A NEW MODEL FOR W,Z, HIGGS BOSONS MASSES CALCULATION AND VALIDATION TESTS BASED ON THE DUAL GINZBURG-LANDAU THEORY

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Abstract

In this paper was re-visited the dual Ginzburg-Landau model for the calculation of Lorenz force, monopoles current, and the energy of vortex lines for a vortex triangular lattice type Abrikosov within a nucleon, to find their meaning. For now, it was found that these energies would correspond to the subatomic particles, W, Z , bosons, *pion* π^{+} , and of nucleon itself. Also, it was determined the fusion temperature of two nucleons.
The model permits to explain the beta decay mechanism of radioisotopes to be the same as the dark counts in the case of superconductors.
A link with gravity as a force that counteracts the destruction of superconductivity, is discussed. In this model to a superconductor analogue, we do not use an a-priori Higgs field, and hence a Higgs boson. The entire work is done in natural units.

1. Introduction

Usually, the masses of W, Z , are calculated by taking into account a priori a Higgs field, and the default using the Higgs mechanism and Higgs boson.
Soon after the advent of QCD, 't Hooft and Mandelstam [1] proposed the dual superconductor scenario of confinement; the QCD vacuum is thought to behave analogously to an electrodynamic superconductor but with the roles of electric and magnetic fields being interchanged: a condensate of magnetic monopoles expels electric fields from the vacuum. If one now puts electric charge and anti-charge into this medium, the electric flux that forms between them will be squeezed into a thin, eventually string-like, Abrikosov-Nielsen-Oleson (ANO) vortex which results in linear confinement.
The dual superconductor mechanism [1] is an alternative that does not require the ad hoc introduction of a Higgs field but instead uses dynamically generated topological excitations to provide the screening supercurrents. For example, U(1)

lattice gauge theory contains Dirac magnetic monopoles in addition to photons. The dual superconductor hypothesis postulates that these monopoles provide the circulating color magnetic currents that constrain the color electric flux lines into narrow flux tubes. 'tHooft has shown that objects similar to the Dirac monopoles in U(1) gauge theory can also be found in non-Abelian SU(N) models.

The results are consistent with a dual version of the Ginzburg-Landau model of superconductivity. Important in understanding field (magnetic) dependence was Abrikosov's field theoretical approaches based on Ginsburg-Landau theory [2] for type I superconductors ($\kappa \lhd 1/\sqrt{2}$, $\kappa = \lambda/\xi$, λ is the penetration depth, ξ the coherence length) and type ones ($\kappa \rhd 1/\sqrt{2}$) II superconductors, which allows magnetic flux Φ to penetrate the superconductor in a regular array quantized in units of elementary flux quantum $\Phi = \pi\hbar c/e$ .Important was the quantization in a ring , flux $\Phi = \left(n + \frac{1}{2}\right)\frac{\hbar c}{e}$, ($n = 0, \pm 1, \cdots$)

In the present paper we revisited G-L model [2],[4],[5],[6],[7],[8],[9], in order to calculate the values of the Lorenz force, the current, and the energies of the Abrikosov vortex lines inside of the nucleon, in natural units, in view to search for its relevance; for the time being, it was found that this would correspond to energies for subatomic particles, such as that of W, Z , bosons, and of pion π^+ . Also the connection with gravity to be analyzed. In this model to a superconductor analogue, we do not use an a-priori Higgs field, and hence a Higgs boson, is still undiscovered, we use only the electrical field generated by the pair $q\bar{q}$.

2. The description of the analogue model of nucleon to a superconductor

The normal cores that exist in type-II superconductors in the mixed state are not sharply delineated. The value of number density of superelectrons of n_s is zero at the centers of the cores and rises over a characteristic distance ξ , the coherence length. The magnetic field associated with each normal core is spread over a region with a diameter of 2λ , and each normal core is surrounded by a vortex of circulating current.

The QCD vacuum can be viewed as a dual superconductor characterized by a monopole condensate [1],[8],[9],[10], when embedding a static $q\bar{q}$ pair into the vacuum. The core of the flux tube is just a normal conducting vortex which is stabilized by solenoidal magnetic supercurrents, j_s, in the surrounding vacuum.

In order to calculate distinctly the energy states (masses) in natural units, firstly we re-derive the field equations of magnetic monopoles current and of the electric flux. Therefore, here is adopted a basic *dual* form of Ginzburg-Landau (G-L) theory [2],[4],[5],[6],[7], which generalizes the London theory to allow the magnitude of the condensate density to vary in space. As before, the superconducting *order parameter* is a complex function $\psi(\vec{x})$, where $|\psi(\vec{x})|^2$ is the condensate density n_s. Also is defined the

wave function $\psi(\vec{x}) = \sqrt{n_s}\exp(i\varphi(\vec{x}))$, where n_s is the London (bulk) condensate density, and φ are real functions describing the spatial variation of the condensate. The characteristic scale over which the condensate density varies is ξ, the G-L coherence length or the vortex core dimension . The x denote the radial distance of points from the z-axis, the superconductor occupying the half space $x \rhd 0$. Outside of the superconductor in the half space $x \lhd 0$, one has $B = E = H = H_0$, where, "the external" vector H_0 is parallel to the surface. The Ψ theory of superconductivity [2] is an application of the Landau theory of phase transitions to superconductivity. In this case, some scalar complex ψ function fulfils the role of the order parameter.
First of all, we write the magnetic induction $B = curlA = \nabla \times A$, where A is the electromagnetic field potential. To obtain the full system of equations we must incorporate the Maxwell equation

$$\nabla \times B = \frac{4\pi}{c} j = \frac{1}{c^2 \varepsilon_0} j \qquad (1)$$

and the divergence

$$\nabla \cdot B = 0 \qquad (2)$$

The extended Maxwell's equations (in cgs) which allow for the possibility of "magnetic charges" analog with electric charges (monopoles condensate), the Gauss' law for magnetism is $divB \neq 0 = 4\pi \rho_m$,and the Faraday's law of induction contains a new term $\frac{4\pi}{c}$ or, in SI, $\mu_0 j_m$, $where \rightarrow \mu_0 = \frac{1}{c^2 \varepsilon_0}$; $-\nabla \times E = \frac{1}{c}\frac{\partial B}{\partial t} + \frac{4\pi}{c} j_m$, also, the Ampere law is identical to the one without monopoles: $\nabla \times B = \frac{1}{c}\frac{\partial E}{\partial t} + \frac{4\pi}{c} j_e$

The Ampere's law, expressed as the integral over any arbitrary loop, where J_s is the current enclosed by this loop, is:

$$\oint B \cdot dl = \mu_0 J_s \qquad (3)$$

A charged particle moving in a $B-$ field experiences a *sideways* force that is proportional to the strength of the magnetic field , the component of velocity that is perpendicular to the magnetic field and the charge of the particle. This force is known as Lorentz' force and is given by :

$$F_L = q(E + vB) + \frac{q_m}{\mu_0}(B - v(E/c^2)) \qquad (4)$$

, where, q_m-the magnetic charge, B in $[Teslas]$, F_L in $[N]$)

In absence of a magnetic field. one gets for free energy of the superconductor, J.Pitaevski [2]:

$$f = f_n + \int \left(\frac{\hbar^2}{4m} |\nabla \psi|^2 + a|\psi|^2 + \frac{b}{2}|\psi|^4 \right) dV \qquad (5)$$

Here, f_n is the free energy at $\psi = 0$, i.e. f_n is the free energy of the normal state.

Let us consider the behavior in presence of a magnetic field. The density of the magnetic field is $B^2/8\pi$ must be added to the integrand (5). But this is insufficient in the gradient term in (5) is not invariant with respect of gauge transformations:

$$A \to A + \nabla \gamma \qquad (6)$$

And for phase transformation

$$\varphi \to \varphi + 2e\gamma/\hbar c \qquad (7)$$

The gradient of phase φ defines the velocity of the superconductive pairs (in our case of the monopoles condensate!)

$$v_s = \frac{\hbar}{2m} \nabla \varphi \qquad (8)$$

Equation (8) is not invariant under a such transformation. To restore the required invariance , one must include a further term containing the vector potential

$$v_s = \frac{\hbar}{2m} \left(\nabla \varphi - \frac{2e}{\hbar c} A \right) \qquad (9)$$

Finally, one gets for the superconducting current density

$$j_s = n_s v_s e = \frac{e\hbar}{2m} n_s \left(\nabla \varphi - \frac{2e}{\hbar c} A \right) \qquad (10)$$

, and the magnetic induction is

$$B = \nabla \times A \qquad (11)$$

Applying the curl operator to both sides of (10) and using (11) , we obtain the London equation

$$\nabla \times j_s = \frac{e^2 n_s}{mc} \frac{\varepsilon_0 c}{\varepsilon_0 c} B = \frac{\varepsilon_0 c}{\lambda^2} B \qquad (12)$$

Therefore, to restore the invariance in (5), one substitute for $|\nabla \psi|^2$ the combination $|[\nabla - i(2e/\hbar c)A]|^2$, which is obviously gauge invariant. The final expression for the free energy then takes the form

$$f = f_n + \int \left\{ \frac{\hbar^2}{2m} \left| \left(\nabla - i \frac{2e}{\hbar c} A \right) \psi \right|^2 + a|\psi|^2 + \frac{b}{2}|\psi|^4 + \frac{B^2}{8\pi} \right\} dV \qquad (13)$$

Here, the magnetic induction must be expressed as in (11). One can obtain the basic equations of Ginzburg-*Landau* theory by varying this functional with respect to A and ψ^*. Carrying first variation with respect to A, we find after a simple calculation:

$$\delta f = \int \left[c\frac{ie\hbar}{2m}(\psi^{*}\nabla\varphi - \psi\nabla\psi^{*}) + \frac{2e^2}{m}|\psi|^2 A + \frac{curlB}{4\pi}\right]\delta A dV +$$
$$+ \int div(\delta A \times B)\frac{dV}{4\pi} = 0 \qquad (14)$$

The second integral can be transformed into an integral over remote surface and disappears. To minimize the free energy, the expression in the brackets must be equal to zero. This results in the Maxwell equation

$$curlB = \frac{4\pi}{c} j_s = \frac{1}{c^2\varepsilon_0} j_s (in\_SI) \qquad (14.1)$$

,or

$$\nabla \times \nabla \times A = \frac{4\pi}{c}.j_s = \frac{1}{c^2\varepsilon_0} j_s \qquad (15)$$

, provided that the current density is given by

$$j_s = \frac{ie\hbar}{2m}\left(\psi^{*}\nabla\psi - \psi\nabla\psi^{*}\right) + \frac{2e^{*2}}{m.c}|\psi|^2.A \qquad (15.1)$$

According to the definition of n_s we can substitute $\psi = \sqrt{n_s}\exp(i\varphi)$. Then (15.1) becomes

$$j_s = \frac{\hbar e}{2m}|\Psi|^2\left(\nabla\varphi - \frac{2e}{\hbar c}A\right) \qquad (16)$$

Equation (16) coincides with (10). This justifies our identification of $|\psi|^2$ with n_s .Variation of (13) with respect ψ^{*} gives, after simple integration by parts,

$$\delta f = \int \left[-\frac{\hbar^2}{4m}\left(\nabla - i\frac{2e}{\hbar c}A\right)^2\psi + a\psi + b|\psi|^2\psi \right]\delta\psi^{*} dV +$$
$$+ \frac{\hbar^2}{4m}\oint\left(\nabla\varphi - i\frac{2e}{\hbar c}A\psi\right)\delta\psi^{*}\cdot dS = 0 \qquad (17)$$

The second integral is over the surface of the sample. The volume integral vanishes when

$$-\frac{\hbar^2}{4m}\left(\nabla - i\frac{2e}{\hbar c}A\right)^2\psi + a\psi + b|\psi|^2\psi = 0 \qquad (18)$$

Equations (15) and (18) form the complete system of the Ginzburg-Landau(G-L) theory.

In equation (16), to emphasize: $\lambda = \left(\frac{\varepsilon_0.m.c^2}{n_s.e^2}\right)^{1/2} = 1.17e-16[m]$, I did a lot of multiplications , and I used the quantized flux: $\Phi_0 = \frac{\pi\hbar c}{e}$, and $|\Psi|^2 = n_s$;

$n_s = 3\_monopoles/V * 1.e-45m^3$, $V = 4/3\pi r^3 = 2$, $r = 0.48[fm]$
$\varepsilon_0 = 8.8e-12[C^2.N^{-1}.m^2]$.

Since, the magnetic charge of monopole being [16]
$g_d = 4\pi\varepsilon_0 \frac{\hbar c}{2e} = \frac{4\pi\varepsilon_0\hbar c}{e^2} e = \frac{137}{2} e = 68.5e$, and assuming that the classical electron radius be equal to "the classical monopole radius" from which one has the monopole mass $m_M = g_d^2 m_e / e^2 = 4700 m_e$, the value of λ remains unmodified.
Thus, we obtain

$$j_s = \frac{\hbar e.n_s}{2m} \nabla\varphi - \frac{2e^2 n_s}{mc} A \tag{19}$$

$$j_s = \frac{\hbar c}{2e} \frac{e}{c} \frac{e n_s}{\varepsilon_0 mc} c\varepsilon_0 \nabla\varphi - \frac{2e^2 n_s}{\varepsilon_0 mc^2} \varepsilon_0 cA$$

,or

$$j_s = \frac{\pi}{2\pi} \frac{\hbar c}{e} \frac{1}{\lambda^2} c\varepsilon_0 \nabla\varphi - \frac{2}{\lambda^2} \varepsilon_0 cA$$

,or

$$j_s = \frac{1}{2\pi} \Phi_0 \frac{1}{\lambda^2} c\varepsilon_0 \nabla\varphi - \frac{2}{\lambda^2} \varepsilon_0 cA \tag{20}$$

We can assume that the induction vector B is directed along the z-axis. Then the vector potential A can be chosen along the y-axis and

$$B = \frac{dA}{dx} \tag{21}$$

We must solve the G-L equations (15) and (18) for this one-dimensional problem subject to the $s-n$ boundary conditions:

$$x \to -\infty, \psi \to 0, B \to H_c, \tag{22}$$
$$x \to \infty, \psi \to (a/b)^{1/2}, B \to 0$$

The quantity $\left[\nabla - i\frac{e}{\hbar c}\right] |\psi|^2$ is gauge invariant, J.Pitaevski [2], when $A \to A + \nabla\varphi$.
If we transforming the equation dimensionless by:

$$\bar{x} = \frac{x}{\lambda}, \ \bar{A} = \frac{A}{H_c \lambda}, \ \bar{B} = \bar{\nabla} \times \bar{A} = \frac{B}{H_c} \tag{23}$$

Substituting these variables into G-L equations (18) and (15). The G-L equations for our one-dimensionally problem take the form (here are omitted the hats):

$$\psi'' - \kappa^2 \left[\left(\frac{1}{2} A^2 - 1 \right) \psi + \psi^3 \right] = 0 \tag{24}$$

, and

$$A'' - A\psi^{3} = 0 \qquad (25)$$

The boundary conditions (22) are:
$\psi = 0, E = A' = 1$ for $x \to -\infty$
$\psi = 1, A' = 0$ for $x \to \infty$
Note that the boundary condition $A = 0$
Equations (24) and (25) give

$$\frac{2}{\kappa^{2}}\psi'^{2} + A'^{2} - (A^{2} - 2)\psi^{2} - \psi^{4} = constnt \qquad (26)$$

This expression is an "energy", and as follows from boundary conditions that this energy must equal unity.

$$\frac{2}{\kappa^{2}}\psi'^{2} + A'^{2} - (A^{2} - 2)\psi^{2} - \psi^{4} = 1 \qquad (27)$$

For $\kappa = \lambda/\xi \triangleleft 1$ when $\lambda \triangleleft \xi$ the electrical field penetrates only slightly into superconducting phase, and the penetration is of order $1/\sqrt{\kappa}$, the wave function is small in this region and gives only a small contribution. Let us consider the distance $x \triangleleft\triangleleft \frac{1}{\kappa}$ and $\kappa^{2}A^{2} \triangleleft\triangleleft 1$. Then one can neglect the right-hand side (r.h.s) of (24) and the solution matched to (29) bellow is $\psi = \kappa x/\sqrt{2}$. Substituting this in (25), we find $A'' = \kappa^{2}x^{2}/\sqrt{2}$.

The main contribution arises from the region where ψ changes rapidly, which is of the order of $\frac{1}{\kappa}$.

There is not electric field in this region and one can put $A = 0$ in (27). Solving this equation for ψ', we have

$$\psi' = \frac{\kappa}{\sqrt{2}}(1 - \psi^{2}) \qquad (28)$$

This equation have a simple solution

$$\psi = \tanh(\kappa x/\sqrt{2}) \qquad (29)$$

The superconductors of second kind are those with $\kappa \triangleright 1/\sqrt{2}$, and $\lambda \triangleright \xi$.
We now consider the phase transition in superconductors of the second kind.
For this we can omit the non-linear $(|\psi|^{2}\psi)$ term in (18), we have

$$\frac{1}{4m}\left(-i\hbar - \frac{2e}{c}A\right)^{2}\psi = |a|\psi \qquad (30)$$

This equation coincides with the Schrodinger equation for a particle of mass $2m$ and charge $2e$ (in the case of dual, the factor 2 for the charge, which is specific to the "pairs", it is actually 1) in a magnetic field H_0 (in our case the chromo-electrical flux

$E(0)$). The quantity $|a|$ plays the role of energy ($E\psi$) of that equation. The minimum energy for a such particle in a uniform electro-magnetic field is

$$\varepsilon_{(0)} = \frac{1}{2}\hbar\omega_B = \frac{1}{2}\hbar\frac{2eH_0}{8mc}\left[J.s\frac{C*Kgm}{Cs^2 Kg*m/s}\right] \Rightarrow [J]$$, H_0-an "external" electro-magnetic field of a dipole created by the pair $u\bar{u}$ (the chromoelectrical colors field)

$$H_0 = E_0 = \frac{de}{4\pi\varepsilon_0 r^3} = 8.33e24\left[\frac{N}{C}\right] \quad (30.1)$$

,where $r \cong 0.05[fm]$-is the electrical flux tube radius, $d = 0.48[fm]$-the distance between the two quarks charges, usually $H[A/m]$, but here is used as $B = \mu_0 H\left[\frac{J}{Am^2}\right]$

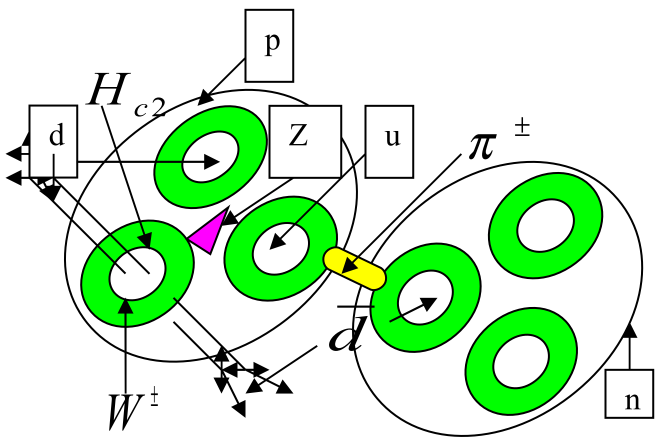


Fig.1a. Abrikosov's triangular lattice for a nucleon (proposal)

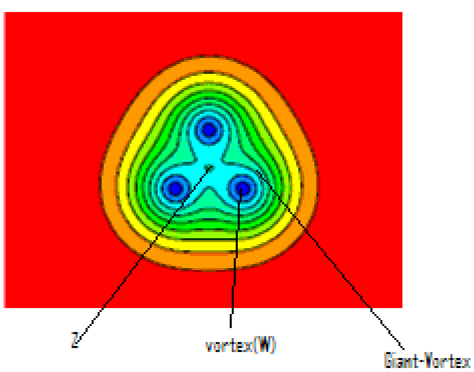


Fig.1b. The Giant-Vortex type arrangement for the nucleon

Hence, equation (30) has a solution only if $|a| \triangleright 2\hbar * eH_0/8mc$, when following power-law conformal map is applied for complex number of the r.h.s of (30), or equivalently if the electro-magnetic field is less than an upper critical field, see fig.1a.

$$H_0 \le \frac{4mc|a|}{\hbar e} \le H_{c2} = \frac{\Phi_0}{2\pi\xi^2} = \frac{\pi\hbar c}{2\pi e\xi^2} = 8.33e24\left[\frac{N}{C}\right] \qquad (31)$$

, and in terms of

$$B_{c2} = H_{c2} = \frac{\pi\hbar c}{2\pi e\xi^2 \cdot c} = 2.7e16\left[\frac{J}{Am^2}\right]$$

The particle energy is

$\varepsilon_{(0)} = \frac{1}{2}\frac{\hbar^2}{8m\xi^2} = 6.28e-08[J] = 6.28e-25[Kg] \Rightarrow 392[GeV]$, with $\lambda \triangleright \xi$;

$\xi = \frac{\lambda}{\kappa} = \frac{0.117}{1.05} = 0.1114[fm]$, or $\kappa \triangleright 1/\sqrt{2} \triangleright 1 = 1.05$ (of type II-superconductor).

One of the characteristic lengths for the description of superconductors is called the coherence length. It is related to the Fermi velocity for the material and the energy gap ($k_B T_c$) associated with the condensation to the superconducting state. It has to do with the fact that the superconducting electron density cannot change quickly-there is a minimum length over which a given change can be made, lest it destroy the superconducting state. For example, a transition from the superconducting state to a normal state will have a transition layer of finite thickness which is related to the coherence length.

However, superfluids possess some properties that do not appear in ordinary matter. For instance, they can flow at low velocities without dissipating any energy—i.e. zero viscosity. At higher velocities, energy is dissipated by the formation of quantized vortices, which act as "holes" in the medium where superfluidity breaks down.

More exactly, this quantity is called the correlation or healing length [2] , and is defined as $\xi(T) \cong \xi_0\left(\frac{T_c}{T_c - T}\right)^{1/2} \triangleright\triangleright \xi_0$

, where $\xi_0 = a\hbar\upsilon_F/E_g$ (31.1)

is for $T \to 0$, $a = 2/\pi$ from [17], E_g -gap energy, k_B Boltzmann constant; at confinement $T_c = 175[MeV] \to 2e12[K]$, and the Fermi velocity of electrons (monopoles) is

$$\upsilon_F = \frac{\sqrt{2*4700m_e E_F}}{4700m_e} \qquad (31.2)$$

, where as the Fermi energy we have for monopoles condensate viewed as boson condensate $E_{bosonCond} = 3.31 \frac{\hbar^2 n_s^{2/3}}{4700 m_e} \cong T_c k_B = 0.7 E_F$

, where $E_F = \frac{\hbar^2}{2*4700 m_e} \left(3\pi^2 n_s\right)^{2/3}$ (31.3)

, numerically, we have:

$E_F = 9.32e-12[J] \to 55[MeV]$

,where $V = 1.5[fm]^3$, and the velocity of monopole is

$\upsilon_F = 0.55e8 \triangleleft c = 2.997e8[m/s]$

,and $\xi_0 = 1.02e-16[m]$ at $T \to 0$ (31.4)

Note that, if we use only the mass of electrons (as in the case of superconductors), the velocity obtained is greater than the speed of light, so this strengthens the use monopole condensate.

In the following we will consider the structure of the mixed state. The main problem is to understand how the electric field penetrate in the bulk of the superconductor. Let us again consider a superconducting cylinder in the electric field. It is natural to expect that the normal regions , with their accompanying electric field, are cylindrical tubes parallel to the field. The electrical flux inside such tube must be integral multiple n of the flux quantum

$$\Phi_0 = \pi\hbar c/e \to usually \frac{\pi\hbar}{e} = 2.07e-15[Tm^2] \quad (32)$$

The electrical field is concentrated inside the tube. At large distances from the tube it is shielded by annular superconducting flowing around the tube. This current is analog of the superfluid velocity field surrounding the vortex lines in the superfluid liquid. We can then picture the mixed state as an array of quantized vortex lines. Such vortex lines were predicted by A.A. Abrikosov in 1957. Their existence is crucial for explaining the proprieties of type II superconductors (dual in our case).
The presence of a vortex line in the center of the tube increases the free energy of the superconducting media. The G-L equations are solved analytically only for $\lambda \triangleright\triangleright \xi$ (near T_c this means $\kappa \triangleright\triangleright 1$). Thus, when the electrical flux is applied parallel to the superconducting cylinder, the first flux penetrating should be located along the axis of the cylinder.
Substituting j_s from Maxwell equation, we can rewrite (10) as:

$$\frac{e\hbar}{2m}\frac{2e}{\hbar c} n_s \left(\nabla\varphi \frac{2\pi\hbar c}{2\pi\, 2e} - A \right) = \frac{e^2 n_s c\varepsilon_0}{mc^2\varepsilon_0} \left(\nabla\varphi \frac{2\Phi_0}{2\pi} - A \right) = \frac{1}{\lambda^2} c\varepsilon_0 \left(\nabla\varphi \frac{2\Phi_0}{2\pi} - A \right) = j_s$$

From Maxwell equation (in SI):

$$curlB = \frac{1}{c^2\varepsilon_0} j_s$$

$$\left(\nabla\varphi \frac{2\Phi_0}{2\pi} - A\right) = \frac{\lambda^2}{c\varepsilon_0}\frac{c}{c} j_s = c\lambda^2 curlB$$

, or

$$A + c\lambda^2 \nabla \times B = 2\Phi_0 \nabla\varphi / 2\pi \qquad (33)$$

The phase φ in presence of vortex line is not a single-valued function of the coordinates. For a vortex line with minimum flux Φ_0, the phase increase by 2π on traversing a closed contour that enclose the line. Thus the integral along such a contour is

$$\oint \nabla\varphi \cdot dl = 2\pi \qquad (34)$$

Integrating (33) we find

$$\oint (A + c\lambda^2 \nabla \times B) \cdot dl = 2\Phi_0 \qquad (35)$$

It is not difficult to check that in the range

$$\lambda \triangleright\triangleright x \triangleright\triangleright \xi \qquad (36)$$

The second term from l.h.s of (35) gives the main contribution. We take the contour of integration in (35) a circle of radius x. For this geometry the vector $(\nabla \times B)$ has only one component $(\nabla \times B)_\varphi$ along the contour.

The integration is then simple and we have

$$(\nabla \times B)_\varphi = -\frac{dB}{dx} = \frac{1}{c}\frac{2\Phi_0}{2\pi x\lambda^2} \qquad (37)$$

To note (in cgs):

$$(\nabla \times B)_\varphi = \frac{4\pi}{c} en_s v_{s\varphi}$$

Equation (37) then gives $v_{s\varphi} = \hbar/2mx$ for the superfluid velocity as it must be for a vortex line in a superfluid of particles with mass $2m$.

Integrating of (37) for B gives

$$B(x) = \frac{2\Phi_0}{2\pi\lambda^2 c}\log\left(\frac{\lambda}{x}\right) \qquad (38)$$

This equation is valid in the interval (36) with logarithmic accuracy.

Notice also that every vortex carries the flux Φ_0 and hence the mean value of B over the cross-section of the cylinder is

$$\overline{B} = 2\nu\Phi_0 \qquad (39)$$

, where ν is the number of lines per unit area. This result is invalid near the upper critical flux H_{c2} where the cores of the vortex lines begin to overlap. To calculate this number we have to take into account the interaction between vortex lines. As the first step we have to find the electrical field trough a loop of arbitrary radius surrounding the line without the restriction (36) . Let us calculate the curl of the both sides of (33) .
Note that

$$curl\nabla\varphi = 2\pi \cdot n_z \cdot \delta(x) \qquad (40)$$

, and $curlA = B$
where

$\delta(x)$ -the Dirac function

Where r is the two-dimensional radius-vector in the $x - y$ plane and n_z is a unit vector along axis z (We assume that the axis of the vortex line coincides with z). Indeed, integrating $\nabla\varphi$ along the contour encircling the line and transforming the integral by Stokes' theorem into an integral over a surface spanning the contour, we have according to (34)

$$\oint \nabla\varphi \cdot dl = \int curl\nabla\varphi \cdot dS = 2\pi \qquad (41)$$

Since this equation must be satisfied for any such contour of integration , we have (40).

Finally, we obtain

$$B + c\lambda^2 curlcurlB = 2n_z\Phi_0\delta(x) \qquad (42)$$

Using the vector identity $curlcurlB = \nabla divB - \Delta B = -\Delta B$, we obtain

$$B - c\lambda^2 \cdot \Delta B = 2\Phi_0\delta(x) \qquad (43)$$

This equation is valid only at all distances

$$x \rhd\rhd \xi \qquad (44)$$

Throughout all the space except the line $x = 0$ equation (43) coincides with the London equation (12)
The $\delta(x)$ function on r.h.s defines the character of the solution at $x \to 0$. Actualy this singularity has already been defined in (38), which is valid at small x.
The solution of this equation at $x \to \infty$ is $B(r) = const \cdot K_0(x/\lambda)$, where K_0 is the Hankel function of imaginary argument. The coefficient must be defined by matching with the solution of (38). Using the asymptotic formula $K_0(x) \approx \log(2/\gamma x)$ for $x \lhd\lhd 1$,

where $\gamma = e^{C} \cong 1.78$ (C is Euler's constant), we finally have

$$B(x) = \frac{2\Phi_0}{2\pi\lambda^2 c} K_0(x/\lambda) \qquad (45)$$

Using equation (45) we can rewrite (38) as:

$$B(x) = \frac{2\Phi_0}{2\pi\lambda^2 c} \log\frac{2\lambda}{\gamma x}, \quad x \lhd\lhd \lambda \qquad (46)$$

In opposite limit of large distances one can use the asymptotic expression $K_0(x) \approx (\pi/2x)^{1/2} e^{-x}$ for $x \rhd\rhd 1$. Thus, at large distances from the axis of the vortex line the field decreases according to

$$B(x) = \frac{2\Phi_0}{c(8\pi x\lambda^3)^{1/2}} e^{-x/\lambda}, \quad x \rhd\rhd \lambda \qquad (47)$$

Accordingly the superconductive current density decreases (in SI):

$$j_\varphi = -\frac{c}{4\pi}\frac{dB}{dx}\left(4\pi c\varepsilon_0\right) = \frac{2c^2\varepsilon_0\Phi_0}{8(2\pi^3 x\lambda^5)^{1/2} c} e^{-x/\lambda} \qquad (48)$$

We can now calculate the energy ε of the vortex line. The magnetic part of free energy corresponding to London equation is given by the integral.

$$F_B = \frac{1}{8\pi}\int\left[B^2 + c\lambda^2\left(curlB\right)^2\right]dV \qquad (48.1)$$

Indeed, by varying the expression with respect to B, we immediately obtain the London equation (12). The main contribution to the integral is due to the second term, which contains a logarithmic divergence. Substituting (37) in (48.1), and integrating in the range (36), we obtain for the energy per unit length of vortex line.

$$\varepsilon = \left(\frac{2\Phi_0}{4\pi\lambda c}\right)^2 \log\left(\frac{\lambda}{\xi}\right) \qquad (49)$$

Equation (49), explains why only vortex lines with the minimum flux Φ_0 are the most favorable. The energy of a line is proportional to the square of its magnetic flux. Thus, the fragmentation of one line with the flux $n\Phi_0$ into n lines with flux Φ_0 results in an n-fold gain in energy.

A discussion of the physical background of this energy can be found, e.g. in the books [13], [14], [15] , as related to Dirichlet's energy and harmonic maps.

Thus, in [13], when is induced a magnetic stray field h which has a certain energy, according to the static Maxwell equation, the stray field satisfies $curl(h) = 0$; $div(u + h) = 0$, where u, is extended by 0 outside Ω. The first equation implies that $-h$ can be written as the gradient of function U. By the second equation, this U is a solution of $\Delta U = div(u)$ in the distribution sense (since, $curl(\nabla U) = 0$, and $div(\nabla U) = \Delta U$). There exists exactly one solution such that the integral

$$\frac{1}{2}\int_{R^3}|\nabla U|^2\,dx = \frac{1}{2}\int_{\Omega}u\cdot\nabla U dx \qquad (49.1)$$

is finite, and for this choice of U, this integral gives the main contribution to the micromagnetic energy. It is called the magnetostaic energy [13].

In our terms, $B = u = const$, $\nabla U = curlB = \frac{\partial B}{\partial x}$, since
$\Delta B = \Delta U = 0 \to div(u) = 0 \to u = const$.

Substituting $u = B\big|_{x \lhd\lhd \lambda} = \frac{2\Phi_0}{2\pi\lambda^2 c}$ from (46) with $x \approx \lambda/10 \to \log(...) \Rightarrow \cong 1$ on the boundary, or the dual gauge component of the total electrical field

, when $B^{monopoles} = 4.65e16\left(\frac{J}{Am^2}\right)$ (49.2)

,and ∇U from (37), one have

$$\varepsilon = \frac{1}{2}\int_{\Omega} c\lambda^2 \frac{1}{8\pi}\frac{2\Phi_0}{2\pi\lambda^2 c}4\pi c\varepsilon_0\frac{2\Phi_0}{2\pi\lambda^2 xc}dx =$$
$$c^2\varepsilon_0\int_{\Omega}\left(\frac{2\Phi_0}{4\pi\lambda c}\right)^2\frac{1}{x}dx = c^2\varepsilon_0\left(\frac{2\Phi_0}{4\pi\lambda}\right)^2\log(x)\Big|_{\xi}^{\lambda} = \qquad (49.3)$$
$$c^2\varepsilon_0\left(\frac{2\Phi_0}{4\pi\lambda c}\right)^2\log\left(\frac{\lambda}{\xi}\right)$$

Here, the factor $4\pi c\varepsilon_0$ is used to convert from $(cgs) \to (SI)$.
Because the magnetic induction of the monopoles current which is powered by electric field given by a pair of quarks (H_0), $B^{monopoles} \geq 2\cdot H_0 \cong H_{c2}$, as resulting from the comparison (49.2) with (30.1) and (31), it has the raw flow consequences squeezing this cromoelectrical flux into a vortex line, followed by forcing an organization into a triangular Abrikosov lattice, see figure 1.
The core of every vortex can be considered to contain a vortex line, and every particle in the vortex can be considered to be circulating around the vortex line. Vortex lines can start and end at the boundary of the fluid or form closed loops.
The presence of vortex line which increases the free energy of the superconducting media with εL, it is thermodynamically favorable if the contribution is negative; i.e. if

$\varepsilon L - \Phi_0/c\cdot H_0 L/4\pi\mu \lhd 0$, and $B_0 = \frac{H_0}{\mu_0}$, $\mu_0 = 1/c^2\varepsilon_0$,or

$$H_0 \rhd H_{c1} = \frac{4\pi\varepsilon\mu_0 c}{\Phi_0} \qquad (49.4)$$

Substituting (49.3) in (49.4), we find the lower critical field

$$B_0 = H_{c1} = \frac{2\Phi_0}{2\pi\lambda^2}\log\left(\frac{\lambda}{\xi}\right) = \frac{\pi\hbar c}{\pi\lambda^2 c}\log(\kappa) = 1.e15\left[\frac{J}{Am^2}\right] \qquad (49.5)$$

, where $\xi = 0.1114$, and when near the axis, for $x = 0.116 \cong \xi$, when the induction is
$B(\xi) \cong 2.e15 \cong 2H_{c1}$ (49.6)

Let us the results obtained to the calculation of the energy of interaction of vortex lines. It is important that equation (43), which defines the distribution of the field, is linear one. It means that under condition (44) the field produced by different vortex lines is additive. Let us consider two vortex lines placed at x_1 and x_2 separated by a distance d from each other. Then, $B = B_1 + B_2$. The energy of the lines is given by (48.1). Let us transform the first term in integrand by means of (42) (to multiply with B), which gives

$$\begin{aligned} & B^2 + c\lambda^2 (curlB)^2 = \\ & c\lambda^2 \left[- B \cdot curlcurlB + (curlB)^2\right] + \\ & 2\Phi_0 B_z(x)\left[\delta(x - x1) + \delta(x - x_2)\right] \end{aligned} \tag{50}$$

The first term in the r.h.s can be transformed into the form

$$\begin{aligned} & - B \cdot curlcurlB + (curlB)^2 = \\ & div(B \times curlB) \end{aligned} \tag{51}$$

The volume integration of this term in (48.1) can be reduced to an integration over a remote surface. This integral disappears, because of the fast decrease of the field. Because we are interested here in the energy of interaction of the lines, we must takes into account only "the mixed terms" of the type $B_{2z}(x)\delta(x - x_1)$. (Terms likes $B_{1z}(x)\delta(x - x_1)$ contribute to the self-energy of the vortex lines (49). Now the integration in (48.1) is trivial. We have for the interaction energy

$$L\varepsilon_{\text{int}} = \frac{2L\Phi_0}{8\pi}\left(B_2(x1) + B_1(x2)\right) \tag{52}$$

Both terms on the right contribute equally and using (45) we have

$$\varepsilon_{\text{int}}(d) = \frac{2\Phi_0}{4\pi} B_d(x) = \frac{4\Phi_0^2}{8\pi^2\lambda^2} K_0\left(\frac{d}{\lambda}\right) \tag{53}$$

One can also use the asymptotic expression for ε_{int} (see (47))

$$\varepsilon_{\text{int}} = \frac{4\Phi_0^2}{2^{7/2}\pi^{3/2}\lambda^2}\left(\frac{\lambda}{d}\right)^{1/2} e^{-x/\lambda}, \; x \triangleright\triangleright \lambda \tag{54}$$

When the distance $d \approx \lambda \triangleright\triangleright \xi$ the cores of vortex lines overlap [2]. The equation (42) is no longer valid. However, (39) is still valid.

Let us consider a closed contour near the surface of the cylinder. The change of wave function on passing round the contour is $2\pi\nu S$, where S is the cross-section area of the cylinder and ν -the number of vortex lines. One obtain from (16) that the electric flux is

$$\Phi = 2\Phi_0 \nu S - \frac{2m}{e\hbar}\oint \frac{j_s}{n_s} \cdot dl \tag{55}$$

Let us recall that a similarly relationship [4], [1], it was introduced for the first time by London, called fluxoid equation.

Each fluixoid, or vortex, is associated with a single quantum of flux represented as Φ_0 ,and is surrounded by a circulating suppercurrent , j_s , of spatial extent, λ . As the applied field increases, the fluxoids begin to interact and as the consequence ensembles themselves into a lattice. A simple geometrical argument for the spacing, d of a triangular lattice then gives the flux quantization condition [13],

$$Bd^2 = \frac{2}{\sqrt{3}}\Phi_0 \qquad (56)$$

, where B , is the induction.

The solution of Ginzburg-Landau phenomenological free energy (13) is useful for understanding the Abrikosov flux lattice. The coordinate-dependent order parameter φ describes the flux vortices of periodicity of a triangular lattice. Fluctuations from φ change the state to ψ , the minimization of free energy with respect to ψ , gives the ground state $\varphi(r/0)$.

The free energy is given by,

$$f = f_n + \int \left\{ \frac{\hbar^2}{2m} \left| \left(\nabla - i\frac{2e}{\hbar c}A \right)\psi \right|^2 + a|\psi|^2 + \frac{b}{2}|\psi|^4 + \frac{(B - H_0)^2}{8\pi} \right\} dV \qquad (57)$$

, the average magnetic induction is $\vec{B}(-y,0,0)$. The free energy has solutions of vortices of triangular form. The coordinates of the three vertices of a triangular vortex are given by $(0,0), (l,0)$, and $\left(\frac{1}{2}, \frac{\sqrt{3}}{2} \right) l$. The fluctuation from ground state corresponding to that of triangular lattice is that for small fluctuations. The deviation of the free energy from the mean-field value $F - F_{FM}$ with respect to the thermal energy, $k_B T$, can be used to obtain the physical properties of the fluctuations which are useful for understanding the melted vortex lattices. The deviation from the triangular Abrikosov lattice is defined as

$$D = \langle |\psi - a_1 \varphi(r/0)|^2 \rangle / a_1^2 \qquad (58)$$

which uses the spatial and thermal averages calculated with the probability $\exp(-F/k_B T)$. Classically,

$$D = \frac{k_B T}{F - F_{MF}} \qquad (59)$$

measures the fluctuations from the triangular vortex state. The fluctuation in the distance between vortexes becomes:

-case **1,** $(1 - T_{FM}/T_c) \cong 10^{-5} c^{-4/3} B^{2/3}$ (60)

-case **2**, $1 - T_{FM}/T_c \cong c^{-1} B^{5/4}$; (61)

-case **3,** a vortex transition below the transition temperature see [12]

, where, T_{FM} -the flux-lattice melting temperature, and $c = 0.1$ from Lindemann criterion of lattice melting when $d^2 = c^2 l^2$, and the flux quantization condition $l^2 = \Phi_0 / B$, $B = 2\pi n/\kappa$.

For numerical values $T_c = 175[MeV]$, in case of symmetry breaking, the case 1, results $T_{FM} \approx T_c$, and in case 2, results $T_{FM} \cong 100[keV]$, by using (56) in place of $\Phi_0 / B \cong d^2$ with $d = 0.3982[fm]$ (a very precisely value), and $\kappa \cong 1$, which is the temperature of fusion (melting!) of two nucleons.

This triangular lattice corresponds to the arrangement of the quarks pairs $u\bar{u}, u\bar{u}, d\bar{d}$ in the frame of a nucleon, see fig.1a, fig.1b.

A direct numerical analysis allows to obtain the following values for the current, force and energy. Thus, from (48) the current is given by:

$$j_\varphi = \frac{2c\Phi_0}{8(2\pi^3 x\lambda^5)^{1/2}} \frac{c\varepsilon_0}{c} e^{-x/\lambda} \cong 1.15e7[A/fm^2] \qquad (62)$$

,where $x \cong \lambda$,

For $x = 2 \cdot \lambda$, the current density decreases at $j_F \cong 3.e5[A/fm^2]$

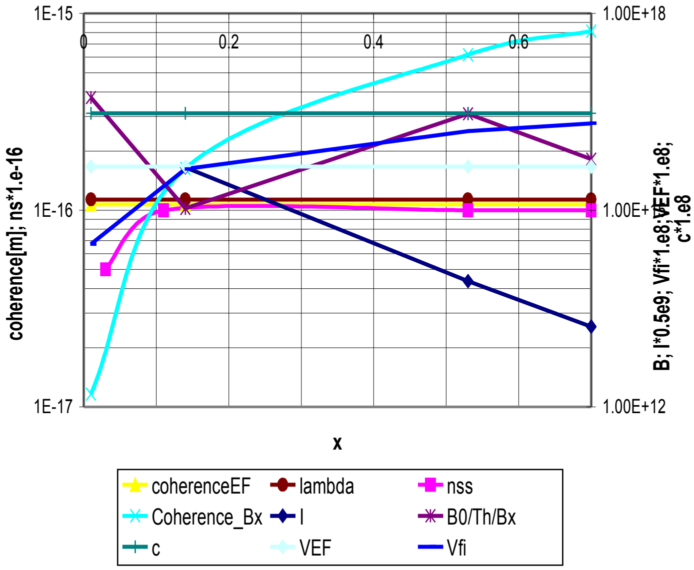
Note that velocity υ_F , moreover, if one considers the monopole current given by equation (10), as $j_\varphi = n_s v_F g_D$

, where the magnetic charge is:

$$g_d = 4\pi\varepsilon_0 \frac{\hbar c}{2e} = \frac{4\pi\varepsilon_0 \hbar c}{e^2} e = \frac{137}{2} e = 68.5e \qquad (63)$$

If we use the range $x \cong 0.1 \leq \lambda$, then the current is obtained by derivation of (46):

$$j_\varphi = \frac{1}{4}\frac{1}{x}\frac{1}{\lambda^2}\frac{4\pi\hbar c}{e}\frac{c^2\varepsilon_0}{c} = \frac{1}{4}\frac{1}{x}\frac{1}{\lambda^2} g_D c = \frac{n_s}{V}\upsilon_{Fi} g_D \rightarrow$$
$$\frac{\upsilon_{Fi}}{c} = \frac{1}{9.89} = 0.302e8[m/s] \qquad (64)$$



In order to make a correct choice of coherence length, were plotted in figure 2. expressions: (64), (31.3) (46), (48) and n_s, all associated with the range of x. The result indicates that for $x \rhd 0.1[fm]$, the velocity becomes larger than of the light, and the coherence grows faster, reaching values larger than the radius of the nucleon. Also, small values with those of the $\xi << \lambda$, it follows that $B > B_{c2} = 2.7e16$, when B_{c2} is given by (31), as a function of the ξ, or by (46) as $B(x)$.

Therefore, the best choice is to consider $\xi_0 \approx \lambda$, when $\upsilon_F < c$, but strictly $\lambda \geq \xi$, as

$$0.111 \leq \xi \leq 0.112 \qquad (64.1)$$

That correspond with the value calculated above (31.1) as a Fermi velocity. This result marks the essential proof of this model, namely the consideration of the monopole condensate.

From (4) and (47), the Lorentz' force is:

$$F_L = q v_{Fi} B \cong 2.25.e4[N] \qquad (65)$$

,when B is given by (46) and $x \cong \lambda$, for the upper limit:

$$B(x) = \frac{2\Phi_0}{2\pi\lambda^2 c}\log\frac{2\lambda}{\gamma x} \cong 4.7e15[J/Am^2] \qquad (66)$$

With B from (47) and for $x \rhd\rhd \lambda$, we have

$$B(x) = \frac{2\Phi_0}{c(8\pi x\lambda^3)^{1/2}} e^{-x/\lambda} = 3.8e-16\left[\frac{J}{Am^2}\right] \qquad (67)$$

, for $x = 72\lambda = 8.4[fm]$

, then, the force becomes $F_L \cong 1.8e-26[N]$, or in terms of energy

$\varepsilon_{barrier} = F_L * x = 945[MeV]$ (68)

,or the nucleon overall.

In case of $x \cong \xi \to (0)$

$$B(0) = \frac{2\Phi_0}{2\pi\lambda^2 c}\log\left(\frac{\lambda}{x}\right) = 1.03e15\left[\frac{J}{Am^2}\right] \quad (69)$$

, which respect (49.6).

The magnetic energy results from (49), and (49.3), and for ($\lambda \triangleright\triangleright x \triangleright\triangleright \xi$) from (36):

$$\varepsilon = c^2\varepsilon_0\left(\frac{2\Phi_0}{4\pi\lambda c}\right)^2\log\left(\frac{\lambda}{\xi}\right) = 1.09e-10[J/fm] \Rightarrow 0.66[GeV/fm] \quad (70)$$

, the force on the flux tube (string tension).

Now, from (54) and $d \approx (4 \div 6)\lambda \triangleright\triangleright \xi$, we have

$$\varepsilon_{int} = c^2\varepsilon_0\frac{4\Phi_0^2}{2^{7/2}\pi^{3/2}\lambda^2}\left(\frac{\lambda}{d}\right)^{1/2}e^{-x/\lambda} = 2.3e-11[J/fm] \Rightarrow 144[MeV] \quad (71)$$

What would be the value of the mass of the pion π^+, composed of a pair of quarks $u\bar{d}$ interacting at a distance $d \approx 2/3 \cong 5.65 * \lambda \cong 0.66[fm]$ of the radius of the nucleus.

Now, others important values of energy:

$\varepsilon_0(0) = \varepsilon_{int}(d = x - \lambda; x = 0.14) * 0.117[fm] \cong 1.e-09[J]$ (71.1)

, and from (69) with $x \cong \xi = 0.107[fm]$; (71.2)

$\varepsilon_{0h} = Vc^2\varepsilon_0(2H_{c1})^2/8\pi = 5.e-11[J]$ (71.3)

Now, the vortex energy is:

$\varepsilon_{vortex} = Vc^2\varepsilon_0 H_{c2}^2/8\pi = 1.16e-08[J]$ (71.4)

, where V -is the volume, see fig.1, accordingly, the corresponding equivalently masses are

$M = \varepsilon_{vortex}/c^2 \Rightarrow 73[GeV]$

, which seems to be equal to the mass of W boson.

The energy of the neutral boson Z is assimilated with the vortex-vortex three pairs interaction energy [22], $\varepsilon_Z = 3 * \varepsilon_{int-pair} = 91[GeV]$, when from (71)

$\varepsilon_{int-pair} = \varepsilon_{int}(d = 0.117 - 0.116; x = 1.4\lambda) = 4.85e-09[J] \to 30.33[GeV]$, (72.1)

is the energy of each of three pairs of vortex outermost $(d \cong 0)$ vortices lines which interacting (repel) at the center of the triangle situated at $x = 1.4\lambda$, thus, being generated

a neutral current in the zone of Z during the triangular arrangement of the lattice, see fig.1a, or fig.1b.
Now, is possible that the vortices start to coalesce into a giant vortex (GV) [26], see, fig. 1b. ,
Thus, from (71), results an another energy state-maximum possible ($d \cong 0$), probable that of *Higgs boson (H):*

$$\varepsilon_H = 3 * \varepsilon_{\text{int}}(d = 0.117 - 0.116; x = \lambda) = 2.17e - 08[J] \to 135[GeV] \qquad (72.2)$$

Notice that this is not in fact a particle, since contain others subparticles ($W, Z, u, d, monopoles$), so during high energy protons collision (CERN) can not be obtained as itself.
Here, a factor of 2 was introduced to correct on $2e$ for "pairs" in the G-L model.

3. Beta decay halftime calculation- an essential test of model validation

Below we will demonstrate that the mechanism for beta decay of radioisotopes is the same as the dark counts in the case of superconductors [2].

In [3], are discussed three types of possible fluctuations in superconducting strip (nucleon) which result in dissipation. Each one causes transition to the normal state from the metastable superconducting state when currents are close to the critical value I_c: (a) Spontaneous nucleation of a normal-state belt across the
strip with $2\pi - \varphi$ phase slip as in thin wires (a every phase slip meaning Φ_0 energy released).
(b) Spontaneous nucleation of a single vortex near the edge of the strip and its motion across to the opposite edge accompanied by a voltage pulse.
(c) Spontaneous nucleation of vortex-antivortex pairs and their unbinding as they move across the strip to opposite edges due to the Lorentz force, as well as the opposite process of nucleation of vortices and antivortices at the opposite edges and their annihilation in the strip middle.
In [3] are derived the energy barriers for three dissipative processes mentioned within the GL theory. Consider a thin-film strip (one of three vortexes of the nucleus) of width $w = r * \lambda$, see fig 1a, fig.1b. We choose the coordinates so that $0 \le x \le w$. Since we are interested in bias currents which may approach depairing values, the suppression of the superconducting order parameter (ψ) must be taken into account. Also in [3], is used the standard GL functional , given above in (13).
We will use the case (a), a vortex crossing from one strip edge to the opposite one induces a phase slip without creating a normal region across the strip (one of three vortexes of nucleus) width. When, is treating the vortex as a particle moving in the energy potential formed by the superconducting currents around vortex center inside the strip and by the Lorentz force induced by the bias current. In [3], it was derived the energy potential and is found the vortex crossings rate (phase slips and corresponding voltage pulses) in the framework of Langevin equation for viscous vortex motion by invoking the known solution of the corresponding Fokker-Planck equation.
Finally, from[3] the asymptotic estimate for the dark counts rate, results as:

$$R_v(I,\nu_h) = \frac{4k_B T c^2 R_\Omega}{\pi\Phi_0^2}\left(\frac{\pi\nu_h^3}{2}\right)^{1/2}\left(\frac{\pi\xi}{w}\right)^{\nu_h+1} Y\left(\frac{I}{\mu^2 I_0}\right) \quad (73)$$

, and where the bias current is :

$$I = \frac{2w}{\pi\xi} I_0 \kappa (1-\kappa^2) \quad (74.1)$$

$$I_0 = \varepsilon_0 \frac{c\Phi_0}{8\pi\Lambda}; \Lambda = \frac{2\lambda^2}{h_z} \quad (74.2)$$

Here, $h_z \cong \lambda$ -the axial (z) height of the monopole condensate.
Here, the critical current at which the energy barrier vanishes for a single vortex crossing:

$$I_c = \frac{2\mu^2 w I_0}{2.72\pi\xi}; \quad (74.3)$$

And the thermodynamic critical field is :

$$H_c = \frac{\Phi_0}{2\sqrt{2}\pi\xi\lambda c} \quad (74.4)$$

, where $\mu^2 = 1-\kappa^2$, and

$$Y(z) = \left(1+z^2\right)^{(\nu+1)/2} \exp\left[\nu z \tan^{-1}(1/z)\right] \quad (74.5)$$

, where

$\upsilon_h = \tau_{GL}(\varepsilon_{vortex} - Q_{bind})/\hbar$ -is the energy of the vortex during crossing the barrier of height $\varepsilon_{vortex} - Q_{bind}$ by quantum tunneling in place of the thermal activation as in [3], and overpassing an ohmic resistance along a transverse path way of the nuclide:

$$R_\Omega = \frac{R_q R_{nuclide}}{R_q + 2\pi(\xi/w)^2 R_{nuclide}} \quad (75)$$

Here, $\varepsilon_{vortex} = M_W$ from (71.4), and Q_{bind} is the beta decay energy as obtained from the data of each radionuclide of beta decay type (Nuclide chart 2010).
In the case of beta disintegration $n \to p + e^- + \nu_e$, or

$udd \to uud + e^- + \nu_e + W^-(80GeV)$

,or and the bias current is: $d(-1/3e) + 2*3/3e = u(+2/3e) + e$

In β^+ decay, energy is used to convert a proton into a neutron, while emitting a positron (e^+) and an electron neutrino (ν_e):

$Energy + p \to n + e^+ + \nu_e$

So unlike β^-; β^+ decay cannot occur in isolation because it requires energy due to the mass of the neutron being greater than the mass of the proton. β^+ decay can only happen inside nuclei when the value of the binding energy of the mother nucleus is less than that of the daughter nucleus. The difference between these energies goes into the reaction of

converting a proton into a neutron, a positron and a neutrino and into the kinetic energy of these particles.
In all the cases where β^+ decay is allowed energetically (and the proton is a part of a nucleus with electron shells) it is accompanied by the electron capture (EC) process, when an atomic electron is captured by a nucleus with the emission of a neutrino:
$Energy + p + e^- \to n + \nu_e$
However, in proton-rich nuclei where the energy difference between initial and final states is less than $2m_e c^2 \cong 0.56MeV$, then β^+ decay is not energetically possible, and electron capture is the sole decay mode.
This decay is also called K-capture because the inner most electron of an atom belongs to the K-shell of the electronic configuration of the atom, and this has the highest probability to interact with the nucleus.
Therefore, the bias current is: $e + u(2/3e) - 2*3/3e = d(-1/3e)$
At the first sight, the ohmic resistance of this ad-hoc electrical circuit created by the bias current $I(e\mp)$ due of quarks transformation $(d \to u)$, or $(EC(u \to d)$, is given as:

$$R_{nuclide} = \frac{Q_{bind}}{\tau_{GL}} \frac{1}{V_{vortex}^2} \qquad (76)$$

, and the superconducting quantum resistance is: $R_q = \hbar/(2e)^2 = 6.5k\Omega$
,where the vortex potential is $V_{vortex} = H_0\xi$, H_0 from (30.1)
Giordano [19] has suggested that phase slips due to macroscopic quantum tunneling may be the cause of the low temperature resistance tail in the 1D wires he studied in zero field. One possible mechanism for our low temperature resistivity tail could be quantum tunneling of vortices through the energy barrier [20]. One expects a crossover from thermal activation to quantum tunneling to occur when [21], in (73) in place of thermal activation we use the quantum tunneling: $k_B T = \hbar/\tau_{GL}$
A vortex moving from $x = 0 \to w$, during the time τ_{GL}.
We estimate the total interaction energy interaction with the neighborhood vortexes or with the one giant-vortexes, fig.1b, of others nucleons from the nuclide nucleus, during the time τ_{GL} along the vortex path by matching (74.1), (74.2) and (74.4) as:

$$Q_{bind} \cong (\Phi_0 I/c) = \frac{\Phi_0}{c} \frac{2w}{\pi\xi} \kappa (1-\kappa^2) \frac{\varepsilon_0 c \Phi_0 h_z}{8\pi \, 2\lambda^2} = \\ = \frac{c^2 \varepsilon_0 \pi \xi^2 h_z}{2} H_c^2 \frac{I}{I_0} \qquad (77)$$

, where the ratio $\frac{I}{I_0 \mu^2} = z$ was chosen as a variable in (73), through (74.5);
This is, in fact, the work done by the Lorentz force on the vortex path of the length w.
Now, we proceed to application to some radionuclides which decay beta, and beginning with the neutron.
Thus, the lifetime of the free neutron is a basic physical quantity, which is relevant in a variety of different fields of particle and astrophysics. Being directly related to the weak interaction characteristics it plays a vital role in the determination of the basic parameters

like coupling constants or quark mixing angles as well as for all cross sections related to weak $p-n$ interaction. From the most precise measurement within this class of experiments, results $\tau_n = 886.3[s]$.

From Nuclide chart-2010, result: $^{99}Mo\,(\beta^-, T_{1/2} = 65h, Q = 1.356MeV)$;

^{85}Kr, $Q_\beta = 0.687MeV$ and $T_{1/2} = 48h$, $\gamma-ray = 514KeV(0.46\%) \to T_{1/2} = 10.756yr$;

$\gamma-ray = 151KeV(95\%) \to T_{1/2} = 4.48h$; $^{137}_{55}Cs \to {}^{137}_{56}Ba + e^- + \bar{\nu}$, $Q_\beta = 1.175MeV$,

$\gamma-ray = 661KeV(85\%) \to T_{1/2} = 30.8yr$ etc

Numerically, with these data result: $\tau_{GL} = 1.5e-24[s]$, $Y = 2560$, $\nu_h \cong 157$, and with $w = r\lambda$ as variable, the evolution of dark count rate R_v, and of R_Ω, for different isotopes are given in fig. 5.

Here, the fraction of the bias current to critical current I/I_0 as used in $Y(z)$ from (74.5) : was deduced separately for $^{137}_{55}Cs$ as that of the plateau zone in fig.6 , respectively of $I/\mu^2 I_0 \cong 0.005$, by using the condition $R_v/T^{1/2} \cong 1$. We can observe that this value corresponds with the expected value from quarks transformation of $\cong 1(e^\pm)*v_{vortex}*1.6e-19r_0[Am] \to 124[A]$, where the vortex crossing velocity is $v_{vortx} = \lambda/\tau_{GL}$, and r_0 -K shell radius. Therefore, the bias current, which is perpendicularly on the monopoles current, is $I = 0.005\mu^2 I_0 = 150[A]$; where, $\mu^2 = 0.111$, and the monopoles current is: $I_0 \cong 3.e5[A]$ as given by (74.2), and $I_c = 1.6e4[A]$ from (74.3). From (77), results $Q_{bind} \cong 2.92e-13[J]$ or near equally with Q_β of the almost of nuclides, for example, for ^{100}Mo, $Q_\beta = 1.356MeV \to 2.17e-13[J]$.

Now, in case of quantum tunneling transmission coefficient [18] is $T = e^{-\frac{Q_\beta \tau_{GL}}{\hbar}} \cong 1$, but only when exists a process which facilitates the vortex crossing at this low energy $Q_{bind} \cong Q_\beta$, like the phase slip as was fully explained above.

Thus, it was established a logarithmic equation of the β decay rate which resulting a straight line as a function of the barrier width $(w = r\lambda)$ for every nuclide, fig.5, it decreasing in case of long lived nuclides, like ^{60}Fe. Therefore, this evolution is a decisive validation test of entirely model.

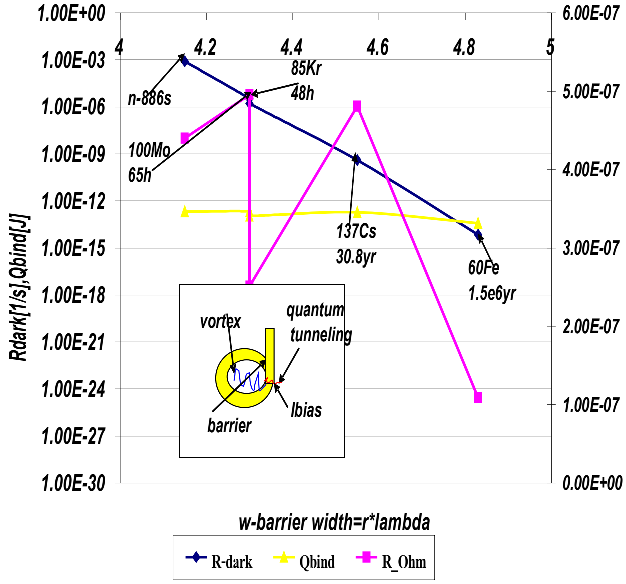


Fig.5. The evolution of dark count (β decay) rate as function of barrier width.

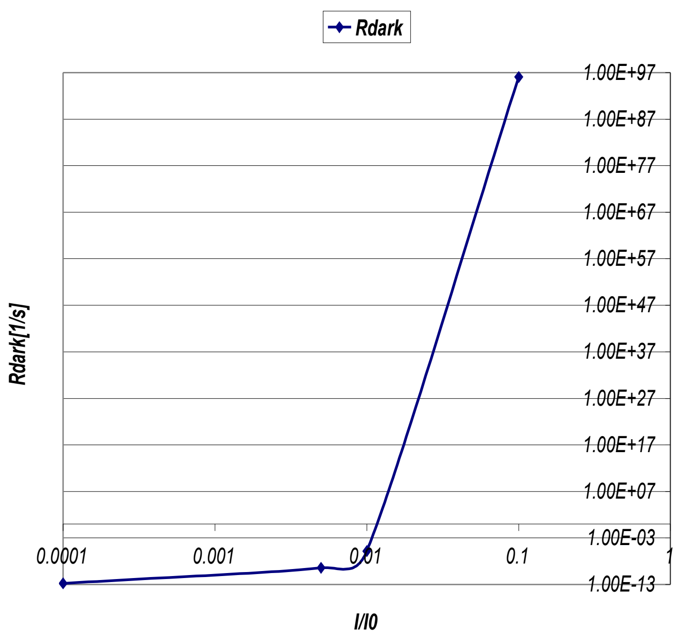


Fig.6 The evolution of the dark count rate (β) decay as a function of the bias current.

4. Connection with gravity

Now, in case of superconductors, applying an external current density j to the vortex system, the flux lines start to move under the action of the Lorenz force $F_L = jB/c$. Within a homogeneous system the driving Lorenz force is counteracted by the friction force $F_\eta = -\eta v$ alone, where v is the steady state velocity of the vortex system $v = j \cdot B / c\eta$, and η is Bardeen-Stephen viscous drag coefficient G.Blatterand [2]. The point-like defect exerting a force f_{imp} on the vortex produces a deformation at the impurity $u(r_{pin})$. In order to produce strong pinning the (negative) curvature of the pinning energy overcompensate the elasticity of the lattice.

However, as the field increases above H_{c2}, more and more vortex lines invade the superconductor. If the field increases even more, the superconducting regions separating the vortex lines becomes thinner and thinner until, finally, the whole material is filled with the magnetic field, and the superconductivity is destroyed.
This is for superconductors; in our case, what it is going to lock this inherent destruction of the superconductivity. Maybe there is an additional force (but of mechanical nature, being knew that in the vortex core for fluids is a negative pressure $-\Delta p$) equal to the Lorentz' force, such as the force of gravity.
Below we give a possible breakthrough possible explanation for a such gravity force.
Thus, if we look at a very simplified (scalar form) of Einstein's equation after multiplying with curvature radius ζ^2, the radius (object radius) R of curvature of spacetime is given as:

$$\varepsilon = \frac{2\zeta^2}{R^2} = \frac{8\pi G.p\zeta^2}{c^4} \quad (78)$$

If the pressure p on the surface of the tube is considered to be generated by the gravitation force equal with the *contra- Lorenz' force* $|F_L|$ applied on the curvature of space-time ζ situated in the center of vortex, its role being to counteracted the destruction of superconductivity.

$$4\pi\zeta^2 p = F_L = \frac{c^4}{G}\varepsilon = \mathrm{K}\,\varepsilon \quad (79)$$

With Lorentz' force calculated above

$$|F_L| = \mathrm{K}\,\varepsilon = \mathrm{K}\,\frac{\zeta_{nucleon}}{R} = \mathrm{K}\,\frac{4GM}{Rc^2} = 2.25e4[N]$$
$$\rightarrow \mathrm{K} = \frac{2.25e4}{4.28e-39} = 0.5e43 \quad (80)$$

, where $\varepsilon = \frac{\zeta_{nucleon}}{R} = \frac{4GM}{Rc^2} = \frac{4*6.67e-11*1.6e-27}{1.e-15*1.e17} = 4.28e-39$ (81)

,and K -"he vacuum elasticity"
,or from (79)

$$\mathrm{K} = \frac{c^4}{G} = 1.2e44 \quad (82)$$

Now, if we consider $B_{c2} \rightarrow K = 5e43$

So, to check this rationale, firstly, we consider the attraction of a nucleon-Earth when the spacetime curvature of the Earth is chosen little over the Schwarzschild radius

$$|F_G| = K\,\varepsilon_{Earth-nucleon} = \frac{GMm_p}{R^2_{Earth}} = \Rightarrow \varepsilon = \frac{\frac{GMm_p}{R^2}}{\frac{c^4}{G}} = \frac{1}{16}\frac{4GM}{Rc^2}\frac{4Gm_p}{Rc^2} =$$

$$\varepsilon_{Earth} \cdot \varepsilon_{nucleon\to Earth} = \frac{1}{16} 2.5e-09 * 6.7e-61 = 1.04e-70 \tag{83}$$

$$or \Rightarrow \frac{F_G}{K} = \frac{1.6e-26}{1.2e44} = 1.3e-70$$

Therefore, in the case of a nucleon, if we use in place of the curvature ζ , which is too smaller $4.7e-54[m]$ than of Plank length, we use just it as the lower limit, then is obtained an invariant, a surprising result:

$$l_P = \sqrt{\frac{\hbar G}{c^3}}$$

$$\frac{2}{R^2} = \frac{8\pi G}{c^4}\frac{F_L}{4\pi l_P^2} = \frac{8\pi G}{c^4}\frac{c^3}{4\pi\hbar G}\frac{ec\pi\hbar c}{\pi\lambda^2 ec} \cong \frac{1}{\lambda^2} \tag{84}$$

$$\frac{1}{R^2_{Curv-nucleon}} = \frac{6.7e-11 * 2.25e5}{1.6e-35^2 2.997e8^4} \Rightarrow R_{Curv-nucleon} \cong 1.e-16[m] \cong \lambda$$

5. Conclusions

In this paper was re-visited a model G-L, in order to calculate the Lorenz force, the current, and the energies of the Abrikosov vortex lines inside of the nucleon. Thus, it was found that these energies correspond of subatomic particles, W , Z , H bosons, and of meson π . So, the nucleon can be seen as a triangular lattice with three pairs of quarks-antiquarks in the tips of the triangle or as giant vortex due of the coalescence of vortices lines of three vortexes (W) . These axial vortexes (filaments) interacting in the lateral plane. A connection with gravity as a counteracted force to the superconductivity destruction, is discussed.
All of the keys of this model, as being analogous to a superconductor clinging very well, starting with the use of Maxwell's equation with monopoles, further mass, charge, and the number of monopoles (density), which define the penetration depth and the coherence length, and finally to the connection with gravity. Also, we can say that, because no free quarks were detected, the same is true for monopoles, both of which are confined together and in full in nucleons, when the temperature of the universe has reached $2*10^{12}\,{}^0K$. The model permits to explain the beta decay mechanism of radioisotopes to be the same as the dark counts in the case of superconductors.

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