\gamma-4\delta}}\right)\right]\bigotimes\omega(q)\bigotimes d^3\chi\bigotimes d\tau$$

$$+\mathbb{C}(q_0)\bigotimes\mathbb{C}(\delta)\bigotimes\mathbb{C}(\gamma)\bigotimes\mathbb{C}(\mathcal{J})\bigotimes\left(\left\lfloor\frac{|\mathbb{I}|}{2}\right\rfloor+\right.$$

$$\left.\triangleq\right)\bigotimes\left|\frac{\epsilon^4}{(1+\tau+|q|)^{1-c(\gamma)\otimes\mathbb{C}(\delta)\otimes\mathbb{C}(\gamma)\otimes\mathbb{C}(\psi)\otimes\mathbb{C}(\varphi)\otimes\mathbb{C}(\phi)\otimes\mathbb{C}(\mathcal{J})\otimes\epsilon\left(\left\lfloor\frac{|\mathbb{I}|}{2}\right\rfloor+\triangleq\right)\otimes\mathfrak{E}}\otimes(1+|q|)^{\frac{1}{2}+2\delta}\ \boxed{\sum_{|\kappa|^{\blacksquare}+|\mathrm{M}|^{\ddagger}-\mathbb{I}}\left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^\kappa}\Lambda\right|^2\bigotimes\omega(q)\bigotimes d^3\chi\bigotimes d\tau}}\right|^{\frac{1}{2}}$$

$$\left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\mathcal{J}}}\hbar_{\epsilon_\alpha}\right|$$

$$\cong \frac{1}{(1+\tau+|q|)(1+|q|)^{1+\gamma}} \bigotimes \left[\sum_{|\mathcal{J}|\leq|\zeta|+2} \int_{\zeta_{\tau_1}^{\varsigma}}^{\square} \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\mathcal{J}}}\hbar_{\epsilon_\alpha}\right|^2 \bigotimes \omega(q) \bigotimes d^3\chi\right]$$

$$+ \sum_{|\kappa|\leq|\mathbb{I}|} \int_{\tau_1}^{\tau} \left[\left[\int_{\zeta_\tau^{\varsigma}}^{\square}\left[\mathcal{O}\left(\mathbb{C}(q_0) \bigotimes \mathbb{C}(\delta) \bigotimes \mathbb{C}(\gamma) \bigotimes \mathbb{C}(\psi) \bigotimes \mathbb{C}(\varphi) \bigotimes \mathbb{C}(\phi) \bigotimes \mathbb{C}(\mathcal{J}) \bigotimes \mathbb{E}\left(\left\lfloor\frac{|\mathbb{I}|}{2}\right\rfloor + \right.\right.\right.\right.\right.$$

$$\left.\triangleq\right) \bigotimes \frac{\epsilon \otimes \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\kappa}}\hbar\right|^2}{(1+\tau+|q|)}\Bigg)$$

$$+ \mathcal{O}\left(\mathbb{C}(q_0) \bigotimes \mathbb{C}(\delta) \bigotimes \mathbb{C}(\gamma) \bigotimes \mathbb{C}(\psi) \bigotimes \mathbb{C}(\varphi) \bigotimes \mathbb{C}(\phi) \bigotimes \mathbb{C}(\mathcal{J}) \bigotimes \mathbb{E}\left(\left\lfloor\frac{|\mathbb{I}|}{2}\right\rfloor + \right.\right.$$

$$\left.\triangleq\right) \bigotimes \frac{\epsilon \otimes \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\kappa}}\hbar\right|^2}{(1+\tau+|q|)}\Bigg)\Bigg] \bigotimes \omega(q) \bigotimes d^3\chi\Bigg] \bigotimes d\tau$$

$$+ \int_{\tau_1}^{\tau} \int_{\zeta_\tau^{\varsigma}}^{\square} \Bigg[\mathbb{C}(q_0) \bigotimes \mathbb{C}(\delta) \bigotimes \mathbb{C}(\gamma) \bigotimes \mathbb{C}(\psi) \bigotimes \mathbb{C}(\varphi) \bigotimes \mathbb{C}(\phi) \bigotimes \mathbb{C}(\mathcal{J}) \bigotimes \mathbb{E}\left(\left\lfloor\frac{|\mathbb{I}|}{2}\right\rfloor + \right.$$

$$\left.\triangleq\right) \bigotimes \frac{\epsilon^4}{(1+\tau+|q|)^{1-c(\gamma)\otimes\mathbb{C}(\delta)\otimes\mathbb{C}(\gamma)\otimes\mathbb{C}(\psi)\otimes\mathbb{C}(\varphi)\otimes\mathbb{C}(\phi)\otimes\mathbb{C}(\mathcal{J})\otimes\epsilon\left(\left\lfloor\frac{|\mathbb{I}|}{2}\right\rfloor+\triangleq\right)\otimes\mathfrak{E}} \otimes (1+|q|)^2} \sum_{|\kappa|^{\blacksquare}+|\mathrm{M}|^{\ddagger}-\mathbb{I}} \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\kappa}}\hbar\right|^2 \bigotimes \omega(q) \bigotimes d^3\chi \bigotimes d\tau\Bigg]$$

$$\left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{J}}\mathcal{H}_{\epsilon_{\alpha}}\right|$$

$$\cong \frac{1}{(1+\tau+|q|)(1+|q|)^{1+\gamma}} \bigotimes \left[\sum_{|J|\leq|\zeta|+2} \int_{\zeta_{\tau_1}^{\varsigma}}^{\square} \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{J}}\mathcal{H}_{\epsilon_{\alpha}}\right|^2 \bigotimes \omega(q) \bigotimes d^3\chi\right]$$

$$+ \sum_{|\kappa|\leq|\mathbb{I}|} \int_{\tau_1}^{\tau} \left[\left[\int_{\zeta_{\tau}^{\varsigma}}^{\square} \left[\mathcal{O}\left(\mathbb{C}(q_0) \bigotimes \mathbb{C}(\delta) \bigotimes \mathbb{C}(\gamma) \bigotimes \mathbb{C}(\psi) \bigotimes \mathbb{C}(\varphi) \bigotimes \mathbb{C}(\phi) \bigotimes \mathbb{C}(\mathcal{J}) \bigotimes \mathbb{E}\left(\left|\frac{|\mathbb{I}|}{2}\right| + \right.\right.\right.\right.\right.$$

$$\left.\triangleq\right) \bigotimes \frac{\epsilon \otimes \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\kappa}}\mathcal{H}\right|^2}{(1+\tau+|q|)}\Bigg)$$

$$+ \mathcal{O}\left(\mathbb{C}(q_0) \bigotimes \mathbb{C}(\delta) \bigotimes \mathbb{C}(\gamma) \bigotimes \mathbb{C}(\psi) \bigotimes \mathbb{C}(\varphi) \bigotimes \mathbb{C}(\phi) \bigotimes \mathbb{C}(\mathcal{J}) \bigotimes \mathbb{E}\left(\left|\frac{|\mathbb{I}|}{2}\right| + \right.\right.$$

$$\left.\triangleq\right) \bigotimes \frac{\epsilon \otimes \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\kappa}}\mathcal{H}\right|^2}{(1+\tau+|q|)}\Bigg)\Bigg] \bigotimes \omega(q) \bigotimes d^3\chi\Bigg] \bigotimes d\tau$$

$$+ \int_{\tau_1}^{\tau} \int_{\zeta_{\tau}^{\varsigma}}^{\square} \Bigg[\mathbb{C}(q_0) \bigotimes \mathbb{C}(\delta) \bigotimes \mathbb{C}(\gamma) \bigotimes \mathbb{C}(\psi) \bigotimes \mathbb{C}(\varphi) \bigotimes \mathbb{C}(\phi) \bigotimes \mathbb{C}(\mathcal{J}) \bigotimes \mathbb{E}\left(\left|\frac{|\mathbb{I}|}{2}\right| + \right.$$

$$\left.\triangleq\right) \bigotimes \frac{\epsilon^4}{(1+\tau+|q|)^{1-c(\gamma)\otimes\mathbb{C}(\delta)\otimes\mathbb{C}(\gamma)\otimes\mathbb{C}(\psi)\otimes\mathbb{C}(\varphi)\otimes\mathbb{C}(\phi)\otimes\mathbb{C}(\mathcal{J})\otimes\epsilon\left(\left|\frac{|\mathbb{I}|}{2}\right|+\triangleq\right)\otimes\mathfrak{E}} \otimes (1+|q|)^2} \sum_{|\kappa|^{\blacksquare}+|\mathrm{M}|^{\ddagger}-\mathbb{I}} \left|\nabla^{(m)}\mathcal{L}_{\mathbb{Z}^{\kappa}}\mathcal{H}\right|^2 \bigotimes \omega(q) \bigotimes d^3\chi \bigotimes d\tau\Bigg]$$

$$\int_{\mathbb{S}^2}^{\square} \int_{r=\mathcal{R}(\Omega)}^{r=\infty} \lim_{r\to\infty} \left(\frac{r^2}{(1+t+r)^{\alpha} \otimes (1+|q|)} \bigotimes \frac{\omega(q)}{(1+|q|)^2} \bigotimes |\partial_r \phi_{\mathcal{V}}|^2 \bigotimes dr^2 \bigotimes d\sigma^2(t)\right) c(\gamma) \bigotimes \left|\nabla^{(m)}\phi_{\mathcal{V}}\right|^2$$

$$\left[\sum_{|\kappa|\leq|\mathbb{I}|} \frac{\epsilon \otimes \left|\nabla^{(m)}\partial\mathcal{L}_{Z^{\kappa}}\Lambda_{\mathcal{L}}\right|^2}{(1+\tau+|q|)^{1-c(\gamma)\otimes\mathbb{C}(\delta)\otimes\mathbb{C}(\gamma)\otimes\mathbb{C}(\psi)\otimes\mathbb{C}(\varphi)\otimes\mathbb{C}(\phi)\otimes\mathbb{C}(\mathcal{J})\otimes\epsilon\left(\left|\frac{|\mathbb{I}|}{2}\right|+\triangleq\right)\otimes\mathfrak{E}} \otimes (1+|q|)^{2\gamma-4\delta}}\right]$$

$$\int \mathbb{C}(q_0) \bigotimes \mathbb{C}(\delta) \bigotimes \mathbb{C}(\gamma) \bigotimes \mathbb{C}(\psi) \bigotimes \mathbb{C}(\varphi) \bigotimes \mathbb{C}(\phi) \bigotimes \mathbb{C}(\mathcal{J}) \bigotimes \mathbb{E}\left(\left|\frac{|\mathbb{I}|}{2}\right| + \right.$$

$$\left.\triangleq\right) \bigotimes \sum_{|\kappa|\leq|\mathbb{I}|} \frac{\epsilon \otimes \left|\nabla^{(m)}\partial\mathcal{L}_{Z^{\kappa}}\Lambda\right|^2}{(1+\tau+|q|)^{1-c(\gamma)\otimes\mathbb{C}(\delta)\otimes\mathbb{C}(\gamma)\otimes\mathbb{C}(\psi)\otimes\mathbb{C}(\varphi)\otimes\mathbb{C}(\phi)\otimes\mathbb{C}(\mathcal{J})\otimes\epsilon\left(\left|\frac{|\mathbb{I}|}{2}\right|+\triangleq\right)\otimes\mathfrak{E}} \otimes (1+|q|)^{2\gamma-4\delta}}$$

$$\bigotimes \omega(q) \bigotimes d^3\chi \bigotimes d\tau \frac{\epsilon}{(1+\tau+|q|)^2}$$

$$\sum_{|\kappa|\leq|\mathbb{I}|} \left[ \left|\nabla^{(m)} \partial \mathcal{L}_{\mathcal{Z}^\kappa} \Lambda\right|^2 \right] \frac{\epsilon^4}{(1+\tau)^{1-c(\gamma)\otimes\mathbb{C}(\delta)\otimes\mathbb{C}(\gamma)\otimes\mathbb{C}(\psi)\otimes\mathbb{C}(\varphi)\otimes\mathbb{C}(\phi)\otimes\mathbb{C}(\mathcal{J})\otimes\epsilon\left(\left\lfloor\frac{|\mathbb{I}|}{2}\right\rfloor+\triangleq\right)\otimes\mathfrak{E}} \otimes (1+|q|)^{2\gamma-4\delta}}$$

**Postulado Adicional:** Cuando una partícula supermasiva o masiva, según el caso o cuando una antipartícula supermasiva o masiva, según el caso o cuando las partículas o antipartículas antes referidas, según sea el caso, se aproximan, alcanzan o superan la velocidad de la luz, o finalmente, cuando su estado de energía es infinitamente superior a cero, sin perjuicio de su carga, en cualquiera de estos casos, no solamente se deforma geométricamente el espacio cuántico en el que interactúan, sino que también, la morfología inherente a las partículas o antipartículas antes referidas, se deforma.

La deformación de una partícula o una antipartícula a la que converjan las características anteriores, queda expresada así:

$$|\mathfrak{Q}_t| = \langle \varphi \frac{\xi}{\sqrt{\zeta\pi}} \lambda_\epsilon (\delta_{\blacksquare})^2 \rangle \left|\Theta_\eta\right|$$

**REFERENCIAS BIBLIOGRÁFICAS ADICIONALES.**


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**APÉNDICE C.**

**(a) Formalización Matemática en relación a la Teoría Cuántica de Espacios Curvos, esto por la interacción de partículas supermasivas y masivas y antipartículas supermasivas y masivas respectivamente.**

**1. Cuantización Canonical y leyes de conservación.**

$$ds^2 = g_{\mu\nu}(\chi)d\chi^\mu d\chi^\nu, \delta[\phi'(\chi'), \nabla'\phi'(\chi'), g'_{\mu\nu}(\chi')]$$

$$= \delta[\phi(\chi), \nabla\phi(\chi), g_{\mu\nu}(\chi)] \int d^\eta \chi \mathcal{L}(\phi\nabla\phi g_{\mu\nu})\, \partial_\mu \left(\frac{\partial\mathcal{L}}{\partial(\partial_\mu\phi_\alpha)}\delta\phi_\alpha\right) - \frac{\partial\mathcal{L}}{\partial\phi_\alpha} g_{\mu\nu}(\chi)$$

$$\longrightarrow g'_{\mu\nu}(\chi') = \frac{\partial\chi^\lambda}{\partial\chi'^\mu}\frac{\partial\chi^\sigma}{\partial\chi'^\nu} g_{\lambda\sigma}(\chi)\delta_o g_{\mu\nu}(\chi) \equiv g'_{\mu\nu}(\chi') - g_{\mu\nu}(\chi) = \mathcal{L}_\epsilon g_{\mu\nu}$$

$$= \nabla_\mu\epsilon_\nu + \nabla_\nu\epsilon_\mu \delta\mathcal{S} \int d^\eta\chi \frac{\delta\mathcal{S}}{\delta g_{\mu\nu}(\chi)} \delta_0 g_{\mu\nu}(\chi) \int dv_\chi\, \mathcal{T}^{\mu\nu}\nabla_\mu\epsilon_\nu$$

$$\equiv -2|g|^{-\frac{1}{2}} \frac{\delta\mathcal{S}}{\delta g_{\mu\nu}(\chi)} \nabla_\mu(\mathcal{T}^{\mu\nu}\epsilon_\nu) = |g|^{-\frac{1}{2}}\partial_\mu\left(|g|^{-\frac{1}{2}}\mathcal{T}^{\mu\nu}\epsilon_\nu\right)$$

$$= (\nabla_\mu\mathcal{T}^{\mu\nu})\epsilon_\nu + \mathcal{T}^{\mu\nu}\nabla_\mu\epsilon_\nu \int dv_\chi\, (\nabla_\mu\mathcal{T}^{\mu\nu})\epsilon_\nu\mathcal{T}_{\mu\nu}$$

$$+ \frac{2}{|g|^{-\frac{1}{2}}}\frac{\delta\mathcal{S}}{\delta g^{\mu\nu}} \mathcal{G}(t) \int d^{\eta-1}\chi[\pi_\alpha\delta\phi_\alpha - \Theta^o_\nu\delta\chi^\nu] = \frac{\partial\mathcal{L}}{\partial(\partial_0\phi_\alpha)}\{\phi_\alpha(\vec{\chi},t), \pi_\beta(\vec{\chi},t)\}$$

$$= i\delta_{\alpha,\beta}\delta(\vec{\chi}-\vec{\chi})\epsilon\xi^\mu(\chi)\rho_\lambda \int d^{\eta-1}\chi\, \Theta^o_\lambda\mathcal{L}_\epsilon g_{\mu\nu}\nabla_\mu\xi_\nu$$

$$+ \nabla_\nu\xi_\mu(\nabla_\mu\mathcal{T}^{\mu\nu}\xi_\nu)\partial_\mu\left(|g|^{-\frac{1}{2}}\mathcal{T}^{\mu\nu}\xi_\nu\right)\mathcal{P}_\xi \equiv \int d\mathcal{V}_\chi \mathcal{T}^0_\nu(\chi)\xi^\nu(\chi)\,\tilde{g}_{\mu\nu}(\chi)$$

$$= \Omega^{2\rho}(\chi)g_{\mu\nu}(\chi)1 + |\lambda(\chi)|\delta_0 g_{\mu\nu}(\chi) = \tilde{g}_{\mu\nu}(\chi) - g_{\mu\nu}(\chi) = \lambda(\chi)g_{\mu\nu}(\chi)\delta_0\phi(\chi)$$

$$= \tilde{\phi}(\chi) - \phi(\chi)$$

$$= \rho\lambda(\chi)\phi(\chi) \int d^\eta\chi \left\{\frac{\delta\mathcal{S}}{\delta\phi}\delta_0\phi + \frac{\delta\mathcal{S}}{\delta g_{\mu\nu}}\delta_0 g_{\mu\nu}\right\} \int d^\eta\chi \frac{\delta\mathcal{S}}{\delta g_{\mu\nu}(\chi)} g_{\mu\nu}(\chi)\lambda(\chi)$$

**2. Campo Escalar en espacios cuánticos curvos.**

$$\delta = \int d^\eta \chi \mathcal{L} \frac{1}{2} |g|^{\frac{1}{2}} (g^{\mu\nu} \partial_\mu \phi \partial_\nu \phi - m^2 \phi^2 - \xi \mathcal{R} \phi^2) g_{\mu\nu}(\chi) \longrightarrow \tilde{g}_{\mu\nu}(\chi) = 1 + |\lambda(\chi)| g_{\mu\nu}(\chi) \tilde{\phi}(\chi)$$

$$\longrightarrow \phi(\chi) = \left(1 - \frac{1}{2}\lambda(\chi)\right) \phi(\chi) |g|^{\frac{1}{2}} \mapsto |\tilde{g}|^{\frac{1}{2}} = (1 - 2\lambda)|g|^{\frac{1}{2}} g^{\mu\nu} \longrightarrow \tilde{g}^{\mu\nu}$$

$$= (1 - \lambda) g^{\mu\nu} \Gamma^\mu_{\nu\tau} \mapsto \tilde{\Gamma}^\mu_{\nu\tau} = \Gamma^\mu_{\nu\tau} + \frac{1}{2}(\delta^\mu_\tau \partial_\nu \lambda + \delta^\mu_\nu \partial_\tau \lambda - g^{\mu\sigma} g_{\nu\tau} \partial_\sigma \lambda) \mathcal{R} \mapsto \tilde{\mathcal{R}}$$

$$= (1 - \lambda)\mathcal{R} + 3\Box\lambda$$

$$\bar{\mathcal{L}} = \frac{1}{2} |\tilde{g}|^{\frac{1}{2}} \left(\tilde{g}^{\mu\nu} \partial_\mu \tilde{\phi} \partial_\nu \tilde{\phi} - \frac{1}{6} \tilde{\mathcal{R}} \tilde{\phi}^2\right)$$

$$= \frac{1}{2}(1 + 2\lambda)|g|^{\frac{1}{2}} \left\{(1 - \lambda) g^{\mu\nu} \partial_\mu \left[\left(1 - \frac{1}{2}\lambda\right)\phi\right] \partial_\nu \left[\left(1 - \frac{1}{2}\lambda\right)\phi\right]\right.$$

$$\left. - \frac{1}{6}[(1 - \lambda)\mathcal{R} + 3\Box\lambda](1 - \lambda)\phi^2\right\}$$

$$= \frac{1}{2}|g|^{\frac{1}{2}} \left\{g^{\mu\nu} \partial_\mu \phi \partial_\nu \phi - g^{\mu\nu} \phi \partial_\mu \lambda \partial_\nu \phi - \frac{1}{6} \mathcal{R} \phi^2 - \frac{1}{2}(\Box\lambda)\phi^2\right\}$$

$$= -\frac{1}{2}|g|^{\frac{1}{2}} g^{\mu\nu} \phi \partial_\mu \lambda \partial_\nu \phi - \frac{1}{4}|g|^{\frac{1}{2}}(\Box\lambda)\phi^2$$

$$- \partial_\mu \left(\frac{1}{4}|g|^{\frac{1}{2}} g^{\mu\nu} \phi^2 \partial_\nu \lambda \ln \Omega\right) \Omega^2 g_{\mu\nu} \Omega^{-1} \phi(\Box + m^2 + \xi\mathcal{R})\phi$$

$$\mathcal{T}^{\mu\nu} = \nabla^\mu \phi \nabla^\nu \phi - \frac{1}{2} g^{\mu\nu} \nabla^\rho \phi \nabla_\rho \phi + \frac{1}{2} g^{\mu\nu} m^2 \phi^2 - \xi \left(\mathcal{R}^{\mu\nu} - \frac{1}{2} g^{\mu\nu} \Re\right) \phi^2$$

$$+ \xi [g^{\mu\nu} \Box(\phi^2) - \nabla^\mu \nabla^\nu (\phi^2)] \delta g^{\mu\nu} - g^{\mu\rho} g^{\nu\sigma} \delta g_{\rho\sigma} \delta |g|^{\frac{1}{2}}$$

$$= \frac{1}{2}|g|^{\frac{1}{2}} g^{\mu\nu} \delta g_{\mu\nu} \delta \mathcal{R} - \mathcal{R}^{\mu\nu} \delta g_{\mu\nu} + g^{\rho\sigma} g^{\mu\nu} (\delta g_{\rho\sigma;\mu\nu} - \delta g_{\rho\mu;\sigma\nu}) \delta \mathcal{S}$$

$$= \frac{1}{2} \int d^\eta \chi \, |g|^{\frac{1}{2}} \left\{\frac{1}{2} g^{\mu\nu} \delta g_{\mu\nu} (g^{\rho\sigma} \partial_\rho \phi \partial_\sigma \phi - m^2 \phi^2 - \xi \mathcal{R} \phi^2) - \delta g_{\mu\nu} \nabla^\mu \phi \nabla^\nu \phi\right.$$

$$\left. - \xi [-\mathcal{R}^{\mu\nu} \delta g_{\mu\nu} + g^{\rho\sigma} g^{\mu\nu} (\delta g_{\rho\sigma;\mu\nu} - \delta g_{\rho\mu;\sigma\nu})] \phi^2\right\} \int d^\eta \chi \, |g|^{\frac{1}{2}} g^{\rho\sigma} g^{\mu\nu} \delta g_{\rho\sigma;\mu\nu} \phi^2$$

$$= \int d^\eta \chi |g|^{\frac{1}{2}} g^{\rho\sigma} \delta g_{\rho\sigma} \Box(\phi^2) \int d^\eta \chi \, |g|^{\frac{1}{2}} g^{\rho\sigma} g^{\mu\nu} \delta g_{\rho\mu;\sigma\nu} \phi^2$$

$$= \int d^\eta \chi |g|^{\frac{1}{2}} g^{\sigma\mu} g^{\lambda\nu} \delta g_{\mu\nu} \nabla_\sigma \nabla_\lambda (\phi^2)$$

$$\frac{d}{dt}(f_1 f_2) = i\int d^{\eta-1}\chi|g|^{\frac{1}{2}}\partial_0 g^{0\nu} f_1^*(\vec{\chi},t)\overleftrightarrow{\partial}_\nu f_2(\vec{\chi},t)$$

$$= i\int d^{\eta-1}\chi|g|^{\frac{1}{2}}\nabla_\mu\left(g^{\mu\nu} f_1^*\overleftrightarrow{\partial}_\nu f_2\right)$$

$$- i\int d^{\eta-1}\chi\partial_i\left(|g|^{\frac{1}{2}} g^{i\nu} f_1^*\overleftrightarrow{\partial}_\nu f_2\right) i\int_\sigma^{\square} d\sigma\,|g|^{\frac{1}{2}}\eta^\nu f_1^*\overleftrightarrow{\partial}_\nu f_2 (f_1 f_2)_{\sigma'} - (f_1 f_2)_\sigma$$

$$= i\int_\nu^{\square} d^\eta\chi\,|g|^{\frac{1}{2}}\nabla^\mu\left(f_1^*\overleftrightarrow{\nabla}_\mu f_2\right)$$

**3. Modelo Cosmológico en espacios cuánticos curvos.**

$$ds^2 = dt^2 - \alpha^2(t)(d\chi^2 - d\gamma^2 - dz^2)\square\phi\alpha^{-3}\partial_t(\alpha^3\partial_t\phi)$$

$$- \alpha^{-2}\sum_i \partial_i^2\phi\sum_\kappa\left\{A_{\vec{\kappa}} f_{\vec{\kappa}}(\chi) + A_{\vec{\kappa}}^\dagger f_{\vec{\kappa}}^*\right\}\mathcal{V}^{-1}e^{i\vec{\kappa}\cdot\vec{\chi}}\psi_\kappa(\tau)\frac{d^2\psi_\kappa}{d\tau^2}$$

$$+ \kappa^2\alpha^4\psi_\kappa(\tau)\int\left(\mathcal{V}_{\alpha_1}^3\right)^{-\frac{1}{2}}(2\omega_{1\kappa})^{-\frac{1}{2}}\exp[i(\vec{\kappa}\cdot\vec{\chi} - \omega_{1\kappa}t)]dt'\,[\phi(\vec{\chi},t),\pi(\vec{\chi}',t)]$$

$$= \alpha^3(t)\sum_{\vec{\kappa}} f_{\vec{\kappa}}(\vec{\chi},t)\partial_t f_{\vec{\kappa}}^*(\vec{\chi}',t) - f_{\vec{\kappa}}^*(\vec{\chi},t)\partial_t f_{\vec{\kappa}}(\vec{\chi}',t)$$

$$\hbar(\vec{\chi},t) = \sum_{\vec{\kappa}}\left\{f_{\vec{\kappa}}(\vec{\kappa},t)(f_{\vec{\kappa}},\hbar) - f_{\vec{\kappa}}^*(\vec{\chi},t)\left(f_{\vec{\kappa}}^*,\hbar\right)\right\}$$

$$= i\int d^3\chi'\alpha^3(t)\sum_{\vec{\kappa}}\left\{f_{\vec{\kappa}}(\vec{\chi},t)\partial_t f_{\vec{\kappa}}^*(\vec{\chi}',t) - f_{\vec{\kappa}}^*(\vec{\chi},t)\partial_t f_{\vec{\kappa}}(\vec{\chi}',t)\right\}\hbar(\vec{\chi}',t)$$

$$+ i\int d^3\chi'\alpha^3(t)\sum_{\vec{\kappa}}\left\{f_{\vec{\kappa}}(\vec{\chi},t) f_{\vec{\kappa}}^*(\vec{\chi}',t) - f_{\vec{\kappa}}^*(\vec{\chi},t)\partial_t f_{\vec{\kappa}}(\vec{\chi}',t)\right\}\partial_t\hbar(\vec{\chi}',t)$$

$$= i\delta(\vec{\chi} - \vec{\chi}')$$

**4. Partícula Cosmológica en relación a espacios cuánticos curvos.**

$$\psi_\kappa^{(\pm)} \sim (2\alpha^3\omega_{2\kappa})^{-\frac{1}{2}} \exp(\mp i\omega_{2\kappa}\alpha_2^3\tau)\psi_\kappa(t) = \alpha_\kappa\psi_\kappa^{(+)}(\tau) + \beta_\kappa\psi_\kappa^{(-)}(\tau)$$

$$\sim \left[\alpha_\kappa e^{-i\alpha_2^3\omega_{2\kappa}\tau} + \beta_\kappa e^{i\alpha_2^3\omega_{2\kappa}\tau}\right]\psi_\kappa\partial_\tau\psi_\kappa^* - \psi_\kappa^*\partial_\tau\,\psi_\kappa|\alpha_\kappa|^2 - |\beta_\kappa|^2 f_{\vec{\kappa}}$$

$$\sim (\mathcal{V}\alpha_2^3)^{-\frac{1}{2}}(2\omega_{2\kappa})^{-\frac{1}{2}} e^{i\vec{\kappa}\cdot\vec{\chi}}\left[\alpha_\kappa e^{-i\omega_{2\kappa}\tau}\right.$$

$$\left.+ \beta_\kappa e^{i\omega_{2\kappa}\tau}\right]\phi(\chi)\sum_{\vec{\kappa}}\left\{\alpha_{\vec{\kappa}} g_{\vec{\kappa}}(\chi) + \alpha_{\vec{\kappa}}^\dagger g_{\vec{\kappa}}^*(\chi)\right.$$

$$\left.\sim (\mathcal{V}\alpha_2^3)^{-\frac{1}{2}}(2\omega_{2\kappa})^{-\frac{1}{2}} \exp[i(\vec{\kappa}\cdot\vec{\chi} - \omega_{2\kappa}\tau)]\right\} \mathrm{A}_{\vec{\kappa}} + \beta_\kappa^*\,\mathrm{A}_{-\vec{\kappa}}^\dagger\left[\alpha_{\vec{\kappa}}\alpha_{\overrightarrow{\kappa'}}^\dagger\right]$$

$$= \delta_{\vec{\kappa}\overrightarrow{\kappa'}}(|\alpha_\kappa|^2 - |\beta_\kappa|^2) = \delta_{\vec{\kappa}\overrightarrow{\kappa'}}\langle \mathrm{N}_{\vec{\kappa}}\rangle_{\tau\mapsto\infty}\langle 0|\alpha_{\vec{\kappa}}^\dagger\alpha_{\vec{\kappa}}|0\rangle|\beta_\kappa|^2$$

**5. Spin cero en espacios cuánticos curvos.**

$$\Box\phi + (m^2 + \xi\mathcal{R})\phi\Re$$

$$= 6\left[\left(\frac{\dot{\alpha}}{\alpha}\right)^2 + \left(\frac{\ddot{\alpha}}{\alpha}\right)\right]\alpha^{-3}\partial_t(\alpha^3\partial_t\phi)$$

$$-\alpha^{-2}\sum_i \partial_i^2\phi(m^2 + \xi\mathcal{R})\phi\sum_{\vec{\kappa}}\{\mathrm{A}_{\vec{\kappa}} f_{\vec{\kappa}}(\chi) - A_{\vec{\kappa}}^\dagger f_{\vec{\kappa}}^*(\chi)\}$$

$$\sim \left(\mathcal{V}_{\alpha_1}^3\right)^{-\frac{1}{2}}(2\omega_{1\kappa})^{-\frac{1}{2}} \exp[i(\vec{\kappa}\cdot\vec{\chi} - \omega_{1\kappa}t)]dt'\phi\sum_{\vec{\kappa}}\{\alpha_{\vec{\kappa}} g_{\vec{\kappa}}(\chi) + \alpha_{\vec{\kappa}}^\dagger g_{\vec{\kappa}}^*(\chi)\}$$

$$\sim \left(\mathcal{V}_{\alpha_1}^3\right)^{-\frac{1}{2}}(2\omega_{2\kappa})^{-\frac{1}{2}} \exp[i(\vec{\kappa}\cdot\vec{\chi} - \omega_{2\kappa}t)]\left[\left(\frac{\kappa}{\alpha^2}\right) + m^2\right]^{\frac{1}{2}}\alpha_{\vec{\kappa}}\mathrm{A}_{\vec{\kappa}} + \beta_\kappa^*\mathrm{A}_{-\vec{\kappa}}^\dagger[\alpha_{\vec{\kappa}}\alpha_{\overrightarrow{\kappa'}}]_\pm$$

$$= \alpha_\kappa\beta_{\kappa'}^*\left[\mathrm{A}_{\vec{\kappa}}\mathrm{A}_{-\overrightarrow{\kappa'}}^\dagger\right]_\pm + \alpha_{\kappa'}\beta_\kappa^*\left[\mathrm{A}_{-\vec{\kappa}}^\dagger\mathrm{A}_{\overrightarrow{\kappa'}}\right]_\pm = (\alpha_\kappa\beta_\kappa^* \pm \alpha_\kappa\beta_\kappa^*)\delta_{\vec{\kappa}-\overrightarrow{\kappa'}}\left[\alpha_{\vec{\kappa}}\alpha_{\overrightarrow{\kappa'}}^\dagger\right]_\pm$$

$$= (|\alpha_\kappa|^2 \pm |\beta_\kappa|^2)\delta_{\vec{\kappa},\overrightarrow{\kappa'}}$$

**6. Invariante conforme.**

$$\mathcal{L} = \frac{1}{2}|g|^{\frac{1}{2}}\left(g^{\mu\nu}\partial_\mu\phi\partial_\nu\phi - \frac{1}{6}\mathcal{R}\phi^2\right)\tilde{g}_{\mu\nu}(\chi) = \Omega^2(\chi)g_{\mu\nu}(\chi)\tilde{\phi}(\chi)$$

$$= \Omega^{-1}(\chi)\phi(\chi)\frac{\delta S}{\delta\varphi}\frac{\delta\tilde{S}}{\delta\varphi}\frac{\delta\tilde{S}}{\delta\tilde{\varphi}}\Omega^{-1}\left(\square + \frac{1}{6}\mathcal{R}\right)\phi$$

$$= \Omega^3\left(\widehat{\square} + \frac{1}{6}\mathcal{R}\right)\eta\int_{\square}^{\tau}\alpha^{-1}(t')dt'\int ds^2$$

$$= dt^2 - \alpha^2(t)(d\chi^2 - d\gamma^2 - dz^2)\,\tilde{f}_{\vec{\kappa}}(\chi)\mathcal{V}^{-1/2}(2\kappa)^{-1/2}\exp[i(\vec{\kappa}\cdot\vec{\chi} - \kappa\eta)]\,f_{\vec{\kappa}}(\chi)$$

$$= \alpha^{-1}(t)\tilde{f}_{\vec{\kappa}}(\chi)$$

$$= \left(2\mathcal{V}\alpha^3(t)\omega_\kappa(\tau)\right)^{-1/2}\exp\left[i\left(\vec{\kappa}\cdot\vec{\chi} - \int_{\square}^{\tau}\omega_\kappa(\tau')dt'\right)\phi\right]\sum_{\vec{\kappa}}\{\mathrm{A}_{\vec{\kappa}}f_{\vec{\kappa}}(\chi) + \mathrm{A}_{\vec{\kappa}}^{\dagger}f_{\vec{\kappa}}^{*}(\chi)\}$$

**7. Dinámica de partículas en espacios cuánticos curvos.**

$$\alpha_{\vec{\kappa}} = \alpha_\kappa\mathrm{A}_{\vec{\kappa}} + \beta_\kappa^{*}\mathrm{A}_{-\vec{\kappa}}^{\dagger}|\alpha_\kappa|^2 - |\beta_\kappa|^2\eta(\vec{\kappa})\eta(-\vec{\kappa})|0\rangle = (\eta!)^{-1}\langle 0|(\alpha_{-\vec{\kappa}})^{\eta}(\alpha_{\vec{\kappa}}^{\eta})|0\rangle\alpha_{\vec{\kappa}}|0\rangle = \beta_{\vec{\kappa}}^{*}\mathrm{A}_{-\vec{\kappa}}^{\dagger}|0\rangle$$

$$= \beta_\kappa^{*}(\alpha_\kappa^{*})^{-1}\alpha_{-\vec{\kappa}}^{\dagger}|0\rangle\eta(\vec{\kappa})(-\vec{\kappa})|0\rangle = (\eta!)^{-1}\left|\frac{\beta_{\kappa_j}^{*}}{\alpha_{\kappa_j}^{*}}\right|^{\eta}\left\langle 0\middle|(\alpha_{-\vec{\kappa}})^{\eta}\left(\alpha_{-\vec{\kappa}}^{\dagger}\right)^{\eta}\middle|0\right\rangle$$

$$= (\eta!)^{-\frac{1}{2}}\left|\frac{\beta_{\kappa_j}^{*}}{\alpha_{\kappa_j}^{*}}\right|^{\eta}\left\langle\eta(-\vec{\kappa})\middle|\left|\left(\alpha_{-\vec{\kappa}}^{\dagger}\right)^{\eta}\right|0\right\rangle\left|\eta(-\vec{\kappa})\right\rangle$$

$$= (\eta!)^{-\frac{1}{2}}\left(\alpha_{-\vec{\kappa}}^{\dagger}\right)^{\eta}|0\rangle\langle\{\eta_j(\vec{\kappa}_j)\}|0\rangle\prod_j\left|\frac{\beta_{\kappa_j}^{*}}{\alpha_{\kappa_j}^{*}}\right|^{\eta_j}\langle 0|0\rangle\sum_{\{\eta_j(\vec{\kappa}_j)\}}\langle\{\eta_j(\vec{\kappa}_j)\}|\{\eta_j(\vec{\kappa}_j)\}|0\rangle$$

$$\sum_{\{\eta_j(\vec{\kappa}_j)\}}|\langle\{\eta_j(\vec{\kappa}_j)\}|0\rangle|^2$$

$$= \left(\sum_{\{\eta_j(\vec{\kappa}_j)\}}\prod_j\left(\frac{\beta_{\kappa_j}^{*}}{\alpha_{\kappa_j}^{*}}\right)^{2\eta_j}\right)|\langle 0|0\rangle|^2\prod_j\sum_{\eta_j=0}\left|\frac{\beta_{\kappa_j}^{*}}{\alpha_{\kappa_j}^{*}}\right|^{2\eta_j}\left|\alpha_{\kappa_j}\right|^2\Bigg(1$$

$$-\left|\frac{\beta_{\kappa_j}}{\alpha_{\kappa_j}}\right|^2\left|\alpha_{\kappa_j}\right|^{-2}\Bigg)|\langle\{\eta_j(\vec{\kappa}_j)\}|0\rangle|^2\,\mathcal{P}_\eta(\vec{\kappa}) = \left|\frac{\beta_\kappa}{\alpha_\kappa}\right|^{2\eta}|\alpha_\kappa|^{-2}\langle\mathrm{N}_{\vec{\kappa}}\rangle_{\tau\mapsto\infty} = \sum_{\eta=0}^{\infty}\eta\mathcal{P}_\eta(\vec{\kappa})$$

$$= \sum_{\vec{\kappa}}|\beta_\kappa|^2 = (2\pi^2\alpha_2^3)^{-1}\int_0^{\infty}d\kappa\,\kappa^2\,|\beta_\kappa|^2$$

**8. Partícula Cosmológica: Solución Exacta.**

$\alpha(\tau)$

$$= \left\{\alpha_1^4 + e^{\zeta}\left[(\alpha_2^4 - \alpha_1^4)(e^{\zeta}+1) + \beta\right](e^{\zeta}+1)^{-2}\right\}^{\frac{1}{4}} \left\{\frac{\alpha_2^4 + \alpha_1^4}{2} + \frac{\alpha_2^4 - \alpha_1^4}{2}\tanh\left(\frac{\zeta}{2}\right)\right\}^{\frac{1}{4}} \left\{\alpha_1^4\right.$$

$$\left. + \frac{\beta}{4\cosh^2\left(\frac{\zeta}{2}\right)}\right\}^{\frac{1}{4}} d$$

$$= \frac{1}{2}\left[1 - (1 + 4\kappa^2\delta^2\beta)^{\frac{1}{2}}\right]\psi_\kappa(1+\mu)^d\mu^{-c_1}f(\mu)\mu(\mu+1)f'' + \left[(2d - 2c_1 + 1)\mu + \left(1 - 2_{c_1}\right)\right]f'$$

$$+ (d - c_1 + c_2)f\psi_\kappa = \mathrm{N}_1\mu^{-c_1}(1+\mu)^d\mathcal{F}(d - c_1 + c_2, d - c_1 - c_2, 1 - 2c_1 - \mu)$$

$$= (\mu)^{-d+c_1-c_2}\mathcal{AF}(d - c_1 + c_2, d + c_1 + c_2, 1 + 2c_1 - \mu^{-1})$$

$$+ (\mu)^{-d+c_1+c_2}\mathcal{BF}(d - c_1 - c_2, d + c_1 - c_2, 1 - 2c_1$$

$$- \mu^{-1})\left|\frac{\Gamma(1-2c_1)\Gamma(-2c_2)}{\Gamma(d-c_1-c_2)\Gamma(1-c_1-c_2-d)}\right|\left|\frac{\Gamma(1-2c_1)\Gamma(2c_2)}{\Gamma(d-c_1+c_2)\Gamma(1-c_1+c_2-d)}\right|\left(e^{\tau\delta^{-1}}\right)^{-i\kappa\delta\alpha_2^2}$$

$$e^{-i\alpha_2^2\kappa\tau}e^{-i\alpha_2^3\omega_{2\kappa}\tau}$$

$$\left|\frac{\beta_\kappa}{\alpha_\kappa}\right|^2 = \frac{\Gamma(d-c_1-c_2)\Gamma(1+c_1+c_2-d)\Gamma(d+c_1+c_2)\Gamma(1-c_1-c_2-d)}{\Gamma(d-c_1+c_2)\Gamma(1+c_1-c_2-d)\Gamma(d+c_1-c_2)\Gamma(1-c_1+c_2-d)}$$

$$= \frac{\sin\pi(d-c_1+c_2)\sin\pi(d+c_1-c_2)}{\sin\pi(d-c_1-c_2)\sin\pi(d+c_1+c_2)}$$

**9. Distribución de cuerpo negro.**

$$\mathcal{P}_\eta(\vec{\kappa}) = \left|\frac{\beta_\kappa}{\alpha_\kappa}\right|^{2\eta}\left(1 - \left|\frac{\beta_\kappa}{\alpha_\kappa}\right|^{2\eta}\right) \approx \frac{\exp[2\pi\kappa\delta(\alpha_>^2 - \alpha_<^2)]}{\exp[2\pi\kappa\delta(\alpha_>^2 + \alpha_<^2)]} = \exp[-\eta\mu\kappa]\frac{\left|\frac{\beta_\kappa}{\alpha_\kappa}\right|^2}{1 - \left|\frac{\beta_\kappa}{\alpha_\kappa}\right|^2}$$

$$= \frac{1}{\exp(\mu\kappa) - 1}\langle \mathrm{N}\rangle(2\pi^2\alpha_2^3)^{-1}\int_0^\infty d\kappa\,\kappa^2[\exp(\mu\kappa) - 1]^{-1}$$

**10. Espacio - tiempo de Sitter en espacios cuánticos curvos.**

$$ds^2 = d\mathcal{T}^2 - d\mathcal{W}^2 - d\mathcal{X}^2 - d\mathcal{Y}^2 - d\mathcal{Z}^2, ds^2 = dt^2 - e^{2\mathcal{H}t}(d\chi^2 - d\gamma^2 - dz^2), ds^2$$

$$= (\mathcal{H}\eta)^{-2}(d\eta^2 - d\chi^2 - d\gamma^2 - dz^2)\partial_t^2\phi + 3\mathcal{H}\partial_t\phi$$

$$- e^{-2\mathcal{H}t}\sum_i \partial_t^2\phi + \mathcal{M}^2\phi\, f_{\vec{\kappa}}(\vec{\chi}, t)\left(2\mathcal{V}e^{3\mathcal{H}t}\right)^{-\frac{1}{2}} e^{i\vec{\kappa}\cdot\vec{\chi}}\hbar_\kappa v^2 \frac{d^2}{dv^2}\hbar_\kappa + v\frac{d}{dv}\hbar_\kappa + (v^2 - \nu^2)\hbar_\kappa$$

$$\sim \left(\omega_\kappa(t)\right)^{-\frac{1}{2}} \exp\left[-i\int_{\square}^{\tau}\omega_\kappa(t')dt'\right]\hbar_\kappa(\tau)\sqrt{\frac{\pi}{2\mathcal{H}}}\left\{\mathfrak{E}(\kappa)\mathcal{H}_\nu^{(2)}(v)\right.$$

$$\left.+ \mathcal{F}(\kappa)\mathcal{H}_\nu^{(1)}(v)\right\}\hbar_{\kappa'}(\tau')\sqrt{\frac{\pi}{2\mathcal{H}}}\left\{\mathfrak{E}(\kappa')\mathcal{H}_\nu^{(2)}(v)\right.$$

$$\left.+ \mathcal{F}(\kappa')\mathcal{H}_\nu^{(1)}(v)\right\} f_{\vec{\kappa}}(\vec{\chi}, t)\frac{1}{2}\sqrt{\frac{\pi}{\mathcal{H}}}\mathcal{V}^{-\frac{1}{2}}e^{-\frac{3}{2}\mathcal{H}t}\mathcal{H}_\nu^{(1)}\left(\kappa\mathcal{H}^{-1}e^{-\mathcal{H}t}\right)e^{i\vec{\kappa}\cdot\vec{\chi}}\left(\mathcal{V}e^{3\mathcal{H}t}\right)^{-\frac{1}{2}}\left(2\kappa e^{-\mathcal{H}t}\right)^{-\frac{1}{2}}$$

$$\exp\left(i\kappa\mathcal{H}^{-1}e^{-\mathcal{H}t}\right) e^{i\vec{\kappa}\cdot\vec{\chi}}\mathcal{H}_{1/2}^{(1)}(v) - i\sqrt{\frac{2}{\pi v}}e^{iv}$$

**11. Expansiones perturbativas en espacios cuánticos curvos.**

$$\mathcal{L} = \frac{1}{2}|g|^{\frac{1}{2}}\left(g^{\mu\nu}\partial_\mu\phi\partial_\nu\phi - 2\mathcal{V}(\phi)\right)\int ds^2 = dt^2 - \alpha^2(t)(d\chi^2 - d\gamma^2 - dz^2)\alpha^{-3}\,\partial_t(\alpha^{-3}\partial_t\phi_0)$$

$$+\frac{d\mathcal{V}}{d\ddot{\phi}_0} + 3\mathcal{H}(t)\dot{\phi}_0 + \mathcal{V}'(\phi_0)\mathcal{H}^2\left(\frac{16\pi\mathfrak{G}}{3}\right)\rho\frac{\ddot{\alpha}}{\alpha} = \dot{\mathcal{H}} + \mathcal{H}^2$$

$$= -\left(\frac{8\pi\mathfrak{G}}{3}\right)\left(\frac{1}{2}(\dot{\phi}_0)^2 + \mathcal{V}(\phi_0)\right)(\rho + 3p)\rho\frac{1}{2}(\dot{\phi}_0)^2 + \mathcal{V}(\phi_0)\rho\frac{1}{2}(\dot{\phi}_0)^2 - \mathcal{V}(\phi_0)\dot{\mathcal{H}}$$

$$= -4\pi\mathfrak{G}\dot{\phi}_0^2\frac{1}{2}(\dot{\phi}_0)^2 \preccurlyeq \mathcal{V}(\phi_0)\mathcal{H}^2 \approx \left(\frac{8\pi\mathfrak{G}}{3}\right)\mathcal{V}(\phi_0)\left|\mathcal{V}'(\phi_0)\dot{\phi}_0\mathcal{H}^{-1}\right| \preccurlyeq \mathcal{V}(\phi_0)\dot{\phi}_0$$

$$\approx -\frac{\mathcal{V}'(\phi_0)}{(3\mathcal{H})}\frac{1}{16\pi\mathfrak{G}}\left(\frac{\mathcal{V}'}{\mathcal{V}}\right)^2 \preccurlyeq 1, \epsilon$$

$$\equiv \frac{1}{16\pi\mathfrak{G}}\left(\frac{\mathcal{V}'}{\mathcal{V}}\right)^2 - \frac{1}{3\mathcal{H}}\mathcal{V}''(\phi_0)\dot{\phi}_0 + \frac{\dot{\mathcal{H}}}{3\mathcal{H}^2}\mathcal{V}'(\phi_0)\left|\mathcal{V}''(\phi_0)(\dot{\phi}_0)^2\right|$$

$$\preccurlyeq \left|\mathcal{H}\dot{\mathcal{V}}(\phi_0)\right|\left|\frac{1}{8\pi\mathfrak{G}}\frac{\mathcal{V}''(\phi_0)}{\mathcal{V}(\phi_0)}\right| \succcurlyeq |\eta|$$

$$\equiv \frac{1}{16\pi\mathfrak{G}}\frac{\mathcal{V}''(\phi_0)}{\mathcal{V}(\phi_0)}\partial_t^2\delta\phi + 3\mathcal{H}\partial_t\delta\phi - e^{-2\mathcal{H}t}\sum_i\partial_i^2\delta\phi$$

$$+\mathcal{V}''(\phi_0)\delta\phi\sum_{\vec{\kappa}}\{\mathrm{A}_{\vec{\kappa}}f_{\vec{\kappa}}(\chi) + \mathrm{A}_{\vec{\kappa}}^{\dagger}f_{\vec{\kappa}}^{*}(\chi)\}\left(2\mathcal{V}\alpha^3(t)\right)^{-\frac{1}{2}}e^{i\vec{\kappa}\cdot\vec{\chi}}\hbar_\kappa(\tau)$$

$$\simeq \left(2\mathcal{V}\alpha^3(t)\right)^{-\frac{1}{2}}\left(\frac{2\kappa}{\alpha(t)}\right)^{-\frac{1}{2}}\exp\left[i\left(\vec{\kappa}\cdot\vec{\chi} - \int_{\square}^{\tau}\frac{\kappa}{\alpha(t')}dt'\right)\phi\right]$$

$$f_{\vec{\kappa}}(\vec{\chi},t) = \frac{1}{2}\sqrt{\frac{\pi}{\mathcal{H}}}\mathcal{V}^{-\frac{1}{2}}e^{-\frac{3}{2}\mathcal{H}t}\mathcal{H}_{\nu}^{(1)}\left(\kappa\mathcal{H}^{-1}e^{-\mathcal{H}t}\right)e^{i\vec{\kappa}\cdot\vec{\chi}}\langle 0|\delta\phi(\vec{\chi},t)|0\rangle$$

$$= \mathcal{P}_{\phi}(\kappa,t)\kappa^{-1}d\kappa\left\langle 0\middle|\delta\phi(\vec{\chi},t)\delta\phi\left(\vec{\chi'},t'\right)\middle|0\right\rangle = \sum_{\vec{\kappa}} f_{\vec{\kappa}}(\vec{\chi},t)\, f_{\vec{\kappa}}^{*}\left(\vec{\chi'},t'\right)$$

$$= \frac{1}{2(2\pi)^3}[\alpha(t)\alpha(t')]^{-3/2}\int d^3\kappa\, e^{i\vec{\kappa}\cdot(\vec{\chi}-\vec{\chi'})}\hbar_{\kappa}(\tau)\hbar_{\kappa}^{*}(\tau')\langle 0|\delta\phi(\vec{\chi},t)^2|0\rangle$$

$$= \left(4\pi^2\alpha^3(t)\right)^{-1}\int_0^{\infty} d\kappa\,\kappa^2|\hbar_{\kappa}(\tau)|^2\,\mathcal{P}_{\phi}(\kappa,t)$$

$$= \left(4\pi^2\alpha^3(t)\right)^{-1}\kappa^3|\hbar_{\kappa}(\tau)|^2\langle 0|\delta\phi(\vec{\chi}_1,t)\delta\phi(\vec{\chi}_2,t)|0\rangle$$

$$= \int_0^{\infty}\mathcal{P}_{\phi}(\kappa,t)\frac{\sin(\kappa|\vec{\chi}_1-\vec{\chi}_2|)}{\kappa|\vec{\chi}_1-\vec{\chi}_2|}\frac{d\kappa}{\kappa}\langle 0|\delta\phi(\vec{\chi},t)^2|0\rangle_{phys}$$

$$= \left(4\pi^2\alpha^3(t)\right)^{-1}\int_0^{\infty} d\kappa\,\kappa^2\left\{|\hbar_{\kappa}(\tau)|^2 - \omega_{\kappa}(t)^{-1} - \left(\mathcal{W}_{\kappa}(t)^{-1}\right)^{(2)}\right\} - \frac{5\mathcal{H}^2m^4}{8\omega_{\kappa}(t)^7}$$

$$+ \frac{3\mathcal{H}^2m^2}{4\omega_{\kappa}(t)^5} + \frac{\mathcal{H}^2}{\omega_{\kappa}(t)^3}\hbar_{\kappa}(\tau)\sqrt{\frac{\pi}{2\mathcal{H}}}\mathcal{H}_{\nu}^{(1)}(\upsilon)$$

**12. Métrica Adiabática.**

$$ds^2 = dt^2 - \alpha^2(t)d\vec{\chi}^2\mathcal{L}\frac{1}{2}|g|^{\frac{1}{2}}\left(g^{\mu\nu}\partial_\mu\phi\partial_\nu\phi - m^2\phi^2 - \xi\mathcal{R}\phi^2\right)(\Box + m^2 + \xi\mathcal{R})f_{\vec{\kappa}}(\chi)$$

$$\sim (\mathcal{V}\alpha(t)^3)^{-\frac{1}{2}}\left(2\omega_\kappa(t)\right)^{-\frac{1}{2}}\exp\left[i\left(\vec{\kappa}\cdot\vec{\chi} - \int_{\Box}^{\tau}\omega_\kappa(\tau')dt'\right)\right]\phi_\kappa\sum_{\vec{\kappa}}\{\mathrm{A}_{\vec{\kappa}}f_{\vec{\kappa}}(\chi)$$

$$+ \mathrm{A}_{\vec{\kappa}}^{\dagger}f_{\vec{\kappa}}^{*}(\chi)\}\,(2\mathcal{V})^{-1}\alpha(t)^{-\frac{3}{2}}\hbar_\kappa(t)e^{i\vec{\kappa}\cdot\vec{\chi}}\frac{d^2}{dt^2}\hbar_\kappa$$

$$+ \Omega_\kappa\omega_\kappa^2\omega_\kappa(t)\left(\frac{\kappa^2}{\alpha(t)^2} + m^2\right)^{\frac{1}{2}}\sigma(t)\left(6\xi - \frac{3}{4}\right)\left(\frac{\dot{\alpha}}{\alpha}\right)^2$$

$$+ \left(6\xi - \frac{3}{2}\right)\frac{\ddot{\alpha}}{\alpha}\mathcal{W}_\eta^{-\frac{1}{2}}\mathcal{W}(t)^{-\frac{1}{2}}\hbar\Omega^{-\frac{1}{2}}\exp\left(\pm it\int_{\Box}^{\tau}\Omega\mathcal{W}_\eta(t')dt'\right)$$

$$+ \mathcal{O}(\mathcal{T}^{-\eta})\Omega(1+\epsilon)^{\frac{1}{2}}\frac{d^2\hbar}{dt^2} + \left[\mathcal{W}^2 - \mathcal{W}^{\frac{1}{2}}\left(\frac{d^2}{dt^2}\mathcal{W}^{-\frac{1}{2}}\right)\right]2\mathcal{W}\delta\hbar - \Omega^2\omega^2 + \sigma$$

$$+ \mathcal{W}^{\frac{1}{2}}\frac{d^2}{dt^2}\mathcal{W}^{-\frac{1}{2}}\langle 0|\phi(\chi)\phi(\chi')|0\rangle\sum_{\vec{\kappa}}f_{\vec{\kappa}}(\chi)f_{\vec{\kappa}}^{*}(\chi)$$

$$= \frac{1}{2(2\pi)^2}[\alpha(t)\alpha(t')]^{-\frac{3}{2}}\int d^3\,\kappa e^{i\vec{\kappa}\cdot(\vec{\chi}-\vec{\chi})}\hbar_\kappa(t)\hbar_\kappa^{*}(t')\langle 0|\phi(\chi)^2|0\rangle$$

$$= \left(4\pi^2\alpha^3(t)\right)^{-1}\int_0^\infty d\kappa\,\kappa^2|\hbar_\kappa(\tau)|^2\langle 0|\phi(\chi)\phi(\chi')|0\rangle$$

$$\propto \int d^3\,\kappa e^{i\vec{\kappa}\cdot(\vec{\chi}-\chi')}\kappa^{-1}e^{-i\kappa\int_{t'}^{t}\alpha^{-1}dt'}\hbar_\kappa(t)$$

$$\sim \mathcal{W}_\kappa^{-\frac{1}{2}}(t)\exp\left(-i\int_{\Box}^{\tau}\omega_\kappa(t')dt'\right)\langle 0|\phi(\chi)^2|0\rangle$$

$$\sim \left(4\pi^2\alpha^3(t)\right)^{-1}\int_0^\infty d\kappa\,\kappa^2\omega_\kappa(t)^{-1}\,\langle 0|\phi(\chi)^2|0\rangle$$

$$\sim \left(4\pi^2\alpha^3(t)\right)^{-1}\int_0^\infty d\kappa\,\kappa^2\,\{(\mathcal{W}_\kappa^{-1})^{(0)} + (\mathcal{W}_\kappa^{-1})^{(2)} + (\mathcal{W}_\kappa^{-1})^{(4)}$$

$$+ \mathcal{O}(\mathcal{T}^{-\eta})\}\ddot{\alpha}^2\omega^3\xi'\dot{\alpha}^2\langle 0|\phi(\chi)^2|0\rangle_{phys}\left(4\pi^2\alpha^3(t)\right)^{-1}\int_0^\infty d\kappa\,\kappa^2\,\{|\hbar_\kappa(t)|^2 - \omega_\kappa(t)^{-1}$$

$$- (\mathcal{W}_\kappa(t)^{-1})^{(2)}\}$$

$$\langle 0|\mathcal{T}_{\mu}^{\mu}|0\rangle = -\nabla^{\mu}\phi\nabla_{\mu}\phi + 2m^2\phi^2 + \frac{1}{6}\mathcal{R}\phi^2 + \frac{1}{2}\Box(\phi^2)\lim_{\kappa\mapsto\infty}\int_0^{\kappa} d\kappa\kappa^2\,\mathcal{W}_{\kappa}$$

$$\sim \lim_{\kappa\mapsto\infty}\{\kappa^4\mathcal{O}(\mathcal{T}^0) + \kappa^2\mathcal{O}(\mathcal{T}^{-2}) + \ln\kappa\mathcal{O}\,(\mathcal{T}^{-4})\}\langle 0|\mathcal{T}_{\mu}^{\mu}|0\rangle_{phys}$$

$$= m^2\left(4\pi^2\alpha^3(t)\right)^{-1}\int_0^{\infty} d\kappa\,\kappa^2\left\{|\hbar_{\kappa}(t)|^2 - \omega_{\kappa}(t)^{-1} - (\mathcal{W}_{\kappa}(t)^{-1})^{(2)}\right.$$

$$\left. - (\mathcal{W}_{\kappa}(t)^{-1})^{(4)}\right\}m^2\langle 0|\mathcal{T}_{\mu}^{\mu}|0\rangle_{phys}$$

$$- m^2\left(4\pi^2\alpha^3(t)\right)^{-1}\int_0^{\infty} d\kappa\,\kappa^2\,(\mathcal{W}_{\kappa}(t)^{-1})^{(4)}\langle 0|\mathcal{T}_{\mu}^{\mu}|0\rangle_{phys}$$

$$- \left(4\pi^2\alpha^3(t)\right)^{-1}\lim_{m\mapsto\infty} m^2\int_0^{\infty} d\kappa\,\kappa^2\,(\mathcal{W}_{\kappa}(t)^{-1})^{(4)}\left[6\left(\frac{\ddot{\alpha}}{\alpha} + \frac{\dot{\alpha}^2}{\alpha^2} + \frac{\ddot{\alpha}}{\alpha} + \frac{\ddot{\alpha}^2}{\alpha^2}\right.\right.$$

$$\left.\left. + \frac{\ddot{\alpha}^2\dot{\alpha}}{\alpha^3\ddot{\alpha}^4}\right)\right]^2\left\{\Box\mathcal{R} - \left(\mathcal{R}^{\mu\nu}\mathcal{R}_{\mu\nu} - \frac{1}{3}\mathcal{R}^2\right)\right\}$$

**13. Tensor Energía – Momentum.**

$$\nabla_{\mu}\langle 0|\mathcal{T}_{\mu}^{\mu}|0\rangle_{phys}\langle 0|\mathcal{T}^{\mu\nu}|0\rangle$$

$$\sim \langle 0|\mathcal{T}^{\mu\nu}|0\rangle^{(0)} + \langle 0|\mathcal{T}^{\mu\nu}|0\rangle^{(2)}\mathcal{T}^{-2} + \langle 0|\mathcal{T}^{\mu\nu}|0\rangle^{(4)}\mathcal{T}^{-4}$$

$$+ \mathcal{O}(\mathcal{T}^{-\eta})\xi^{\mu}\alpha(t)\delta_0^{\mu}\mathfrak{L}_{\xi}g_{\mu\nu}(\chi)\lambda(\chi)g_{\mu\nu}(\chi)2\dot{\alpha}(t)\mathfrak{L}_{\xi}g_{\mu\nu}$$

$$= \xi^{\alpha}\partial_{\alpha}g_{\mu\nu} + g_{\mu\alpha}\partial_{\nu}\xi^{\alpha} + g_{\alpha\nu}\partial_{\mu}\xi^{\alpha} = 2\nabla_{\left(\nu^{\mu}\xi\right)}\nabla_{\mu}(\langle\mathcal{T}^{\mu\nu}\rangle\xi_{\nu})$$

$$= \frac{1}{2}\lambda\langle\mathcal{T}^{\mu\nu}\rangle g_{\mu\nu}\frac{1}{2}\int d^4\chi\sqrt{-g}\lambda\langle\mathcal{T}_{\mu}^{\mu}\rangle$$

$$= \int_{\tau_2}^{\Box} d^3\chi\sqrt{-g}\langle\mathcal{T}^{\sigma\nu}\rangle\xi_{\nu} - \int_{\tau_1}^{\Box} d^3\chi\sqrt{-g}\langle\mathcal{T}^{\sigma\nu}\rangle\xi_{\nu}\int d^4\chi\,\alpha^3(t)\dot{\alpha}(t)\langle\mathcal{T}_{\mu}^{\mu}\rangle$$

$$= \int_{\tau_2}^{\Box} d^3\chi - \alpha^4(t_2)\langle\mathcal{T}_{00}\rangle - \int_{\tau_1}^{\Box} d^3\chi - \alpha^4(t_1)\langle\mathcal{T}_{00}\rangle\int_{\tau_1}^{\tau_2} dt\,\alpha^3(t)\dot{\alpha}(t)\,\langle\mathcal{T}_{\mu}^{\mu}(t)\rangle$$

$$= \alpha^4(t_2)\langle\mathcal{T}_{00}(t_2)\rangle - \alpha^4(t_1)\langle\mathcal{T}_{00}(t_1)\rangle dt\,\dot{\alpha}\frac{d}{dt}g(t_2) - g(t_1)g(t) + \mathfrak{E}$$

$$\mathcal{W} = \int_{\tau}^{\square} d^4\chi \sqrt{-g}\kappa_0 \mathcal{R}$$

$$+ \frac{\hbar}{64\pi^2} \int d^4\chi\sqrt{-g} \left[ -m^4 \ln\left|\frac{\mathcal{M}^2}{m^2}\right| + m^2\bar{\xi}\mathcal{R}\left(1 - 2\ln\left|\frac{\mathcal{M}^2}{m^2}\right|\right) - 2\alpha_2 \ln\left|\frac{\mathcal{M}^2}{m^2}\right| \right.$$

$$\left. + \frac{3}{2}\bar{\xi}^2\mathcal{R}^2 \right] + \frac{i}{64}\int d^4\chi\sqrt{-g}\,(\mathcal{M}^4 + 2\bar{\alpha}_2)\Theta(-\mathcal{M}^2)$$

**14. Renormalización.**

$$ds^2 = g_{\mu\nu}(\chi)d\chi^\mu d\chi^\nu(\Box + m^2 + \xi\mathcal{R})\phi \sum_{\bar{j}} \left\{A_{\bar{j}} f_{\bar{j}}(\chi) + A_{\bar{j}}^\dagger f_{\bar{j}}^*(\chi)\right\} \mathfrak{G}_{\mathfrak{F}}(\chi,\chi')$$

$$= i\langle 0|\mathcal{T}\phi(\chi)\phi(\chi')|0\rangle \left(\Box_\chi + m^2 + \xi\mathcal{R}(\chi)\right) - \delta(\chi,\chi') \equiv |g(\chi)|^{-\frac{1}{2}}\delta(\chi-\chi')$$

$$\sim \Delta^{\frac{1}{2}}(\chi,\chi')(4\pi)^{-\frac{\eta}{2}} \int_0^\infty ds(i\delta)^{-\frac{\eta}{2}} \exp\left[im^2\delta + \frac{\sigma(\chi,\chi')}{2i\delta}\right] \Delta\,(\chi,\chi')$$

$$= -|g(\chi)|^{-\frac{1}{2}} \det[-\partial_\mu\partial_{\nu'}\sigma(\chi,\chi')]\,|g(\chi')|^{-\frac{1}{2}} = \frac{1}{2}\tau(\chi,\chi')^2$$

$$\sim i\Delta^{\frac{1}{2}}(\chi,\chi')(4\pi)^{-\frac{\eta}{2}} \int_0^\infty ids(i\delta)^{-\frac{\eta}{2}}$$

$$\times \exp\left[-im^2\delta + \frac{\sigma(\chi,\chi')}{2i\delta}\right] \mathfrak{F}(\chi,\chi';i\delta)\,\langle 0|\phi(\chi)\phi(\chi')|0\rangle_{phys}$$

$$= \lim_{\eta\mapsto 4} \left\{\langle 0|\phi(\chi)\phi(\chi')|0\rangle\right.$$

$$+\, i \times i\Delta^{\frac{1}{2}}(\chi,\chi')(4\pi)^{-\frac{\eta}{2}}$$

$$\left.\times \int_0^\infty ids(i\delta)^{-\frac{\eta}{2}} \exp\left[-im^2\delta + \frac{\sigma(\chi,\chi')}{2i\delta}\right] \times \left(1 + \alpha_1(\chi,\chi')(i\delta)\right)\right\} \langle 0|\mathcal{T}_\mu^\mu(\chi)|0\rangle_{phys}$$

$$= m^2\langle 0|\phi^2(\chi)|0\rangle \lim_{\substack{\eta\mapsto 4\\ m\mapsto 0}} m^2 \left\{\langle 0|\phi^2(\chi)|0\rangle\right.$$

$$\left. +\, i \times i(4\pi)^{-\frac{\eta}{2}} \int_0^\infty ids(i\delta)^{-\frac{\eta}{2}} \exp[-im^2\delta] \times \left(\left(1 + \alpha_1(\chi)(i\delta)\right) + \left(1 + \alpha_1(\chi)(i\delta)\right)^2\right)\right\}$$

$$= \lim_{\substack{\eta\mapsto 4\\ m\mapsto 0}} m^2\langle 0|\phi^2(\chi)|0\rangle - \lim_{\substack{\eta\mapsto 4\\ m\mapsto 0}} m^2(4\pi)^{-\frac{\eta}{2}} \int_0^\infty ids(i\delta)^{-\frac{\eta}{2}} \exp[-im^2\delta] \times \alpha_2(\chi)(i\delta)^2$$

$$= \lim_{\substack{\eta\mapsto 4\\ m\mapsto 0}} \left\{m^2(4\pi)^{-2} \int_0^\infty ids\exp[-im^2\delta]\right\} \alpha_2(\chi)$$

$$= -(4\pi)^{-2}\alpha_2(\chi)\big|_{\xi=\frac{1}{6}} \int_0^\infty ds\exp[-i(m^2 - i\epsilon)\delta]$$

$$= \frac{1}{im^2}\frac{1}{360}\mathcal{R}_{\alpha\beta\gamma\delta}\mathcal{R}^{\alpha\beta\gamma\delta} - \frac{1}{360}\mathcal{R}_{\alpha\beta}\mathcal{R}^{\alpha\beta} - \frac{1}{360}\Box\mathcal{R}\mathfrak{C}_{\alpha\beta\gamma\delta}\mathfrak{C}^{\alpha\beta\gamma\delta}$$

$$= \mathcal{R}_{\alpha\beta\gamma\delta}\mathcal{R}^{\alpha\beta\gamma\delta} - 2\mathcal{R}_{\alpha\beta}\mathcal{R}^{\alpha\beta} + \frac{1}{3}\mathcal{R}^2\langle 0|\mathcal{T}_\mu^\mu(\chi)|0\rangle_{phys}\left\{\Box\mathcal{R} - \left(\mathcal{R}_{\alpha\beta}\mathcal{R}^{\alpha\beta} - \frac{1}{3}\mathcal{R}^2\right)\right\}$$

**15. Aproximación de Gauss.**

$$\mathfrak{G} \equiv \mathcal{R}_{\alpha\beta\gamma\delta}\mathcal{R}^{\alpha\beta\gamma\delta} - 4\mathcal{R}_{\alpha\beta}\mathcal{R}^{\alpha\beta} + \mathcal{R}^2\langle 0|\mathcal{T}_\mu^\mu(\chi)|0\rangle_{phys}$$

$$= \frac{1}{4\pi^2}\left\{\frac{1}{240}\mathfrak{C}_{\alpha\beta\gamma\delta}\mathfrak{C}^{\alpha\beta\gamma\delta} + \mathrm{B}_\delta\mathfrak{G} + \mathfrak{C}_\delta\Box\mathfrak{R}\right\}\langle 0|\mathcal{T}_\mu^\mu(\chi)|0\rangle_{phys}$$

$$= \frac{1}{4\pi^2}\{\mathrm{A}_\delta\mathfrak{C}_{\alpha\beta\gamma\delta}\mathfrak{C}^{\alpha\beta\gamma\delta} + \mathrm{B}_\delta\mathfrak{G} + \mathfrak{C}_\delta\Box\mathfrak{R}\}$$

$$\mathfrak{G}_{\mathfrak{F}}(\chi,\chi') = i\int_0^\infty ds\,\exp[-im^2\delta]\,\langle\chi,\delta|\chi',0\rangle i\frac{\partial}{\partial\delta}\langle\chi,\delta|\chi',0\rangle = \left(\Box_\chi + \xi\mathcal{R}(\chi)\right)\langle\chi,\delta|\chi',0\rangle_{Gauss}$$

$$= -\,i\Delta^{\frac{1}{2}}(\chi,\chi')(4\pi\delta)^{-\frac{\eta}{2}}\exp\left[\frac{\sigma(\chi,\chi')}{2i\delta} - i\left(\xi - \frac{1}{6}\right)\mathcal{R}_\delta\right]$$

**16. Regularización Hadamard.**

$$\mathfrak{G}^{(1)}(\chi,\chi') = \frac{\Delta^{-\frac{1}{2}}(\chi,\chi')}{(4\pi\delta)^{-\frac{\eta}{2}}}\left(\frac{2}{\sigma(\chi,\chi')} + v_\eta(\chi,\chi')\ln\sigma(\chi,\chi') + \omega_\eta(\chi,\chi')\right)\sigma_\eta v_0 + v_{0,\mu}\sigma^\mu$$

$$= \left(\frac{1}{6}\right)\mathcal{R} - \Delta^{-\frac{1}{2}}\left(\Delta^{\frac{1}{2}}\right)_\nu^\mu v_\eta + \frac{v_{\eta,\mu}\sigma^\mu}{\eta+1}$$

$$= \frac{1}{2\eta(\eta+1)}\left(\Delta^{-\frac{1}{2}}\left(\Delta^{\frac{1}{2}}v_{\eta-1}\right)_\nu^\mu - \left(\frac{1}{6}\right)\mathcal{R}_{v_{\eta-1}}\right)\omega_\eta + \frac{\omega_{\eta,\mu}\sigma^\mu}{\eta+1}$$

$$= \frac{1}{2\eta(\eta+1)}\left(\Delta^{-\frac{1}{2}}\left(\Delta^{\frac{1}{2}}\omega_{\eta-1}\right)_\nu^\mu - \left(\frac{1}{6}\right)\mathcal{R}_{\omega_{\eta-1}}\right) - \frac{v_\eta}{\eta+1}$$

$$- \frac{1}{2\eta^2(\eta+1)}\left(\Delta^{-\frac{1}{2}}\left(\Delta^{\frac{1}{2}}v_{\eta-1}\right)_\nu^\mu - \left(\frac{1}{6}\right)\mathcal{R}_{v_{\eta-1}}\right)$$

$$\mathfrak{G}_{reg}^{(1)}(\chi,\chi') \equiv \mathfrak{G}^{(1)}(\chi,\chi') - \mathfrak{G}^{\mathcal{L}}(\chi,\chi')\langle\phi^2(\chi)\rangle_{reg} \equiv \lim_{\chi'\mapsto\chi}\mathfrak{G}_{reg}^{(1)}(\chi,\chi')$$

$$\mathcal{T}_{\mu\nu} = \frac{2}{3}\nabla_\mu\phi\nabla_\nu\phi - \frac{1}{6}g_{\mu\nu}\nabla^\alpha\phi\nabla_\alpha\phi - \frac{1}{3}\phi\nabla_\mu\nabla_\nu\phi + \frac{1}{3}g_{\mu\nu}\phi\nabla^\alpha\nabla_\alpha\phi - \frac{1}{6}\left(\mathcal{R}_{\mu\nu} - \frac{1}{2}g_{\mu\nu}\mathcal{R}\right)\phi^2\langle\mathcal{T}_{\mu\nu}(\chi)\rangle$$

$$= \lim_{\chi'\mapsto\chi}\mathfrak{T}_{\mu\nu}(\chi,\chi')$$

$$= \frac{1}{3}\left(\nabla_\mu\nabla_{\nu'}\mathfrak{G}^{(1)} + \nabla_{\mu'}\nabla_\nu\mathfrak{G}^{(1)}\right) - \frac{1}{6}g_{\mu\nu}\nabla_\alpha\phi\nabla^{\alpha'}\mathfrak{G}^{(1)} - \frac{1}{6}\left(\nabla_\mu\nabla_\nu\mathfrak{G}^{(1)} + \nabla_{\mu'}\nabla_{\nu'}\mathfrak{G}^{(1)}\right)$$

$$+ \frac{1}{6}g_{\mu\nu}\left(\nabla_\alpha\nabla^\alpha\mathfrak{G}^{(1)} + \nabla_{\alpha'}\nabla^{\alpha'}\mathfrak{G}^{(1)}\right) - \frac{1}{6}\left(\mathcal{R}_{\mu\nu} - \frac{1}{2}g_{\mu\nu}\mathcal{R}\right)\mathfrak{G}^{(1)}\langle\mathcal{T}_{\mu\nu}(\chi)\rangle_{reg}$$

$$\equiv \langle\mathcal{T}_{\mu\nu}\rangle^0_{reg} - \frac{1}{2(4\pi)^2}g_{\mu\nu}v_1(\chi,\chi')$$

$$\mathcal{T} = \frac{\hbar\kappa}{2\pi\kappa_\beta\overline{\overline{\mathcal{R}_{\mu\nu}}}} = \Lambda\overline{g_{\mu\nu}} = \Omega^{-2}\overline{g_{\mu\nu}}\overline{\mathfrak{G}}_{\mathfrak{F}}(\chi,\chi')$$

$$= \Omega^{-1}(\chi)\mathfrak{G}(\chi,\chi')\Omega^{-1}(\chi')\mathfrak{G}_{\mathfrak{E}}(\chi,\chi')\int_0^\infty d\mu\kappa(\chi,\chi'\mu)\left(\frac{\partial}{\partial\mu} - \frac{\partial^2}{\partial\tau^2} - \nabla_i\nabla^i + \square\right.$$

$$\left. + \frac{1}{6}\mathcal{R}\right)\kappa(\chi,\chi'\mu)(\tau,\tau'\mu)\beta^{-1}\sum_{\eta=-\infty}^{\infty}\exp\left(-\frac{4\mu\pi^2\eta^2}{\beta^2}\right.$$

$$-\frac{2\pi i\eta}{\beta}(\tau$$

$$\left.-\tau')\right)\mathfrak{G}_{Gauss}(\tau,\chi,0,\chi')\frac{\Delta^{\frac{1}{2}}}{4\pi\beta r}\frac{\sinh(2\pi r/\beta)}{\cosh(2\pi r/\beta) - \cos(2\pi r/\beta)}\langle\hat{\phi}^2\rangle_{Gauss}\left(\frac{4\pi^2}{\beta^2\Omega^2}\right.$$

$$\left.-\frac{\square\Omega}{\Omega^3}\right)\overline{\mathfrak{R} - \Omega^2}\left(\frac{\Lambda}{4\pi^2}\beta_{loc}^{-2} - \beta_{acc}^{-2}\left(\frac{\alpha}{2\pi}\right)^2\right)d\bar{s}^2$$

$$= e^{2\alpha\xi}\left(d\eta^2 - d\xi^2 - e^{-2\alpha\xi}dy^2 - e^{-2\alpha\xi}dz^2\right)\delta^\mu_\nu\tilde{g}_{\alpha\beta}(\chi')\frac{\delta}{\delta\tilde{g}_{\alpha\beta}(\chi')}\left(|\tilde{g}|^{1/2}\mathcal{T}^\mu_\nu(\chi)\right)$$

$$= \tilde{g}_{\nu\gamma}(\chi)\frac{\delta}{\delta\tilde{g}_{\mu\gamma}(\chi)}\left(|\tilde{g}|^{1/2}\mathcal{T}^\lambda_\lambda(\chi')\right)\bar{\mathcal{T}}^\mu_\nu$$

$$= \Omega^{-4}\mathcal{T}^\mu_\nu - 8\alpha_\delta\Omega^{-4}\left\{-\left(\mathfrak{C}^{\alpha\mu}_{\beta\nu}\ln\Omega\right)^\beta_\alpha + \frac{1}{2}\mathcal{R}^\alpha_\beta\mathfrak{C}^{\alpha\mu}_{\beta\nu}\ln\Omega\right\}$$

$$+ \beta_\delta\left\{\left(4\bar{\mathcal{R}}^\beta_\alpha\bar{\mathfrak{C}}^{\alpha\mu}_{\beta\nu} - 2\bar{\mathcal{H}}^\mu_\nu\right) - \Omega^{-4}\left(4\mathcal{R}^\beta_\alpha\mathfrak{C}^{\alpha\mu}_{\beta\nu} - 2\mathcal{H}^\mu_\nu\right)\right\} - \frac{1}{6}\gamma_\delta\left\{\bar{\mathbb{I}}^\mu_\nu - \Omega^{-4}\mathbb{I}^\mu_\nu\right\}$$

$$\mathcal{H}_{\mu\nu} = \mathcal{R}^\rho_\mu\mathcal{R}_{\rho\nu} - \frac{2}{3}\mathcal{R}\mathcal{R}_{\mu\nu} - \frac{1}{2}\mathcal{R}_{\rho\sigma}\mathcal{R}^{\rho\sigma}g_{\mu\nu} + \frac{1}{2}\mathcal{R}^2g_{\mu\nu}\mathbb{I}_{\mu\nu} = 2\mathcal{R}_{\mu\nu} - 2g_{\mu\nu}\square\mathcal{R} - \frac{1}{2}g_{\mu\nu}\mathcal{R}^2 + 2\mathcal{R}\mathcal{R}_{\mu\nu}$$

$$d\bar{s}^2 = -\left(1 - \frac{\Lambda r^2}{3}\right) \times \left\{ d\tau^2 + \frac{dr^2}{\left(1 - \frac{\Lambda r^2}{3}\right)^2} + \frac{r^2}{\left(1 - \frac{\Lambda r^2}{3}\right)} (d\theta^2 + sin^2\theta d\phi^2) \right\}$$

**17. Coordenadas espaciales en espacios cuánticos curvos: Momentum normal.**

$$\xi^\mu = (d\chi^\mu / d\lambda)_{\mathcal{Q}} \frac{d^2\gamma^\alpha}{d\lambda^2} \Gamma^\alpha_{\beta\gamma}(y) \frac{d\gamma^\beta}{d\lambda} \frac{d\gamma^\gamma}{d\lambda}$$

$$= \Gamma^\alpha_{\beta\gamma}(y) \xi^\beta(\gamma) \xi^\gamma(\gamma) g_{\mu\nu}(\mathcal{Q}) \eta_{\mu\nu} \tau \int_{\mathcal{Q}}^{\mathcal{P}} d\sigma \left( g_{\alpha\beta} \frac{d\chi^\alpha}{d\sigma} \frac{\partial \chi^\beta}{\partial\sigma} \right)^{1/2} g_{\alpha\beta}(\gamma)$$

$$= \eta_{\alpha\beta} - \frac{1}{3} \mathcal{R}_{\alpha\mu\beta\lambda}(0) \gamma^\mu \gamma^\lambda - \frac{1}{3!} \mathcal{R}_{\alpha\gamma\beta\lambda,\mu}(0) \gamma^\lambda \gamma^\mu \gamma^\gamma + \frac{1}{5!} \left( -6\mathcal{R}_{\alpha\delta\beta\gamma,\lambda\mu} + \frac{16}{3} \mathcal{R}_{\lambda\beta\mu^\rho} \right)_0 \gamma^\lambda \gamma^\mu \gamma^\gamma \gamma^\delta$$

$$- \Gamma^\nu_{(\alpha\beta)} \left[ 2\Gamma^\nu_{\sigma(\alpha} \Gamma^\sigma_{\beta\gamma)} - \partial_{(\alpha} \Gamma^\nu_{\beta\gamma)} \right]_{\chi_0} \gamma^\alpha \gamma^\beta \gamma^\gamma \left( \Box_\chi + m^2 + \xi \mathcal{R}(\chi) \right) \mathfrak{G}(\chi, \chi') = -\delta(\chi - \chi')$$

$$\equiv |g(\chi)|^{-\frac{1}{4}} \overline{\mathfrak{G}}(\chi, \chi') \delta(\gamma)$$

$$= -\eta^{\mu\nu} \partial_\mu \partial_\nu \overline{\mathfrak{G}} - \left[ m^2 + \left( \xi - \frac{1}{6} \right) \mathcal{R} \right] \overline{\mathfrak{G}} - \frac{1}{3} \mathcal{R}^\nu_\alpha \gamma^\alpha \partial_\nu \overline{\mathfrak{G}} + \frac{1}{3} \mathcal{R}^{\mu\ \nu}_{\alpha\ \beta} \gamma^\alpha \gamma^\beta \partial_\mu \partial_\nu \overline{\mathfrak{G}} - \left( \xi - \frac{1}{6} \right) \mathcal{R}_\alpha \gamma^\alpha \overline{\mathfrak{G}}$$

$$+ \left( -\frac{1}{3} \mathcal{R}^\nu_{\alpha\beta} + \frac{1}{6} \mathcal{R}^\nu_{\alpha\beta} \right) \gamma^\alpha \gamma^\beta \partial_\nu \overline{\mathfrak{G}}$$

$$+ \frac{1}{6} \mathcal{R}^{\mu\ \ \nu}_{\alpha\ \beta,\gamma} \gamma^\alpha \gamma^\beta \gamma^\gamma \partial_\mu \partial_\nu \overline{\mathfrak{G}} - \frac{1}{2} \left( \xi - \frac{1}{6} \right) \| \mathcal{R}_{\alpha\beta} \gamma^\alpha \gamma^\beta \overline{\mathfrak{G}} \| \langle \Box \mathcal{R}_\alpha \beta \mathcal{R}_{\kappa\lambda} \mathcal{R}^\lambda_\alpha \mathcal{R}_{\lambda\beta} \mathcal{R}^{\lambda\mu\kappa}_\alpha \mathcal{R}_{\lambda\mu\kappa\beta} \mathcal{R}^{\kappa\ \nu}_{\alpha\ \beta} \mathcal{R}_\kappa \gamma \partial_\nu \overline{\mathfrak{G}} \rangle$$

$$\mathfrak{G}(\chi,\chi')$$

$$= -\int \frac{d^\eta \kappa}{(2\pi)^\eta} e^{iky}\, \overline{\mathfrak{G}}(\kappa,\chi)\big(-\eta^{\mu\nu}\kappa_\mu\kappa_\nu + m^2\big)\overline{\mathfrak{G}}_2(\kappa,\chi) + \left(\xi - \frac{1}{6}\right)\mathcal{R}\overline{\mathfrak{G}}_0(\kappa,\chi)$$

$$+ \frac{1}{3}\mathcal{R}_\alpha^\nu(i\kappa_\nu)\left(i\frac{\partial}{\partial\kappa_\alpha}\right)\overline{\mathfrak{G}}_0(\kappa,\chi) - \frac{1}{3}\mathcal{R}_{\alpha\beta}^{\mu\nu}(i\kappa_\mu)(i\kappa_\nu)\left(i\frac{\partial}{\partial\kappa_\alpha}\right)\left(i\frac{\partial}{\partial\kappa_\beta}\right)\overline{\mathfrak{G}}(\kappa)\left(\xi - \frac{1}{6}\right)\mathcal{R}(-\kappa^2 + m^2)^{-2}$$

$$+ i\left(\xi - \frac{1}{6}\right)\mathcal{R}_\alpha(-\kappa^2 + m^2)^{-1}\frac{\partial}{\partial\kappa_\alpha}(-\kappa^2 + m^2)^{-1} + \left(\xi - \frac{1}{6}\right)^2\mathcal{R}^2(-\kappa^2 + m^2)^{-3}$$

$$+ \alpha_{\alpha\beta}(-\kappa^2 + m^2)^{-1}\frac{\partial}{\partial\kappa_\alpha}\frac{\partial}{\partial\kappa_\beta}(-\kappa^2 + m^2)^{-1}\left\|\square\mathcal{R}_{\alpha\beta}\mathcal{R}_{\kappa\lambda}\mathcal{R}_\alpha^\lambda\mathcal{R}_{\lambda\beta}\mathcal{R}_\alpha^{\lambda\mu\kappa}\mathcal{R}_{\lambda\mu\kappa\beta}\mathcal{R}_{\alpha\ \beta}^{\kappa\ \nu}\mathcal{R}_\kappa\right\|\eta_{\alpha\beta}(-\kappa^2$$

$$+ m^2)^{-3}\frac{\partial}{\partial\kappa_\alpha}\frac{\partial}{\partial\kappa_\beta}(-\kappa^2$$

$$+ m^2)^{-2}\int\frac{d^4\kappa}{(2\pi)^\eta}\frac{\partial}{\partial\kappa_\alpha}(-\kappa^2 + m^2)^{-2}\int\frac{d^4\kappa}{(2\pi)^\eta}\frac{\partial}{\partial\kappa_\beta}(-\kappa^2$$

$$+ m^2)^{-3}\int\frac{d^\eta\kappa}{(2\pi)^\eta}\left(\frac{i\pi^2}{2m^2(2\pi)^4}\right)\left\|\square\mathcal{R}_{\alpha\beta}\mathcal{R}^{\alpha\beta}\mathcal{R}_{\alpha\beta\gamma\delta}\mathcal{R}^{\alpha\beta\gamma\delta}\right\|\int\frac{d^\eta\kappa}{(2\pi)^\eta}\,id\delta\,\exp[-i\delta(-\kappa^2$$

$$+ m^2)]\int\frac{d^\eta\kappa}{(2\pi)^\eta}\exp[-i\delta(-\kappa^2 + m^2) + i\kappa\gamma]\frac{i}{(4\pi)^{\eta/2}}(i\delta)^{-\eta/2}\exp\Big[-im^2\delta$$

$$+ \frac{\sigma(\chi,\chi')}{2i\delta}\Big]\int_0^\infty\frac{id\delta}{(i\delta)^{-\eta/2}}\exp\left[-im^2\delta + \frac{\sigma}{2i\delta}\right]$$

**(b) Agujeros negros cuánticos.**

**1. Cuantización General.**

$$(-g)^{1/2}\partial_\mu\left[(-g)^{1/2}g^{\mu\nu}\partial_\nu\phi\right]\int d\omega'\big(\alpha_{\omega'}\alpha_\omega + \alpha_{\omega'}^\dagger\beta_{\omega'}^*\big)\int d\omega'\big(\alpha_{\omega_1\omega}^\dagger\alpha_{\omega_2\omega}^* - \beta_{\omega_1\omega}^\dagger\beta_{\omega_1\omega}^*\big)$$

$$+ c_{\omega\omega'}^\dagger q_{\omega\omega'}^* - c_{\omega_1\omega}^\dagger q_{\omega_1\omega}^* - c_{\omega_2\omega}^\dagger q_{\omega_2\omega}^*\delta(\omega_1 - \omega_2)$$

**2. Métrica de Schwarzschild.**

$$ds^2 = \left(1 - \frac{2\mathcal{M}}{r}\right)dt^2 - \left(1 - \frac{2\mathcal{M}}{r}\right)dr^2 - r^2 d\theta^2 - r^2 sin^2\theta d\phi^2 \left|\frac{\Delta}{\rho^2}\right| [dt - \alpha sin^2\theta d\phi]^2$$

$$- \frac{sin^2\theta}{\rho^2}[(r^2 + \alpha^2)d\phi - \alpha dt]^2 - \frac{\rho^2}{\Delta}dr^2 - \rho^2 d\theta^2 \frac{d\phi}{dt}\Omega_{\mathcal{H}}$$

$$\equiv \frac{\alpha}{\alpha^2 + r_\pm^2}\left(\frac{\mathcal{D}}{d\lambda}\right)\left(\frac{d\chi^\mu}{d\lambda}\right)\frac{1}{2}g_{\mu\nu}\frac{d\chi^\mu}{d\lambda}\frac{d\chi^\nu}{d\lambda}\rho_{\mu\nu} \equiv \frac{\partial\mathcal{L}}{\left(\frac{d\chi^\mu}{d\lambda}\right)}$$

$$= g_{\mu\nu}\frac{d\chi^\nu}{d\lambda}\left(1 - \frac{2\mathcal{M}}{r}\right)\frac{dt}{d\lambda}\mathfrak{E}r^2\frac{d\phi}{d\lambda}$$

$$= \mathcal{L}\left(\frac{dr}{d\lambda}\right)^2 + \frac{\mathcal{L}^2}{r^2}\left(1 - \frac{2\mathcal{M}}{r}\right)\mathfrak{E}^2\frac{dt}{d\lambda}$$

$$\mp\left(1 - \frac{2\mathcal{M}}{r}\right)^{-1}\frac{dr^*}{d\lambda}\frac{dv}{d\lambda}2\left(1 - \frac{2\mathcal{M}}{r}\right)^{-1}\mathfrak{E}\frac{dv}{d\lambda}2\mathfrak{E}\frac{4\mathcal{M}}{\mathfrak{E}\lambda} - 4\mathcal{M}\ln\frac{\lambda}{\kappa_1}\left(\frac{v - v_0}{\kappa_1\kappa_2}\right)$$

$$\mu(v) = 4\mathcal{M}ln\left(\frac{v_0 - v}{\mathcal{K}}\right)\rho_\omega \sim \omega^{\frac{1}{2}}r^{-1}\exp(-i\omega\mu(v))\delta(\theta,\phi)\alpha_{\omega\omega'} =$$

$$\mathfrak{C}\int_{-\infty}^{v_0} dv\left(\frac{\omega'}{\omega}\right)^{1/2} e^{i\omega' v}e^{-i\omega\mu(v)}\beta_{\omega\omega'} = \mathfrak{C}\int_{-\infty}^{v_0} dv\left(\frac{\omega'}{\omega}\right)^{1/2} e^{-i\omega' v}e^{-i\omega\mu(v)}\alpha_{\omega\omega'} =$$

$$-\mathfrak{C}\int_{\infty}^{\mu\nu} ds'\left(\frac{\omega'}{\omega}\right)^{1/2} e^{i\omega' s'}e^{i\omega'\mu\nu}\exp\left[i\omega 4\mathcal{M}\ln\left(\frac{is'}{\mathcal{K}}\right)\right]\beta_{\omega\omega'} =$$

$$\mathfrak{C}\int_{-\infty}^{\mu\nu} ds'\left(\frac{\omega'}{\omega}\right)^{1/2} e^{-i\omega' s'}e^{-i\omega'\mu\nu}\exp\left[i\omega 4\mathcal{M}\ln\left(-\frac{is'}{\mathcal{K}}\right)\right]$$

$$\Gamma(\omega_1)\delta(\omega_1 - \omega_2)$$

$$= \int d\omega'\left(\alpha^*_{\omega_1\omega'}\alpha^*_{\omega_2\omega'}\right.$$

$$\left.- \beta^*_{\omega_1\omega'}\beta^*_{\omega_2\omega'}\right)\langle 0|\alpha^\dagger_\omega\beta^*_\omega|0\rangle\int d\omega'\left|\alpha^\dagger_{\omega_1\omega'}\right|^2 - \left|\beta^*_{\omega_1\omega'}\right|^2\lim_{\mathcal{T}\mapsto\infty}\frac{1}{2\pi}\int_{-\tau/2}^{\tau/2} dt\exp[i((\omega_1$$

$$- \omega_2))t]\int d\omega_1\int d\omega_2\,\mathrm{A}(\omega_1)\mathrm{A}(\omega_2)e^{i[\gamma(\omega_1)-\gamma(\omega_2)]}(\rho_{\omega_1},\rho_{\omega_2})\Gamma(\omega)\int d\omega'\langle|\alpha_{\rho\omega'}||\beta_{\rho\omega'}|\rangle^2\delta(\theta,\phi)$$

**3. Métrica de Kerr.**

$$\rho^4\left(\frac{dr}{d\lambda}\right)^2=[(r^2+\alpha^2)\mathfrak{E}-\alpha\mathfrak{L}_z]^2-\mathcal{K}_{\mathcal{C}}\Delta\rho^4\left(\frac{d\theta}{d\lambda}\right)^2=-(\alpha\mathfrak{E}\sin\theta-\mathfrak{L}_z cosec\,\theta)^2+\mathcal{K}_{\mathcal{C}}\rho^2\left(\frac{dt}{d\lambda}\right)$$

$$=\Delta^{-1}\{[(r^2+\alpha^2)^2-\Delta\alpha^2\sin^2\theta]\mathfrak{E}-2\alpha\mathcal{M}r\mathfrak{L}_z\}\rho^2\left(\frac{dt}{d\lambda}\right)$$

$$=\Delta^{-1}[2\alpha\mathcal{M}r\mathfrak{E}+(\rho^2-2\mathcal{M}r)\mathfrak{L}_z cosec^2\,\theta]\frac{dt}{d\lambda}\mathfrak{E}/\Delta\frac{d\phi}{d\lambda}\ \alpha\mathfrak{E}/\Delta(r^2+\alpha^2)^2$$

$$-\Delta\alpha^2\sin^2\theta=\rho^2(r^2+\alpha^2)^2+2\alpha^2\mathcal{M}r\sin^2\theta\frac{dr^*}{d\lambda}\frac{r^2+\alpha^2}{\Delta}\tilde{\phi}_+\equiv\phi-\frac{\alpha}{r_+^2+\alpha^2}t$$

$$=\phi-\Omega_{\mathcal{H}}\tau\frac{d\tilde{\phi}_+}{d\lambda}=\frac{\alpha\mathfrak{E}}{\Delta}-\frac{\alpha}{r_+^2+\alpha^2}\frac{r^2+\alpha^2}{\Delta}\mathfrak{E}=-\Omega_{\mathcal{H}}\mathfrak{E}(r+r_+)/(r+r_-)$$

$$\frac{d\mu}{d\lambda}=\frac{dt}{d\lambda}-\frac{dr^*}{dr}\frac{dr}{d\lambda}=2\mathfrak{E}\frac{r^2+\alpha^2}{\Delta}\frac{d\mu}{d\lambda}=2\frac{(r_+-\mathfrak{E}\lambda)^2+\alpha^2}{\mathfrak{E}\lambda[\mathfrak{E}\lambda-(r_+-r_-)]}\mu$$

$$=2\mathfrak{E}\lambda-\left(\frac{1}{\alpha_+}\right)\ln\frac{\mathfrak{E}\lambda}{\kappa_1}+\left(\frac{1}{\alpha_-}\right)\ln\{[\mathfrak{E}\lambda-(r_+-r_-)]/\kappa_1'\}$$

$$\mu(v)\approx-\left(\frac{1}{\kappa}\right)\ln\left[\frac{(v-v_0)}{\kappa}\right]\alpha_+\frac{1}{2}(r_+-r_-)$$

$$/(r_+^2+\alpha^2)|\alpha_{\omega\omega'}|^2\exp[2\pi\kappa^{-1}(\omega-m\Omega_{\mathcal{H}})]|\beta_{\omega\omega'}|^2\langle \mathrm{N}_{\omega lm}\rangle$$

$$=\Gamma_{lm}(\omega)\{\exp[2\pi\kappa^{-1}(\omega-m\Omega_{\mathcal{H}})]-1\}^{-1}$$

**4. Entropía.**

$$d\delta=\frac{4\pi\mathcal{M}\left(\mathcal{M}+\sqrt{\mathcal{M}^2-\alpha^2}\right)}{\sqrt{\mathcal{M}^2-\alpha^2}}\left\{d\mathcal{M}-\left[\frac{\alpha}{2\mathcal{M}\left(\mathcal{M}+\sqrt{\mathcal{M}^2-\alpha^2}\right)}\right]d(\alpha\mathcal{M})\right\}$$

$$=\frac{4\pi\mathcal{M}^2}{\sqrt{\mathcal{M}^2-\alpha^2}}d\mathcal{M}+4\pi\mathcal{M}d\mathcal{M}-\frac{2\pi\alpha}{\sqrt{\mathcal{M}^2-\alpha^2}}d(\alpha\mathcal{M})$$

$$=d\left(2\pi\mathcal{M}^2+2\pi\mathcal{M}\sqrt{\mathcal{M}^2-\alpha^2}\right)\int_{r=r_+}^{\square}\sqrt{g_{\theta\theta}g_{\phi\phi}}d\theta d\phi\,4\pi(r_+^2+\alpha^2)$$

$$=8\pi\mathcal{M}\left(\mathcal{M}+\sqrt{\mathcal{M}^2-\alpha^2}\right)$$

**5. Tensor energía – momentum de Hawking.**

$$\mathfrak{G}(\chi,\chi') = \frac{1}{2}\langle 0|\phi(\chi)\phi(\chi') + \phi(\chi')\phi(\chi)|0\rangle \mathfrak{G}^{\mathcal{U}}(\chi,\chi') - \mathfrak{G}^{\mathcal{HH}}(\chi,\chi')$$

$$= -(4\pi rr')^{-1} \int_0^{\infty} d\omega\omega^{-1} e^{-i\omega(t-t')} \frac{1}{(e^{8\pi\mathcal{M}\omega} - 1)^{-1}}$$

$$\times \sum_{m,\eta} \Upsilon_\eta^m(\theta,\phi)\, \Upsilon_\eta^{m*}(\theta',\phi') \mathcal{R}_{\omega\eta}(r) \mathcal{R}_{\omega\eta}^*(r') + c \otimes c \frac{d^2\mathcal{R}}{d\bar{r}^2}$$

$$+ [\omega^2 - \eta(\eta+1) r^{-3}(r - 2\mathcal{M}) r^{-4}(r - 2\mathcal{M})] \Re \bar{r}$$

$$+ 2\mathcal{M} \ln\left(\frac{r}{(2\mathcal{M})} - 1\right) \tau_{\omega\eta} e^{-i\omega\bar{r}} \sum_{\kappa=0}^{\infty} c_\kappa \left(\frac{r}{(2\mathcal{M})} - 1\right)^{\kappa} \frac{d\omega}{\omega}$$

$$\times \sum_{\eta=0}^{\infty} \int \frac{d\omega}{\omega} \left(e^{8\pi\mathcal{M}\omega} - 1\right)^{-1} (2\eta+1) \hbar_{\omega\eta}(r) g_{\omega\eta}(r) \frac{\mathcal{L}}{4\pi r(r - 2\mathcal{M})} f_{\omega\eta}(r)$$

$$f_{\omega\eta}(r) = 2\frac{(\gamma_2 - 3\delta)}{r(r - 2\mathcal{M})} + 2\gamma_1 \frac{(r - 3\mathcal{M})}{r^2(r - 2\mathcal{M})} + 2\left[\eta(\eta+1)\frac{r - 4\mathcal{M}}{r} - \omega^2 \frac{r^3}{r - 2\mathcal{M}}\right] \frac{\epsilon}{r^4}$$

$$g_{\omega\eta}(r) = 2\frac{\delta}{r(r - 2\mathcal{M})} - 2\left[2\eta(\eta+1)\frac{r - 2\mathcal{M}}{r} + \omega^2 \frac{r^3}{r - 2\mathcal{M}}\right] \frac{\epsilon}{r^4}$$

$$\hbar_{\omega\eta}(r) = -2\frac{\delta}{r(r - 2\mathcal{M})} + 2\gamma_1 \frac{(r - 3\mathcal{M})}{r^2(r - 2\mathcal{M})}$$

$$- 2\left[\eta(\eta+1) + \frac{r - 4\mathcal{M}}{r} + 5\omega^2 \frac{r^3}{r - 2\mathcal{M}}\right] \frac{\epsilon}{r^4} \left|\frac{d\mathcal{R}_{\omega\eta}}{d\bar{r}}\right| \Re_{\omega\eta}^* \frac{d_i \mathcal{R}_{\omega\eta}}{d\bar{r}^i} + c \otimes c$$

$$ds^2 = e^{2\psi}\left(1 - \frac{2\mathcal{M}(r,v)}{r}\right) dv^2 + 2e^{\psi} dv dr + r^2 d\Omega^2$$

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**APÉNDICE D.**

**Formalización lagrangiana relativa a gravedad cuántica, morfología de las partículas y antipartículas supermasivas y de las hiperpartículas y agujeros negros cuánticos en espacios curvos.**

$$\mathcal{L}_{SM}(x) \equiv (a,b) \simeq (b,a)$$

$$= -\frac{1}{2\pi}\partial^{\mu}\partial_{\nu}\partial^{\nu}\partial_{\mu}\widehat{\partial_{\nu}^{\mu}\partial_{\mu}^{\nu}}g_{\mu}^{a}g_{a}^{\mu}g_{\nu}^{b}g_{b}^{\nu} - g_s f^{ab} f_{ab}\partial^{\mu}\partial_{\nu}\partial^{\nu}\widetilde{\partial_{\mu}\partial_{\nu}^{\mu}}\partial_{\mu}^{\nu}g_{\mu}^{a}g_{a}^{\mu}g_{\nu}^{b}g_{b}^{\nu} - \frac{1}{4\pi}\overline{g_S^2 f^{cd} f_{cd}\partial^{\mu}\partial_{\nu}\partial^{\nu}\partial_{\mu}\partial_{\nu}^{\mu}\partial_{\mu}^{\nu}g_{\mu}^{c}g_{c}^{\mu}g_{\nu}^{d}g_{d}^{\nu}}$$

$$- \partial^{\mu}W_{\mu}\partial^{\nu}W_{\nu} - M^2 W_{\mu}^{+}\dddot{W_{\nu}^{-}}W_{\mu}^{-}W_{\nu}^{+}W_{+}^{\mu}W_{-}^{\nu}W_{-}^{\mu}W_{+}^{\nu} - \frac{1}{2\pi}\partial^{\mu}\partial_{\nu}\partial^{\nu}\partial_{\mu}\partial_{\nu}^{\mu}\partial_{\mu}^{\nu}Z_{\mu}^{0}Z_{\nu}^{0}Z_{0}^{\mu}Z_{0}^{\nu} - \frac{1}{2}\partial^{\mu}A_{\nu}\partial^{\nu}A_{\mu} - \frac{1}{2}c_m^2 M^2 Z_{\mu}^{0}Z_{\nu}^{0}Z_{0}^{\mu}Z_{0}^{\nu}$$

$$- igc_w\left(\partial^{\mu}\partial_{\nu}\partial^{\nu}\partial_{\mu}\partial_{\nu}^{\mu}\partial_{\mu}^{\nu}Z_{\mu}^{0}Z_{\nu}^{0}Z_{0}^{\mu}Z_{0}^{\nu}\left(W_{\mu}^{+}W_{\nu}^{-}W_{\mu}^{-}W_{\nu}^{+}\right)\right) - Z_{\mu}^{0}\left(\partial^{\mu}\partial_{\mu}W_{\mu}^{+}W_{\mu}^{-}W_{+}^{\mu}W_{-}^{\mu}\right) + Z_{\nu}^{0}(\partial^{\nu}\partial_{\nu}W_{\nu}^{+}W_{\nu}^{-}W_{+}^{\nu}W_{-}^{\nu})$$

$$- igS_w\left(\partial^{\mu}A_{\nu}\partial^{\nu}A_{\mu}\left(W_{\mu}^{+}W_{\nu}^{-}W_{\mu}^{-}W_{\nu}^{+}W_{+}^{\mu}W_{-}^{\nu}W_{-}^{\mu}W_{+}^{\nu}\right)Z_{\mu}^{0}Z_{\nu}^{0}Z_{0}^{\mu}Z_{0}^{\nu}\right) - A_{\mu}\left(\partial^{\mu}\partial_{\mu}W_{\mu}^{+}W_{\mu}^{-}W_{+}^{\mu}W_{-}^{\mu}Z_{\mu}^{0}Z_{0}^{\mu}\right) + A_{\nu}\left(\partial^{\nu}\partial_{\nu}W_{\nu}^{+}W_{\nu}^{-}W_{+}^{\nu}W_{-}^{\nu}Z_{\nu}^{0}Z_{0}^{\nu}\right)$$

$$- \frac{1}{2g^2}\left(\overline{\overline{\partial^{\mu}A_{\nu}\partial^{\nu}A_{\mu}\left(W_{\mu}^{+}W_{\nu}^{-}W_{\mu}^{-}W_{\nu}^{+}W_{+}^{\mu}W_{-}^{\nu}W_{-}^{\mu}W_{+}^{\nu}Z_{\mu}^{0}Z_{\nu}^{0}Z_{0}^{\mu}Z_{0}^{\nu}\right)}}\right) + g^2 c_w^2\left(\partial^{\mu}A_{\nu}\partial^{\nu}A_{\mu}\left(W_{\mu}^{+}W_{\nu}^{-}W_{\mu}^{-}\widetilde{W_{\nu}^{+}W_{+}^{\mu}}W_{-}^{\nu}W_{-}^{\mu}W_{+}^{\nu}Z_{\mu}^{0}Z_{\nu}^{0}Z_{0}^{\mu}Z_{0}^{\nu}\right)\right)$$

$$+ g^2 S_w^2\left(\overbrace{\partial^{\mu}A_{\nu}\partial^{\nu}}^{A_{\mu}\left(W_{\mu}^{+}W_{\nu}^{-}W_{\mu}^{-}W_{\nu}^{+}W_{+}^{\mu}W_{-}^{\nu}W_{-}^{\mu}W_{+}^{\nu}Z_{\mu}^{0}Z_{\nu}^{0}Z_{0}^{\mu}Z_{0}^{\nu}\right)}\right) - g^2 c_w S_w\left(\underbrace{\left(W_{\mu}^{+}W_{\nu}^{-}W_{\mu}^{-}W_{\nu}^{+}W_{+}^{\mu}W_{-}^{\nu}W_{-}^{\mu}W_{+}^{\nu}Z_{\mu}^{0}Z_{\nu}^{0}Z_{0}^{\mu}Z_{0}^{\nu}\right)}_{\partial^{\mu}A_{\nu}\partial^{\nu}A_{\mu}}\right)$$

$$- \frac{1}{2\pi}\left(\overrightarrow{\partial H^{\mu}AH_{\nu}H\partial^{\nu}HA_{\mu}\left(W_{\mu}^{+}W_{\nu}^{-}W_{\mu}^{-}W_{\nu}^{+}W_{+}^{\mu}W_{-}^{\nu}W_{-}^{\mu}W_{+}^{\nu}Z_{\mu}^{0}Z_{\nu}^{0}Z_{0}^{\mu}Z_{0}^{\nu}H^{\mu}H_{V}H_{\nu}^{\mu}H_{\mu}^{\nu}\right)}\right) + \left\|\overrightarrow{\frac{\frac{\frac{1}{2\pi}}{\overline{d^{\curlywedge}em^{C}\gamma}}}{GUM_{Scw}^{2}}(2M^2H^2H^3)}\Bigg/\prod_{\sigma}^{\rho}\frac{2M}{\partial\beta_{\eta}^{\xi}}\frac{\overline{\partial h^4}}{\partial\mathcal{G}\mathcal{M}^2}\right\|^2 - \left|\frac{2g_c^2M_S^2}{\partial\Psi\Phi\zeta}\right\rangle - \langle\partial\lambda|$$

$$\otimes\left|\frac{\dfrac{\frac{\partial\omega}{\partial\Delta\nabla\theta}}{\prod_{\triangleq}^{\dagger}\infty\oiiint_{j}^{i}k\int_{\partial}\left|\dfrac{\frac{\phi_{\mu}^{+}\phi_{\nu}^{-}\phi_{\mu}^{-}\phi_{\nu}^{+}}{\phi_{+}^{\mu}\phi_{-}^{\nu}\phi_{-}^{\mu}\phi_{+}^{\nu}}}{\phi_{\mu}^{0}\phi_{\nu}^{0}\phi_{0}^{\mu}\phi_{0}^{\nu}}\right|^{2}}\left(\varphi\psi\omega\lambda_{\mu}^{+}\varphi\psi\omega\lambda_{\nu}^{-}\varphi\psi\omega\lambda_{\mu}^{-}\varphi\psi\omega\lambda_{\nu}^{+}\left|\frac{2\varphi\psi\omega\lambda}{\varphi\psi\omega\lambda}\right|_{+}^{\mu}\varphi\psi\omega\lambda_{-}^{\nu}\varphi\psi\omega\lambda_{-}^{\mu}\varphi\psi\omega\lambda_{+}^{\nu}\left|\frac{\frac{1}{2\pi\varphi\psi\omega\lambda}}{\varphi\psi\omega\lambda}\right|_{\mu}^{0}\varphi\psi\omega\lambda_{\nu}^{0}\varphi\psi\omega\lambda_{0}^{\mu}\varphi\psi\omega\lambda_{0}^{\nu}\right)\Re}{\left\langle 2M^{\phi\varphi\lambda\kappa}\sqrt{\dfrac{\int_{\partial}\left\|\dfrac{\frac{\frac{2\xi\eta}{\zeta\epsilon\varepsilon}}{\frac{\delta\alpha}{o\sigma\rho}}}{\Psi\Omega}\right\|^{1/2}\square = \mathcal{L}_{Higgs} =}{\left(\partial^{\mu}\partial_{\nu}\partial^{\nu}\partial_{\mu} + \frac{1}{2i}g_1B^{\mu}B_{\nu}B^{\nu}B_{\mu} + \frac{1}{2j}g_2B^{\mu}B_{\nu}B^{\nu}B_{\mu} + \frac{1}{2i}g_1W^{\mu}W_{\nu}W^{\nu}W_{\mu} + \frac{1}{2j}g_2W^{\mu}W_{\nu}W^{\nu}W_{\mu}\right) - m_H^2\phi'\phi - \frac{v^2}{2v^2}}}\right|}\right\rangle$$

$$\left| \partial_i \partial^j \partial_j \partial^i f^{ab\varphi} t_{ba\omega} t^{ab\varphi} f_{ba\omega}(x) \right.$$

$$= \int_\partial \langle \frac{\frac{\partial^\theta \partial_\emptyset F_\sigma^\rho \gamma\beta}{\varepsilon\epsilon\vartheta\pi}}{\frac{\Delta\nabla}{\tau}} \rangle + \prod_b^a \lambda \coprod_a^b \lambda\, H_{iggs}$$

$$\left. - W^a W_b \widehat{W^b W_a} W_b^a W_a^b \widehat{{}_b^a W_a^b} W - \widehat{\eta^\theta \eta_\beta} \eta_{\phi\nu\,\Omega}^{\sigma\mu\,\alpha} \eta / \mathbb{R}^4 \right| \langle d\tau^2 |$$

$$\mathcal{L}_{SM}(y) \equiv (a,b) \simeq (b,a)$$

$$= -\frac{1}{2\pi} \partial^\mu \partial_\nu \partial^\nu \partial_\mu \widehat{\partial_\nu^\mu \partial_\mu^\nu} g_\mu^a g_a^\mu g_\nu^b g_b^\nu - g_s f^{ab} f_{ab} \partial^\mu \partial_\nu \partial^\nu \widetilde{\partial_\mu \partial_\nu^\mu} \partial_\mu^\nu g_\mu^a g_a^\mu g_\nu^b g_b^\nu - \frac{1}{4\pi} \overline{g_S^2 f^{cd} f_{cd} \partial^\mu \partial_\nu \partial^\nu \partial_\mu \partial_\nu^\mu \partial_\mu^\nu g_\mu^c g_c^\mu g_\nu^d g_d^\nu}$$

$$- \partial^\mu W_\mu \partial^\nu W_\nu - M^2 W_\mu^+ \dddot{W_\nu^-} W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu - \frac{1}{2\pi} \partial^\mu \partial_\nu \partial^\nu \partial_\mu \partial_\nu^\mu \partial_\mu^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu - \frac{1}{2} \partial^\mu A_\nu \partial^\nu A_\mu - \frac{1}{2} c_m^2 M^2 Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu$$

$$- igc_w \left( \partial^\mu \partial_\nu \partial^\nu \partial_\mu \partial_\nu^\mu \partial_\mu^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu (W_\mu^+ W_\nu^- W_\mu^- W_\nu^+) \right) - Z_\mu^0 (\partial^\mu \partial_\mu W_\mu^+ W_\mu^- W_+^\mu W_-^\mu) + Z_\nu^0 (\partial^\nu \partial_\nu W_\nu^+ W_\nu^- W_+^\nu W_-^\nu)$$

$$- igS_w \left( \partial^\mu A_\nu \partial^\nu A_\mu (W_\mu^+ W_\nu^- W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu) Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu \right) - A_\mu \left( \partial^\mu \partial_\mu W_\mu^+ W_\mu^- W_+^\mu W_-^\mu Z_\mu^0 Z_0^\mu \right) + A_\nu \left( \partial^\nu \partial_\nu W_\nu^+ W_\nu^- W_+^\nu W_-^\nu Z_\nu^0 Z_0^\nu \right)$$

$$- \frac{1}{2g^2} \left( \overline{\overline{\partial^\mu A_\nu \partial^\nu A_\mu (W_\mu^+ W_\nu^- W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu)}} \right) + g^2 c_w^2 \left( \partial^\mu A_\nu \partial^\nu A_\mu (W_\mu^+ W_\nu^- W_\mu^- \widetilde{W_\nu^+ W_+^\mu} W_-^\nu W_-^\mu W_+^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu) \right)$$

$$+ g^2 S_w^2 \left( \overbrace{\partial^\mu A_\nu \partial^\nu}^{A_\mu (W_\mu^+ W_\nu^- W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu)} \right) - g^2 c_w S_w \left( \underbrace{(W_\mu^+ W_\nu^- W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu)}_{\partial^\mu A_\nu \partial^\nu A_\mu} \right)$$

$$- \frac{1}{2\pi} \left( \overrightarrow{\partial H^\mu A H_\nu H \partial^\nu H A_\mu (W_\mu^+ W_\nu^- W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu H^\mu H_V H_\nu^\mu H_\mu^\nu)} \right) + \left\| \frac{\overrightarrow{\frac{\frac{1}{2\pi}}{\frac{d^\curlywedge em^C \gamma}{GUM_{Scw}^2}} (2M^2 H^2 H^3)}}{\prod_\sigma^\rho \frac{2M}{\partial \beta_\eta^\xi} \frac{\overline{\partial h^4}}{\partial \mathcal{G} \mathcal{M}^2}} \right\|^2 - \left| \frac{2 g_c^2 M_S^2}{\partial \Psi \Phi \zeta} \right\rangle - \langle \partial \lambda |$$

$$\otimes \left| \frac{\frac{\frac{\partial \omega}{\partial \Delta \nabla \theta}}{\prod_{\triangleq}^{\dagger} \infty \oiiint_j^i k \int_\partial \left| \frac{\frac{\phi_\mu^+ \phi_\nu^- \phi_\mu^- \phi_\nu^+}{\phi_+^\mu \phi_-^\nu \phi_-^\mu \phi_+^\nu}}{\phi_\mu^0 \phi_\nu^0 \phi_0^\mu \phi_0^\nu} \right|^2} \left( \varphi\psi\omega\lambda_\mu^+ \varphi\psi\omega\lambda_\nu^- \varphi\psi\omega\lambda_\mu^- \varphi\psi\omega\lambda_\nu^+ \left| \frac{2\varphi\psi\omega\lambda}{\varphi\psi\omega\lambda} \right|_+^\mu \varphi\psi\omega\lambda_-^\nu \varphi\psi\omega\lambda_-^\mu \varphi\psi\omega\lambda_+^\nu \left| \frac{\frac{1}{2\pi\varphi\psi\omega\lambda}}{\varphi\psi\omega\lambda} \right|_\mu^0 \varphi\psi\omega\lambda_\nu^0 \varphi\psi\omega\lambda_0^\mu \varphi\psi\omega\lambda_0^\nu \right)}{\overrightarrow{\left\langle 2M^{\phi\varphi\lambda\kappa} \sqrt{\frac{\Re}{\int_\partial \left\| \frac{\frac{\frac{2\xi\eta}{\zeta\epsilon\varepsilon}}{\frac{\delta\alpha}{o\sigma\rho}}}{\Psi\Omega} \right\|^{1/2} \square = \mathcal{L}_{Higgs} = \left( \partial^\mu \partial_\nu \partial^\nu \partial_\mu + \frac{1}{2i} g_1 B^\mu B_\nu B^\nu B_\mu + \frac{1}{2j} g_2 B^\mu B_\nu B^\nu B_\mu + \frac{1}{2i} g_1 W^\mu W_\nu W^\nu W_\mu + \frac{1}{2j} g_2 W^\mu W_\nu W^\nu W_\mu \right) - m_H^2 \phi' \phi - \frac{v^2}{2v^2}}} \right.}} \right\rangle$$

$$\left| \partial_i \partial^j \partial_j \partial^i f^{ab\varphi} t_{ba\omega} t^{ab\varphi} f_{ba\omega}(x) \right.$$

$$= \int_{\partial} \langle \frac{\frac{\partial^\theta \partial_\emptyset F_\sigma^\rho \gamma\beta}{\varepsilon\epsilon\vartheta\pi}}{\frac{\Delta\nabla}{\tau}} \rangle + \prod_b^a \lambda \coprod_a^b \lambda H_{iggs}$$

$$- W^a W_b \widehat{W^b W_a} W_b^a \widehat{W_a^b {}_b^a W_a^b} W - \widehat{\eta^\theta \eta_\beta} \eta_{\phi\nu\,\Omega}^{\sigma\mu\,\alpha} \eta / \mathbb{R}^4 \left.\right| \langle d\tau^2 |$$

$$\mathcal{L}_{SM}(z) \equiv (a,b) \simeq (b,a)$$

$$= -\frac{1}{2\pi} \partial^\mu \partial_\nu \partial^\nu \partial_\mu \widehat{\partial_\nu^\mu \partial_\mu^\nu} g_\mu^a g_a^\mu g_\nu^b g_b^\nu - g_s f^{ab} f_{ab} \partial^\mu \partial_\nu \partial^\nu \widetilde{\partial_\mu \partial_\nu^\mu} \partial_\mu^\nu g_\mu^a g_a^\mu g_\nu^b g_b^\nu - \frac{1}{4\pi} \overline{g_S^2 f^{cd} f_{cd} \partial^\mu \partial_\nu \partial^\nu \partial_\mu \partial_\nu^\mu \partial_\mu^\nu g_\mu^c g_c^\mu g_\nu^d g_d^\nu}$$

$$- \partial^\mu W_\mu \partial^\nu W_\nu - M^2 W_\mu^+ \dddot{W_\nu^-} W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu - \frac{1}{2\pi} \partial^\mu \partial_\nu \partial^\nu \partial_\mu \partial_\nu^\mu \partial_\mu^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu - \frac{1}{2} \partial^\mu A_\nu \partial^\nu A_\mu - \frac{1}{2} c_m^2 M^2 Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu$$

$$- igc_w \left( \partial^\mu \partial_\nu \partial^\nu \partial_\mu \partial_\nu^\mu \partial_\mu^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu (W_\mu^+ W_\nu^- W_\mu^- W_\nu^+) \right) - Z_\mu^0 (\partial^\mu \partial_\mu W_\mu^+ W_\mu^- W_+^\mu W_-^\mu) + Z_\nu^0 (\partial^\nu \partial_\nu W_\nu^+ W_\nu^- W_+^\nu W_-^\nu)$$

$$- igS_w \left( \partial^\mu A_\nu \partial^\nu A_\mu (W_\mu^+ W_\nu^- W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu) Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu \right) - A_\mu \left( \partial^\mu \partial_\mu W_\mu^+ W_\mu^- W_+^\mu W_-^\mu Z_\mu^0 Z_0^\mu \right) + A_\nu \left( \partial^\nu \partial_\nu W_\nu^+ W_\nu^- W_+^\nu W_-^\nu Z_\nu^0 Z_0^\nu \right)$$

$$- \frac{1}{2g^2} \left( \overline{\overline{\partial^\mu A_\nu \partial^\nu A_\mu (W_\mu^+ W_\nu^- W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu)}} \right) + g^2 c_w^2 \left( \partial^\mu A_\nu \partial^\nu A_\mu (W_\mu^+ W_\nu^- W_\mu^- \widetilde{W_\nu^+ W_+^\mu} W_-^\nu W_-^\mu W_+^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu) \right)$$

$$+ g^2 S_w^2 \left( \overset{A_\mu (W_\mu^+ W_\nu^- W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu)}{\widehat{\partial^\mu A_\nu \partial^\nu}} \right) - g^2 c_w S_w \left( \underbrace{(W_\mu^+ W_\nu^- W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu)}_{\partial^\mu A_\nu \partial^\nu A_\mu} \right)$$

$$- \frac{1}{2\pi} \left( \overrightarrow{\partial H^\mu A H_\nu H \partial^\nu H A_\mu (W_\mu^+ W_\nu^- W_\mu^- W_\nu^+ W_+^\mu W_-^\nu W_-^\mu W_+^\nu Z_\mu^0 Z_\nu^0 Z_0^\mu Z_0^\nu H^\mu H_\nu H_\nu^\mu H_\mu^\nu)} \right) + \left\| \frac{\overrightarrow{\frac{\frac{1}{2\pi}}{\frac{d^{\wedge} em^C \gamma}{GUM_{Scw}^2}} (2M^2 H^2 H^3)}}{\Pi_\sigma^\rho \frac{2M}{\partial \beta_\eta^\xi} \frac{\overline{\partial h^4}}{\partial \mathcal{G} \mathcal{M}^2}} \right\|^2 - \left| \frac{2g_c^2 M_S^2}{\partial \Psi \Phi \zeta} \right\rangle - \langle \partial \lambda |$$

$$\otimes \left| \frac{\dfrac{\frac{\partial \omega}{\partial \Delta \nabla \theta}}{\Pi_{\triangleq}^{\dagger} \infty \oiiint_j^i k \int_\partial \left| \frac{\frac{\phi_\mu^+ \phi_\nu^- \phi_\mu^- \phi_\nu^+}{\phi_+^\mu \phi_-^\nu \phi_-^\mu \phi_+^\nu}}{\phi_\mu^0 \phi_\nu^0 \phi_0^\mu \phi_0^\nu} \right|^2} \left( \varphi\psi\omega\lambda_\mu^+ \varphi\psi\omega\lambda_\nu^- \varphi\psi\omega\lambda_\mu^- \varphi\psi\omega\lambda_\nu^+ \left| \frac{2\varphi\psi\omega\lambda}{\varphi\psi\omega\lambda} \right|_+^\mu \varphi\psi\omega\lambda_-^\nu \varphi\psi\omega\lambda_-^\mu \varphi\psi\omega\lambda_+^\nu \left| \frac{\frac{1}{2\pi\varphi\psi\omega\lambda}}{\varphi\psi\omega\lambda} \right|_\mu^0 \varphi\psi\omega\lambda_\nu^0 \varphi\psi\omega\lambda_0^\mu \varphi\psi\omega\lambda_0^\nu \right)}{\left\langle 2M^{\phi\varphi\lambda\kappa} \sqrt{\overline{\overline{\int_\partial \left\| \frac{\frac{2\xi\eta}{\zeta\epsilon\varepsilon}}{\frac{\frac{\delta\alpha}{o\sigma\rho}}{\Psi\Omega}} \right\|^{1/2} \square = \mathcal{L}_{Higgs} = \left( \partial^\mu \partial_\nu \partial^\nu \partial_\mu + \frac{1}{2i} g_1 B^\mu B_\nu B^\nu B_\mu + \frac{1}{2j} g_2 B^\mu B_\nu B^\nu B_\mu + \frac{1}{2i} g_1 W^\mu W_\nu W^\nu W_\mu + \frac{1}{2j} g_2 W^\mu W_\nu W^\nu W_\mu \right) - m_H^2 \phi' \phi - \frac{v^2}{2v^2}}}} \right|} \frac{\Re}{} \right\rangle$$

$$\left|\partial_i\partial^j\partial_j\partial^i f^{ab\varphi}t_{ba\omega}t^{ab\varphi}f_{ba\omega}(x)\right.$$

$$= \int_{\partial} \langle \frac{\frac{\partial^\theta\partial_\emptyset F_\sigma^\rho\gamma\beta}{\varepsilon\epsilon\vartheta\pi}}{\frac{\Delta\nabla}{\tau}} \rangle + \prod_b^a \lambda \coprod_a^b \lambda H_{iggs}$$

$$\left. - W^a W_b \widehat{W^b W_a} W_b^a W_a^b {}_b^a\widehat{W_a^b}W - \widehat{\eta^\theta\eta_\beta}\eta_{\phi\nu}^{\sigma\mu}{}_\Omega^\alpha\eta/\mathbb{R}^4 \right| \langle d\tau^2|$$

$$\langle\mathcal{L}_{SM}$$

$$= \frac{1}{2}\partial_\nu g_\mu^a\partial_\mu g_\nu^b - g_s f^{abc}\partial_\mu g_\nu^a \widehat{g_\nu^b g_\nu^c}\partial_\nu g_\mu^a g_\mu^b g_\mu^c - \frac{1}{4}g_s^2 f^{abc}f^{ade}g_\mu^b g_\mu^c g_\mu^d g_\mu^d g_\nu^b g_\nu^c g_\nu^d g_\nu^d - \overline{\partial_\nu W_\mu^+\partial_\nu W_\mu^-\partial_\mu W_\nu^+\partial_\mu W_\nu^-} - M^2 W_\mu^+ \widetilde{W_\mu^-} W_\nu^+ W_\nu^-$$

$$- \frac{1}{2}\partial_\nu Z_\mu^0\partial_\mu Z_\nu^0 - \frac{1}{2}c_\omega^2 M^2 Z_\mu^0 Z_\nu^0 - \frac{1}{2}\partial_\mu\mathcal{A}_\nu\partial_\nu\mathcal{A}_\mu - igc_\omega\left(\partial_\nu Z_\mu^0(W_\mu^+W_\nu^-W_\mu^-W_\nu^+) - Z_\mu^0 Z_\nu^0(\partial_\nu W_\mu^+\partial_\nu W_\mu^-\partial_\mu W_\nu^+\partial_\mu W_\nu^-)\right)$$

$$- igs_\omega\left(\partial_\mu\mathcal{A}_\nu\partial_\nu\mathcal{A}_\mu(W_\mu^+W_\mu^-W_\nu^+W_\nu^-) - \mathcal{A}_\mu(\partial_\nu W_\mu^+\partial_\nu W_\mu^-\partial_\mu W_\nu^+\partial_\mu W_\nu^-) - \mathcal{A}_\nu(\partial_\nu W_\mu^+\partial_\nu W_\mu^-\partial_\mu W_\nu^+\partial_\mu W_\nu^-)\right) - \frac{1}{2g^2}W_\mu^+W_\nu^-W_\mu^-W_\nu^+$$

$$+ g^2c_\omega^2(Z_\mu^0W_\mu^+W_\mu^-Z_\nu^0W_\nu^+W_\nu^-) + g^2s_\omega^2(\mathcal{A}_\mu W_\mu^+W_\mu^-\mathcal{A}_\nu W_\nu^+W_\nu^-) + g^2c_\omega s_\omega(\mathcal{A}_\mu Z_\mu^0(W_\mu^+W_\mu^-)\mathcal{A}_\nu Z_\nu^0(W_\nu^+W_\nu^-) - 2\mathcal{A}_\mu W_\mu^+W_\mu^-Z_\mu^0\mathcal{A}_\nu W_\nu^+W_\nu^-Z_\nu^0)$$

$$- \frac{1}{2}\partial_\mu\mathcal{H}\partial_\nu\mathcal{H} - 2M^2 \propto_h \mathcal{H}^2 - \partial_\mu\phi^+\partial_\nu\phi^-\partial_\nu\phi^+\partial_\nu\phi^- - \frac{1}{2}\partial_\mu\phi^0\partial_\nu\phi^0\partial_\nu\phi^0\partial_\nu\phi^0$$

$$- \beta_h\left(\frac{2M^2}{g^2} + \frac{2M}{g\mathcal{H}} + \frac{1}{2}(\mathcal{H}^2 + \phi^0\phi^+\phi^0\phi^- + 2\phi^0\phi^+\phi^0\phi^-)\right) + \frac{2M^4}{g^2\propto_h} - g\propto_h M(\mathcal{H}^3 + \mathcal{H}\phi^0\phi^0 + 2\mathcal{H}\phi^+\phi^-) - 1/8g^2\propto_h(\mathcal{H}^4 + (\phi^0)^4$$

$$+ 4(\phi^+\phi^-)^2 + 4(\phi^0)^2\phi^+\phi^- + 4\mathcal{H}^2\phi^+\phi^- + 2(\phi^0)^2\mathcal{H}^2) - gMW_\mu^+W_\mu^-W_\nu^+W_\nu^-\mathcal{H} - \frac{1}{2gM}c_\omega^2 Z_\mu^0 Z_\nu^0\mathcal{H}$$

$$- \frac{1}{2ig}\left(W_\mu^+(\phi^0\partial_\mu\phi^- - \phi^-\partial_\mu\phi^0) - W_\mu^-(\phi^0\partial_\mu\phi^+ - \phi^+\partial_\mu\phi^0) - W_\nu^+(\phi^0\partial_\nu\phi^- - \phi^-\partial_\nu\phi^0) - W_\nu^-(\phi^0\partial_\nu\phi^+ - \phi^+\partial_\nu\phi^0)\right)$$

$$- \frac{1}{2g}\left(W_\mu^+(\mathcal{H}\partial_\mu\phi^- - \phi^-\partial_\mu\mathcal{H})W_\mu^-(\mathcal{H}\partial_\mu\phi^+ - \phi^+\partial_\mu\mathcal{H})W_\nu^+(\mathcal{H}\partial_\nu\phi^- - \phi^-\partial_\nu\mathcal{H})W_\nu^-(\mathcal{H}\partial_\nu\phi^+ - \phi^+\partial_\nu\mathcal{H})\right)$$

$$+ \frac{1}{2g}\frac{1}{c_\omega}\left(Z_\mu^0(\mathcal{H}\partial_\mu\phi^0 - \phi^0\partial_\mu\mathcal{H})Z_\nu^0(\mathcal{H}\partial_\nu\phi^0 - \phi^0\partial_\nu\mathcal{H})\right) + M\left(\frac{\partial^{\mu\nu}\phi^\dagger\partial_{\mu\nu}\phi^\star}{c_\omega Z_\mu^0\partial_\mu\phi^0} + W_\mu^+\partial_\mu\phi^- + W_\mu^-\partial_\mu\phi^+\right)$$

$$- \frac{igs_\omega^2}{c_\omega}MZ_\mu^0(W^+\phi^- - W^-\phi^+)igs_\omega M\mathcal{A}_\mu(W_\mu^+\phi^- + W_\mu^-\phi^+) - ig - \frac{d^4c_\omega^2}{dc_\omega}Z_\mu^0(\phi^+\partial_\mu\phi^- - \phi^-\partial_\mu\phi^+) + igs_\omega\mathcal{A}_\mu(\phi^+\partial_\mu\phi^- - \phi^-\partial_\mu\phi^+)$$

$$- 1/4g^2W_\mu^+W_\mu^-(\mathcal{H}^2 + (\phi^0)^2 + 2\phi^+\phi^-)$$

$$- \frac{\frac{1}{8}g^2}{c_\omega^2 Z_\mu^0 Z_\nu^0} - \underset{d_j^\lambda}{\rightarrow}\rangle$$

$$\left|\left\|\left[\!\left[\begin{matrix}(\mathcal{H}^2 + \\ \phi^0)^2 + \\ (2s_\omega^2-1)^2\phi^+\phi^- - \frac{\frac{\partial}{\partial g^2 s_\omega^2}}{c_\omega Z_\mu^0\phi^0(W_\mu^+\phi^- + W_\mu^-\phi^+)} - \frac{\frac{\partial}{\partial ig^2 s_\omega^2}}{c_\omega Z_\mu^0}\mathcal{H}(W_\mu^+\phi^- + W_\mu^-\phi^+) + \\ \frac{1}{2g^2}s_\omega\mathcal{A}_\mu\phi^0(W_\mu^+\phi^- + W_\mu^-\phi^+) + \frac{1}{2ig^2}s_\omega\mathcal{A}_\mu\mathcal{H}(W_\mu^+\phi^- + W_\mu^-\phi^+) - \frac{g^2s_\omega}{c_\omega}(2c_w^2-1)Z_\mu^0\mathcal{A}_\mu\phi^+\phi^- - g^2s_\omega^2\mathcal{A}_\mu\mathcal{A}_\nu\phi^+\phi^- + \\ \frac{1}{2ig_s}\lambda_{ij}^a\left(\underset{q\sigma^i}{\rightarrow}\varphi^\mu\underset{q\sigma^j}{\rightarrow}\right)g_\mu^a \underset{e^\lambda}{\rightarrow}(\partial\varphi + m_e^\lambda)e^\lambda \underset{\nu^\lambda}{\rightarrow}\partial\varphi + m_\nu^\lambda\nu^\lambda \underset{\mu_j^a}{\rightarrow}\underset{\nu^\lambda}{\rightarrow}\partial\varphi\end{matrix}\right]\!\right]\right\|_{m_\mu^\lambda}\right| - \mu_j^\lambda$$

$$(\varphi\partial + m_d^\lambda) d_j^\lambda + i g_{s_\omega \mathcal{A}_\mu} \left( -\left(\underset{e^\lambda}{\rightarrow} \varphi^\mu e^\lambda\right) + \frac{2}{3\left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu \mu_j^\lambda\right)} - \frac{1}{3\left(\underset{d^\lambda}{\rightarrow}\varphi^\mu d^\lambda\right)} + \frac{ig}{4c_\omega Z_\mu^0\left(\underset{\nu^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5)\nu^\lambda\right)} \right.$$

$$+ \left(\underset{e^\lambda}{\rightarrow}\varphi^\mu(4s_\omega^2 - 1 - \varphi^5)e^\lambda\right) + \left(\underset{d_j^\lambda}{\rightarrow}\varphi^\mu\left(\frac{4}{3s_\omega^2} - 1 - \varphi^5\right) d_j^\lambda\right) + \left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu\left(1 - \frac{8}{3s_\omega^2} + \varphi^5\right)\mu_j^\lambda\right)$$

$$\left. + (\frac{ig}{\sqrt[2]{2}W_\mu^+\left(\underset{\nu^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5) U^{lep}{}_\xi^k e^k\right)}\right) + \left(\underset{\mu_j^\lambda}{\rightarrow}\varphi^\mu(1+\varphi^5) C_{k\lambda} d_j^k\right)$$

$$+ \frac{ig}{\sqrt[2]{2}W_\mu^-\left(\underset{e^\kappa}{\rightarrow} U^{lep\dagger} \frac{{}^\nu\psi\lambda}{\kappa\varphi}{}_\xi\rho\varpi - \triangleq \prod_{\odot\oplus\tau}^{\oplus\odot\gamma}\otimes \frac{\coprod_\nu^\mu ijk}{\bigotimes\sigma}\Omega\Psi\Phi\Delta(1+\varphi^5)\nu^\lambda + \underset{d_j^\kappa}{\rightarrow} C_{*\kappa}^{\dagger\lambda}\varphi_{\nu\eta}^{\mu\zeta\eta}(1+\varphi^5)\mu_j^\lambda\right)}$$

$$+ \frac{ig}{2M\sqrt[2]{2}\phi^+\left(-m_c^\kappa\left(\underset{\nu^\lambda}{\rightarrow}U^{lep}{}_\xi^k e^k(1-\varphi^5)\epsilon^\kappa\right) + m_\mu^\lambda \underset{\mu_j^\lambda}{\rightarrow} U^{lep\dagger}(1+\varphi^5)\varepsilon^\kappa\right)}$$

$$+ \frac{ig}{2M\sqrt[2]{2}\phi^-\left(m_c^\kappa\left(\underset{\nu^\lambda}{\rightarrow}U^{lep}{}_\xi^k e^k(1-\varphi^5)\epsilon^\kappa\right) \pm m_\mu^\lambda\underset{\mu_j^\lambda}{\rightarrow}U^{lep\dagger}(1+\varphi^5)\varepsilon^\kappa\right)} - \frac{g}{2m_\nu^\lambda}\frac{\mathcal{H}}{M}\left(\underset{\nu^\lambda}{\rightarrow}\nu^\lambda\right)$$

$$-\frac{\frac{\frac{\frac{g}{2m_c^\lambda}}{M\mathcal{H}\left(\underset{e^\lambda}{\rightarrow}e^\lambda\right)}}{1}}{4\underset{\nu^\lambda}{\rightarrow}M_{\lambda\kappa}^R(1-\gamma_5)\nu^\kappa} + \frac{\frac{ig}{2m_\nu^\lambda}}{M\phi^0\left(\underset{\nu^\lambda}{\rightarrow}\gamma^5\nu^\lambda\right)} - \frac{\frac{ig}{2m_c^\lambda}}{M\phi^0\left(\underset{e^\lambda}{\rightarrow}\gamma^5 e^\lambda\right)} - \frac{1}{4\underset{\nu^\kappa}{\rightarrow}M_{\lambda\kappa}^R(1-\gamma_5)\underset{\nu^\kappa}{\rightarrow}}$$

$$+ \frac{ig}{2M\sqrt[2]{2}\phi^+\left(-m_d^\kappa\left(\underset{\mu_j^\lambda}{\rightarrow}C_{\lambda\kappa}(1-\varphi^5)d_j^\kappa\right) + m_d^\kappa\left(\underset{\mu_j^\lambda}{\rightarrow}C_{\lambda\kappa}(1-\varphi^5)d_j^\kappa\right)\right)}$$

$$+ \frac{ig}{2M\sqrt[2]{2}\phi^-\left(m_d^\lambda\left(\underset{d_j^\lambda}{\rightarrow}C_{\lambda\kappa\wedge\theta*}^\dagger(1+\varphi^5)\mu_j^\kappa\right) \pm m_d^\lambda\left(\underset{d_j^\lambda}{\rightarrow}C_{\lambda\kappa\wedge\nabla*}^\dagger(1+\varphi^5)\mu_j^\kappa\right)\right)} - \frac{g}{2m_\mu^\lambda}M\mathcal{H}\left(\underset{\mu_j^\lambda}{\rightarrow}\mu_j^\lambda\right)$$

$$- \frac{g}{2m_d^\lambda}\frac{\mathcal{H}}{M}\left(\underset{d_j^\lambda}{\rightarrow}d_j^\lambda\right) + \frac{\frac{ig}{2m_\mu^\lambda}}{M}\phi^0\left(\underset{\mu_j^\lambda}{\rightarrow}\gamma^5\mu_j^\lambda\right) - \frac{\frac{ig}{2m_d^\lambda}}{M}\phi^0\left(\underset{d_j^\lambda}{\rightarrow}\gamma^5 d_j^\lambda\right) + \underset{G^a}{\rightarrow}\partial^2 G^a + g_s f^{abc}\partial_\mu \underset{G^a}{\rightarrow} G^b g_\mu^c$$

$$+ \underset{\alpha^+}{\rightarrow}(\partial^2 - M^2)\alpha^+ + \underset{\alpha^-}{\rightarrow}(\partial^2-M^2)\alpha^- + \underset{\alpha^0}{\rightarrow}\left(\partial^2 - \frac{M^2}{c_\omega^2}\right)\alpha^0 + \underset{b}{\rightarrow}\partial^2 b + igc_\omega W_\mu^+\left(\partial_\mu \underset{\alpha^0}{\rightarrow}\underset{\alpha^-}{\rightarrow} - \partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^0}{\rightarrow}\right)$$

$$+ igs_w W_\mu^+\left(\partial_\mu \underset{b}{\rightarrow}\alpha^- - \partial_\mu\underset{a}{\rightarrow}b^-\right) + igc_\omega W_\mu^-\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^0}{\rightarrow} - \partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right) + igs_\omega W_\mu^-\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^0}{\rightarrow} - \partial_\mu\underset{\alpha^0}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)$$

$$+ igc_\omega Z_\mu^0\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^-}{\rightarrow} - \partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right) + igs_\omega\mathcal{A}_\mu\left(\partial_\mu\underset{\alpha^+}{\rightarrow}\underset{\alpha^-}{\rightarrow} - \partial_\mu\underset{\alpha^-}{\rightarrow}\underset{\alpha^+}{\rightarrow}\right)$$

$$- 1$$

$$/2gM \left\langle \frac{\underset{\alpha^+}{\rightarrow}\alpha^+\mathcal{H}\hbar\mathbb{R}^4}{h} + \underset{\alpha^-}{\rightarrow}\alpha^-\mathcal{H} + 1 - \frac{2c_\Im^2}{2c_\omega igM\left(\underset{\alpha^+}{\rightarrow}a^0\phi^+ - \underset{\alpha^-}{\rightarrow}a^0\phi^-\right)} + \frac{1}{2c_\omega igM\left(\underset{\alpha^0}{\rightarrow}a^-\phi^+ - \underset{\alpha^0}{\rightarrow}a^+\phi^-\right)}\right.$$

$$\left. + igMs_\omega\left(\underset{\alpha^0}{\rightarrow}a^-\phi^+ - \underset{\alpha^0}{\rightarrow}a^+\phi^-\right) + 1/2igM\left(\underset{\alpha^+}{\rightarrow}a^+\phi^0 - \underset{\alpha^-}{\rightarrow}a^-\phi^0\right)\right\rangle$$

$$\Phi(x) = \begin{pmatrix} \phi^+ \\ \phi^0 \end{pmatrix} = \frac{1}{\sqrt{2}} \begin{pmatrix} \phi_1 + i\phi_2 \\ \phi_3 + i\phi_4 \end{pmatrix} \qquad \mathcal{L}_{SBS} = (\mathcal{D}_\mu \Phi)^\dagger (\mathcal{D}^\mu \Phi) - V(\Phi)$$

$$V(\Phi) = \mu^2 \Phi^\dagger \Phi + \lambda (\Phi^\dagger \Phi)^2 \quad |\Phi|^2 = \Phi^\dagger \Phi = -\frac{\mu^2}{2\lambda} = \frac{v^2}{2}$$

$$\Phi(x) = \begin{pmatrix} \phi^+ \\ \phi^0 \end{pmatrix} \longrightarrow \frac{1}{\sqrt{2}} \begin{pmatrix} 0 \\ v \end{pmatrix}$$

$$\Phi(x) = \frac{1}{\sqrt{2}} e^{i \frac{\vec{\xi}(x) \cdot \vec{\tau}}{v}} \begin{pmatrix} 0 \\ v + \mathrm{h}(x) \end{pmatrix}$$

$$U(\xi) = e^{-i \frac{\vec{\xi}(x) \cdot \vec{\tau}}{v}}$$

$$\begin{aligned} \Phi' &= U(\xi)\Phi = \tfrac{1}{\sqrt{2}} \begin{pmatrix} 0 \\ v + \mathrm{h}(x) \end{pmatrix} \\ \left( \frac{\vec{\tau}\, \vec{\mathrm{W}}'_\mu}{2} \right) &= U(\xi) \left( \frac{\vec{\tau}\, \vec{\mathrm{W}}_\mu}{2} \right) U^{-1}(\xi) - \tfrac{i}{g} (\partial_\mu U(\xi)) U^{-1}(\xi) \\ \mathrm{B}'_\mu &= \mathrm{B}_\mu \end{aligned}$$

$$\mathcal{L} = \mathcal{L}_{bos.} + \mathcal{L}_{ferm.} + \mathcal{L}_{SBS}$$

$$(\mathcal{D}_\mu \Phi)^\dagger (\mathcal{D}^\mu \Phi) = \frac{v^2}{8} [\mathrm{g}^2 (W_{1\mu}^2 + W_{2\mu}^2) + (\mathrm{g} W_{3\mu} - \mathrm{g}' B_\mu)^2]$$

$$\begin{aligned} W^{\pm}_{\mu} &= \frac{1}{\sqrt{2}}(W^1_{\mu} \mp W^2_{\mu}) \\ Z_{\mu} &= \cos\theta_W W^3_{\mu} - \sin\theta_W B_{\mu} \\ A_{\mu} &= \sin\theta_W W^3_{\mu} + \cos\theta_W B_{\mu} \end{aligned} \qquad \tan\theta_W \equiv \frac{g'}{g}$$

$$M_W = \frac{1}{2} g v$$

$$M_Z = \frac{1}{2} v\sqrt{g^2 + g'^2}$$

$$\begin{aligned} g &= \frac{e}{\sin\theta_W} \\ g' &= \frac{e}{\cos\theta_W} \end{aligned} \qquad m_H^2 = 2\lambda v^2 \qquad \mu \to \nu_{\mu}\bar{\nu}_e e$$

$$v = (\sqrt{2}G_F)^{-\frac{1}{2}}$$

$$\mathcal{L}_{YW} = \lambda_e \bar{\ell}_L \Phi e_R + \lambda_u \bar{q}_L \tilde{\Phi} u_R + \lambda_d \bar{q}_L \Phi d_R + h.c.$$

$$\ell_L = \begin{pmatrix} e \\ \nu_e \end{pmatrix}_L, \begin{pmatrix} \mu \\ \nu_{\mu} \end{pmatrix}_L, \begin{pmatrix} \tau \\ \nu_{\tau} \end{pmatrix}_L$$

$$q_L = \begin{pmatrix} u \\ d \end{pmatrix}_L, \begin{pmatrix} c \\ s \end{pmatrix}_L, \begin{pmatrix} t \\ b \end{pmatrix}_L$$

$$\begin{aligned} \ell'_L &= U(\xi)\ell_L; \qquad e'_R = e_R \\ q'_L &= U(\xi)q_L; \qquad u'_R = u_R;\ d'_R = d \end{aligned}$$

$$\begin{aligned} m_e &= \lambda_e \frac{v}{\sqrt{2}} \\ m_u &= \lambda_u \frac{v}{\sqrt{2}} \\ m_d &= \lambda_d \frac{v}{\sqrt{2}} \end{aligned}$$

$$\mathcal{H}_c \equiv \frac{1}{2\pi}\prod_i^k(x) + \prod_k^i(x)\partial^i\partial_k A^k A_i(x) + \frac{1}{4\pi}F^{ki}(x)F_{ik}(x)$$

$$= H_c \oiiint_i^k d^3\chi[\frac{1}{2\pi}\prod_i^k(x) + \prod_k^i(x)\partial^i\partial_k A^k A_i(x) + \frac{1}{4\pi}F^{ki}(x)F_{ik}(x)]$$

$$= \overrightarrow{H^\rho H_c H^c H_\rho H_c^\rho H_\rho^c \varrho} \equiv \oiiint_i^k \frac{d^3\chi^\lambda}{\partial\hbar}\partial\mho\partial\Omega\partial^2\mathbb{R}^4/\partial G_\varepsilon\partial R_e\|\widehat{d\lambda \triangleq d\phi}\|$$

$$\mathcal{H}_{ab} \equiv \frac{1}{2\pi}\prod_i^k(x) + \prod_k^i(x)\partial^i\partial_k A^k A_i(x) + \frac{1}{4\pi}F^{ki}(x)F_{ik}(x)$$

$$= H_c \oiiint_i^k d^3\chi[\frac{1}{2\pi}\prod_i^k(x) + \prod_k^i(x)\partial^i\partial_k A^k A_i(x) + \frac{1}{4\pi}F^{ki}(x)F_{ik}(x)]$$

$$= \overrightarrow{H^\rho H_c H^c H_\rho H_c^\rho H_\rho^c \varrho} \equiv \oiiint_i^k \frac{d^3\chi^\lambda}{\partial\hbar}\partial\mho\partial\Omega\partial^2\mathbb{R}^4/\partial G_\varepsilon\partial R_e\|\widehat{d\lambda \triangleq d\phi}\|$$

$$\mathcal{H}_{bc} \equiv \frac{1}{2\pi}\prod_i^k(x) + \prod_k^i(x)\partial^i\partial_k A^k A_i(x) + \frac{1}{4\pi}F^{ki}(x)F_{ik}(x)$$

$$= H_c \oiiint_i^k d^3\chi[\frac{1}{2\pi}\prod_i^k(x) + \prod_k^i(x)\partial^i\partial_k A^k A_i(x) + \frac{1}{4\pi}F^{ki}(x)F_{ik}(x)]$$

$$= \overrightarrow{H^\rho H_c H^c H_\rho H_c^\rho H_\rho^c \varrho} \equiv \oiiint_i^k \frac{d^3\chi^\lambda}{\partial\hbar}\partial\mho\partial\Omega\partial^2\mathbb{R}^4/\partial G_\varepsilon\partial R_e\|\widehat{d\lambda \triangleq d\phi}\|$$

$$\mathcal{H}_c \equiv \frac{1}{2\pi}\prod_i^k(y) + \prod_k^i(y)\partial^i\partial_k A^k A_i(y) + \frac{1}{4\pi}F^{ki}(x)F_{ik}(y)$$

$$= H_c \oiiint_i^k d^3\gamma[\frac{1}{2\pi}\prod_i^k(y) + \prod_k^i(y)\partial^i\partial_k A^k A_i(y) + \frac{1}{4\pi}F^{ki}(y)F_{ik}(y)]$$

$$= \overrightarrow{H^\rho H_c H^c H_\rho H_c^\rho H_\rho^c \varrho} \equiv \oiiint_i^k \frac{d^3\gamma^\lambda}{\partial\hbar}\partial\mho\partial\Omega\partial^2\mathbb{R}^4/\partial G_\varepsilon\partial R_e\|\widehat{d\lambda \triangleq d\phi}\|$$

$$\mathcal{H}_{ab} \equiv \frac{1}{2\pi}\prod_{i}^{k}(y) + \prod_{k}^{i}(y)\partial^i\partial_k A^k A_i(y) + \frac{1}{4\pi}F^{ki}(y)F_{ik}(y)$$

$$= H_c \oiiint_{i}^{k} d^3\gamma[\frac{1}{2\pi}\prod_{i}^{k}(y) + \prod_{k}^{i}(y)\partial^i\partial_k A^k A_i(y) + \frac{1}{4\pi}F^{ki}(y)F_{ik}(y)]$$

$$= \overrightarrow{H^\rho H_c H^c H_\rho H_c^\rho H_\rho^c \varrho} \equiv \oiiint_{i}^{k} \frac{d^3\gamma^\lambda}{\partial\hbar}\partial\mho\partial\Omega\partial^2\mathbb{R}^4/\partial G_\varepsilon\partial R_e\|d\widehat{\lambda \triangleq \mathrm{d}\phi}\|$$

$$\mathcal{H}_{bc} \equiv \frac{1}{2\pi}\prod_{i}^{k}(y) + \prod_{k}^{i}(y)\partial^i\partial_k A^k A_i(y) + \frac{1}{4\pi}F^{ki}(y)F_{ik}(y)$$

$$= H_c \oiiint_{i}^{k} d^3\gamma[\frac{1}{2\pi}\prod_{i}^{k}(y) + \prod_{k}^{i}(y)\partial^i\partial_k A^k A_i(y) + \frac{1}{4\pi}F^{ki}(y)F_{ik}(y)]$$

$$= \overrightarrow{H^\rho H_c H^c H_\rho H_c^\rho H_\rho^c \varrho} \equiv \oiiint_{i}^{k} \frac{d^3\gamma^\lambda}{\partial\hbar}\partial\mho\partial\Omega\partial^2\mathbb{R}^4/\partial G_\varepsilon\partial R_e\|d\widehat{\lambda \triangleq \mathrm{d}\phi}\|$$

$$\mathcal{H}_{c} \equiv \frac{1}{2\pi}\prod_{i}^{k}(z) + \prod_{k}^{i}(z)\partial^i\partial_k A^k A_i(z) + \frac{1}{4\pi}F^{ki}(x)F_{ik}(z)$$

$$= H_c \oiiint_{i}^{k} d^3z[\frac{1}{2\pi}\prod_{i}^{k}(z) + \prod_{k}^{i}(z)\partial^i\partial_k A^k A_i(z) + \frac{1}{4\pi}F^{ki}(z)F_{ik}(z)]$$

$$= \overrightarrow{H^\rho H_c H^c H_\rho H_c^\rho H_\rho^c \varrho} \equiv \oiiint_{i}^{k} \frac{d^3z^\lambda}{\partial\hbar}\partial\mho\partial\Omega\partial^2\mathbb{R}^4/\partial G_\varepsilon\partial R_e\|d\widehat{\lambda \triangleq \mathrm{d}\phi}\|$$

$$\mathcal{H}_{ab} \equiv \frac{1}{2\pi}\prod_{i}^{k}(z) + \prod_{k}^{i}(z)\partial^i\partial_k A^k A_i(z) + \frac{1}{4\pi}F^{ki}(z)F_{ik}(z)$$

$$= H_c \oiiint_{i}^{k} d^3z[\frac{1}{2\pi}\prod_{i}^{k}(z) + \prod_{k}^{i}(z)\partial^i\partial_k A^k A_i(z) + \frac{1}{4\pi}F^{ki}(z)F_{ik}(z)]$$

$$= \overrightarrow{H^\rho H_c H^c H_\rho H_c^\rho H_\rho^c \varrho} \equiv \oiiint_{i}^{k} \frac{d^3z^\lambda}{\partial\hbar}\partial\mho\partial\Omega\partial^2\mathbb{R}^4/\partial G_\varepsilon\partial R_e\|d\widehat{\lambda \triangleq \mathrm{d}\phi}\|$$

$$\mathcal{H}_{bc} \equiv \frac{1}{2\pi}\prod_i^k(z) + \prod_k^i(z)\partial^i\partial_k A^k A_i(z) + \frac{1}{4\pi}F^{ki}(z)F_{ik}(z)$$

$$= H_c \oiiint_i^k d^3z[\frac{1}{2\pi}\prod_i^k(z) + \prod_k^i(z)\partial^i\partial_k A^k A_i(z) + \frac{1}{4\pi}F^{ki}(z)F_{ik}(z)]$$

$$= \overrightarrow{H^\rho H_c H^c H_\rho H_c^\rho H_\rho^c \varrho} \equiv \oiiint_i^k \frac{d^3z^\lambda}{\partial\hbar}\partial\mho\partial\Omega\partial^2\mathbb{R}^4/\partial G_\mathcal{E}\partial R_e\|d\widehat{\lambda \triangleq \mathrm{d}}\phi\|$$

$$\{F(x),G(x)\}_{D\bowtie} =\circledast \{F(x),G(x)\}\oplus$$

$$-\coprod_\varphi^\gamma \psi \prod_\gamma^\varphi \lambda$$

$$\approxeq \int_\partial \oiiint_\upsilon^\mu \frac{\zeta}{\beta} d^3\mu v^3 \frac{\mu v_3 \mu v^d \mu v_d v\mu^3 v\mu_3 v\mu^d v\mu_d \phi^\mu \phi_v \phi^v \phi_\mu \varphi^v \varphi_\mu \varphi^\mu \varphi_v \phi^{\mu v}\phi_{v\mu}\phi^{v\mu}\phi_{\mu v}\varphi^{\mu v}\varphi_{v\mu}\varphi^{v\mu}\varphi_{\mu v} C^{-1\pi}_{\mu v v c^{-i\omega t} m c_\hbar^4}}{\frac{\partial\alpha\beta}{\partial h}\mho\frac{\Omega\oint\frac{\partial\dagger}{\partial\pi}}{\partial\Delta} - d^4\nabla\otimes\langle d \ltimes \frac{dr}{dt} d \rtimes dr^2 \leftthreetimes d\theta sin^2 d\varphi \rightthreetimes d\tau\rangle^{e^{-i\omega t}}\square}$$

$$\{F(y),G(y)\}_{D\bowtie} =\circledast \{F(y),G(y)\}\oplus$$

$$-\coprod_\varphi^\gamma \psi \prod_\gamma^\varphi \lambda$$

$$\approxeq \int_\partial \oiiint_\upsilon^\mu \frac{\zeta}{\beta} d^3\mu v^3 \frac{\mu v_3 \mu v^d \mu v_d v\mu^3 v\mu_3 v\mu^d v\mu_d \phi^\mu \phi_v \phi^v \phi_\mu \varphi^v \varphi_\mu \varphi^\mu \varphi_v \phi^{\mu v}\phi_{v\mu}\phi^{v\mu}\phi_{\mu v}\varphi^{\mu v}\varphi_{v\mu}\varphi^{v\mu}\varphi_{\mu v} C^{-1\pi}_{\mu v v c^{-i\omega t} m c_\hbar^4}}{\frac{\partial\alpha\beta}{\partial h}\mho\frac{\Omega\oint\frac{\partial\dagger}{\partial\pi}}{\partial\Delta} - d^4\nabla\otimes\langle d \ltimes \frac{dr}{dt} d \rtimes dr^2 \leftthreetimes d\theta sin^2 d\varphi \rightthreetimes d\tau\rangle^{e^{-i\omega t}}\square}$$

$$\{F(z),G(z)\}_{D\bowtie} =\circledast \{F(z),G(z)\}\oplus$$

$$-\coprod_\varphi^\gamma \psi \prod_\gamma^\varphi \lambda$$

$$\approxeq \int_\partial \oiiint_\upsilon^\mu \frac{\zeta}{\beta} d^3\mu v^3 \frac{\mu v_3 \mu v^d \mu v_d v\mu^3 v\mu_3 v\mu^d v\mu_d \phi^\mu \phi_v \phi^v \phi_\mu \varphi^v \varphi_\mu \varphi^\mu \varphi_v \phi^{\mu v}\phi_{v\mu}\phi^{v\mu}\phi_{\mu v}\varphi^{\mu v}\varphi_{v\mu}\varphi^{v\mu}\varphi_{\mu v} C^{-1\pi}_{\mu v v c^{-i\omega t} m c_\hbar^4}}{\frac{\partial\alpha\beta}{\partial h}\mho\frac{\Omega\oint\frac{\partial\dagger}{\partial\pi}}{\partial\Delta} - d^4\nabla\otimes\langle d \ltimes \frac{dr}{dt} d \rtimes dr^2 \leftthreetimes d\theta sin^2 d\varphi \rightthreetimes d\tau\rangle^{e^{-i\omega t}}\square}$$

$$\mathcal{L} = -\frac{1}{4\pi}f^{ab}(x)t_{ab}(x)f_{ab}t^{ab}f_{ba}^{ab}(x)t_{ba}^{ab}(x)f_{ab}^{ba}(x)t_{ab}^{ba}(x) \neq \mathcal{L}$$

$$= -\frac{1}{4\pi}f^{ba}(x)t_{ba}(x)f_{ba}t^{ba}f_{ab}^{ba}(x)t_{ab}^{ba}(x)f_{ba}^{ab}(x)t_{ba}^{ab}(x)$$

$$\mathcal{L} = -\frac{1}{4\pi}f^{ab}(y)t_{ab}(y)f_{ab}t^{ab}f_{ba}^{ab}(y)t_{ba}^{ab}(y)f_{ab}^{ba}(y)t_{ab}^{ba}(x) \neq \mathcal{L}$$

$$= -\frac{1}{4\pi}f^{ba}(y)t_{ba}(y)f_{ba}t^{ba}f_{ab}^{ba}(y)t_{ab}^{ba}(y)f_{ba}^{ab}(y)t_{ba}^{ab}(y)$$

$$\mathcal{L} = -\frac{1}{4\pi}f^{ab}(z)t_{ab}(z)f_{ab}t^{ab}f_{ba}^{ab}(z)t_{ba}^{ab}(z)f_{ab}^{ba}(z)t_{ab}^{ba}(z) \neq \mathcal{L}$$

$$= -\frac{1}{4\pi}f^{ba}(z)t_{ba}(z)f_{ba}t^{ba}f_{ab}^{ba}(z)t_{ab}^{ba}(z)f_{ba}^{ab}(z)t_{ba}^{ab}(z)$$

$$\left\| \{B(x,k), C(x,k)/\Phi\Psi\kappa\varphi\theta \right.$$

$$= \delta \prod_{b}^{a}(x,k)\lambda\phi \oint_{\sigma}^{\varphi} d^3 z[\delta_b^a B(x,k)\lambda\phi/\delta_b^a A_{ab}(x,k)\lambda\phi$$

$$/\delta_b^a C(x,k)\lambda\phi \prod_{a}^{b}(x,k)\lambda\phi \oint_{\sigma}^{\varphi} d^3 z[\delta_a^b B(x,k)\lambda\phi/\delta_a^b C(x,k)\lambda\phi$$

$$\left. /\delta\delta_a^b A_{ba}(x,k)\lambda\phi \prod_{ba}^{ab}(x,k)\,\lambda\phi \right\|^{-1/2}$$

$$\left\| \{B(y,k), C(y,k)/\Phi\Psi\kappa\varphi\theta \right.$$

$$= \delta \prod_{b}^{a}(y,k)\lambda\phi \oint_{\sigma}^{\varphi} d^3 z[\delta_b^a B(y,k)\lambda\phi/\delta_b^a A_{ab}(y,k)\lambda\phi$$

$$/\delta_b^a C(y,k)\lambda\phi \prod_{a}^{b}(y,k)\lambda\phi \oint_{\sigma}^{\varphi} d^3 z[\delta_a^b B(y,k)\lambda\phi/\delta_a^b C(y,k)\lambda\phi$$

$$\left. /\delta\delta_a^b A_{ba}(y,k)\lambda\phi \prod_{ba}^{ab}(y,k)\,\lambda\phi \right\|^{-1/2}$$

$$\left\| \{B(z,k), C(z,k)/\Phi\Psi\kappa\varphi\theta \right.$$

$$= \delta \prod_{b}^{a}(z,k)\lambda\phi \oint_{\sigma}^{\varphi} d^3 z[\delta_b^a B(z,k)\lambda\phi/\delta_b^a A_{ab}(z,k)\lambda\phi$$

$$/\delta_b^a C(z,k)\lambda\phi \prod_{a}^{b}(z,k)\lambda\phi \oint_{\sigma}^{\varphi} d^3 z[\delta_a^b B(z,k)\lambda\phi/\delta_a^b C(z,k)\lambda\phi$$

$$\left. /\delta\delta_a^b A_{ba}(z,k)\lambda\phi \prod_{ba}^{ab}(z,k)\,\lambda\phi \right\|^{-1/2}$$

$$\left\| \frac{\frac{u\sqrt{2}}{d\sqrt{2}}}{u,d,u',d'} = \left[\phi' M'^{d} d'_{R} + \phi M^{u} u_{L} + \phi' \widehat{\widehat{M'^{u}}} u'_{L} + \phi M^{d} d_{L} + \phi' M'^{d} d'_{L} \overline{\left(\frac{u'_{L}}{d'_{L}}\right)\left(\frac{u_{L}}{d_{L}}\right)\left(\frac{u'_{R}}{d'_{R}}\right)\left(\frac{u_{R}}{d_{R}}\right)}\right] \right.$$

$$/\tau^2 = \xi_{\lambda\Omega\psi}^{\sigma\varsigma\zeta} \Sigma\iiiint \text{ħ}\text{ф}\widetilde{\text{ҌӁӞ}}\text{ҖДҜҹӜӼ}\varsigma\pi mc^{\mathbb{R}^4} \left\| (u'_{L} d'_{L} u'_{R} d'_{R})\phi M^{u} u_{R} + \phi' M'^{u} u'_{R} + \phi M^{d} d_{R} \right.$$