International Journal of High Energy Physics
2018; 5(1): 55-62
http://www.sciencepublishinggroup.com/j/ijhep
doi: 10.11648/j.ijhep.20180501.16
ISSN: 2376-7405 (Print); ISSN: 2376-7448 (Online)

The Possibility of Particles Forming from a Bose-Einstein Condensate, in an Intense Magnetic or Gravitational Field

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To cite this article:
Marius Arghirescu. The Possibility of Particles Forming from a Bose-Einstein Condensate, in an Intense Magnetic or Gravitational Field. *International Journal of High Energy Physics*. Vol. 5, No. 1, 2018, pp. 55-62. doi: 10.11648/j.ijhep.20180501.16

Received: May 13, 2018; **Accepted**: May 29, 2018; **Published**: June 13, 2018

Abstract: In the paper - based on a previous work regarding the cold particles forming process as collapsed cold clusters of gammons- considered as pairs: $\gamma^* = (e^-e^+)$ of axially coupled electrons with opposed charges, is analyzed the possibility of gammons pre-cluster forming from a Bose-Einstein condensate formed in the magnetic and in the gravitational field of a star. By known relations of a BEC forming, it is argued that- in the magnetic field of a star, the forming of a gammonic BEC with particles density N_0 corresponding to those of a pre-cluster of gammons which may generates a particle-like stable cluster, may occurs- for a transition temperature $T_{BE} \approx 10^3$K, in a specific interval of field intensity and of temperature: B = ($2.2\text{x}10^6 \div 8.3\text{x}10^7$) T and $T_p = (4.8\text{x}10^{-11} \div 1.8\text{x}10^{-10})$ K. The possible mechanism of the formed BEC transforming into pre-clusters of gammons which may become particle-like collapsed BEC, is a pearlitization mechanism, resulted as fragmentation of the formed BEC. It is argued that the particles forming from chiral quantum vacuum fluctuations is possible at T →0K, either by a vortexial, magnetic-like field corresponding to $B \geq 10^4$ T or by already formed gammons, in a "step-by-step" process.

Keywords: Bose-Einstein Condensate, Bosonic Cluster, Elementary Particles, Magnetic Field Confining, Black Hole, Magnetar

1. Introduction

It is known that –according to the Superfluid vacuum theory (SVT, [1]), sometimes known as the „BEC vacuum theory", the fundamental physical vacuum is viewed as superfluid or as a Bose–Einstein condensate (BEC), with microscopic structure of fermion and antifermion pairs, describable by a macroscopic wave function, the visible matter appearing as excitations from this superfluid vacuum. In addition to single-particle excitations, the superfluid vacuum is capable of having real and virtual bound or quasibound composite excitations which are akin to bosons of integer spin which in particular are quanta of some interactions such as the electromagnetic interactions. However, the generation mechanism of real particles with non-null rest mass from virtual states of a quantum vacuum with low density, is not clear, even if the theory of the rest mass generation by the Higgs field gives an answer to this problem.

Also, the SVT not clarify some other problems such as the nature of force which generates virtual particle-like states, how the specific properties of each resulted particle/ sub-particle are generated and how is explained the mass spectra of the generated particles, (for example, of those called "elementary particles", resulted from or by cosmic radiation).

In a theory developed by author in the book: "The cold Genesis of Matter and Fields" [2, 3] is argued the possibility of a cold genesis of elementary particles in a very strong magnetic field, comparable to those of a magnetar or gravistar, in accordance with a resulted quasi-crystalline model of quark and particle, resulted as Bose-Einstein condensate of N gammons, considered as pairs $\gamma^*(e^{*+}- e^{*-})$ of quasi-electrons with diminished mass m_e^*, charge $e^* \approx (^2/_3)$e and magnetic moment μ_e^*, whose etherono-quantonic vortex of the magnetic moment: $\Gamma^*_\mu(r) = \Gamma_A + \Gamma_B$, is formed of sinergonic etherons ($m_s \approx 10^{-60}$ kg)- generating the magnetic potential A and of quantons ($m_h = h/c^2 = 7.37\text{x}10^{-51}$ kg) - generating vortex-tubes that materializes the B-field lines of magnetic induction.

The used electron model is with the charge: $e = S^0/k_1$ contained by its surface $S^0 = 4\pi a^2$ of radius: a = 1.41fm – close to the value of the nucleon radius resulted from the expression of the nuclear volume: $r_n \approx 1.25 \div 1.5$ fm, and with an exponential variation of its density: $\rho_e = \rho_e^0 \cdot e^{-r/\eta}$; with: $\rho_e^0 = 22.24\ kg/m^3$ *and* $\eta = 0.965\ fm$. It is argued that the electron may be formed at cold by an etherono-quantonic Γ^*_μ-vortex of magnetic field vortex-tubes which materializes the B-field lines of a magnetaric field $B \to 10^{12}$T formed around an electronic superdense kernel (centroid). approximated as cylindrical, with $r_0 \approx 10^{-18}$m. The electric field intensity E, the electric charge q and the magnetic induction B the results in the form:

$$E_s(r) = k_1 \cdot \rho_e(r) \cdot v_c^2 = \frac{1}{2} k_1 \cdot \frac{\Delta p_c}{\Delta t}; \quad q_s = \frac{4\pi \cdot r_q^2}{k_1}; \quad B = k_1 \cdot \rho_\mu(r) \cdot v_c; \ (k_1 = \frac{4\pi \cdot a^2}{e} = 1.56x10^{-10} \frac{m^2}{C}; \ v_c \approx c) \quad (1)$$

The resulted quark/particle model explains the nuclear force as an attraction of the nucleon's impenetrable volume υ_i in the field of $N^p = (2N+1)$- superposed vortices $\Gamma^*_\mu(r)$ of another nucleon, having an exponential variation of quanta impulse density: $p_\mu = \rho_\mu c$, according to equation:

$$V_n(r) = \upsilon_i P_n = V_n^0 \cdot e^{-r/\eta^*}; \ V_n^0 = \upsilon_i P_n^0; \ P_n(r) = (1/2)\rho_n(r) \cdot c^2 \quad (2)$$

with: $\upsilon_i(0.6fm) \approx 0.9fm^3$- the impenetrable quantum volume of the nucleon; $\rho_n^0 \approx N^p \cdot \rho_e^0$, and with $\eta^* = 0.755fm$, resulted by the condition: $\rho_\mu(a, e^*) \approx \rho_e(a, e^*) = (^2/_3)\rho_e(a, e) \sim e^* = (^2/_3)e$, [2-4].

The proton results in CBT by a neutral part with an attached electron (as in the Anderson's model [5]).

The virtual radius: r_μ^n of the proton's magnetic moment, μ_p, results –in the theory, by a degenerate Compton radius $r_\lambda = \lambda/2\pi = \hbar/m_p c$ of the attached positron, which decreased when the protonic positron was included in the N^p cluster volume, (N^p –the number of quasielectrons of the particle), from the value: $r_\mu^e = 3.86x10^{-13}m$, to the value: $r_i = r_\mu^p = 0,59fm$, as a consequence of the increasing of the impenetrable quantum volume mean density in which is included the protonic positron centrol: m_0, from the value: $\overline{\rho}_e$ to the value: $\overline{\rho}_n \cong f_d \cdot N^p \cdot \rho_e$.

This phenomenon may explain the neutron according to a "dynamid" model, with a degenerate electron with degenerate magnetic moment: $\mu_e^s = -4.597\mu_N$ rotated inside the quantum volume of a proton by the etherono-quantonic vortex $\Gamma(\mu_p)$ of its magnetic moment μ_p, with a speed $v_e \approx 1.7x10^{-2}c$, to an orbital with a radius: $r_e^* \approx 1.283$ fm [6] under dynamic equilibrium of forces on tangent and radial directions. The difference between the neutron' mass and the proton' mass: $\Delta_n \approx 2.6\ m_e$, is given by a "weson" w^- composed of the attached negatron and a linking gammon: $\sigma(e^{*+} - e^{*-})$ which is transformed into an electronic antineutrino given as pair of electronic centroids (with null spin, identical with the electronic neutrino, resulted as Majorana particle), by the loss of the quantum volume of quasielectrons, the quasielectron mass resulting of value: $m_e^* = (\Delta_n - 1)/2 \approx 0.81\ m_e$, [2-4, 6].

$$^0n_e = (N^p + w^-) = (N^p + e^- + \sigma) \to {}^1p_r + e^- + \overline{\nu}_e + \in_\sigma(889keV); \quad (3)$$

The model may explain also the reaction of K-electron capture: $p_r + e^+ \to n_e + \nu_e$, by the conclusion that the electronic neutrino results- in this reaction, by the coupling of the electron's superdense centroid with the centroid of the protonic positron having degenerate magnetic moment, with the loss of the quantum volume.

The theory, which predicted the existence of a preon $z^0 \approx 34\ m_e$, experimentally evidenced in 2015 but considered as X- boson of a fifth force, of leptons to quark binding, argues a preonic model of quarks whose stability was explained by a quasi-crystalline model of z^0-preon and of the quark core.

By CGT was argued the fact that- in a cold genesis model, the preon z^0 may results as cluster of n = 42 degenerate electrons with the mass: $m_e^* \approx 0.81\ m_e$ and with the super-dense kernels (centroids) vortexially confined in a volume of radius $r_z < 0.2$ fm, the z^0 cluster being given as a pair of quarcins: $c^{*\pm} = 21\ m_e^*$, with hexagonal symmetry (7x3 =21 quasielectrons).

The resulted sub-structure of the fundamental elementary particles, considered as formed "at cold", by quarks with effective mass (giving the particle's mass by the sum rule) and fractional electric charge $q^* = (+^2/_3 e; -^1/_3 e)$, formed as preonic clusters, is given by the preon z^0 considering also the existence of the zerons: $z_1 = 3z^0 = 102\ m_e$; $z_2 = 4z^0 = 136\ m_e$; $z_\pi = (z_1 + z_2) = 7z^0 = 238\ m_e$, with the following sub-structures [2-4, 6]:

Table 1. *Elementary particles: (theoretic mass) / (experimentally determined mass).*

Basic quarks: $m_1 = (z_2 - m_e^*) = 135.2\ m_e$,	$m_2^- = m_1 + e^- + \sigma_e = 137,8\ m_e$; $m_2^- \to m_1 + e^- + \overline{\nu}_e$; $(\sigma_e = (e^{+*} + e^{-*}) \to \overline{\nu}_e)$
Derived quarks: $p^+ (n^-) = m_1 (m_2) + 2z_\pi$	$n^- = p^+ + e^- + \sigma_e \to p^+ + e^- + \overline{\nu}_e$; $\lambda = n^- (p) + z_\pi$;; $s = \lambda + z_2$; $v^- = \lambda^- + 2z_2$
Mesons: $(q - \overline{q})$	Baryons: (q-q-q)
$\mu^- = 2Z_1 + e^- = 205\ m_e / \mu^+ = 206.7\ m_e$	$-p_r = 2p + n = 1836.2m_e$; $n_e = 2n + p = 1838.8m_e$; / p_r^+, $n_e = 1836.1$; $1838.7m_e$;
$\pi^o = m_1 + \overline{m}_1 = 270.4m_e$;/ $\pi^0 = 264.2\ m_e$	$-\Lambda^o = s + n + p = 2212.8\ m_e$; / $\Lambda^0 = 2182.7\ m_e$
$\pi^+ = m_1 + \overline{m}_2 = 273\ m_e$;/ $\pi^+ = 273.2\ m_e$	$-\Delta^{(++;+;0;-)} = s^\pm + \lambda^\pm + p^+(n^-) = 2445.6$; $2453.4\ m_e$; $/\Delta^{\pm;0} = 2411 \pm 4\ m_e$
$K^+ = m_1 + \overline{\lambda} = 987\ m_e$;/ $K^+ = 966.3\ m_e$	$-\Sigma^+ = v + 2p = 2346.2m_e$; $\Sigma^- = v + 2n = 2351.4m_e$;/$\Sigma^+$, $\Sigma^- = 2327$; $2342.6\ m_e$
$K^o = m_2 + \overline{\lambda} = 989.6\ m_e$;/ $K^o = 974.5\ m_e$	$-\Sigma^o = v + n + p = 2348.8\ m_e$ / $\Sigma^0 = 2333\ m_e$;
$\eta^o = m_2 + \overline{s} = 1125.6\ m_e$;/ $\eta^0 = 1073\ m_e$;	$-\Xi^o = 2s + p = 2586.8\ m_e$; $\Xi^- = 2s + n = 2589.4\ m_e$; /$\Xi^0$, $\Xi^- = 2572$; $2587.7\ m_e$;
	$-\Omega^- = 3v = 3371.4\ m_e$; / $\Omega^- = 3278\ m_e$.

The classical, pre-quantum mechanism of the preonic cold quarks forming and of dark matter bosons forming was explained in a relative recent paper of the author [7] by the cold genesis of two preonic bosons with hexagonal

symmetry: $z_\pi = 7z^0$; $z_2 = 4z^0$, by the magnetic interaction between constituents, as a mechanism with the next steps:
a)z^{0*}/z^0 -pre-cluster/cluster forming, with the aid of magnetic confinement; b) z_2^*/z_2- and z_π^*/z_π- pre-cluster/cluster forming; c) $(q^{\pm}/q^0)$- quark or pseudo-quark pre-cluster/cluster forming; d) pre-cluster of quarks or pseudo-quarks forming; e) elementary particle/dark boson forming.

The total collapsing is impeded- according to the model, by a repulsive force of a scalar field generated by remanent thermal vibrations of the electronic centroids (kernels) which determines a local increasing of the quantum static pressure.

The formed structures corresponds- according to the model, to an organized (quasi-crystallin) collapsed Bose-Einstein condensate [7], with quasi-crystallin kernel given by an arrangement with hexagonal symmetry of the electronic centroids, having- in the model, a barel-like form, with a diameter of 10^{-18} m [2-4].

The possibility of Bose-Einstein condensate forming in a magnetic field and in a gravitational field was studied in some reference papers [8, 9].

The collapsing of a BEC, corresponding to a sharply density increasing of the formed condensate, was obtained experimentally with ~15000 atoms of ^{85}Rb cooled in a magnetic trap at ~3nK with B ≈ 162Gs [10], being observed a remnant condensate as fraction of the initial condensate and a missing atoms part.

The stability of the remnant condensate that was observed during the collapse of attractive BECs was explained by the existence of an absolute stable minimum that appears only if the energy is nonlocal, as consequence of the condensate's transition which occurs when the scattering length 'a' from the Gross-Pitaevskii equation is tuned from zero scattering length to a negative scattering length, determined by the magnetic field, as a linear function of $1/(B - B_0)$, where B_0 is the Feshback resonance position [11].

It was shown also that the transition temperature of a BEC formed in a magnetic field, decreases with the strength of the B-field, according to the relation: $(\bar{B}) = T_0[1- (^2/_5)\cdot R(\bar{B})]$, with $R(\bar{B}) \sim 1 + (\bar{B})^2$.

It was considered theoretically also the possibility to describe the dark matter as a non-relativistic, Newtonian Bose-Einstein gravitational condensate, [12] but at the atomic level and the possibility to consider a black hole as a Bose-Einstein condensate of gravitons [13].

In the present paper we analyze the possibility of gammons pre-clusters forming, specific to cold formed quarks or pseudo-quarks (corresponding to neutral bosons), as Bose-Einstein condensate produced in the magnetic and the gravitational field of a star which ensures at its surface the condition: $T < T_{BE}$.

2. The Bose-Einstein Condensate of Gammons in a Magnetic Field

According to a pre-quantum analyze of the forming process of a collapsed cluster of gammons considered as gammonic pairs: $\gamma^* = (e^-e^+)$ of axially coupled electrons with opposed charges [7], it resulted that –under a specific Bose-Einstein condensate forming temperature, T_{BE}, the magnetic interaction between the gammons is enough for the gammons pre-cluster forming and self-confining, with the forming of a stable particle-like cluster, if the external magnetic field B not exceed a critical value B_c given by the condition that the V_B (B- γ^*) potential to be lower than the $V_\gamma(\gamma^* - \gamma^*)$ potential: $V_B = \mu_e\cdot B \le V_\gamma(r) = \mu_0\mu_e^2/2\pi r^3$.

The gammonic pairs may results –in the magnetic field of a neutronic star, from nuclear γ-emissions resulted particularly by K-electron capture: $p_r + e^+ \rightarrow n_e + \gamma$ and by combinations between electrons resulted from attracted atoms and positrons resulted as β^+ -radiation emitted by protons transformed into neutrons: $p_r \rightarrow n_e + e^+ + \nu$, which are trapped in the star's magnetic field, in which has the Hamiltonian:

$$H = \frac{(p - e\cdot\bar{A})^2}{2m} - \frac{e\cdot\hbar}{2m}\bar{\sigma}\cdot\bar{B} = \frac{p_\lambda^2}{2m} - \bar{\mu}\cdot\bar{B} \quad (4)$$

with A, B, p_λ -the magnetic potential, the magnetic induction and respective-the canonic impulse.

Is of particular interest to know which category of stars may offer conditions for particles cold genesis.

It is known that the quantum nature of a cold gas is evident when the distance between particles is smaller than the thermal wavelength, i.e: $l_i = N^{-1/3} \le \lambda_t = h/p_k$, ($p_k = \sqrt{(2mE_k)}$). In a magnetic B-field, the energy of a charged particle, m, is: $E_B = p^2/2m + \mu_e\cdot B$; ($\mu_e = e\hbar/2m\cdot c$).

Because that in CGT the gammons have a magnetic moment μ_γ given by the axially coupling of negatron and positron, according to the similitude principle, we may use for the proposed study a relation of the T_{BE} as those deduced by Rojas and Villegas for the non-relativistic case ($E_k = \pi k_B T$) of charged particles [8], of the form:

$$\frac{L}{\lambda_t} \cong \upsilon\cdot N; \quad \Rightarrow \quad T_B = \frac{4\pi^2\hbar^3 c}{eBm\cdot k_B L}N = \frac{2\pi^2\hbar^4}{\mu_1 m^2 k_B L}N; \quad \mu_1 = \mu_e\cdot B >> k_B T \quad (5)$$

$$\frac{N_0}{N} = \frac{\lambda_t}{L\cdot\sqrt{\mu_1}}; \quad N = \frac{\sqrt{\pi}}{\upsilon\sqrt{\mu_1}}; \quad \upsilon = \frac{\lambda_t h\cdot c}{e\cdot B} = \frac{\lambda_t\hbar^2\pi}{\mu_1 m}; \quad \lambda_t = \frac{h}{\sqrt{2\pi\, m\cdot k_B T}}; \quad (6)$$

in which: T_B - the temperature necessary for having a macroscopic fraction of the total density of charged particles in the ground state; L - the dimension of the ground state system parallel to the external magnetic B- field; N; N_0 - the density of m- particles outside and in the B-E condensate; λ_t - the thermal wavelength; $\upsilon = \lambda_t hc/eB$- the elementary cell and

$e B\hbar/2m\cdot c = \mu_1$ - the effective chemical potential, corresponding to a magnetic potential: $\mu_1 = \mu_e\cdot B$.

For $T \ll T_B$ we have almost all the particles in the ground state n = 0 and a true BEC exists.

From eqns. (4a) and (4b) it results that:

$$N = \frac{\sqrt{\pi}}{\upsilon\sqrt{\mu_1}} = \sqrt{\frac{\mu_1}{\pi}}\frac{m}{\lambda_t \hbar^2} = \frac{L\sqrt{\mu_1}}{\lambda_t} N_0 \;\; ; \;\; \Rightarrow L = \frac{m}{N_0 \hbar^2 \sqrt{\pi}} \;\; ; \quad (7)$$

Considering-according to CGT [7], that the pre-cluster corresponding to the un-collapsed Bose-Einstein condensate of gammons ($m = m_\gamma \approx 2m_e = 1.82\text{x}10^{-30}$kg) has the distance between the degenerate electrons, of meta-stable equilibrium, of value: a = 1.41 fm, it results from eq. (6) that: $N_0 \approx 1/a^3 = 3.57\text{x}10^{44}$ and: $L \approx 2.5\text{x}10^{-7}$m.

The pre-cluster of a cold formed quark (~377 degenerate gammons) corresponds- in consequence, to a fragmentation part, of radius $r_p = a\cdot(377)^{-1/3} \approx 7.2a = 10.2$ fm, resulted as consequence of a 'pearlitization' phenomenon generated by the decreasing of the inter-distance $l_i = N^{-1/3} < \lambda_t$, the quasi-crystallin form of the pre-cluster and thereafter- of the particle-like collapsed cluster, resulting by magnetic interaction between 'residual' magnetic moments of the gammonic bosons [7].

In the absence of a magnetic field and a gravitic field, supposing that it exists a concentration of gammons $N \approx 10^{24}$,for example, it results-according to the specific relation of BEC transition temperature:

$$T_{BE}(B=0) = 3.3125 \cdot \frac{\hbar^2}{m\cdot k_B} N^{\frac{2}{3}} \quad (8)$$

that the temperature of transition to a BEC state is of the order: $T_{BE}^1 = 1464$ K.

Because that- according to eqn. (4), the external B-field decreases the value of $T_{BE,}$ we may choose a test temperature $T_B \approx 10^3$ K. Also, considering a degenerate charge of quasielectrons forming the gammonic pair equal to those of up-quark [2-4]: $e^* \approx (^2/_3)e$ and a magnetic moment of the gammon: $\mu_\gamma \approx (m_e/m_\gamma)\cdot(^2/_3)\mu_{BP} \approx 3\text{x}10^{-24}$ J/T, (μ_{BP} –the Procopiu-Bohr magneton: $9.28\text{x}10^{-24}$ J/T), resulted from the un-canceled axially coupled magnetic moments of the $e^{*\pm}$ - charges, it results from eqns. (3) and (4) that:

$$N = \frac{L\sqrt{\mu_1}}{\lambda_t} N_0 = \frac{\mu_1 m_\gamma^2 k_B T_B L}{2\pi^2 \hbar^4} \;\; ; \;\; \Rightarrow \lambda_t\sqrt{\mu_1} = h\sqrt{\frac{\mu_1}{2\pi\cdot m_\gamma k_B T_p}} = \frac{2\pi^2\hbar^4}{m_\gamma^2 k_B T_B} N_0 \;\; ; \;\; \sqrt{\frac{\mu_1}{T_p}} = \frac{\pi\cdot\hbar^3 N_0}{T_B}\sqrt{\frac{2\pi}{m^3 k_B}} \quad (9)$$

With $T_B \approx 10^3$, it results that: $\lambda_t\sqrt{\mu_1} = 1.9\text{x}10^{-11}$ and $\sqrt{(T_p/\mu_1)} = 2.7\text{x}T_B$, with T_p - the temperature to which the pre-cluster P^c of gammonic particles density N_0 is formed. Choosing some values for T_B and B, will results the corresponding values for $\mu_1 = \mu_\gamma\cdot B$ and for T_p. For example, for $T_B = 10^3$ K and $B = 10^6$ T, it results that $T_p \approx 2.2\text{x}10^{-11}$K, $\lambda_t = 1.12\text{x}10^{-2}$ m and $N = 1.38\text{x}10^{31}$.

The previous conclusion of the gammon's magnetic moment value is based on the CGT's conclusion that the etherono-quantonic vortex $\Gamma_\mu = 2\pi r_\lambda c$ induced by the chirality of the electron's superdense kernel (centroid) is the cause of the electron's charge forming and not inverse.

Linde [14] suggested that very high values of the magnetic field, exceeding 10^{11}T, may generate the condensation of $W^\pm$ bosons resulted from the electro-weak interaction theory.

In our case, a magnetic field $B \approx 10^{11}$T gives- with $T_B = 10^3$ K, a value $T_p \approx 2.2\text{x}10^{-6}$K. But- according to CGT, for the P^c-pre-cluster collapsing the potential μ_1 must be lower than the potential of magnetic interaction between gammons at a rougly approximate distance $d_\lambda = \lambda/2\pi$ with $\lambda = h/m_\gamma c = 1.93\text{x}10^{-13}$m: $V_\mu = \mu_0/2\pi(\mu_\gamma^2/d_\lambda^2) = 2.5\text{x}10^{-16}$ J, resulting that- for the pre-cluster's forming, it is necessary a B –field lower than a critical value: $B_c = 8.3\text{x}10^7$ T or a supplementary force that may compensate the repulsion between the gammonic magnetic moments oriented parallel with the field $B > B_c$.

The inferior limit of the B-field is given by the conclusion that the quantum vacuum temperature is given by quantons, ($m_h = 7.37\text{x}10^{-51}$kg) according to the relation: $k_B T_h \approx m_h c^2$ resulting that $T_h \approx 4.8\text{x}10^{-11}$K, which corresponds by eqn. (8) and by $T_B = 10^3$ K, to $B_l = 2.2\text{x}10^6$ T and which is comparable with the Hawking's temperature at which the surface of a massive "black hole" of mass $M \geq 10^5$ solar masses may radiate (may emits Hawking's radiation).

We may conclude also that the dynamic pressure of the quantonic vortex-tubes which materializes the magnetic induction field lines – according to CGT, may decrease the temperature T_h of the quantum vacuum.

Also, if we choose a lower transition temperature T_B, for example: $T_B = 10^2$ K, by eqn. (8) and with $B = B_l = 2.2\text{x}10^6$ T (or with $T_B = 10^3$ K but with a lower B-field), will results a temperature of the P^c –pre-cluster forming: $T_p = 4.8\text{x}10^{-13}$ K- lower than the considered limit T_h.

So, maintaining the test temperature $T_B = 10^3$ K, it results that we have an interval: $B = (2.2\text{x}10^6 \div 8.3\text{x}10^7)$ T in which is fulfilled the condition: $T_p \geq T_h$ and which corresponds by eqn. (8) to: $T_p = (4.8\text{x}10^{-11} \div 1.8\text{x}10^{-10})$ K.

The gammonic particles concentration N corresponding to the values: $T_B = 10^3$K; $B = (2.2\text{x}10^6 \div 8.3\text{x}10^7)$T, results- from eqn. (8), of value:

$N = N_0\, L\cdot\mu_1/\lambda_t\sqrt{\mu_1} = (3.1\text{x}10^{31} \div 1.17\text{x}10^{33}) > 10^{24}$ - much higher than the limit imposed by the eqn. (7) of T_{BE} (B =0).

Because that- according to the last astrophysical data, the determined values of the "black hole" magnetic field are much lower than those predicted by the theoretical models [15], it results that the previous deduced conditions for B and T_p may exists only in the outer space at enough far distance of a magnetaric star.

For example, if we have- according also to eqn. (1), a magnetaric field:

$$B(R) = k_1\boldsymbol{\rho}_c v_c = k_1\boldsymbol{\rho}_0\left(\frac{R_0}{R}\right)^2 c\frac{R_0}{R} = B_0\left(\frac{\boldsymbol{R}_0}{\boldsymbol{R}}\right)^3 \quad (10)$$

with $B_0 \approx 10^{11}$ T at the magnetar's surface, $S_0(R_0)$, it results that the values: B= ($2.2\text{x}10^6 \div 8.3\text{x}10^7$) T are attained in the interval: $\Delta R_T = (35\div10{,}6)R_0$.

Taking into account also the cooling effect of the magnetic field, resulted according to CGT and by the effect of the μ_1 potential, it results that in the outer space of a magnetar, in the distance interval ΔR_T, the specific condition: T_p = ($4.8\text{x}10^{-11} \div 1.8\text{x}10^{-10}$) K, of P^c -pre-clusters forming, may be fulfilled.

Also, we may hypothesize that such specific conditions for B-field and T_p may be generated also by a rotational black hole with electrically charged surface, (model permitted by the general relativity).

In a Gross-Pitaevskii equation, of the BEC's wave function:

$$\left(-\frac{\hbar^2}{2\text{m}}\frac{\partial^2}{\partial r^2}+V(r)+V_i(a_s)\right)\psi(r)=\mu\cdot\psi(r)\ ; \qquad V_i(a_s)=\frac{4\pi\cdot\hbar^2 a_s}{m}|\psi|^2\ ; \quad \text{N}_\text{p} = \int|\psi|^2 d^3r \tag{11}$$

specific to temperatures much smaller than T_{BE}, in which: m is the boson's mass, a_s is the scattering length, μ is the chemical potential and N is the number of bosons, the possibility of bosons confining in an etherono-quantonic vortex-tube ξ_B which materializes the magnetic field lines, can be equated by considering a negative value of the coherent scattering lengt (a) –corresponding to an attractive interaction, the external potential V (r) being- in this case, a magneto-gravitic potential V_{MG} given by the local gradient ∇_r ($\rho_\Gamma c$) of the etherono-quantonic vortex-tubes $\boldsymbol{\xi_B}$ that materializes the field lines of magnetic induction B, [2-4].

3. The Gravito-Magnetic Potential of the Magnetic Field Lines

When the total attractive potential: $V_a = -(V_{MG} + V_i)$ is much higher than k_BT, we have: $\mu \approx \mu_1 = V_a$, which is –in this case, the effective chemical potential.

If $V_i = \mu_\gamma\cdot B$, it results that the considered magneto-gravitic potential V_{MG} decreases the value of the B-field at which a BEC with gammons may be obtained, resulted from the obtained equation: $\lambda_t\sqrt{\mu_1} = 1.9\text{x}10^{-11}$, with: $T_B = 10^3$ K and $T_p \approx T_h = 4.8\text{x}10^{-11}$K. For equate this effect, we may use the hypothesis of the magnetic fluxon $\phi_0 = h/2e \approx 2\text{x}10^{-15}$ Wb, considering that the ξ_B -vortex-tubes of the B-field are fluxon ϕ_0 and that they have a linear decreasing of the impulse density: $p_c = \rho(r)\cdot(\omega\cdot r) = \rho(r)\cdot c$ for $r \le r_\phi$ (specific to the vortex-tubes) and a mean density: ρ_ϕ approximate equal with those resulted from the local B_l –field value resulted from eqn. (1): $B_l = k_1\rho_B c$, $\rho_B(R) = \rho_B^0(R_0/R)^3$.

For a surface S = 1m^2, the fluxons number n_ϕ rectangular on S are given according to the equation:

$$\phi = B\cdot S = B\cdot 1 = n_\phi\phi_0;\ \Rightarrow\ n_\phi = B\cdot 1/\phi_0; \tag{12}$$

Considering an unit length of the fluxons: l_ϕ = 1m, the fluxon's mass on unit length m_ϕ is given according to the relations:

$$\text{m}_\varphi = \int 2\pi r\rho_\varphi^0\frac{r_0}{r}dr=\pi\cdot r_\varphi^2\cdot\rho_\varphi=\pi\cdot r_\varphi^2\frac{B(R)}{k_1\cdot c}=\frac{B(R)}{k_1\cdot c}\frac{1}{n_\varphi}=\frac{\varphi_0}{k_1 c}=\frac{h}{2e\cdot k_1 c}=4.27x10^{-14}kg/m; \qquad \text{k}_1=1.56x10^{-10}\frac{m^2}{C} \tag{13}$$

It results also that: $r_\phi = \sqrt{(m_\phi k_1 c/B(R))}$. For example, for B $\approx 10^6$T it results: $r_\phi = 4.47\text{x}10^{-11}$m –corresponding- by the equality: $l_i = 2r_\phi$, to N = $1.4\text{x}10^{30}$ and for B = 10^{11}T it results: $r_\phi = 1.41\text{x}10^{-13}$m –corresponding -by the equality: $l_i = 2r_\phi$, to N = $4.45\text{x}10^{37}$, (compared with $N_0 = 3.57\text{x}10^{44}$). Assuming- according to CGT [2-4], that the vortex-tubes $\boldsymbol{\xi_B}$ are formed around vectorial photons (vectons) of 2.7K microwave radiation of the quantum vacuum, identified in CGT as electric field quanta having a gauge radius: $r_v \approx 0.41a$ = 0.578fm [4] and that the electron has a small impenetrable quantum volume: $\upsilon_i^e = 1.15\text{x}10^{-4}\text{fm}^3$ [6], from eqn. (12) it results by the eqns. (2) and (12) that:

$$\text{V}_\text{MG}(\text{r}) = \frac{\upsilon_i}{2}\rho_\varphi(r)\cdot c^2=\frac{\upsilon_i c^2}{4\pi\text{r}}\sqrt{\frac{m_\varphi\cdot B(R)}{k_1\cdot c}}=\frac{\upsilon_i\cdot c}{4\pi k_1\cdot\text{r}}\sqrt{\varphi_0 B(R)}\ ; \qquad \rho_\varphi(\text{r})=\rho_\varphi^0\frac{\text{r}_\text{v}}{\text{r}}=\frac{m_\varphi}{2\pi\cdot r_\varphi}\frac{1}{\text{r}}\ ; \quad \text{m}_\varphi = 2\pi\rho_\varphi^0 r_v r_\varphi\ ; \tag{14}$$

with:

$$\mu_1 = \mu_\gamma\cdot\text{B(R)} + \text{K}_\text{M}\frac{\sqrt{\text{B(R)}}}{\text{r}}\quad ;\quad \text{K}_\text{M} = \frac{\upsilon_i^e\cdot c}{4\pi\ k_1}\sqrt{\varphi_0} = 7.87\text{x}10^{-40}\left(\frac{\text{J}\cdot\text{m}}{\sqrt{\text{T}}}\right)\ ;\quad \text{r}_\varphi=\sqrt{\frac{m_\varphi k_1\cdot c}{B(R)}} \tag{15}$$

For $l_i = N^{-1/3} = r_\phi$, we have:

$V_{MG}(r_\phi) = (\upsilon_i^e\cdot c)\ B(R)/4\pi k_1 = 1.76\text{x}10^{-32}B(R)$-

i.e- a neglijible value comparative to:

$V_B = \mu_e\cdot B \approx 3\text{x}10^{-24}B(R)$.

But the magneto-gravitic potential $V_{MG}(r)$ may be important for the confining of bosons with small or null magnetic moment, of the order of $10^{-31}\div10^{-34}$ J/T, as those of the neutrino: $\mu_\nu \approx 10^{-10}\mu_B$ or those of photons and may explain- in the last case, the electron's forming as collapsed Bose-Einstein condensate of photons with super-dense kernel in a magnetaric-like field [2-4].

Also, we may conclude that in the case of neutral mesons and baryons having small or null magnetic moment but an impenetrable quantum volume of the size order: $(1\div10^{-2})fm^3$, the potential V_{MG} may generates dark matter bosons in a magnetaric-like field, by mesons cold confining.

For example, for the confining of π-mesons with $\upsilon_i^{\pi} \approx 2.5x10^{-2}fm^3$ [5] by a magnetaric field: $B \approx 10^{11}T$, it results from eqn (13), that: $r_\phi = 1.4x10^{-13}m$ and $V_{MG}(r_\phi) \approx 3.8x10^{-19}J \approx 2.4$ eV, corresponding to a confining force: $F_{MG}(r_\phi) = 2.7x10^{-6}$ N.

In the same-time, it results that-by the V_{MG} potential, the ξ_B-vortex-tubes helps the pearlitization of a formed BEC into pre-clusters with N_0- density of particles and relative small number of bosons and the gammonic pre-clusters' collapsing and their transforming into particles.

For example, considering a radius r_p of meta-stable equilibrium of a drop of BEC formed by the BEC's pearlitization and maintained by the equilibrium between the force generated by the internal thermal energy $F_t(r_p) = V\cdot N_0k_BT_i$ and the force generated by the surface tension, σ:

$$\frac{dE}{dr} = -P_0\frac{dV}{dr} + \sigma\frac{dS}{dr} = 0 \ ; \ V = \frac{4\pi}{3}r^3 \ ; \ S = 4\pi\cdot r^2; \qquad (16)$$

because that $\sigma = (½)F_\gamma/l$, (the force rectangular on unit length), for: $N_0 \approx 1/a^3 = 3.57x10^{44}$, (a = 1.41 fm- the metastable equilibrium inter-distance between gammons [7]), and because the antiparallel magnetic moments of two adjacent gammons of a precluster have a residual (reciprocal) value given by: $E_\gamma = 2m_ec^2 \approx V_e(a,e^*) + V^e_\mu(a,e^*) \approx 3V^e_\mu(a,e^*)$ and: $B(d) \approx E(d)/c$, [7], giving: $e^* \approx \sqrt{(^2/_3)}\cdot e$, it results that:

$$\mu_1(a) = \frac{m_e}{m_\gamma}\frac{e^*c\cdot d}{2} = \mu_{BP}\sqrt{\frac{2}{3}}\cdot\frac{d}{2\cdot r_\lambda}; \ r_\lambda = \frac{\hbar}{m_ec}; \ e^* = \frac{4\pi(0.9d)^2}{k_1} = \sqrt{\frac{2}{3}}e \ ; \ d = a \qquad (17)$$

and–by CGT, because $m_ec^2 = e^2/8\pi\varepsilon_0a$, it results that:

$$V^e_\mu(a) = -\frac{e^{*2}}{8\pi\varepsilon_0a} = -\left(\frac{2}{3}\right)\frac{e^2}{8\pi\varepsilon_0a}; \ \Rightarrow \ \frac{F_\gamma}{1} \approx \frac{F^e_\mu}{a} = \frac{\mu_0}{2\pi}\frac{2}{3}\frac{\mu^2_{BP}}{r^2_\lambda a^3} = \frac{e^2}{12\pi\varepsilon_0a^3} \qquad (18)$$

and because the electric force between gammons may be neglected, the meta-stable equilibrium radius has the form:

$$r_p = \frac{2\sigma}{P_0} = \frac{F_\gamma}{l\cdot P_0} \approx \frac{\mu_0}{3\pi}\frac{\mu^2_{BP}}{r^2_\lambda a^3}\frac{1}{N_0k_BT_i} = \frac{\mu_0}{3\pi}\frac{\mu^2_{BP}}{r^2_\lambda}\frac{1}{k_BT_B} \approx 5.5x\frac{10^{-6}}{T_B} \ [m] \qquad (19)$$

For $T_B \approx 10^3K$ it results: $r_p \approx 5x10^{-9}$ m, so the pearlitization with the forming of quasi-cylindrical pre-clusters of baryonic neutral particles corresponding to a radius: $r_b < r_a$ may be formed by large oscillations of the internal temperature T_i - given by the zeroth vibrations, around the value $T = T_B$.

If we consider a BEC of z^0-preons- formed by clusterizing and collapsing process as neutral couple of two quarcins ($m_q \approx 17m_e$) with degenerate charge e^*, axially coupled, with the same value N_0 and with $T_B' \approx 86K$ –given by (8), it results from eqns. (17)-(19), that: $\mu_z \approx \mu_\gamma/17$ and: $r_p' \approx 4x10^{-11}m$.

Under this value r_p of metastable equilibrium, because the decreasing of the internal energy, the residual (reciprocal) magnetic moments of the gammons generates the pre-cluster's collapsing, without destruction- conform to CGT.

If the internal pre-cluster's temperature T_i is maintained close to the metastable equilibrium value T_B, the pre-cluster's collapsing may still occur in a strong magnetic field, by the aid of the magneto-gravitic potential $V_{MG}(r_\phi)$, according to the model.

So, it is argued the conclusion that also a static but strong magnetic field may create conditions for BEC forming and-particularly, for particle-like collapsed BEC forming, by bosons capturing with the ξ_B-vortex-tubes which materializes the B-field lines.

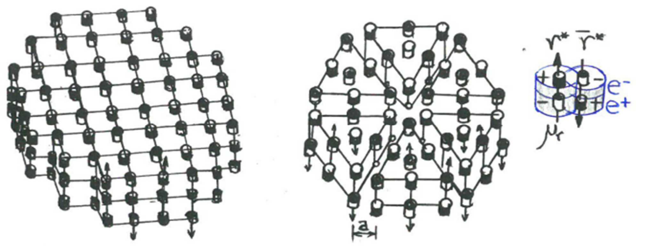

Figure 1. *Part of a crystallized gammonic pre-cluster which may result by a BEC's pearlitizing, (CGT).*

It results-in consequence, two plausible scenario of particles cold genesis-according to CGT: a) by clusterization, from z^{0*}- preonic pre-clusters, in a step-by step scenario, by steps of z^*-/q^{0*}- pre-clusters cold collapsing, or: b) by the pearlitization of a bigger BEC, by the temperature oscillation around the value T_B, with the cold collapsing of the resulted BEC pre-cluster but without destruction.

Relative to the particles genesis from quantum vacuum fluctuations, considered in SVT but also in CGT- as chiral (vortexial) fluctuations, contrary to the scenario of spontaneous particles-antiparticles pairs forming from virtual particle-like pairs, supposed by the Heisemberg's nedetermination relation of quantum mechanics, it results – from the previous analyze, that the fermions and bosons forming process is possible only by enough strong vortexial fluctuations in the etherono-quantonic quantum vacuum-which determine also the speed of the process and the mass of the formed particles, resulting as more plausible a "step-by-step" scenario of particles forming by chiral fluctuations, beginning with the vectorial photons forming- process possible also at lower density of the quantum vacuum, comparable with those of a lower magnetic field: $\rho_B(B) \approx \rho(m_p)$.

For example, for the cold genesis of a quantum of 2.7K radiation, if it is formed from two vectorial photons named "vectons" in CGT, with mass: $m_v = 2.3x10^{-40}kg$ and considered with an inertial mass of gauge radius: $r_v = 0.41a = 0.6fm$- in the free state, it results that: $\rho_B(B) \approx \rho(m_v) = 2.5x10^5$ kg/m^3, resulting that a vortexial magnetic-like field corresponding to $B_v = k_1\rho_Bc \approx 10^4$ T may generates vectons from the primordial dark energy- composed of etherons and quantons ($m_hc^2 = h\cdot1$), according to CGT, the cold genesis of electrons being possible at higher values of magnetic-like energy density, in a magnetaric-like field, [9, 10].

It results- according to CGT, that the forming of virtual particles from the energy of quantum vacuum by chiral fluctuation and their transforming into real particles involve either a magnetic-like (vortexial) field of values higher than a critical value: $B_v \approx 10^4$ T, or already formed gammonic pairs $\gamma^*(e^-e^+)$ and a low temperature: $T << 10^3$K, and because that the relative stability of its specific structure is ensured only by the existence of superdense kernels (centroids), resulted from confined quantons- in CGT, which stabilizes the formed vortex(es) and its vortexial structure.

The explaining of the strong interaction with mass excess, in which the total mass of resulted particles exceed the total mass of particles entered in reaction, results as in the case of reaction:

$\pi^-(\overline{m}_1+m_2) + p_r(2p^+ + n^-) + Q \rightarrow \Lambda^o(s+n+p) + K^o(m_2 + \overline{\lambda})$, by the participation of real bosons of quantum vacuum, particularly-dark matter bosons, formed by quark-antiquark pairs, with the intrinsic energy m_bc^2 lower than the interaction energy, Q_i, [3,4,7].

For a Bose-Einstein condensate in a gravitational potential $V_g = m \cdot g \cdot y$, because that the transition temperature is increased by the presence of the gravitational field [9], for the forming of a gammonic pre-cluster with a density of gammons: $N_0 \approx 1/a^3 = 3.57 \times 10^{44}$ we may conclude that in the gravitational field of a black hole with a surface temperature $T_t < T_B(g=0)$ given by eqn. (7), the conditions of the P^γ –pre-cluster forming are fulfilled if it is obtained a specific gammons concentration, for example: $N \geq 10^{24}$, for $T_B \approx$ 1464 K. A concentration $N > 10^{24}$ of gammons may results by gammons gravitational attraction toward the black hole's surface, the condition: $T_p < T_{BE}$ at the BH's surface being –in this case, fulfilled, because the very low temperature at the BH's surface.

We may consider also a neutrino magnetic moment: $\mu_v \approx 10^{-10}\mu_B$ corresponding to the superior limit deduced by SuperKamiokande collaboration [16], and a neutrino mass used by CGT: $m_v \approx 10^{-4}m_e = 9 \times 10^{-35}$kg, (comparative with those indicated by recent experimental data [17]: $m_v \approx 1.85$eV $= 3.3 \times 10^{-36}$kg), which corresponds in CGT to a couple of antiparallel electronic centroids with antiparallel chiralities and a radius of its section: $r_0 \approx 10^{-18}$ m.

A Bose-Einstein condensate of neutrinos may be considered as cluster of gammonic superdense centroids confined in a volume comparable with those of a constituent quark mass, (considered in CGT with ~378 gammons with the centroids in a volume $\upsilon_q(r_n \approx 1\text{fm})$, with an approximate density of particles: $N_0^v \approx 10^{47}$ which- in a magnetic B-field, gives- by eqn. (6), a value $L \approx 4.6 \times 10^{-14}$m.

For the situation of a neutrinos flux generated by a star situated in the vicinity of a Black hole, of value comparable with those of the solar neutrinos at the Earth's surface: $\phi_v = n_0 \cdot c \approx 6.5 \times 10^{14}$/m·s, we have: $N = n_0$, resulting- by eqn. (7), that temperatures $T < T_B \approx 6 \times 10^{-5}$K as those considered for the surface of a black hole star, may generates the forming of Bose –Einstein condensate of neutrinos, which- at higher dimensions than those of an atomic nucleus, may initiates the cold forming of a micro-black-hole.

If –instead of antiparallel coupled electronic centroids forming electronic neutrinos we have electronic centroids with antiparallel chiralities axially coupled, it results in consequence –according to the cold genesis quasi-crystallin quark model of CGT, the possibility of particles forming starting with the forming of a Bose-Einstein condensate of electronic centroids with antiparallel chiralities axially and parallely coupled (on axial, respective-on radial direction), which- after the pearlitization of the BEC, may forms mesonic or baryonic quasi-crystallin kernels which initiates the forming of etherono-quantonic vortexes around their center, by the action of quantum and sub-quantum winds, corresponding to magnetic moments which attracts- by the resulted self-potential $V = V_0|\psi|^2$, some photons of the quantum vacuum, (previously formed), which- in this way, generates the quantum volume of the resulted composite particle, according to CGT.

The previous conclusions argues the possibility of dark matter bosons genesis in the field of a black hole or of a magnetar-type star- at an enough long distance from its surface.

4. Conclusions

In the present paper, based on a previous work [7] regarding the cold particles forming process as collapsed cold cluster of gammons- considered as gammonic pairs: $\gamma^* = (e^-e^+)$ of axially coupled electrons with opposed charges, we analyze the possibility of gammons pre-cluster forming, specific to cold formed quarks or pseudo-quarks (corresponding to neutral bosons), as Bose-Einstein condensate formed in the magnetic and in the gravitational field of a star which ensures at its surface the condition: $T < T_{BE.}$

By known relations of a BEC forming, it is argued that- in the magnetic field of a star, the forming of a gammonic Bose-Einstein condensate with particles density N_0 corresponding to those of a pre-cluster of gammons which may generates a particle-like stable cluster, may occurs- for a transition temperature $T_{BE} \approx 10^3$K, in an specific interval of field intensity and of temperature: $B = (2.2 \times 10^6 \div 8.3 \times 10^7)$ T and $T_p = (4.8 \times 10^{-11} \div 1.8 \times 10^{-10})$ K, which may exists in the surrounding vacuum of a magnetar-type star or of a rotational black hole with electrically charged surface, which may generate also a strong magnetic field.

The possible mechanism of the formed BEC transforming into pre-clusters of gammons which may become particle-like collapsed BEC, is a pearlitization mechanism, resulted as fragmentation of the formed BEC.

It is argued also that in the gravitational field of a black hole with a surface temperature $T_t < T_{BE}(g=0)$, the conditions of gammonic pre-clusters forming are fulfilled if it is obtained a specific gammons concentration which may results by gammons gravitational attraction toward the black hole's surface.

Also, it is argued that temperatures $T < T_B$ as those considered for the surface of a black hole star, may generates the forming of Bose –Einstein condensates of neutrinos, which- at higher dimensions than those of an atomic nucleus, may initiates the cold forming of dark matter bosons or of a micro-black-hole.

In the same time, this possibility sustains- by the proposed model of particles forming, the possibility of dark super-heavy particles/bosons existence- supposed by some dark matter models, as particle-like collapsed Bose-Einstein condensate formed in a strong magnetic or/and gravitational field, with a quasi-crystallin arrangement at the particle kernel's level, obtained as consequence of the very low temperature of the formed particle, with the aid of the field, and maintained by the generating of a repulsive potential $V_r(d)$ of short range, by the 'zeroth' vibrations of the super-dense electronic centroids ($\sim 10^{-18}$m diameter) which determines local destruction of internal vortexial structures (cold photons), releasing their energy in form of quantum flux which impede the particle's kernel collapse.

It is argued that the particles forming from quantum vacuum fluctuations- considered in the quantum mechanics, is possible at $T \to 0$K, either by a vortexial, magnetic-like field, corresponding to $B \geq 10^4$ T, with the producing of dense kernel(s) which may stabilize the quantum vortex, or by already formed gammons, in a "step-by-step" process, by clusterizing or pearlitizing and the cold collapsing of the resulted pre-clusters, without their destruction.

The possibility to explain the masses and the magnetic and electric properties of the elementary particles resulted from the cosmic radiation in a preonic model, by a cold clusterizing process and with only two quasi-crystallin basic bosons: $z_2 = 4z^0 = 136\ m_e$; $z_\pi = 7z^0 = 238\ m_e$, indicates –in our opinion, that- after the electrons (negatrons and positrons) forming, the clusterizing was the main process of the particles forming in the Universe, by at least two steps: a)- the quasi-crystallin pre-cluster forming (of gammons or of formed z^0-preons or z_2- and z_π- zerons) and b) -the pre-cluster's cold collapsing, without destruction, with the maintaining of a quasi-crystallin arrangement of electronic centroids at the kernel's level.

The resulted explicative model of particles cold genesis may explain the existence of a huge number of material particles in the Universe by the conclusion of cold ("dark") photons and thereafter- of electronic neutrinos and cold electrons genesis in the Cold Proto-Universe's period, by chiral (vortexial) fluctuations in the 'primordial dark energy'- considered in CGT as omnidirectional fluxes of etherons and quantons circulated through a brownian part of etherons and quantons.

The generalization to the scale of an atomic nucleus permits to consider an atomic nucleus as a (non-collapsed) fermionic condensate with quasi-crystallin arrangement of nucleons, which may explain the nucleonic "magic" numbers of maximal stability [2-4], the nuclear fission reactions- well described by the droplet nuclear model, being explained by a nuclear local phase transformation at the internal temperature increasing –determined by the nucleons' vibrations.

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