The Origin of Dark Energy in the New Scenario of Universe Creation and Evolution (revised 2016)

Stefan Mehedinteanu[1]

[1] CITON-Romania (retired) Senior Researcher; E-Mail: mehedintz@yahoo.com

Key words: LHC, Inflation, reheating, photons creation, quantum critical temperature , quarks, color gluons, Higgs field, epochs, Schwinger effect, polaritons, dark energy, cosmological constant

Abstract

In the work we have advanced another scenario for Universe creation and its evolution, respectively, when the decay of a huge number $\cong 10^{80}$ of Micro-black-holes (micro-virtual black holes) as generated due of Quantum fluctuations at Reheating (at $2.4\times10^{13} \div 8.85\times10^{9}$ GeV), and when themselves till the Confinement epoch (~10^{-6}s; V=2.1GeV; T=10^{15}K) adjust theirs dimensions to that of $e^{+}e^{-}$ pairs (quarks), by radiating **soft free (mass less) photons** and keeping a gravitational charges (mass less gravitons) in event horizon as has recently agreed by Hawking et all (2016). Later at Confinement or Hadrons epoch (~10^{-6}s; V=2GeV; T=10^{13}K), these generate an electrical field (E) that produces a Meissner effect at the interface between normal phase of quarks tubes and the superconducting phase a superconductor magnetic field (B) generated by the soft free photons as color gluons condensate the. The inverse value of the penetration length of B is just $W^{\pm}$ mass at high densities (QED) and, the effective non-abelian color gluon mass ($\approx 2GeV$) at QCD.
After the Ionization time (9.8 billions years), the existing free photons and electrons together form Quantum Wells where are generated $e^{+}e^{-}$ excitons, called polaritons as in Earth's experiments. These polaritons sustains the accelerated expansion of Universe, their mass and energy verifies the cosmological constant, that one can consider them as dark energy. During matter creation (+dark matter) a fix number of particles $\cong 10^{80}$ and a total mass of $M \cong 2.2\times10^{53}[Kg]$ are obtained, that it is a spectacular result, which it could be the essential prove of the entirely model. Also, is proposed a new test for the finally proof of the model as the deduction of the lifetime value of the β^{-} decay of the free neutron.

1. Introduction

When the decay of a huge number $\cong 10^{80}$ of Micro-black-holes (micro-virtual black holes- μBH) as been produced due of Quantum fluctuations [1a] at Reheating ((at$2.4\times10^{13} \div 8.85\times10^{9}$ GeV; t=3.3×10^{-32}s; T=2.6×10^{26}K), that generates during theirs decaying the same number of soft photons [1a],[1c] which condensate later at

Confinement into gluons , and when the Micro-black-holes themselves adjust theirs dimensions to that of electrons ($e^+ e^-$) pair and of others leptons (quarks) but keeping the gravitational charge [1a].
At Confinement (~10^{-6}s; V=2.1GeV; T=10^{13}K) these ex-Micro-black-holes as becoming $e^+ e^-$ pairs (quarks) which gives an external electrical field (E) [1a], that produces later at the interface between normal phase and the superconducting phase a superconductor magnetic field (B) generated by the free photons color gluons condensate a Meissner effect. The inverse value of the penetration length of B is the effective non-abelian color gluon mass ($\approx 2GeV$) at QCD. Thus, finally, the color gluon condensate components (B) which equilibrate the quarks electrical field E (that at theirs turn equilibrate the gravitational charge) gives the expansion rate (curvature) of Universe as expressed through the Hubble length from Einstein Equation [1a].
After the discovery of quark (q) jets in 1975 in $e^+ - e^- \to q\bar{q}$ at SLAC, detailed studies in understanding the hadronisation process, and hence the energy-momentum profiles of the quark jets, were initiated in 1977 by Feynman and Field. These $e^+ e^-$ pair's collisions generate either as $\Upsilon\,(94.6GeV) \to 3g$, $(g - gluons)$ near the characteristic energy of electroweak symmetry breaking $\approx 100GeV$, or $q\bar{q}g(\approx fewGeV)$, a $3-jet$ like in PETRA, DESY experiments, for more details see [1b]. At SLAC these $q\bar{q}g$ flux tube is generated by an external electrical field E by Schwinger effect or $e^+ - e^-$ collision..
Also, it will be shown [1a] that the masses and the number of μBH particles coincide with the numbers of quarks pairs, gluons pairs, electrons pairs, and finally of the new introduced, the polaritons as dark energy after Ionization time, when by tunneling as the **Schwinger effect** with an external electrical field $E \cong E_{cr}$, *here the electric field* E *being induced by* $e^+ - e^-$ *pairs.* It was confirmed that the photons decoupling (at Recombination- H atoms forming) when the Thomson scattering with electrons reaction rate $\Gamma_\gamma = n_e \sigma_T$ becomes smaller than the expansion rate, the photons do not scatter any more, theirs distribution freezes and red shifts (z) with the expansion. The recombination it was reconfirmed to occur at $\approx 3000K$, $z \approx 1100$ at Ionization time.
Recently a new type of system exhibiting spontaneous coherence has emerged—the exciton–polariton condensate. Exciton–polaritons (or polaritons for short) are bosonic quasiparticles that exist inside semiconductor microcavities, consisting of a superposition of an exciton and a cavity photon. Above a threshold density the polaritons macroscopically (visible) occupy the same quantum state, forming a condensate. The polaritons have a lifetime that is typically comparable to or shorter than thermalization times, giving them an inherently non-equilibrium nature.

2. How determine μBH particles production the timeline of Universe

In Inflation models [2], the scale leaving the horizon at a given epoch is directly related to the number $N(\varphi)$ of e-folds of slow-roll inflation that occur after the epoch of horizon exit. Indeed, since H -the Hubble length is slowly varying, we have $d\ln k = d(\ln(aH)) \cong d\ln a = \frac{\dot{a}dt}{a} = Hdt$. From the definition Eq. (38) of [2] this gives

$d\ln k = -dN(\varphi)$ as of eq.(46) from [2], and therefore $\ln(k_{end}/k) = N(\varphi)$, or, $k_{end} = ke^{N}[m]$ where k_{end} is the scale leaving the horizon at the end of slow-roll inflation, or usually $k^{-1} << k_{end}^{-1}[m]$, the correct equation being $k = k_{end}e^{N}[m^{-1}]$. When the wavelength $(k^{-1}[m])$ is large compared to the Hubble length $(H^{-1}[m])$, the distance that light can travel in a Hubble time becomes small compared to the wavelength, and hence all motion is very slow and the pattern is essentially frozen in.

Since, the FLRW metric of the universe must be of the form $ds^2 = a(t)^2 ds_3^2 - c^2dt^2$ where ds_3^2 is a three-dimensional metric that must be one of **(a)** flat space, **(b)** a sphere of constant positive curvature or **(c)** a hyperbolic space with constant negative curvature, or for small commoving time $dt = \dfrac{1}{aHc}$, we can consider the distance as $L = ds \cong a = a_{end}$, so the volume is given by:

$$V_{matter} = (a)^4 \frac{1}{c}[m^3 s]$$

During Universe evolution [2a], the *horizon leave* is when $a_{leave} = k_{leave}/H_{leave} = 1$,; $k_{leave}^{-1} = H_{leave}^{-1} = 10^{-27}[m]$, $t_{leave} = H_{leave}^{-1}/c = 3.3\times 10^{-36}s$; when the *Electroweak epoch* begins. Here the Hubble constant is defined as $H^2 = \dfrac{8\pi}{3}GV \to \dfrac{8\pi GV^4}{3(\hbar c)^3 c^4}$,

Therefore, we consider Micro-black-holes pairs, but that occur with a number density of approximately *one per Quantum bubble ref. [6]cited in [1a], initially it was considered per* Planck volume [1a] , that means $n \cong d_H^{-3} \cong 10^{69}m^{-3}$, for Hubble constant $d_H = H^{-1} = 10^{-23}[m]$ at horizon entry when the field becomes $V = 1.15\times 10^{13}GeV$, $a_{end} = 2.6$, $n_{end\_Inflation} = 10^{69}\times a_{end}^3 = 5.6\times 10^{67}$, see below.

Thus, it was established that these "vacuum fluctuations" which in fact take place at *Reheating* in Universe evolution when the field of Quantum bubble becomes $V = 1.15\times 10^{13}GeV$, $T = 2.66\times 10^{26}$; $t = H^{-1}/c = 3.3\times 10^{-32}$, and when the curvature radius at Horizon entry is $R = 2.4\times 10^{-23}[m]$; Hubble constant is $H_{end}^{-1} = 10^{-23}[m]$; and the mass of μBH particle is $m_{\mu BH} = 2\times 10^{-14}kg$ (see below), and these affect the properties of the vacuum, giving it a nonzero energy known as vacuum energy, itself a type of *zero-point energy*.

Here, we introduce the following our derivation. Thus, from [1a], the Ricci scalar curvature is $\Re = -6(\ddot{a}/a + \dot{a}^2/a^2)$, which reduces to $\Re = \dfrac{6}{c^2a^2}\dot{a}^2$, or

$$\frac{6}{c^2}\left(\frac{\dot{a}^2}{a^2}\right) = \frac{V^4\hbar c}{3M_{Plank}^2(\hbar c)^3c^4} + 2\Lambda \;; \qquad (1)$$

$$\Re = \frac{1}{R^2} = \frac{6H^2}{c^2}[m^{-2}],$$

Since, $a \approx e^{Ht}$,

$\dot{a} = He^{Ht}$;

$H[s^{-1}] = \dfrac{c}{\sqrt{6}R}$; with $V = 1.15\times 10^{13}\,GeV$ at quantum fluctuations, the curvature R is $R \cong 2.4\times 10^{-23}[m]$, see below, and horizon-entry is when $k_{end} = k_{leave}e^{-N}$;
$k_{end} = 2.6\times 10^{23}[m^{-1}]$, $a_{end} = 2.6$, $H_{end} = 10^{23}[m^{-1}]$, $t_{end} = H_{end}^{-1}/c = 3.3\times 10^{-32}\,s$ we chose $N = 8.25$ to match the iterations cycle:
$m_g \to \hbar\nu \to k_B T \to \varepsilon \to R \to H_{end}^{-1} \to a_{end} \to N$, and
the scale arrives at $a_{end} = k_{end}/H_{end} \cong 1$ with $H_{end}^{-1} = 10^{-23}[m]$ at horizon entry.
The field is $V = \varepsilon_{\mu BH} = 1.15\times 10^{13}\,GeV \to 1840[J]$; the volume of μBH particle is $V_{vol} = \lambda_C^4/c = 2.3\times 10^{-124}\,m^3 s$, the Compton length being $\lambda_C = \hbar/mc$; $\lambda_C = 1.6\times 10^{-29}[m]$
.

The number of μBH pairs could be estimated as $N_{\mu BH} = \dfrac{M_{Universe}}{m_{\mu BH}} = 10^{67}$; where
$m_{\mu BH} = 2\times 10^{-14}\,kg$
and the necessary volume is $V_{necessary} = N_{\mu BH}\times\lambda_c^3 = 4.6\times 10^{-20}[m^3]$,
$V_{Universe} = a^4/c \cong 1.56\times 10^{-7}[m^3 s]$
, and the available volume is; $V_{available} = (a)^3 = 17.8[m^3]$.
The proof is given as: the energy of Universe is
$E_{Universe} = M_U c^2 = 2.2\times 10^{53} c^2 = 1.9\times 10^{70}\,J$, so
$N_{\mu BH} = E_{Universe}/\varepsilon_{\mu BH} = 1.9\times 10^{70}/1840 = 10^{67}$ that verifies the above value.
Another proof-the light bending by Earth

Now, in same way as for a nucleon [1c] we can derive a similar formula for the Earth, where in place of the Lorenz force F_L we use the gravitational pressure due of gravity charges on the curvature radius ζ_{Earth} of Earth, which is given as:

$$\left(\frac{\zeta_{Earth}}{R_{Earth}}\right)^2 = \frac{4\pi G(\sqrt{G}M_P)^2 n_{Earth}}{c^4\cdot a^2_{entry\_Horizon(end)}} = 2.46\times 10^{-18}$$

where, $\sqrt{G}M_P = (\hbar c)^{1/2}$ is the gravity charge embedded in the quarks of nucleons of number $n_{nucleons\_Earth}$ inside the Earth: $597.e24/1.67e-27 = 3.57e51$, and the Earth radius is $R_{Earth} = 6.37e6[m]$,
and the Schwarzschild radius

$$\zeta = \frac{2GM}{c^2} = 8.86e-03[m]$$

, or

$$\frac{\zeta^2}{R^2} = \frac{0.00886^2}{(6.37\times 10^6)^2} = 2.1\times 10^{-18}$$

, and the light bending is $\theta = \zeta/R = 1.4\times 10^{-9}$
, that proves the concept of gravity charges.

Now, we will verify for entire Universe, when we have

$\left(\frac{\zeta_U}{R_U}\right)^2 \equiv \frac{4\pi G(\sqrt{G}M_P)^2 n_U}{c^4 \cdot a^2_{entry\_Horizon(end)}} = 4.56$; where $\zeta_U = \frac{2GM_U}{c^2} = 3.25 \times 10^{26}[m]$, and the curvature radius of Universe is $R_U = 1.29 \times 10^{26}[m]$, and the number of particles is $n_U \cong 10^{70}$, so $\frac{\zeta_U^2}{R_U^2} = 6.36$

Also, the force and the energy of **pure** gravity charge (or gravitons) result to be $\varepsilon \cong E = (\sqrt{G}M_P)^2 / a_{end} = \hbar c / a_{end} = 1.14 \times 10^{-26} J$ which remain *frozen* at horizon entry ($a_{end} \cong 2.6$), that could be considered as dark matter particles near without mass $m_{dark} = E/c^2 = 1.28 \times 10^{-43}[kg]$, but of very high Compton length $\lambda_C = \hbar/m_{dark}c = 2.6[m] \cong a_{end}$, and of frequency $\omega = c/\lambda = 1.14 \times 10^8[Hz]$, :

$E_{dark} = 10^{69} \cdot a^3_{end\_dark} \cdot \hbar c / a^1_{end} = 4.7 \times 10^{70}$, $a_{end\_dark} = 4.2 \times 10^9[m]$ at $V = 7.17 TeV$, $t = 6.7 \times 10^{-12} s$ when the **dark particles production ceases**, see bellow.

The average magnitude of the electric field (negative charge) in the event horizon of a micro-black-hole is like that of the model electron given in [7], and where the inside "trapped" photon is similar with the "absorbed" photon from thermal energy V in case of μBH particle, or in other words the electron is a decaying μBH particle, with equation (4) from [1a]:

$$\langle E \rangle = \sqrt{\frac{6\hbar c}{\pi \varepsilon_0 \lambda_C^4}}$$

, it results $\langle E \rangle = 2.9 \times 10^{50}[N/C]$, and where the gravity charge formally corresponds as $\hbar c \to e^2$.

2.1 The μBH particles production end

The Compton space-time volume μBH particle has the size $V_{Compton} = \lambda_C^3 \times (\lambda_C / c) = 6.6 \times 10^{-112}[m^3 s]$.

Where, $\lambda_C = \hbar / m_* c = 2.1 \times 10^{-26}[m]$,

, that result the quarks pairs of mass: $m_* = 1.6 \times 10^{-17}[kg] \to 8.85 \times 10^9 GeV$

$H^{-1}_{end} = 10^{-16}[m]$; $a_{end\_quarks} = 3.4 \times 10^3$; $k^{-1}_{end} = 2.9 \times 10^{-20}[m]$; $N = 17.2$;

$H^{-1}_{leave} = k^{-1}_{leave} = 10^{-27}[m]$, $t = 3.35 \times 10^{-25} s$

$\varepsilon_q = 3 \times 10^{13} / a_{end} = 8.85 \times 10^9 GeV$, $T = 2 \times 10^{23} K$

$n_{pairs} = 10^{69} \cdot 3.9 \times 10^{10} \cong 3.9 \times 10^{79}$

This represent the final number value of future particles like quarks.

The necessary volume is $V_{necessary} = N_{pairs} \times \lambda_c^3 = 1.3 \times 10^{-7}[m^3]$,

, and the available volume is; $V_{available} = (a)^3 = 3.9 \times 10^{10}[m^3]$.

The curvature radius from eq. (1) becomes $R = 4.1 \times 10^{-17}[m]$.

To note that in mean time a lot of the as produced before μBH particles, these already are decayed partially mainly into quarks and gluons, so, the total energy remaining $\cong 10^{70} J$

2.2 The μBH dark particles production end

Where, $\lambda_C = \hbar / m_* c = 2.6\times 10^{-20}[m]$,

, that result the quarks pairs of mass: $m_* = 1.3\times 10^{-23}[kg] \to 7.17\times 10^3 GeV$

$H_{end}^{-1} = 2\times 10^{-3}[m]$; $a_{end\_quarks} = 4.19\times 10^9$; $k_{end}^{-1} = 4.8\times 10^{-13}[m]$; $N = 33.8$;

$H_{leave}^{-1} = k_{leave}^{-1} = 10^{-27}[m]$, $t_{end\_dark} = 6.7\times 10^{-12} s$

$\varepsilon_{end\_dark} = 3\times 10^{13} / a_{end\_dark} = 7.17 TeV$, $T = 6\times 10^{17} K$

$E_{dark} = 10^{69}\cdot a_{end\_dark}^3 \cdot \hbar c / a_{end}^1 = 4.7\times 10^{70} J$

, where available volume is; $V_{available} = (a_{end\_dark})^3 = 7.34\times 10^{28}[m^3]$.

The curvature radius from eq. (1) becomes $R = 6.1\times 10^{-5}[m]$.

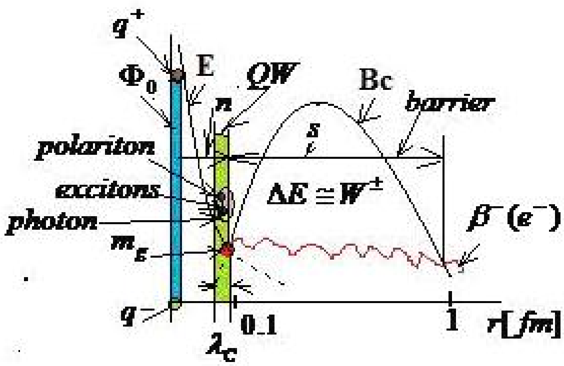
It is possible that the collision (~7TeV) of two protons at LHC to mean the collision of two nucleon quarks which transform in two dark particle, by "losing" the rest of the insight light as two photons of high energy~125 GeV

2.3 The Confinement into nucleons

In the dual-superconductor ($E \leftrightarrow B$) picture for the QCD vacuum, the squeezing of the -electric flux (E) between quarks (as decayed from μBH particles) is realized by the dual Meissner effect, as the result of condensation (as a solenoidal electric current) of **soft photons** as color gluons (bosons) radiated by μBH particles, which is the dual version of the electric charge as the Cooper pair. The order parameter is the vacuum expectation value of the creation operator of gluons (like a condensate under a critical temperature T_c !), such as $e\bar{e}$ for Cooper pairing of electrons in superconductors. The color confinement is based on the analogy between the superconductor and the QCD vacuum. In the superconductor, magnetic field is excluded due to the Meissner effect, which is caused by Cooper-pair condensation. As the result, the magnetic flux is squeezed like the Abrikosov vortex in the type II superconductor [22]. On the other hand, the color-electric flux is excluded in the QCD vacuum, and therefore the squeezed color-flux tube is formed between color sources. Thus, these two systems are quite similar, and can be regarded as the dual version each other. The color-electric field is then excluded in the QCD vacuum through the dual Meissner effect, and is squeezed between color sources to form the hadron flux tube.

Therefore, in case of superconductors an external magnetic flux decreases exponentially into the superconductor, penetrating a distance of the order λ . This distance is called the London penetration depth. In a dual superconductor the roles of magnetic and electric fields are exchanged and the Meissner effect tries to expel electric field lines. Quarks and antiquarks carry opposite color charges, and for a quark–antiquark pair the 'electric' field lines run from the quark to the antiquark. If the quark–antiquark pair is immersed in a

dual superconductor, then the electric field lines get compressed to a flux tube. The energy associated to the tube is proportional to its length, and the potential energy of the quark–antiquark is proportional to their separation. As resulting from [1a] this Lorenz force appears to be necessary in order to equilibrate the gravity charges (gravitons) embedded in the quarks viewed as ex-micro-black-holes, and these gravitons themselves “deforms” the space-time following Einstein-Friedman equation.
So, in this paper we will continue to follow the development of references [8a; 8b; 23a; 23b], especially, as regarding the single flux-tube solution in the dual Ginzburg-Landau (DGL) theory.



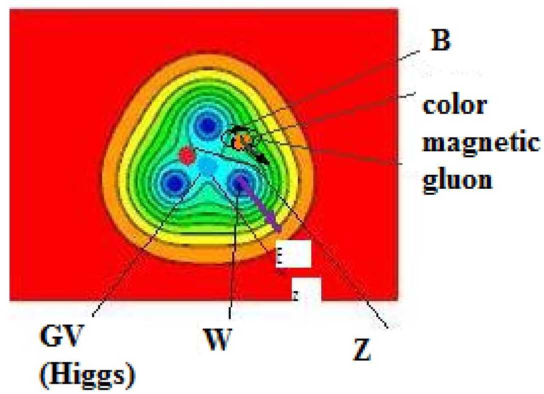


Figure 1.a. The mass generation by dual Meissner effect, the β decay for a free neutron and, the generation of polaritons assimilated with dark energy: n -normal vacuum, s - superconductor, QW -quantum well.

At Confinement we have for the vortex potential $3\times q\bar{q}g$ as from [8a],
$V = \varepsilon = \lambda_C^{-1} = 80GeV$, $\lambda_C = \hbar/mc$, it results with eq. (1a;1.b)
$E = 1.1\times 10^{28}[N/C] \rightarrow B = E/c = 3.7\times 10^{19}[T]$.

Hadrons, along with the valence quarks (q_v) (white) that contribute to their quantum numbers, contain virtual quark–antiquark $(q\bar{q})$ pairs known as *sea quarks* (q_s), see figure 1.b. Sea quarks ($R\bar{R}$) form when a gluon of the hadron's color field splits; this process also works in reverse in that the annihilation of two sea quarks produces a gluon. Free particles have a color charge of zero: baryons are composed of three quarks, but the individual quarks can have red (R), green (G), or blue (B) charges, or negatives.

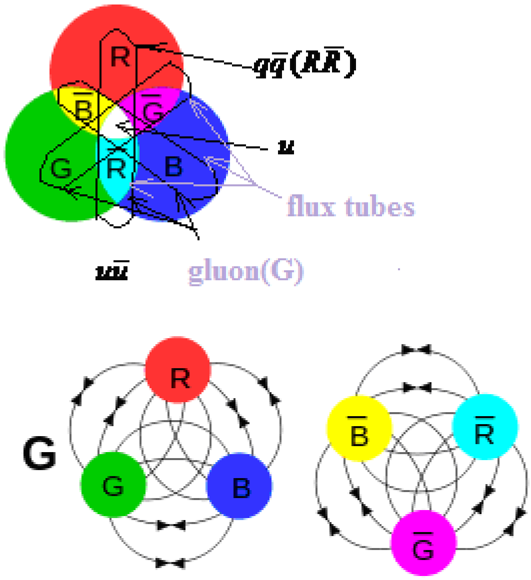


Fig.1.b. Fields due to color charges as in sea quarks ($q\bar{q}(R\bar{R})$) of valence quarks (u), (**G** is the gluon field strength tensor). These are "colorless" combinations. **Top:** Color charge has "ternary neutral states" as well as binary neutrality (analogous to electric charge).

The application of DGL theory to the quark-gluon-plasma (QGP) physics in the ultrarelativistic heavy-ion collisions, or in the early universe, where, a new scenario of the QGP formation via the annihilation of color-electric flux tubes based on the attractive force between them is proposed in [22]. The QGP phase is characterized as the deconfinement and the chiral-symmetry restoration.
There, for the same flux tubes with opposite flux direction (e.g. $R-\bar{R}$ and $\bar{R}-R$), one finds $Q_1=-Q_2$ i.e. $Q_1Q_2=-e^2/3$, so that these flux tubes are attracted each other. It should be noted that they would be annihilated into dynamical gluons in this case.
For the different flux tubes satisfying $Q_1Q_2<0$ (e.g. $R-\bar{R}$ and $B-\bar{B}$), one finds $Q_1Q_2=-e^2/6$, so that these flux tubes are attractive. In this case, they would be unified into a single flux tube (similar to $G-\bar{G}$ flux tube), [8b].
The Compton space-time volume
$V_{Compton}=\lambda_C^3\times(\lambda_C/c)=2\times10^{-73}[m^3s]$.
Where, $\lambda_C=\hbar/m_* c=8.8\times10^{-17}[m]$,
the effective quarks mass is
$m_*=\sqrt{m_e^2c^4+qB\hbar c^2}/c^2$
Or, $m_*=7\times10^{-28}[kg]\to 0.39GeV$
, which is just the $q\bar{q}$ string tension σ . ;
$H_{end}^{-1}=1.5\times10^3[m]$; $a=a_{end}=1.4\times10^{13}$; $k_{end}^{-1}=1.06\times10^{-10}[m]$; $N=39.2$;
$H_{leave}^{-1}=k_{leave}^{-1}=10^{-27}[m]$,
$\varepsilon_{gluon}=3\times10^{13}/a_{end}=2.1GeV$, $T=1\times10^{13}K$; t=10^{-6}s

From [8a], we have H_0-an "external" electro-magnetic field of a dipole created by the pair $u\bar{u}$ (the chromoelectrical colors field)

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

,where $r \cong 0.05[fm]$-is the electrical flux tube radius, $d = 0.48[fm]$-the distance between the two quarks charges, this is in fact equilibrated by the gluons field , and respectively, from eq. (2a;2b) at a more deep penetration $\lambda_{C\_q\bar{q}} = 4.7\times 10^{-16} > \lambda_{C\_g} = 8.6\times 10^{-17}$, see below.

Because the magnetic induction of the color magnetic gluons current which is powered by electric field given by a pair of quarks (H_0), $B^{gluon} \geq 2\cdot H_0 \cong H_{c2}$, 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 1a.

From [8a], we have the lower critical field:

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

where $\xi = 0.1114$, and when near the axis, for $x = 0.116 \cong \xi$, when the induction is $B(\xi) \cong 2\times 10^{15}[T] \cong 2H_{c1}$; $E = cB \cong 6\times 10^{23}$

The penetration of B is

$$\lambda = \left(\frac{\varepsilon_0 .m.c^2}{n_s .e^2}\right)^{1/2}[m],$$ m-gluons mass, n_s-number of gluons per $[m]^3$

$$\Phi_0 = \pi\hbar c/e \to \ usually \frac{\pi\hbar}{e} = 2.07e-15[Tm^2] \to \ Js/C$$

In the case of a homogeneous potential directed along the z-axis, the Einstein stress-energy tensor is:

$$T^{00} = T^{11} = T^{22} = -T^{33} = \rho_B = \frac{\varepsilon_0 c^2 B^2}{8\pi};\ T^{0i} = 0,$$ where $\rho_B[J/m^3]$-the magnetic energy density.

The equivalence between the Lorenz force energy which squeezes the electrical field E_e done by quarks is $\varepsilon_L = ec\lambda_C B$, and at the interface between normal and superconducting phase we have $B \cong E/c$, with $e^{\pm}$ (the quarks as decaying μBH particles) pairs giving E as: $k_B T = \hbar\nu = \varepsilon_L = ec\lambda_C \dfrac{\hbar}{e\lambda_C^2} = c\dfrac{\hbar}{\hbar}mc = mc^2$, and accounting that the inverse of the penetration length $\lambda \cong \lambda_C$.

Also, the interaction energy at interface $E-B$, see figure 1a; 1b. is:

$$\varepsilon = \frac{V_{vol}\varepsilon_0 c^2 B^2}{8\pi} = \rho_B V_{vol} = V[J], \quad (2b)$$

$V_{vol} = 2\pi\lambda_C\lambda_c(4\lambda_C) \cong 8\pi\lambda_C^3$, at Compton length equally with the penetration length $\lambda_C = \lambda$, that results

$$E^2 = \frac{(V)}{\varepsilon_0(\lambda_C^{e*})^3} \qquad (2.c)$$

With V as above is obtained $B \cong E_{q\bar{q}}/c = 1.98\times 10^{15}[T]$, where $E_{q\bar{q}} = 5.9\times 10^{23}$ with eq. (1.a), that are identically with the above values, **indubitable** meaning that this force creates the spacetime curvature and this is equilibrated by the gravity charge, see below.
The cosmological time being $\tau = H^{-1}/c = 5\times 10^{-6}[s]$; $dt = 10^{-16}s$; and the necessary volume is $V_{necessary} = N_{pairs}\times\lambda_c^3 = 2.7\times 10^{31}[m^3]$,
, and the available volume is; $V_{available} = (a)^3 = 2.8\times 10^{39}[m^3]$.
The curvature radius from eq. (2) with $V = 2.1GeV$ becomes $R = 722[m]$.
The total energy is $E_U = 3.8\times 10^{79}\cdot 3.38\times 10^{-10} = 1.29\times 10^{70}J$, near the value calculated above.
Where, $\lambda_C = \hbar/m_* c = 3.6\times 10^{-13}[m]$,
, that result the quarks pairs of mass: $m_* = 9.2\times 10^{-31}[kg] \to 0.52MeV$
$H_{end}^{-1} = 10^{10}[m]$; $a_{end\_quarks} = 5.8\times 10^{16}$; $k_{end}^{-1} = 1.7\times 10^{-7}[m]$; $N = 46.6$; $t = 33s$
$H_{leave}^{-1} = k_{leave}^{-1} = 10^{-27}[m]$, $t = 3.35\times 10^{-25}s$
$\varepsilon_e = 3\times 10^{13}/a_{end} = 5.2\times 10^{-4}GeV$, $T = 1.2\times 10^{10}K$
$n_{pairs} = 10^{69}\cdot V_{end-\mu BH\_production} = 10^{69}\cdot 3.8\times 10^{10} \cong 3.8\times 10^{79}$, where
$V_{end-\mu BH\_production} = 3.9\times 10^{10}[m^3]$ is determined in section 2.1.
The necessary volume is $V_{necessary} = N_{pairs}\times\lambda_c^3 = 1.8\times 10^{42}[m^3]$,
, and the available volume is; $V_{available} = (a)^3 = 1.9\times 10^{50}[m^3]$.
The curvature radius from eq. (1) becomes $R = 1.2\times 10^9[m]$.
The electric field with eq. (1a) $B = 1.5\times 10^9[T]$; $E = 4.4\times 10^{17}[N/C]$. The average magnitude of the electric field inside the quark as for the model electron is with equation (4) from [1a]:

$$\langle E\rangle = \sqrt{\frac{6\hbar c}{\pi\varepsilon_0\lambda^4}}$$

, it results $\langle E\rangle = 5.7\times 10^{17}[N/C]$, for electrons of $\lambda_C = \hbar/m_e c \cong 3.7\times 10^{-13}[m]$

Also, after light decoupling (at Recombination- H atoms forming) when the Thomson scattering with electrons reaction rate $\Gamma_\gamma = n_e\sigma_T$ becomes smaller than the expansion rate, the photons do not scatter any more, theirs distribution freezes and redshifts (z)

with the expansion. The recombination it was reconfirmed to occur at $\approx 3000K$, $z \approx 1100$ at CMBR time.

b) A strong prove of the model basis- the free neutron decay

In the following, we will use some results of above section , but where $\lambda_C = \hbar/m_* c = 2.3e-18[m]$, the effective mass is $m_* = 1.44\times 10^{-25} kg \to V = 81GeV \to E = 1.1\times 10^{28}$, the *critical field* being

$$E_c = \frac{m_*^2 c^3}{e\hbar} \cong 3.5\times 10^{28} > E = 1.1\times 10^{28}[N/C];\ B = E/c = 3.7\times 10^{19}[T].$$

From the above section (2.3), are used the bosons $W^{\pm}$ pairs generated *inside the nucleons* as due of one quark $u\bar{u} \leftrightarrow u$ resultant $\times 3$ flux tubes vortex potential , see figure (1.b), respectively $\varepsilon = mc^2 \cong 81GeV$ - which after the release of an electron that it getting the final beta energy as been equally to the out of barrier turning point after the tunneling, and accounting for the valence nucleons interactions (shell-energy levels). The number of *assaults* of the barrier, like in Gamow theory [20, 21] is $n_a = v_b/R_{inner}$; where the velocity is $v_b \cong (2\varepsilon/m)^{1/2} = 2.3\times 10^8\ m/s$, where, the inner radius of the barrier is $R_{inner} \cong b = 3.5\times 10^{-17}[m]$, see below. For only one of the three vortex-flux tubes ($q\bar{q}g$) we have: $\varepsilon = \hbar eB/m \cong 4\times 10^{-9}[J] \to \cong 25GeV$, with the above (B) which is obtained from eq.(1.a) with the resultant potential $V = 81GeV$, that corresponds to $m_{q\bar{q}} \cong 29GeV$ from 4.1a, the energy of the particle for the first Landau level (as above), and we can see that it results to be equally with $\approx 1/3$ rest mass of the $W^{\pm}$, that resulting $n_a \cong 7.5\times 10^{24} s^{-1}$.

In case of WKB [20], the transmission coefficient is $T = 2\frac{\sqrt{2m|V-Q|}}{\hbar}\Delta r$, and the decay constant $\Gamma = n_a e^{-T}$.

For the thick barrier the transmission coefficient is $T = 2\pi\frac{Qb}{\hbar v} = 2\pi\frac{\sqrt{2mQ}}{\hbar}b$;

, where, the kinetic energy of the particle after the barrier at b is $Q \equiv \frac{1}{2}mv^2$, $b = d_b/2\pi = 3.5\times 10^{-17}[m]$, see below, that results $T = 63$; and the decay constant $\Gamma = 3\times 10^{-3} s^{-1} \to \cong 324s$

To "materialize" a virtual $e^+ - e^-$ pair in a constant electric field E the separation d must be sufficiently large $eEd = 2mc^2$

Probability for separation d as a quantum fluctuation

$$P \propto \exp\left(-\frac{d}{\lambda_{Compton}}\right) = \exp\left(-\frac{2m^2c^3}{e\hbar E}\right) = \exp\left(-\frac{2E_{cr}}{E}\right)$$

The emission (transmission through barrier) is sufficient for observation when $E \approx E_{cr}$, with $Q = 1/2\, mc^2$, results $T = 2\pi \dfrac{mcb}{\hbar} \cong \dfrac{2\pi b}{\lambda_C}$, or

$b \cong d_b/2\pi$.

Now, by using the Schwinger effect as in section 2.1 , the number of $W^{\pm}$ pairs produced inside the nucleon (more inside of the only one resultant flux tube , see figures 1.a; 1.b) due of the potential resultant $u\bar{u} \leftrightarrow 3\times vortex(q\bar{q}g)$ of $V = 80GeV$, results as $R/s = R/V \times V_{vol} = 2.3\times 10^{18} s^{-1} \approx n_a$, where $R/V = 2\times 10^{71}[1/m^3 s]$ and the volume is $V_{vol} \cong (\lambda_C)^3 \cong 1.24\times 10^{-53}[m^3] \geq V_b$, the penetration length being $\lambda_C = 2.3\times 10^{-18}[m]$, and for a four-volume of $\lambda_C^4/c \cong 9.5\times 10^{-80}[m^3 s]$, results as a *permanently rate* $R \cong 10^{-8} W^{\pm}$ *pairs* . To note, that in the previously version of the work [1a], we have used for $V = v.e.v = 247GeV$, and since with this value it results $B = 3.3\times 10^{20}[T]$ and the velocity of W bosons resulted to be $v_b = 7.2\times 10^8 > c = 2.986\times 10^8$, greater than c , that it was not acceptable, so it renounced to consider an external Higgs field $v.e.v$. Otherwise, if this field existed, that means the Universe it remained at about $R = 0.05[m]$.

Thus, it results a main conclusion of this investigation, namely, that the "interacting" potentials inside the nucleons are that were already established in [8a], respectively $\cong 80GeV$ around the valence quarks (u, d) which it seems to be "locked" at the electroweak symmetry breaking ($\approx 100GeV$); that of the Giant Vortex (see the insert in fig. 1.a) at the center of the triangle-the Higgs boson $H = 125GeV$; and that resulting from interaction of $2\times$ interpairs of flux tubes as been the neutral boson $Z = 90GeV$. Therefore, in other words is proved that all the time inside the nucleon are *available* $10^{-8} W^{\pm}$ pairs that seems to corresponds to the "weak interaction" coupling constant 10^{-7} , which is absorbed or emitted by the quarks , resulting an e^+ , or e^- which help the quarks transformation like $(u \rightarrow d)$, respectively $(d \rightarrow u)$ for beta-decay. In our understanding, the created electron takes the energy at the *turning point* out of the barrier equally with the electron itself for unbounded neutrons, or that of the binding energy of nucleon in isotope nucleus, when it *passes* the barrier of gluon condensate characterized by an *quantum tunneling* suppression given as: $\exp(-\Delta E\, \tau/\hbar) \cong 7.3\times 10^{-22}$, where, as the lifetime of $W^{\pm}$ being $\tau \cong 3\times 10^{-25} s$. Here, ΔE corresponds to the height of gluon condensate barrier, due of the *phase slip* with $2\pi - \varphi$ and of a Φ_0 energy release as: $\Delta E = c^2 \Phi_0^2 \varepsilon_0 / d_b$; $d_b \cong k\lambda_C = 1.98\times 10^{-16}$, $k = 85$, where the Compton length is just the penetration length for $W^{\pm}$ pair $\lambda_C = 2.3\times 10^{-18}[m]$, or in other words just the barrier size, and $\Delta E = 1.6\times 10^{-8}[J] \rightarrow 100GeV \approx 3\times 25GeV$ as for $\times 3$ sea quarks color flux tubes, see figures 1.a; 1.b. The value of the resulting flux tube it remains as in (4.2.a), respectively of $0.4GeV$ as the string strength.

Next, we have calculated the color gluons pair's production rate from the free photons. For that, we consider the initial results of Sauter, Heisenberg and Euler and Weisskopf , where, in a seminal work Schwinger derived a central result of strong-field quantum electrodynamics, namely, the rate per unit volume of pair creation R in a constant and uniform electric field of strength E, *when this electric field* E *is induced by quarks pairs as ex-Micro-black-holes,* of leading order behavior [13],

$R = (E/E_{cr})^2 (c/\lambda^4)(8\pi^3)^{-1} * \exp(-\pi E_{cr}/E)$

or $E/E_{cr} << 1$, positron charge e, mass m, Compton wave-length $\lambda = \hbar/mc$ and so-called "critical" electric field

$E_{cr} = m^2c^3/e\hbar$

Thus, the probability (rate) to produce $W^{\pm} \to e^{\pm}$, into a more simple way- without the external interactions of the neutron (free-not bounded), is given as:

$RV \exp(-\Delta E\tau/\hbar) \cong 1.7 \times 10^{-3} s^{-1} \to \tau_{1/2} \cong 582[s] \approx 612s$, that corresponds for *free neutrons decay* (β^-) by emission of an electron and an electron antineutrino to become a proton $n^0 \to p^+ + e^- + \bar{\nu}_e$, with half-life of $611s$, and $Q_{\beta^-} = m_e v^2 = 0.5MeV$.

Now, the energy corresponding to E_{cr} is much higher than E, respectively as from eq. (1.a): $\nu = E_{cr}^2 \varepsilon_0 (\lambda^3_{Compton})$, $\lambda_{Compton} = \hbar/mc$; $\nu = \varepsilon = mc^2$ or

$$\nu = \frac{m_W^4 c^6}{e^2\hbar^2}\frac{\hbar^3}{m_W^3c^3}\frac{4\pi\varepsilon_0}{4\pi} = \frac{m_W c^2 \varepsilon_0 \hbar c 4\pi}{4\pi e^2} \cong \frac{M}{4\pi\alpha} \to \nu \cong 10 \times 80 = 800GeV,$$

$$\alpha = \frac{e^2}{4\pi\varepsilon_0\hbar c} = \frac{1}{137}$$

, since $(E_c/E)^2 = \left(\frac{3.5 \times 10^{28}}{1.1 \times 10^{28}}\right)^2 \cong 10$.

In the classic understanding of β^- disintegration $n \to p + e^- + \bar{\nu}_e$, in ours understanding this occurs when one of the down quarks (d) in the neutron (udd) transforms into an up quark (u) due of interacting with the charge of W^+ boson of the pair $W^{\pm}$, transforming the neutron into a proton (uud). In mean time the other part of this pair W^- boson decays into an electron and an electron antineutrino $udd \to uud + e^- + \nu_e$. Probable the claimed energy of boson W^- is the same as to be the necessarily energy to traverse the gluonic barrier, when it decays into e^- at the end.

The free neutron decay

Consequently, for the β^- decay process, the energy combines well with the existing one, that releasing an electron which penetrates the barrier:

$d \to u + W^+ + W^- \to u + e^- + \bar{\nu}_e$

$d(-1/3e) + e^+(+3/3e) = u(+2/3e) + e^-(-3/3e)$

, since $W^- \to e^-$, and $W^+ \to e^+$

In case of β^+ decay, it can only happen inside nuclei when the daughter nucleus has a greater *binding energy* (and therefore a lower total energy) than the mother 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.
Thus, an opposite process to the above negative beta decay, β^{+} decay of nuclei (only bounded proton) when $p \to n + e^{+} + \nu_{e}$, or $energy + uud + W^{+} + W^{-} \to udd + e^{+} + \nu_{e}$, or, $u(2/3e) + e^{-}(-3/3e) + energy = d(-1/3e) + e^{+}(3/3e)$.
For free proton decay an *added energy* it seems to be necessarily to reduce the barrier width to $d_b = 9 \times 10^{-17}[m]$, when the production rate is:
$RV \exp(-\Delta E\tau/\hbar) \cong 7 \times 10^{-29} s^{-1} \to \tau_{1/2} \cong 10^{28}[s]$, respectively, an increase to $\Delta E = 3.5 \times 10^{-8}[J] \geq 225GeV$ from $\Delta E = 1.6 \times 10^{-8}[J] \to 100GeV$, as for the free neutron, or near $\geq v.e.v = 247GeV$, like at LHC when the gluonic "cover" of protons it was "melted (at least 2 gluons)", and the resulted difference $(\cong 225 - 100 = 125GeV)$ being just that of the Higgs boson (a quanta of energy!) which it was, in this spectacular way "released" [8a] as $2g \to 2\gamma$.
In the process of electron capture, one of the orbital electrons, usually from K or L electron shell, is captured by a proton in the nucleus, forming a neutron and an electron neutrino.

$$p + e^{-} \to n + \nu_{e}$$

About others calculations of beta decay processes of different isotopes, see the author's work [8a].

3. The production of the polaritons as origin of dark energy

To remember some well-known steps of Universe evolution: **Lepton epoch:** Between 1 second and 10 seconds after the Big BangThe majority of hadrons and anti-hadrons annihilate each other at the end of the hadrons epoch, leaving leptons and anti-leptons dominating the mass of the universe. Approximately 10 seconds after the Big Bang the temperature of the universe falls to the point at which new lepton/anti-lepton pairs are no longer created and most leptons and anti-leptons are eliminated in annihilation reactions, leaving a small residue of leptons.

Reionization: *150 million to 1 billion years after the Big Bang*

The first stars and quasars form from gravitational collapse. The intense radiation they emit reionizes the surrounding universe. From this point on, most of the universe is composed of plasma.

The reionization is the process that reionized the matter in the universe after the "dark ages", and is the second of two major phase transition of gas in the universe. As the majority of baryonic matter is in the form of hydrogen, reionization usually refers to the reionization of hydrogen gas.
The second phase change occurred once objects started to condense in the early universe that were energetic enough to ionize neutral hydrogen. As these objects formed and

radiated energy, the universe reverted from being neutral, to once again being an ionized plasma. This occurred between 150 million and one billion years after the Big Bang (at a redshift $6 < z < 20$). At that time, however, matter had been diffused by the expansion of the universe, and the scattering interactions of photons and electrons were much less frequent than before electron-proton recombination. Thus, a universe full of low density ionized hydrogen will remain transparent, as is the case today.
While observations have come in which narrow the window during which the epoch of reionization could have taken place, it is still uncertain which objects provided the photons that reionized the IGM. To ionize neutral hydrogen, an energy larger than 13.6 eV is required, which corresponds to photons with a wavelength of $\cong 91.2nm \rightarrow c/91.2 \times 10^{-9} \cong 3.2 \times 10^{15}\,Hz$ or shorter. This is in the ultraviolet part of the electromagnetic, which means that the primary candidates are all sources which produce a significant amount of energy in the ultraviolet and above. How numerous the source is must also be considered, as well as the longevity, as protons and electrons will recombine if energy is not continuously provided to keep them apart. Altogether, the critical parameter for any source considered can be summarized as its "emission rate of hydrogen-ionizing photons per unit cosmological volume". With these constraints, it is expected that quasars and first generation stars and galaxies were the main sources of energy.

Dwarf galaxies

Dwarfs galaxies are currently the primary candidate source of ionizing photons during the epoch of reIonization. A new study shows that dwarf galaxies contributed nearly 30% of the ultraviolet light during the process of reIonization.

Quasars

Quasars, a class of active galactic nuclei (AGN), were considered a good candidate source because they are highly efficient at converting mass to energy, and emit a great deal of light above the threshold for ionizing hydrogen

The cosmological constant Λ

A cosmological constant has negative pressure, $p = -\rho c^2$ which contributes to the stress-energy tensor that, according to the general theory of relativity, causes accelerating expansion.

The resulting vacuum energy is constant and given by the cosmological constant, see eq. (2), it is often expressed as $10^{-52}\,\mathrm{m}^{-2}$, $10^{-35}\,\mathrm{s}^{-2}$, 10^{-47} GeV^4.

The current density of the observable universe is of the order of 9.44 x 10^{-27}kg m^{-3} and the age of the universe is of the order of 13.8 billion years, or 4.358 x 10^{17}s.

To note the one of the proposed form for dark energy is the cosmological constant. The *dark-energy-dominated* era began after the *matter-dominated era*, i.e. when the Universe was about 9.8 billion years old. As other forms of the matter – dust and radiation –

dropped to very low concentrations, the cosmological constant term started to dominate the energy density of the Universe. The Dark Ages are currently thought to have lasted between 150 million to 800 million years after the Big Bang.
In order to demonstrate this *breakthrough* hypothesis, in the following I extract information from the large literature on polaritons.
A **quantum well (QW)** is a potential well with only discrete energy values. In quantum physics, potential energy may escape a *potential well* without added energy due to the probabilistic characteristics of quantum particles; in these cases a particle may be imagined to tunnel *through* the walls of a potential well.

In Earth experiments [16], the cavity-photon effective mass, it is typically on the order of $10^{-5} m_e$.
Excitons, which result from the Coulomb attraction of one conduction electron and one valence hole, are known to exhibit a bosonic behavior.
The term polariton was introduced by J. J. Hopfield [3] cited in [16] in order to describe coupling between light (photons) and electric dipoles (excitons) in bulk crystals.
Polaritons have been recently demonstrated to exhibit a number of fundamental physical effects: condensation, superfluidity, parametric scattering, quantized vortices and dark oblique solitons.
Strong coupling between photons and excitons is most efficient when the values of their energies and momenta in the cavity are in resonance. The coupling between excitons and photons is determined by the oscillator strength of the exciton and the amplitude of the cavity photon electropotential at the location of the QW. If the coupling strength is greater than the width of the cavity photon and exciton mode the so-called strong coupling regime occurs. In this regime energy oscillates between the exciton and the cavity photon mode resulting in the formation of hybrid lightmatter quasiparticles termed polaritons. These oscillations are called Rabi oscillations. The Rabi frequency is defined as $\Omega = \dfrac{\vec{d}_{i,j} \bullet \vec{E}_0}{\hbar}$

, where $\vec{d}_{i,j}$ is the transition dipole moment (is the electric dipole moment) for the $i \to j$ transition and $\vec{E}_0 = \hat{e}E_0$ is the vector electric field amplitude which includes the polarization. The numerator has dimensions of energy, so dividing by $\hbar$ gives an angular Rabi frequency which is a characteristic of the coupling energy between the excitons and the photons in the cavity. In the simple case of two point charges, one with charge +*q* and the other one with charge −*q*, the electric dipole moment **p** is $p = qd$, where d the displacement vector is pointing from the negative charge to the positive charge.
In Ref. [16], the disorder traps are estimated to have a depth $E_0 \cong 0.5meV$ and size $a \cong 3\mu m$, which with a polariton mass of $m \cong 10^{-4} m_e$ yields a trap frequency $\hbar\omega = \sqrt{E_0\hbar^2 / ma^2} \cong 0.2meV \to \omega = 3 \times 10^{14} Hz$;
In our case with the trap energy of QW as (see below!) at Ionization $E_0 = E_{trap} = 1.5 \times 10^{-21}[J] \to 10meV$; and when the polariton mass results to be of $m = m_{polarit} = 1.6 \times 10^{-38}[kg]$, and the QW width of $a = 2 \times 10^{-5}[m]$, results

$\omega = 1.4 \times 10^{13} Hz$, the same value of frequency from QW evolution near *Reionization* time (shown before) respectively when $B \cong 1.4 \times 10^{-7}[T]$, also, the temperature of the arrived Ionization photons being $T = 100K$, as resulted from interaction of photons with the electron and positron pair $e^{+}e^{-}$ generated at Reionization by Schwinger effect, all to compose QW, which are near equally : $\varepsilon_1 = \varepsilon_2 = \varepsilon$, and so the "arrived" energies here of the photons: $\hbar\varpi_1 = \hbar\varpi_2 = \varepsilon_\gamma = 1.48 \times 10^{-21} \leq \varepsilon_{cavity} = 10meV \to 1.5 \times 10^{-21}[J]$.

That corresponds with Rabi frequency in our QW, of $\Omega = \dfrac{qdE_0}{\hbar} = 4.6 \times 10^{12} Hz$, where, the electric field result to be (see bellow) of $E_0 = 140[N/C]$; and $d \cong a$.

Therefore, with these results, the situation at Reionization time when the polaritons condensate and "leaks" polarized photons is very similarly with the discovery on Earth experiments.

The trap energy is $E_{trap} = \dfrac{\pi^2\hbar^2}{mL^2}$, for our QW results $E_{trap} = 1.4 \times 10^{-20}[J] \cong \varepsilon \to 0.09eV$

Exciton polaritons are two-dimensional quasi particles, which result from the strong coupling between excitons confined in the QWs and photon modes confined in the microcavity.

The strong light-matter coupling in the microcavity system exhibits anti-crossing behavior as a split to two polariton branches: upper polaritons (UPs) and lower polaritons (LPs) showed in Fig. 4 from [17]. The energy difference between two branches is named as vacuum-Rabi splitting (Ω), adopting from atom-cavity terminologies.

When the un-coupled exciton and photon are at resonance, $E_{exc} = E_{cav}$, lower and upper polariton energies have the minimum separation $E_{UP} - E_{LP} = \hbar\Omega \cong 4.6 \times 10^{-22}$, which is often called the `Rabi splitting' in analogy to the atomic cavity Rabi splitting, as mentioned before. Due of the coupling between the exciton and photon modes, the new polariton energies is anti-cross when the cavity energy is tuned across the exciton energy. This is one of the signatures of 'strong coupling'. When $|E_{cav} - E_{exc}| >> \hbar\Omega$, the polariton energies reduce to the same as photon and exciton energies due to the very large detuning between the two modes, and polariton is no longer a useful concept. As discussed in section 3.5 of [17], an internal polariton of certain k decays with a fixed rate $\gamma_{LP}(k)$ to an external photon mode at certain angle θ with the same energy $E_{LP}(k)$ and in plane wavenumber k. Polariton decays in the form of emitting a photon with the same $k_{\Uparrow}$ and total energy $\hbar\omega = E_{LP,UP}$.

Hence dynamical and statistical properties of polaritons are directly conveyed to the external photon flux; polaritons are directly and conveniently studied by their photoluminescence (which should be distinguished from the conventional photoluminescence due to radiative recombination of a quasi-particle).

In current semiconductor samples, we have $\gamma_{cav} = 1 \div 10ps$ and $\gamma_{exciton} \cong 1ns$, hence the polariton lifetime is mainly determined by the cavity photon lifetime $\gamma_{LP} \cong |C|^2 \gamma_{cav}$, and Hopfield coefficient $C \cong 0.2$ for the case $\Delta = 2\hbar\Omega$, and $k_{\Uparrow} = 0[\mu m]^{-1}$.

The emission of a photon preserves the polariton energy and in-plane wave vector. Therefore, the detected photons carry direct information of the polaritons. The intensity of the emission is proportional to the instantaneous polariton population, and the quantum statistical properties of the emission replicate those of the polaritons.
Thus, excitonic systems studied through optical methods are always open systems: excitons are continuously created by optical pumping and then recombine, emitting photons.
The sample from figure 2.of [18] is composed of 12 GaAs quantum wells integrated in a $\frac{\lambda}{2}$–thick AlAs microcavity. The sample is excited non-resonantly at normal incidence with a pulsed Ti-Sapphire laser (spot size $4\mu m$). The excitation wavelength of the laser is set to be about $\approx 80meV$ above the lower polariton energy, and the pulse width of the laser is about $\approx 4ps$ with a repetition rate of 82 MHz. The sample is held at $T = 6K$ in a helium flow cryostat and a potential up to $B = 5T$ can be applied in Faraday-configuration along the growth axis of the structure. The selected device comprises a detuning between microcavity photon energy E_C and QW exciton energy E_X givens as $\delta = E_C - E_X = -7meV$, the Rabi-splitting is determined to $E_{RS} = 12meV$, and an exciton-energy of $E_X = 1.550eV$ was extracted.

3.1 Polaritons Production at Recombination-CMBR Time

We apply again the Schwinger formalism as for fermions production (4.2b), i.e. excitons pairs $e^+ e^-$.
The external field as been induced by gluons (photons) becomes: $V = 0.5eV$ and from eq. (1.a) results:
$E_g \cong 4.3\times 10^5 [N/C]$, due of color magnetic off-diagonal gluons (photons) *condensate* in QW, where:
$\lambda_{C\_exci} = \hbar/m_{exc}c = 7.8\times 10^{-7} < \lambda_{Broglie} = 5\times 10^{-6}[m] \leftarrow T = \varepsilon/k_B = 2760K$;
$\omega = 8.22\times 10^{14}Hz$; $\varepsilon = V = 10^{11}/a \cong 0.5eV$
, and respectively, from eq. (1.a) at a more deep penetration
$\lambda_{C\_exci} = 7.8\times 10^{-7} > \lambda_{C\_g} = 3.6\times 10^{-7}$,
$B \cong E_{exci}/c = 4.6\times 10^{-4}[T]$, where $E_{exci} = 4.3\times 10^5[N/C]$
The effect of the potential B is the same as shifting the *effective mass*
$m_{exc}^2 c^4 = m_e^2 c^4 + qB\hbar c^2 (2j + 1 - \sigma)$, where $m_e \cong 0.46 m_g$, for fermions for each Landau level, and $m_{exc} = 4.3\times 10^{-37}[kg] \to 0.23eV$, the mass of *excitons*.
The Compton space-time volume of QW
$V_{Compton} = \lambda_C^3 \times (\lambda_C/c) = 1.2\times 10^{-33}[m^3 s]$,
the *critical field* $E_c = \dfrac{m_{exc}^2 c^3}{e\hbar} = 1.4\times 10^5[N/C]$; $H_{end}^{-1} = 4\times 10^{22}[m]$; $a_{end} = 2\times 10^{20}$;
from eq. (7) results $k_{end}^{-1} = 205[m]$; $H_{leave}^{-1} = k_{leave}^{-1} = 10^{-29}[m]$, $N = \ln(1/a_{end}) = 72.1$ to

match the iterations cycle: $m_g \to \hbar\nu \to k_B T \to \varepsilon \to R \to H_{end}^{-1} \to a_{end} \to N$. The Universe radius from eq. (7) $R = 1.2\times 10^{22}[m] \to t = 4.1\times 10^{13}[s]$

Therefore, the photons "pumping power" is

$\varepsilon \cong 8.2\times 10^{-20}[J] \to 0.5eV \to m_g = 9\times 10^{-37}kg$, as the *cavity energy* E_{cavity}

, here is considered $d \cong \lambda_c \approx \lambda_{Broglie}$ as the width of QW.

With these values it results from eq. (10), the number of excitons pairs ($e\bar{e}$) created in QW as $\Gamma_{JWKB}/V_C = 10^{32}[m^{-3}s^{-1}]$.

If the pairs production volume is $V_{matter} = (a)^4 \dfrac{1}{c} = 4.8\times 10^{72}[m^3 s]$,

$V_{necessary} = (a)^3 = 7.3\times 10^{60}$, $V_{avabile} = 10^{81}\times \lambda_C^3 = 4.7\times 10^{62}$

and the total mass after photons-excitons interaction is

$M_{polaritons} = 10^{81}\times 9.1\times 10^{-37} \cong 10^{44}[Kg]$.

3.2 Polaritons Production at Reionization Time

If we considered that the fermions are entirely consumed at Recombination, and any others are not possibly to be generated, a new source of electrons and photons seem to be necessarily in order to assure the Universe further expansion into accelerated mode as it was found after 8.5 billions years.

Thus, later (9.8 billions years) appears the *Reionization* of the neutral hydrogen, when an energy larger than 13.6 eV is required, which corresponds to photons with a wavelength of 91.2 nm or shorter. This is in the ultraviolet part of the electromagnetic spectrum, which means that the primary candidates are all sources which produce a significant amount of energy in the ultraviolet and above. Altogether, the critical parameter for any source considered can be summarized as its "emission rate of hydrogen-ionizing photons per unit cosmological volume". With these constraints, it is expected that quasars and first generation stars and galaxies were the main sources of energy.

We apply again the Schwinger formalism as for fermions.

Therefore, the external field as been induced by e^+e^- pairs obtained after ionization of H, $E \to V = 10meV$ and from eq. (1.a;1b) results $E_g \cong 1.4\times 10^2[N/C]$ for the condensate of the free photons in QW, where:

$\lambda_{C\_exci} = \hbar/m_{exc}c = 4.3\times 10^{-5} < \lambda_{Broglie} = 1.2\times 10^{-4}[m] \leftarrow T = \varepsilon/k_B = 107K$;

$\omega = 1.5\times 10^{13}Hz$; $\varepsilon = V = 10^{11}/a \cong 10meV$

$B \cong E_{exci}/c = 1.5\times 10^{-7}[T]$, where $E_{exci} = 44[N/C]$

The effect of the potential B is the same as shifting the *effective mass*

$m_{exc}^2 c^4 = m_e^2 c^4 + qB\hbar c^2(2j + 1 - \sigma)$, where $m_e \cong 0.46 m_g$, for fermions for each Landau level, and $m_{exc} = 7.6\times 10^{-39}[kg] \to 4meV$, the mass of *excitons*.

The Compton space-time volume of QW

$V_{Compton} = \lambda_C^3 \times (\lambda_C / c) = 10^{-26} [m^3 s]$,

the *critical field* $E_c = \dfrac{m_{exc}^2 c^3}{e\hbar} = 455[N/C]$;

$H_{end}^{-1} = 9 \times 10^{25}[m] \to 3 \times 10^{17} s \leftrightarrow 9.8 \times 10^9$ *years*; $a_{end} = 10^{22}$;

$R = 3.8 \times 10^{25}[m] \to t = 1.3 \times 10^{17} s$ from eq. (7) results $k_{end}^{-1} = 8.3 \times 10^3 [m]$;

$H_{leave}^{-1} = k_{leave}^{-1} = 10^{-29}[m]$, we chose $N = 75.8$ to match the iterations cycle:

$m_g \to \hbar\nu \to k_B T \to \varepsilon \to R \to H_{end}^{-1} \to a_{end} \to N$;

Therefore, the photons "pumping power" is

$\varepsilon \cong 1.4 \times 10^{-21}[J] \to 10 meV$, as the *cavity energy* E_{cavity}

, here is considered $d \cong \lambda_c \approx \lambda_{Broglie}$ as the width of QW.

With these values it results from eq. (10) the number of QW excitons pairs ($e^+ e^-$) created as $\Gamma_{JWKB} / V = 10^{25} [1/m^3 s]$

Thus, the number of excitons pairs created as

$N_{excit} = 10^{81} \times \Gamma_{JWKB} / V_C \times V_C = 10^{81} \times 0.14 \cong 1.4 \times 10^{80}$ *particles*.

If the pairs production volume is $V_{matter} = (a)^4 \dfrac{1}{c} = 4.6 \times 10^{79} [m^3 s]$, $a = a_{end}$;

$V_{necessary} = N_{excit} \times (\lambda)^3 = 1.15 \times 10^{67} [m^3]$, the available volume is today

$V_{availbe} = (a)^3 = 1.3 \times 10^{66} [m^3]$,

and the total mass after photons-excitons interaction is

$M_{polaritons} = 1.4 \times 10^{80} \times 1.6 \times 10^{-38} = 2.3 \times 10^{42} [kg]$.

Therefore, with the Quantuum Potential after reionization: $\varepsilon = 10^{11} / a_{end} = 10 meV$, it results $T_c = 100K$, $\nu = 1.4 \times 10^{13} Hz$.

3.3. Today

Today we have $\varepsilon = V / a_{end} = 5 \times 10^{-12} GeV$, $a_{end} = 2 \times 10^{22}$, $H_{end}^{-1} = 3 \times 10^{26} [m]$;;

$R = 1.16 \times 10^{26} [m] \to t = 3.9 \times 10^{17} s$ from eq. (7) results $k_{end}^{-1} = 1.7 \times 10^4 [m]$;

$H_{leave}^{-1} = k_{leave}^{-1} = 10^{-29}[m]$, we chose $N = 76.5$ to match the iterations cycle:

$m_g \to \hbar\nu \to k_B T \to \varepsilon \to R \to H_{end}^{-1} \to a_{end} \to N$;

$m_{exc} = 8.9 \times 10^{-40} [kg] \to 0.5 meV \to 4 \times 10^{-23} [J]$

$\lambda_{C\_exci} = \hbar / m_{exc} c = 3.7 \times 10^{-4} < \lambda_{Broglie} = 4.7 \times 10^{-3} [m] \leftarrow T = \varepsilon / k_B = 2.88K$

$E_g \cong 4.5 \times 10^1 [N/C]$, $B = 4.5 \times 10^{-9} [T]$ $E_{cr} = 150 [N/C]$; $\omega = 4 \times 10^{11} Hz$

$V_{Compton} = \lambda_C^3 \times (\lambda_C / c) = 6.5 \times 10^{-23} [m^3 s]$

With these values it results from eq. (10) the number of QW excitons pairs ($e^+ e^-$) created as $\Gamma_{JWKB} / V = 10^{22} [1/m^3 s]$.

With these values it results from eq. (10), the number of excitons pairs created as $N_{excit} = 10^{81} \times \Gamma_{JWKB}/V_C \times V_C = 10^{80} \times 1.35 \times 10^{22} \times 6.5 \times 10^{-23} \cong 8.8 \times 10^{80}\ particles$.

If the pairs volume is $V_{matter} = (a)^4 \frac{1}{c} = 4.3 \times 10^{80} [m^3 s]$,

$V_{necessary} = N_{excit} \times (\lambda)^3 = 6.8 \times 10^{66} [m^3]$, the available volume is today

$V_{availbe} = (a)^3 = 6.8 \times 10^{66} [m^3]$,

and Using the definition of redshift provided $1 + z = \frac{a_{now}}{a_{then}} = \frac{\lambda_{CMBR}}{\lambda_{now}}$;

$$z = \frac{8.22 \times 10^{14}}{4. \times 10^{11}} = 2055$$

Therefore, the isotropically ancestral photons keeps the imagine of Universe at CMBR time, the production of the new polaritons can continues with the light emitted by different stars (galaxies) which interact in Quantum Well of T_c, that increases the anisotropy of radiation Ionization $\frac{\Delta T}{T} \cong \frac{\Delta \rho}{\rho}$, viewed especially around stars and galaxies. The interaction of polaritons with other lights it producing a blue shift, in this way these clouds are observed around galaxies.

All the calculated values (mass, energy, dimensions) correspond with that were obtained into the Earth experiments for some semiconductors, as shown before. That strengths our hypothesis that these composed particles equivalent energy represent the dark energy, that accelerates the expansion of the Universe. Also, only with such type of QW, it could be produced the necessary number of such particles into a continuously mode.

Using the upper limit of the cosmological constant, the *vacuum energy* in a cubic meter of free space has been estimated to be 10^{-9} [J].

In our case with the data calculated before, we have:

$$\varepsilon_{polariton-today} = 4 \times 10^{-23} \times (8.8 \times 10^{80}) \frac{1}{7 \times 10^{66} [m^3]} = 5 \times 10^{-9} [J/m^3],$$

that corresponds to the density of dark energy (6.91×10^{-27} kg/m^3) as $5 \times 10^{-9}/c^2 = 5 \times 10^{-9}/10^{17} \cong 5 \times 10^{-26}\ kg/m^3$.

It is known that the cosmological constant is $\Lambda = 10^{-46} [GeV]^4$, in our case with the polariton energy today we have: $\Lambda = (\varepsilon_{polariton-today})^4 = (5 \times 10^{-12} GeV)^4 = 6 \times 10^{-46} GeV^4$.

4. Conclusions

The decay of ex-Micro-black-holes of number $\approx 10^{80}$ as $e^+ e^-$ quarks pairs which can generate the external electrical field (E) to condensate the free photons resulting from radiating of the Micro-black-holes as gluons of near the number ($\approx 10^{80}$) and together with the gluon components (B) both contribute to produce expansion rates (curvature) of Universe as expressed through the Hubble length from Einstein Equation when the energy density is of the form $\rho \approx B^2 = E^2/c^2$.

It is confirmed the timeline of Universe.

Then, the inverse value of B penetration length by E is just the bosons $W^{\pm}$ mass at high densities, respectively, the effective non-abelian color magnetic gluon mass at QCD densities. Also, it was shown that this model construction inherently permits the existence of an Quantum Well (QW) inside, as to be necessarily for polaritons production in order *to push continuously* the space-time till the today curvature, and finally, to obtain the value of the cosmological constant as based on the polariton mass of $\approx 4meV$ at reionization and, respectively today of $0.5meV$:
$\Lambda = (\varepsilon_{polariton-today})^4 = (5\times 10^{-12} GeV)^4 = 6\times 10^{-46} GeV^4$, the radiation frequencies at CMB time being $\nu = 3.8\times 10^{14} Hz$; $T = 2830K$; $\lambda = 10^{-6}[m]$ (infrared), and today $\nu = 3.9\times 10^{11} Hz$, $T = 2.7K$, and $\lambda = 0.4mm$ (microwaves).

1. a)Stefan mehedinteanu, What Is Gravity and How Is Embedded in Mater Particles and the Pure Gravity (Gravitons) Dark Matter Particles? (simplistic analysis), https://www.researchgate.net/profile/**Stefan_Mehedinteanu**/publications, 2015; b)A.Ali1, G.Kramer, JETS AND QCD: A Historical Review of the Discovery of the Quark and Gluon Jets and its Impact on QCD, arXiv:1012.2288v2 [hep-ph], 2011; c) Stephen W. Hawking, Malcolm J. Perry and Andrew Strominger, Soft Hair on Black Holes, arXiv:1601.00921v1 [hep-th], 5 Jan 2016. d) Aidan Chatwin-Davies, Adam S. Jermyn, Sean M. Carroll, How to Recover a Qubit That Has Fallen into a Black Hole, Phys. Rev. Lett. 115, 261302 – Published 30 December 2015**;**
2. David H. Lyth, Antonio Riotto, Particle Physics Models of Inflation and the Cosmological Density Perturbation, arxiv:hep-ph/9807278v4, 1999
3. **O. J. Pike**, **F. Mackenroth**, **E. G. Hill** , **S. J. Rose**, A photon–photon collider in a vacuum hohlraum, *Nature Photonics,* **8**, 434–436, (2014)
4. Remo Ruffini, Gregory Vereshchagin, She-Sheng Xue, Electron-positron pairs in physics and astrophysics: from heavy nuclei to black holes, arxiv:0910.0974v3[astro-ph.HE], 2009
5. Stimulated creation of quanta during inflation and the observable universe, Ivan Agullo, Leonard Parker, arxiv:1106.4240v1[astro-ph.CO], 2011
6. U. F. Wichoski , J. A. S. Lima, Big-Bang Cosmology with Photon Creation, arXiv:astro-ph/9708215v2, 1997
7. A. A. Abdo, et al., Discovery of TeV Gamma-Ray Emission from the Cygnus Region of the Galaxy, http://arxiv.org/ftp/astro-ph/papers/0611/0611691.pdf]
8. a)Stefan Mehedinteanu, On the Acceleration of Beta Nuclides Decay by the Photonuclear Reaction, International Journal of Nuclear Energy Science and Engineering (IJNESE) Volume 2, Issue 2 2012 PP. 45-56 www.ijnese.org © World Academic Publishing; b)H. Suganuma, T. Iritani, A. Yamamoto, F. Okiharu, T.T. Takahashi, Lattice QCD Study for Confinement in Hadrons, arxiv:1103.4015v1[hep-lat],2011
9. Dario Grasso, Hector R. Rubinstein, Potential s in the Early Universe, arxiv:astro-ph/0009061v2, 2001
10. A. H. Guth and S. Y. Pi, Phys. Rev. Lett. 49 (1982) 1110

11. Stefan Mehedinteanu, Numerical Analysis Of Pairs Creation By Schwinger Effect In Nucleons And The Beta-Decay Process Acceleration, MEHTAPress, J of Physics & Astronomy, volume 2, Issue 3, 2013
12. a)Stefan Mehedinteanu, The Connection between Quantum Mechanics & Gravity, Prespacetime Journal, January 2014, Volume 5, Issue 1, pp. 44-59; b)Michael Kurz, Are Planck-particles the primordial particles of matter in the universe?, Journal of Unsolved Questions, JUnQ,2, Issue 1-OQ, 1, 2011, http://www.researchgate.net/publication/268740509; c)L.Motz, The Quantization of Mass (or Gravitational Charge) http://www.gravityresearchfoundation.or ... 1/motz.pdf; d)M. Kumar, S. Sahoo, Planck Scale Particles in the Universe, ARPN Journal of Science and Technology, VOL. 3, NO. 1, Jan 2013, http://www.ejournalofscience.org/archive/vol3no1/vol3no1_5.pdf
13. Stefan Mehedinteanu, On the Photonuclear Rates Calculation for Nuclear Transmutation of Beta Decay Nuclides by Application of the Ginzburg-Landau Theory, Journal of Nuclear and Particle Physics 2012, 2(3): 57-70 DOI: 10.5923/j.jnpp.20120203.05
14. Stefan Mehedinteanu, Numerical Analysis Of Pairs Creation By Schwinger Effect In Nucleons And The Beta-Decay Process Acceleration, MEHTAPress, J of Physics & Astronomy, volume 2, Issue 3, 2013
15. Jin Young Kim, Taekoon Lee, Light bending in radiation background, arXiv:1310.6800v1[hep-ph], Oct. 2013
16. Jonathan Keeling, Natalia G. Berloff, Spontaneous rotating vortex lattices in a pumped decaying condensate, arXiV:0706.3686v3[cond-mat.other]
17. A. V. Larionov, V. D. Kulakovskii, S. Ho¨fling, C. Schneider, L. Worschech, A. Forchel, Polarized Nonequilibrium Bose-Einstein Condensates of Spinor Exciton Polaritons in a Potential , PRL 105, 256401 (2010) PHYSICAL REVIEW LETTERS, 2010
18. J. Fischer, S. Brodbeck, B. Zhang, Z. Wang, L. Worschech, H. Deng, M. Kamp, C. Schneider, and S. Höfling, Magneto-exciton-polariton condensation in a sub-wavelength high contrast grating based vertical microcavity, Applied Physics Letters 104, 091117 (2014)
19. James Bateman, Ian McHardy, Alexander Merle, Tim R. Morris, Hendrik Ulbricht1, On the Existence of Low-Mass Dark Matter and its Direct Detection, SCIENTIFIC REPORTS 5 : 8058, | DOI: 10.1038/srep08058
20. S. Mehedinteanu, On the numerical analysis of decay rate enhancement in metallic environment, ACTA PHYSICA POLONICA B No.10, Vol. 38 (2007)
21. R.W. Gurney, E.U. Condon, Phys. Rev. 33, (1929).
22. Suganuma H, et al, Dual Higgs Mechanism for Quarks in Hadrons, arxiv:hep-ph/9502279v1, 1995
23. a)K.H.Bennemann, J.B.Ketterson, Superconductivity conventional and unconventional Superconductors, (chapter of J.Pitaevski), vol.1, Springer, 2008; b)Tsuneo Suzuki, Katsuya Ishiguro, Yoshihiro Mori, Toru Sekido, The

dual Meissner effect in SU(2) Landau gauge, AIP Conf.Proc. 756 (2005) 172-181, arxiv:hep-lat/0410039v1, 2004. c)Tsuneo Suzuki, Katsuya Ishiguro, Yoshihiro Mori, Toru Sekido, The Dual Meissner Effect and Magnetic Displacement Currents, arxiv:hep-lat/0410001v2, 2005. d)Tsuneo Suzuki, A new scheme for color confinement and violation of the non-Abelian Bianchi identities, arxiv:1402.1294v3[hep-lat], 2014.

24. A.Ali1, G.Kramer, JETS AND QCD: A Historical Review of the Discovery of the Quark and Gluon Jets and its Impact on QCD, arXiv:1012.2288v2 [hep-ph], 2011