

Incompleted Field Strength Calculation of the Potential Term Adopted from Landau-Ginzberg Theory Applied in Particle Physics

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Abstract

Completion of field strength calculation of the potential term originated in theories of condensed matter applied in particle physics is discussed.

Keywords

Field Strength Calculation, Potential Term, Landau-Ginzberg Theory, Application in Particle Physics

1. Introduction

There is a widely used potential term in superconductivity, mean field theory, Landau-Ginzberg theory applied in spontaneous symmetry breaking of particle physics [instead of spontaneous the term instantaneous can also be used but symmetry breaking takes time from fractions of a second to hours in condensed matter physics]. Here calculation of the field strength coupling is completed of the potential term for the theory of particle physics. Similar steps are applicable in the theory of condensed matter physics as well. What is missing in Landau-Ginzberg theory is also getting corrected.

Maxwell formulated the theory of electromagnetism unifying electricity and magnetism and predicted the value of light speed. But photon was a massless particle. Klien, Gorden and Proca [1] advanced the theory for massive quantas. Landau and Ginzberg formulated the theory of phase transition in condensed matter physics. J. Goldstone [2] discussed field theories with superconductor solutions. With Weinberg and Salam, Goldstone [3] discussed broken symmetries. P. W. Higgs [4] adopted form of the potential from Landau and Ginzberg & field

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theory from Goldstone applied in symmetry breaking of particle physics and discussed how quantas can acquire mass in the broken symmetry which became popular as Higgs mechanism. Weinberg and Salam formulated the electro-weak theory unifying weak and electromagnetic interactions. They predicted values of W and Z bosons theoretically which are massive quantas and Higgs played a valuable role in the mass generation. It was said that W and Z bosons became massive by eating Higgs. Itself is sufficient to say Higgs mass is less than W and Z boson masses, not higher average values of CERN experiments of year 2012 which are logically ruled out. But neither P. W. Higgs nor S. Weinberg and A. Salam could provide a theoretical value for Higgs quanta in both of their versions of the theory. This is where the present author has played a key role. The most important breakthrough is the completion of field strength calculation of the potential term, the missing part of Higgs, Weinberg and Salam theories and prediction of Higgs quanta mass by the present new author. In electrostatics field strength is square of the charge of the electron in Coulomb Potential; if Higgs had studied this field strength coming from inverse square law of Coulomb he would not have missed the evaluation of the coupling in his noted theory on massive quantas. Higgs and Weinberg's formulation of the theory is elegant but both could not come to the logical conclusion with Salam; their undetermined parameter λ (in Weinberg's version it is h) is simply of the order of e^2 , the square of the charge of the electron except a simple numerical factor.

2. Starting with Lagrangian Density of the Form

$$L = -\frac{1}{2}\nabla\phi_1^2 - \frac{1}{2}\nabla\phi_2^2 - V(\phi_1^2 + \phi_2^2) - \frac{1}{4}\mathbb{F}_{\mu\nu}\mathbb{F}^{\mu\nu}$$

where

$$\nabla_\mu\phi_1 = \partial_\mu\phi_1 - eA_\mu\phi_2$$

$$\nabla_\mu\phi_2 = \partial_\mu\phi_2 + eA_\mu\phi_1$$

$$\mathbb{F}_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$$

In which two real scalar fields ϕ_1 and ϕ_2 & real vector field A_μ are interacting and it is a model used by Goldstone. Metric is taken as $-+++$ Simultaneous gauge transformations are to be applied on $\phi_1 \pm i\phi_2$ and on A_μ , $\phi^+ = \phi_1 + i\phi_2$, complex conjugate of it $\phi^- = \phi_1 - i\phi_2$, $\phi^+\phi^- = |\phi|^2 = \phi_1^2 + \phi_2^2$, $|\phi| = \pm\sqrt{\phi_1^2 + \phi_2^2}$ By Taylor-

Maclaurin expansion $V(|\phi|^2) = V(0) + \frac{1}{1!}V'(|\phi|^2)|\phi|^2 + \frac{1}{2!}V''(|\phi|^2)(|\phi|^2)^2$. Suppose that $V(0) = 0$, $\frac{\partial V(|\phi|^2)}{\partial|\phi|^2} = 0$,

$\frac{\partial^2 V(|\phi|^2)}{\partial(|\phi|^2)^2} > 0$ the condition for minima. Take $V''(|\phi|^2) = \lambda > 0$ to be evaluated by calculation the field

strength of interacting potential. Then $V(|\phi|^2) = \frac{\lambda(|\phi|^2)^2}{2}$ at the minima. Now at minima let the potential be

slightly perturbed by it's continuous rotational symmetry with the selection $\phi_1 = 0$, $\phi_2 = \phi_0$ at $|\phi|^2 = \phi_0^2$. Then

$$V(\phi_0^2) = \frac{\lambda(\phi_0^2)^2}{2}, \quad \phi^\pm = \phi_1 \pm i\phi_2 = \sqrt{\phi_1^2 + \phi_2^2} \left\{ \frac{\phi_1}{\sqrt{\phi_1^2 + \phi_2^2}} \pm \frac{i\phi_2}{\sqrt{\phi_1^2 + \phi_2^2}} \right\} = |\phi| \{ \cos\theta \pm i\sin\theta \} = |\phi| e^{\pm i\theta}, \quad \theta = \tan^{-1} \left\{ \frac{\phi_2}{\phi_1} \right\}$$

what is said be $U(1)$ symmetry. $|\phi^\pm| = |\phi|$, $|e^{\pm i\theta}| = \sqrt{\cos^2\theta + \sin^2\theta} = 1$. Now $U(1)$ symmetry is subjected to be broken at the selected values in the way $\phi_1 + \Delta\phi_1 \rightarrow 0 + \Delta\phi_1$, $\phi_2 + \Delta\phi_2 \rightarrow \phi_0 + \Delta\phi_2$, & simultaneous gauge transformations are subjected to be perturbed as follows,

$$\nabla_\mu(0 + \Delta\phi_1) = \nabla_\mu(\Delta\phi_1) = \partial_\mu(0 + \Delta\phi_1) - eA_\mu(\phi_0 + \Delta\phi_2) = \partial_\mu(\Delta\phi_1) - eA_\mu(\phi_0 + \Delta\phi_2)$$

$$\nabla_\mu(\phi_0 + \Delta\phi_2) = \partial_\mu(\phi_0 + \Delta\phi_2) + eA_\mu(0 + \Delta\phi_1) = \partial_\mu(\phi_0 + \Delta\phi_2) + eA_\mu(\Delta\phi_1)$$

$$L = -\frac{1}{2} \left\{ \left[\partial_\mu (\Delta\phi_1) \right]^2 + \left[\partial_\mu (\Delta\phi_2) \right]^2 + e^2 \left(\phi_0^2 + 2\phi_0 (\Delta\phi_2) + (\Delta\phi_2)^2 + (\Delta\phi_1)^2 \right) A_\mu^2 \right\} \\ + e \left[(\phi_0 + \Delta\phi_2) \partial_\mu (\Delta\phi_1) - (\Delta\phi_1) \partial_\mu (\Delta\phi_2) \right] A_\mu - \frac{\lambda}{2} (\phi_0 + \Delta\phi_2)^4 - \frac{1}{4} \mathbb{F}_{\mu\nu} \mathbb{F}^{\mu\nu}$$

Euler-Lagrange's equations of motion

$$\partial^\mu \left(\frac{\partial L}{\partial \left[\partial_\mu (\Delta\phi_1) \right]} \right) - \frac{\partial L}{\partial (\Delta\phi_1)} = 0 \\ \partial^\mu \left\{ -\partial_\mu (\Delta\phi_1) + e (\phi_0 + \Delta\phi_2) A_\mu \right\} - \left\{ -e^2 (\Delta\phi_1) A_\mu^2 - e \partial_\mu (\Delta\phi_2) A_\mu \right\} = 0$$

In the limit when $\Delta\phi_1 \rightarrow 0, \Delta\phi_2 \rightarrow 0$ the vacuum solution $\partial^\mu \left\{ \partial_\mu (\Delta\phi_1) - e\phi_0 A_\mu \right\} = 0$ considering (1) only oscillations around 0.

$$\partial^\mu \left(\frac{\partial L}{\partial \left[\partial_\mu (\Delta\phi_2) \right]} \right) - \frac{\partial L}{\partial (\Delta\phi_2)} = 0 \\ \partial^\mu \left\{ -\partial_\mu (\Delta\phi_2) - e (\Delta\phi_1) A_\mu \right\} - \left\{ -e^2 \phi_0 A_\mu^2 - e^2 (\Delta\phi_2) A_\mu^2 + e \partial_\mu (\Delta\phi_1) A_\mu - 2\lambda (\phi_0 + \Delta\phi_2)^2 (\phi_0 + \Delta\phi_2) \right\} = 0$$

In the limit when $\Delta\phi_1 \rightarrow 0, \Delta\phi_2 \rightarrow 0$ the vacuum solution $\left\{ \partial^\mu \partial_\mu - 2\lambda\phi_0^2 \right\} \Delta\phi_2 = 0$ considering only oscillations around ϕ_0 the equation $\left\{ -\frac{1}{c^{*2}} \frac{\partial^2}{\partial t^2} + \nabla^2 - 2\lambda\phi_0^2 \right\} \Delta\phi_2 = 0$ describes waves whose quanta (2) has bare mass $m^2 = 2\lambda\phi_0^2$, $m = \sqrt{2\lambda}\phi_0 = \phi_0 (2\lambda)^{1/2}$ and the speed of light propagation $c^* < c$ the speed of light for massless quanta which has zero bare mass that Goldstone was discussing. The important point is massive quanta travel with a lesser light speed than massless quanta. Gravitons and Neutrinos are examples for massive quanta having lesser light speed than for massless photons. $(0, |\phi|) = (0, \pm\phi_0)$ are the coordinates of the minima on complex mathematical plane. There are two such points.

$$\partial_\nu \left\{ \frac{\partial L}{\partial (\partial_\nu A_\mu)} \right\} - \frac{\partial L}{\partial A_\mu} = 0 \quad \text{within the limit } \Delta\phi_1 \rightarrow 0 \text{ and } \Delta\phi_2 \rightarrow 0,$$

$$\partial_\nu \left\{ -\frac{1}{4} (-1)(4) \mathbb{F}^{\mu\nu} \right\} - \left\{ e\phi_0 \partial_\mu \Delta\phi_1 - e^2 \phi_0^2 A_\mu \right\} = 0,$$

$$\partial_\nu \mathbb{F}^{\mu\nu} = e\phi_0 \left\{ \partial_\mu \Delta\phi_1 - e\phi_0 A_\mu \right\} = -e^2 \phi_0^2 \left\{ A_\mu - (e\phi_0)^{-1} \partial_\mu \Delta\phi_1 \right\} = -(e\phi_0)^2 B_\mu = \partial_\nu B^{\mu\nu}$$

From Equation (1),

$$-e\phi_0 \partial^\mu \left\{ A_\mu - (e\phi_0)^{-1} \partial_\mu \Delta\phi_1 \right\} = 0, \partial^\mu B_\mu = 0$$

$$A_\mu = B_\mu + (e\phi_0)^{-1} \partial_\mu \Delta\phi_1, \partial_\nu B^{\mu\nu} + (e\phi_0)^2 B_\mu = 0$$

describes vector waves whose quanta have bare mass $V(0) = 0, \eta = 0, V'(|\phi|^2) = 0$

$$\partial_\nu (\partial^\nu B^\mu - \partial^\mu B^\nu) + (e\phi_0)^2 B^\mu = 0, \left\{ \partial_\nu \partial^\nu + (e\phi_0)^2 \right\} B^\mu = 0 \quad (3)$$

the vacuum solution

$$\left\{ -\frac{1}{c^{*2}} \frac{\partial^2}{\partial t^2} + \nabla^2 + (e\phi_0)^2 \right\} B^\mu = 0, c^* < c$$

and scalar & vector part both are component of the same tensor describing same massive quanta such as graviton or neutrinos propagating with the lesser light speed than massless photon light. So that mass of the quanta derived from two different ways have common value. Therefore $(2\lambda)^{1/2} \phi_0 = e\phi$, $\phi_0 \neq 0$, so that $(2\lambda)^{1/2} = e$,

$$2\lambda = e^2, \quad \lambda = \frac{e^2}{2} = V''(|\phi|^2) = \frac{\partial^2 V(|\phi|^2)}{(\partial|\phi|^2)^2}, \quad \frac{\partial}{\partial|\phi|^2} \left(\frac{\partial V(|\phi|^2)}{\partial|\phi|^2} \right) = \frac{e^2}{2} = \alpha \varepsilon_0 \hbar c > 0, \quad \frac{\partial V(|\phi|^2)}{\partial|\phi|^2} = \frac{e^2}{2} |\phi|^2 + \mu, \quad \mu \text{ is the}$$

first constant of integration $V(|\phi|^2) = \frac{e^2}{4} (|\phi|^2)^2 + \mu |\phi|^2 + \eta$, η the second constant of integration $V(0) = 0$, $\eta = 0$, $V'(|\phi|^2) = 0$ at $|\phi| = \pm \phi_0$, $\frac{e^2 \phi_0^2}{2} + \mu = 0$, $\mu = -\frac{e^2 \phi_0^2}{2} = -\frac{m^2}{2}$, where m is the mass of the quanta propagating with slow light speed the new light that illuminate the entire universe namely graviton light & neutrino light. The propagation speed of new light $c^* < c$ the photon light of the massless quanta. The example for graviton light is the moon light.

$$V(|\phi|^2) = \frac{e^2 |\phi|^4}{4} - \frac{e^2 \phi_0^2 |\phi|^2}{2} = \frac{e^2 (|\phi|^2 - 2\phi_0^2) |\phi|^2}{4} = 0, |\phi| = 0, |\phi| = \pm \sqrt{2} \phi_0$$

and the curve cut the imaginary axis of the complex mathematical plane at those points and at $|\phi| = 0$ it touch the imaginary axis at an apparent maxima $V(|\phi|^2) = \frac{e^2}{4} \left([|\phi|^2 - \phi_0^2]^2 - [\phi_0^2]^2 \right)$ at $|\phi| = \pm \phi_0$ the potential curve has two minima s and $|\phi| = 0$ it acquire zero value. It leads to infinity at infinite limit in both directional parities

$$V(|\pm \phi_0|^2)_{\text{minima}} = -\frac{1}{4} (e\phi_0)^2 \phi_0^2 = -\frac{1}{4} m^2 \phi_0^2$$

$$V(0) = 0, |\phi| \rightarrow \pm \infty, V(|\phi|^2) \rightarrow +\infty$$

$$V(|\phi|^2) = \frac{1}{2} \alpha \varepsilon_0 \hbar c \left([|\phi|^2 - \phi_0^2]^2 - [\phi_0^2]^2 \right)$$

$$V(|\phi|^2) = \frac{e^2}{4} |\phi|^4 - \frac{m^2}{2} |\phi|^2$$

where $|\phi|^2 = \phi_1^2 + \phi_2^2$ and m is the mass of the quanta traveling with slow speed of light.

3. In Particle Physics Related with Electro-Weak Unification

$$M_W \sin \theta_w = \sqrt{M_Z^2 - M_W^2} \cos \theta_w = M_H = \sqrt{\frac{\pi \alpha}{G_F \sqrt{2}}} = v \sqrt{\pi \alpha},$$

$$v = \sqrt{\frac{1}{G_F \sqrt{2}}} = \phi_0, \alpha = \frac{e^2}{4\pi \varepsilon_0 \hbar c} = \frac{e^2}{2\varepsilon_0 \hbar c}, \hbar = \frac{h}{2\pi}$$

$$\sqrt{\pi \alpha} = \frac{e}{2\sqrt{\varepsilon_0 \hbar c}} = \sqrt{2\lambda}, \lambda = \frac{e^2}{8\varepsilon_0 \hbar c} = \frac{\pi \alpha}{2}$$

and reconfirmed in the neighborhood of this peak value by compact muon solenoid in European accelerator for particle physics at Geneva in the Alps Snow Mountain Range in an enchanting picturesque. Higgs Boson is identified as relativistically accelerated heavy graviton and W and Z bosons are identified as relativistic ally accelerated heavy neutrinos & spin is identified as energy scale dependent physical quantity in this analysis. Further

$$M_W = \frac{g v}{2}, M_W^2 = \frac{g^2 v^2}{4}, M_Z = \frac{v}{2} \sqrt{g^2 + g'^2}, M_Z^2 = \frac{1}{4} (g^2 + g'^2) v^2$$

$$M_Z^2 - M_W^2 = \frac{1}{4} g'^2 v^2 = \left(\frac{1}{2} g' v \right)^2, \sqrt{M_Z^2 - M_W^2} = \left(\frac{1}{2} g' v \right)$$

$$\begin{aligned}\cos \theta_w &= \frac{g}{\sqrt{g^2 + g'^2}}, \sin \theta_w = \frac{g'}{\sqrt{g^2 + g'^2}} \\ M_w \sin \theta_w &= \sqrt{M_Z^2 - M_w^2} \cos \theta_w = \frac{1}{2} \frac{gg'}{\sqrt{g^2 + g'^2}} v = \frac{1}{2} ev = M_H \\ g \sin \theta_w &= g' \cos \theta_w = \frac{gg'}{\sqrt{g^2 + g'^2}} = e, \frac{1}{g^2} + \frac{1}{g'^2} = \frac{1}{e^2}, \sqrt{2\lambda} = \frac{e}{2}, \lambda = \frac{e^2}{8}\end{aligned}$$

Multiplying the above relation by factor $\frac{v}{2}$, $v = 246 \text{ GeV}$, $\frac{v}{2} = 123 \text{ GeV}$, $\alpha = \frac{1}{137}$,

$$\left[\frac{1}{2} gv \right] \sin \theta_w = \left[\frac{1}{2} g'v \right] \cos \theta_w = \left[\frac{1}{2} ev \right] = M_H = 37.3 \text{ GeV}/c^2 \text{ the mass of the Higgs Boson as confirmed by}$$

CMS experiment at this peak neighborhood at Geneva in 2012. They have confirmed it 1991 [6] LEP:L3, Delphi, Opal, Aleph experiments also. The present author here provides the important pieces of work with proofs merited missed by Salam and Weinberg in their original papers of electroweak unification where Higgs can feel comfort after long delay. Higgs mass is the perpendicular drawn from the vertex at the right angle on the opposite side hypotenuse of the mass triangle corresponding to coupling constants of electroweak unification theory. g correspond to the strength of coupling of weak interaction and g' corresponds to the strength of coupling of electromagnetic interaction. e the charge of electron and α the fine structure constant & θ_w the Weinberg angle, c the speed of light in vacuum, ϵ_0 the permittivity of vacuum, h the plank constant, G_F the Fermi coupling constant, M_Z the mass of Z boson, M_w the mass of W boson, M_H the mass of Higgs boson, π the common ratio of circumference to diameter of all circles.

4. Conclusions

Field strength of the potential term adopted by P.W. Higgs from Landau-Ginzberg theory applied in particle physics has been theoretically calculated by present author in both Higgs and Weinberg-Salam versions of the theory. Meanwhile field strength was kept undetermined by Higgs, Weinberg-Salam following the way it was first formulated by Landau and Ginzberg. They all expected that it is a phenomenological parameter whose value can be given by experimental basis only. But it is worth to mention that it is hard to do experiments when there is no theoretical expression for this parameter then question arises—what is there to measure when it is not well defined. The important difference between former authors and our self is that present author provides a theoretical prediction for the field strength and Higgs mass which are fully consistent with latest experimental values. Experimenters have to adopt this new version with upgrading and calibrating their instruments.

In this work very important points missed by P. W. Higgs [4] in his first analysis of the Goldstone model were presented. Higgs [4] would not have missed the derivation of lambda coefficient at his time if he had carefully studied Klein-Gordon and Proca equations as scalar and vector component of one tensor corresponding to one massive quanta travelling with slow light speed than massless photon light.

But this point is apparent in the paper written by Kibble [4] and his collaborators at Imperial College in London at their time in which same η_1 is appearing for scalar and vector part of the boson. Even S. Weinberg and A. Salam have missed the point at their time. But E. Witten [5], J. Ellis [6] have come nearby. A. Lahiri [7] also has similar settings. The dot peak value of 2012 CERN experiments is the Higgs mass¹. Very clear picture of what was missing is very much apparent in the review of Julius Runninger [8].

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¹CERN-PH-EP/2012-220, on 2012/08/01, See Figure-7 of Page-18, Distribution of m_{η_1} for the zero-jet $e\mu$ category in the $H \rightarrow WW$ search at center of mass energy $\sqrt{s} = 8 \text{ TeV}$, Luminosity $L = 5.1 \text{ fb}^{-1}$ highest dot peak value as confirmed is $M_H = 38.45 \text{ GeV}/c^2$ submitted to physics letters B, in concurrence with new theory presented in this paper. Not average value of many experiments is the mass of the Higgs boson except the dot peak value noted. [reaction indicates above can be $W \rightarrow HH$].

[Tamma Panni] is the Historic Name of Lanka the present author [alternative E-mail: dealwis_a@yahoo.com] is staying.

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