Dielectrons e^+e^- signals from fusion of QED Coherence and Nuclear states (GDR) in the C-C relativistic heavy ion collision.

Dr. Graziano Mileto (Email: Graziano.Mileto@Istruzione.It), M.I.U.R. (Italy)

Submitted at the Scientific Committee of "Mathematica Italia 7° User Group Meeting, 28-29 Maggio 2015, Napoli".

Abstract

At the start of the treatment it's pointed out that the theory of the QEDC-GDR can describe the C-C collision, as we have seen from the Ca-Ca collision [7]. The heavy ions collisions (h.i.c.), in the particle accelerators, allow to understand how the electromagnetic field merges, around the nuclei, with the nuclear field within the domain of coherence as provided from the *relativistic generalization* of QED Coherent theory, in the coherent vision of the Prof. G. Preparata [1] that has derived the fusion vector potential of electromagnetic and nuclear forces and point out that unforeseen electromagnetic effects inside the hadronic matter, as the GDR, are possible sources of the coherent dilelectronic pairs (e^+e^-) like they are measured in the h.i.c. at all energy, in particular the relativistics, and this show as the old physical models, that doesn't foresee similar electromagnetic fusions in the hadronic condensed matter are insubstantial to understand completely the exact results of experiment. Then, the analysis of the coherence of (e^+e^-) becomes the fulcrum of this work that's proposed of presenting the approach to the coherence on long range. We, finally, show the fanciful agreement in the applications to the ^{12}C+^{nat}C collision at 1.0 A GeV carried out at the BEVALAC from the DLS collaboration.

PACS numbers: 25.75.–q, 24.30.Cz, 13.85.Qk

Keywords: QED Coherence (QEDC), coherent dielectronic (dileptonic) pairs (c.d.p.), heavy ion collision (h.i.c.), light ion collision (l.i.c.), Giant Dipole Resonance (GDR).

Contents

I. INTRODUCTION

In this article we want to show that the unexplained effect of the *di-electron pairs* production (scilicet two lepton or dielectron, or one pair of particles, of opposite charge (e^+e^-) of the coherent type and *entangled*), as measured in the particle accelerators at the relativistic energy and for collisions that happen in the vacuum, it's interpreted much well with the Preparata's theory of QED coherence [1], and for a small number of processes it's due to an inborn process to the QCD that use the quark in the description of the collisional event of light ion collision (*l.i.c.*). Indeed, the existence of the quarks is impossible outside then nucleus because their instability and they aren't particles directly measurables, since are mathematics abstractions not measurable in our spacetime. The nearly whole of the scientific literature on the studies and researches in QCD [49] is **confused** and doesn't accepts the evident constraints and the limitations of his decoherent model [48]. We overlook a certain inertia of this theoretical model that remain incompetent of recognizing the inconsistence of the conjecture of the quarks. Our motto is "Resume Rutherford Law". Our aim is the generalization of the equations of coherence with the theory of Preparata and the hamiltonian that describe the contact forces. The Quantum Fields Theory (QFT) that's the fusion of the quantum mechanics and the special relativity theory, if it's applied in a mode "*incoherent and abstract*" gives rise at the production of a plethora of particles that illusoryly attempt of makes returns at the energetic calculus. In this optics we consider that the theory, for our guide line, is the theory of Preparata on which are based the more recent works [7], since with our scientific article we'll attempt to understanding as the theory [1], that's in the QFT's scheme too, is able to unfold the experimental data in BEVALAC at Lawrence Berkeley National Laboratory at relativistic energy as it has been shown in recent Ref. [7], recognizing it's a particular case that must be generalized in the theory of R. J. Glauber. We underline that the physics which attempts of finding the Quark Gluon Plasma (QGP) [39] in *l.i.c.* and, besides, much of the Monte Carlo type simulation (as MCNPX based on the Bertini model) that are conduct in order to transfer an huge radioactive beams across the shielding of the accelerator apparates [19] find out aberrant conclusions about the safety, because they try to move in our spacetime unreal particles breaking simmetries and are very random. The $(e^+e^-)_{tp}$ are correlated pairs and two principals theories ([25–34] and [35]), which models are called UrQMD (Ultra-relativistic Quantum Moleculars Dynamics) and HSD (Hadron String Dynamics), point out that they are producted from the conventional sources: Dalitz decay of π^0, η, ω and Δ near the direct decay of ρ, ω. But they don't justify the correlation of the $(e^+e^-)_{tp}$ and the surplus of measured pairs: their calculation point out that the $(e^+e^-)_{tp}$ measured signal is rising on the theoretical results of hadronic generators (see Fig. 1 anf Fig. 2). Therefore they lack of natural structure of coherence inborn in Preparata's theory [1].

II. THE UNITARY LIFTING

We know that, generally, it's worth that $U \times U^\dagger \neq I$ in the condition of applicability on the Hilbert spaces; we know, also, that for a

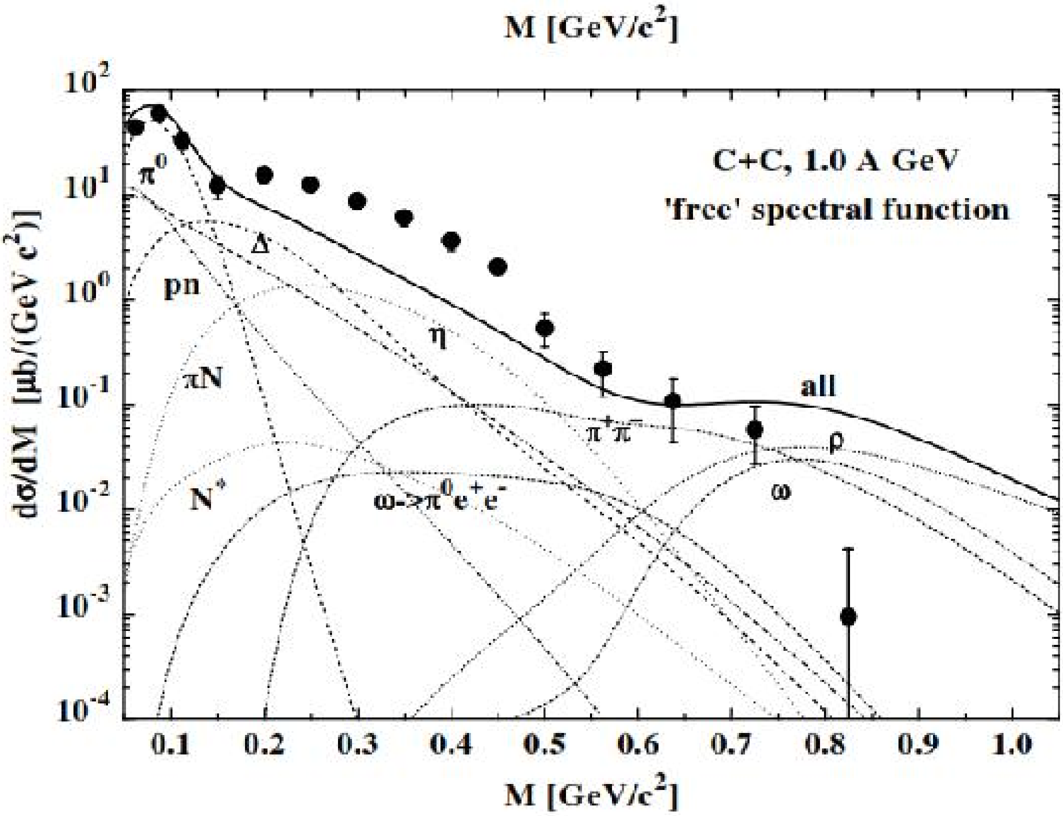

FIG. 1: Fitting dileptonic spectrum with Dalitz and direct decay gnerator [31].

distance more over than 1 fm, all the units are reducible to the conventional units, or when the $\lim\limits_{r>>1\text{ fm}} \hat{I}(r,p,\Psi,\partial\Psi,...) = I$ and $|\hat{I}| << 1$. In the Preparata's Theory this mathematical process comes close to the limit, through an unitary lifting, that has the following form: supposing that the expectation value of the unitary operator[1] is $N \simeq$

[1] We'll use the mathematical notation of the integral of the Ref. [1].

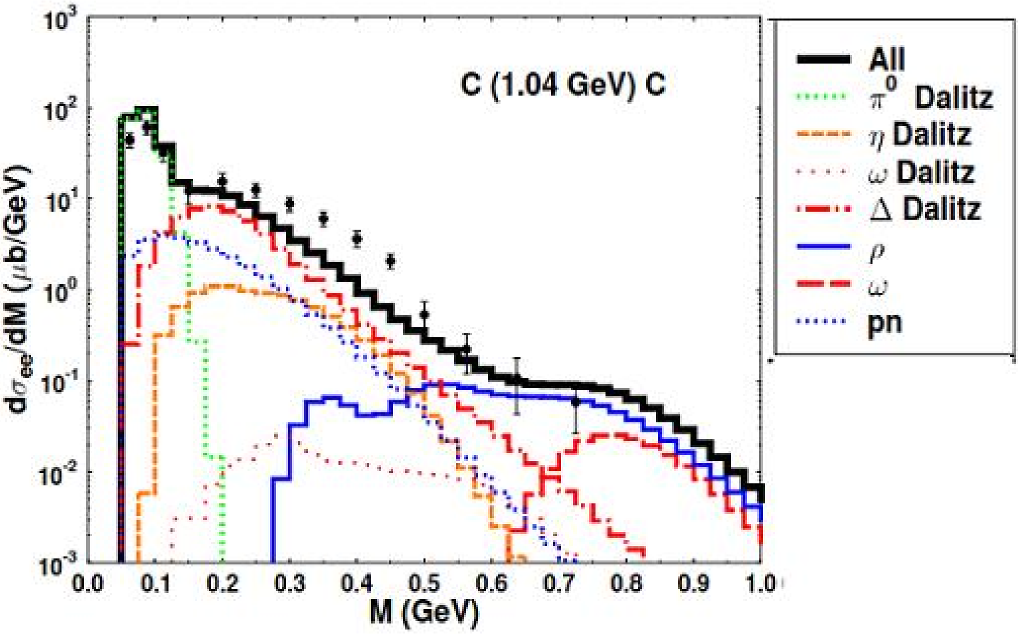

FIG. 2: Fitting dileptonic spectrum by UrQMD model, with Dalitz and direct decay gnerator [35].

$\displaystyle\int_{\vec{x},\alpha} \Psi^\dagger(\vec{r},\alpha,t)\Psi(\vec{r},\alpha,t)$, then if we normalize the wave functions for $\sqrt{N}$ and then replacing them as $\Psi(\vec{r},\alpha,t) \rightsquigarrow \Psi_0(\vec{r},\alpha,t) = \frac{1}{\sqrt{N}}\Psi(\vec{r},\alpha,t)$ and $\Psi^\dagger(\vec{r},\alpha,t) \rightsquigarrow \Psi_0^\dagger(\vec{r},\alpha,t) = \frac{1}{\sqrt{N}}\Psi^\dagger(\vec{r},\alpha,t)$ we obtain the unitary operator $I \simeq \displaystyle\int_{\vec{x},\alpha} \Psi_0^\dagger(\vec{r},\alpha,t)\Psi_0(\vec{r},\alpha,t)$, which imposing that $\mid \vec{r} \mid >> 1$ fm and that $N \longmapsto \infty$ is identically given from $\displaystyle\lim_{r>>1 \text{ fm},\ N\longrightarrow\infty} \hat{I}(r,p,\Psi_0,\partial\Psi_0,...) = I$. In the relativistic *l.i.c.* this condition is satisfied provide that the wave functions are to be determine in the ambit of the coherence domain with radius $\mid \vec{r} \mid \rightsquigarrow R_{CD} = \frac{\pi}{\omega_A}$, where $\omega_A = 0.078A^{-\frac{1}{3}}$ GeV (in natural unit: $\hbar = c = 1$ ed A is the atomic mass number) is the pulsation of giant dipole and the collisions raise the state to be excited for relaxing, then, in

Nucleus	A	ω_A [GeV c]	$T_{\ CD}$[GeV^{-1}c^{-1}]	R_{CD} [GeV^{-1}]	V_{CD} [GeV^{-3}]
Ca	40	0.02281	275.4	137.8	1.0968×10^7
C	12	0.03407	184.4	92.18	3.2823×10^6

TABLE I: Coherent quantity for the Ca and C ion, in natural unit.

Nucleus	A	ω_A [ZHz]	$T_{\ CD}$[zsec]	R_{CD} [fm]	V_{CD} [fm^3]
Ca	40	34.65	0.1813	27.20	84270
C	12	51.76	0.1214	18.19	25220

TABLE II: Coherent quantity for the Ca and C ion, in SI's unit.

a characteristic time of the coherence domain $T_{CD} = \frac{2\pi}{\omega_A}$ in the coherent spherical volume V_{CD}. The Tab. I and II, reassume[2] the coherent quantity for the two nuclei in collisions: for the calculus and the equations of our theoretical result relative to the collision between ^{12}C+^{nat}C at 1.0 A GeV, that there will go to expose, we are sending back to the recent publication [7] in which it has been bring again the measure and the theoretical calculus relative to the collision ^{40}Ca+^{nat}Ca at 1.0 A GeV carried out at the BEVALAC from the DLS collaboration [23, 24].

A. The entities physical characteristics of the interaction process

Now we want to unfold the notions of dileptons and Giant Dipole Resonance (GDR). To unfold what is a dileptons: if we indicate with $\overrightarrow{q}_{tot} = (\vec{q}_+ + \vec{q}_-)$ (where $\vec{q}_+$ is the 3-momentum of the e^+ and $\vec{q}_-$ is the 3-momentum of the e^-) and $q_{0tot} \equiv (q_{0+} + q_{0-})$ (q_{0+} is the energy of the $e^+$and q_{0-} is the energy of the e^-), the unbound state without interaction and, so, without potential of the two particle (one antiparticle of the other), yet, correlated is definite as follow

[2] We remember that 1 GeV^{-1} $\simeq$0.19732696 fm, in natural unit. Again, are used the prefix Z=10^{21} e z=10^{-21} in SI.

Conjecture 1 *a dielectron is a pair* (e^+e^-) *in which the total momentum must satisfy the condition* $|\overrightarrow{q}_{tot}| = \sqrt{q_{0tot}^2 - M_{e^+e^-}^2}$*, without an interaction potential or an hamiltonian, but that is tied by an isomorphism and a physical coherence between the constituents of the pair and its isovalor of energy.*

In which $M_{e^+e^-}$ is the invarinat mass, in the sense that it's the same for all the reference systems. Secondly, we want to characterize what is the notion on GDR explaining the process of interaction between two nuclei. For the two nuclei that undergo collision we take in consideration the collective states represented by the GDR, signed as, for every mass number A of nucleus from the pulsation $\omega_A = 0.078A^{-\frac{1}{3}}$GeV. This mode will couple in resonant way with the zero point of corresponding modes of the coherent electromagnetic field (c.e.f.). Such coupling compels the electromagnetic modes to "align the theirs phases", that is the coupling become coherent. These two coherent electromagnetic fields (linear overlappings of the modes at pulsation ω_A of GDR[3]) surround the two nucleus that go into collision and they are able to cause the transfer of energy and momentum to create the pair (e^+e^-) observed in the experiments of BEVALAC. The enhanced production of pairs of the coherent dielectronic pairs (*c.d.p.*) have origin for the fact that the c.e.f. aligning their independent modes in spherical coherence domain with the same pulsation ω_A, realize a transition from the coherent ground state (*c.g.s.*) onto the perturbative ground state (*p.g.s.*). In the *c.g.s.* the Scrödinger equations for a system of two levels coupled to a single c.e.f. mode and for two wave packet $\varphi_{1,2}(\vec{x}, t)$ with amplitudes $\alpha_{\vec{k}r1,2}$, have an exact solution (as reported in the Ref. [1, page 41, eq. (3.1a), eq. (3.1b) e eq. (3.1c).]). This solution give us, on the *cgs*, the complex expression for the vector potential of c.e.f.

$$\vec{A}(\vec{x}, t) = \left(\frac{4\pi}{3}\right) \frac{1}{\sqrt{\omega_A \cdot V_{CD}}} \frac{\sin(\omega_A \cdot r)}{(\omega_A \cdot r)} e^{-i(\omega_A \cdot t)} \hat{e}, \begin{pmatrix} r < R_{CD} = \frac{2\pi}{\omega_A} \\ \omega_r \approx \omega_A \end{pmatrix} \tag{1}$$

in which we've been placed $\hat{e}_\phi \equiv (-\hat{e}_x \sin\phi + \hat{e}_y \cos\phi)$.

[3] For more in-depth reading on the definition and accurated study on the GR we may indicate [40, 41].

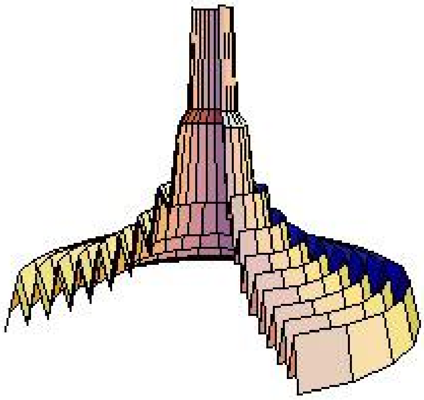

FIG. 3: Graphics representation of the module of the vector potential, given from the eq. (1), of the GDR in the spherical coherence domain.

Definition 2 *the state with the pulsation ω_A, within the spherical coherence domain*[4] V_{CD} *and with the interaction vector potential given from the eq. (1) we may definite GDR's state of the system nucleus -electromagnetic field described by the Coherent QED.*

A graph of this vector potential, that has an effective value of $|\vec{A}_{QEDC-GDR}(1\ R_{CaCD})|_{rms} \simeq 0.0000128\ \frac{Wb}{m}$, that shows as the amplitude has a giant aspect[5] [40, 41], is reported in Fig. 3. During the characteristic time, T_{CD}, the formation of iperdense medium in the *l.i.c.*,

---

[4] We precise, now, that the differential coherent equation aren't valide if the radius of coherence domain is "shrunk" as $R_{CD} \sim 1$ fm, because in this case A should be ~ 0.002.

[5] In the hadronic horizon, $r < 1$ fm, inside the coherence domains, $r < R_{CD}$, the vector potential should can have the same expression of the Hulten [53, page 170, eq. (4.11)] type $A_{Hulten} = A_{H0}\frac{\exp(-b\times r)}{(1-\exp(-b\times r))}$. And it's possible to unfold, as never in the DLS are measured pairs e^-e^- considered background pairs. The realization, however, of isoelectronium states, at high energy, would be to confirm by accurated calculus. This involves that in the frontier of the hadronic horizon

undergo a phase transition from the *pgs* to the *cgs* emitting, also, photonic radiation and hadronic wave matter [1] this is the reason of the issue of the emphasized *c.d.p.*.

III. THE HAMILTONIAN BY THE THEORY OF PREPARATA: *QED COHERENCE IN MATTER.*

To obtain the expression of the vector potential (1) we've re-examined [1] the equations of the motion for a system that it's described by the following Hamiltonian[6]

$$H_{hadr.matter} = \int\limits_{\vec{r},\alpha} \Psi^{\dagger}(\vec{r},\alpha,t) H_0(\vec{r},\alpha,-\imath\vec{\nabla})\Psi(\vec{r},\alpha,t) + H^{(1)}_{rad} + H^{(2)}_{rad} + H_{SR} \tag{2}$$

in which we have placed

$$H^{(1)}_{rad} = e \int\limits_{\vec{r},\alpha} \vec{A}(\vec{r},t)\Psi^{\dagger}(\vec{r},\alpha,t)\vec{J}(\alpha)\Psi(\vec{r},\alpha,t) \tag{3}$$

what will give a first estimate of the dissipative forces including in the Hamiltonian and the other approximation of the 2^{nd} order $H^{(2)}_{rad}$ what doesn't include the operator $\vec{J}(\alpha)$, or

$$H^{(2)}_{rad} = e^2\lambda \int\limits_{\vec{r},\alpha} \vec{A}(\vec{r},t)^2\Psi^{\dagger}(\vec{r},\alpha,t)\Psi(\vec{r},\alpha,t) \tag{4}$$

the latest has, however, a good approximation in the following

$$H^{(2)}_{rad} \approx e^2\lambda \left(\frac{N}{V}\right) \int\limits_{\vec{r},\alpha} \vec{A}(\vec{r},t)^2 = e^2 \left(\frac{N}{V_{CD}}\right) \sum_{\vec{k}\cdot\vec{r}} \frac{\lambda}{\omega_{\vec{k}\cdot\vec{r}}} \alpha^{*}_{\vec{k}\cdot\vec{r}}\alpha_{\vec{k}\cdot\vec{r}} \tag{5}$$

---

inside the coherence domain we neglect the Columbian repulsive force, resulting in the attraction between identical electrons that are measurable at the same time in the DLS but at very low energy.

[6] The hamiltoniana is calculated to distance few superior on the hadronic horizon [$10 \div 20$ fm] whereas the potential has still sense.

that includes the density of the systems in interaction $\left(\frac{N}{V_{CD}}\right)$, or the density of the *c.d.p.*. The Hamiltonian of short range H_{SR} is dependent from forces as those electrostatics for multi interactions-bodies. It's highly allowed too, by our prevision, not hamiltonians interactions that are possible to characterized by an attrative action as for the $\pi^0 = (\hat{e}^+_\uparrow, \hat{e}^-_\downarrow)$ or dependent from forces electrostatics type for repulsive interactions as for the Cooper pairs, $CP \equiv (\hat{e}^-_\uparrow, \hat{e}^-_\downarrow)$. The experimental verification rises from the surveying of Cooper pairs in coincidence, in the products of the hic. The law of the physics foresees, in fact, that the nonlocal interactions and nonhamiltonian type due to wave packet overlapping at short distance is always in attraction on a single pairs and absorbing the coulomb interaction. By the way, we are specifying what we mean for dielectronic true pair (*tp*) and false pair (*fp*) [18, pag. 63]:

- the *fp* of background is a single member of the pair $(e^+e^-)_{fp}$ in which the other *isn't detected* such that in the configuration of the final state is registered only one e^- in one side or only one e^+, without to have signals on the other side[7];

- the number of dileptonic *fp* of background is constituted from the same number of pair with the same sign $(e^-e^-)_{fp}$ and $(e^+e^+)_{fp}$;

- the *tp* is obtained subtracting the number of pairs with the same sign $(e^-e^-)_{fp}$ and $(e^+e^+)_{fp}$ from the number of pairs with opposite sign $(e^+e^-)_{fp}$.

When the $(e^-e^-)_{fp}$ are measured, that are subtracted from the principal signal, it does not other that lead under test the fragmentation of the Cooper pair $CP \equiv (\hat{e}^-_\uparrow, \hat{e}^-_\downarrow)$: these are formed in the iperdense medium, then, they are broken up to be detected as standard e^- in the two arms of the DLS. Theirs previously formation within the hadronic horizon ($r < 1$ fm) is a physical phenomenon not describable by hamiltonian formulation, based on state of the art of our knowledge. All the

[7] In the DLS system, that is a detector system composed by two side, it's possible to happen that both the members of a dilepton pair is detected in only one side: the pair is rejected.

processes that we are able to analyse with an hamiltonian formulation has already been brought supra pointing out even the prominent aspects as the generation of a photon "mass-term" $\int_{\vec{r}} \mu_\lambda^2 \vec{A}(\vec{r},t)^2$, in which $\mu_\lambda^2 = e^2 \left(\frac{N}{V_{CD}}\right) \lambda$, due to the potential interactions in the region of the acceptance. This bosonic mass term is able to generate the invariant mass of *c.d.p.*, perhaps by interacting with the scalar field of the Higgs Boson, in medium, generating the final massive state (e^+e^-) from the initial masseless state $(\gamma\gamma)$ and is the intermediate of electromagnetic and nuclear forces in condesated matter. It comes naturally to think that in the iperdense media the photon acquires a mass not negligible produced by local interactions and integral for contact processes. At this stage we are calculating the invariant mass for the photons, starting from the photonic 4-momenta[8] $\overleftrightarrow{q_1}$ and $\overleftrightarrow{q_2}$; we may write $M_{\gamma\gamma}^2 \equiv \left(\overleftrightarrow{q_1} + \overleftrightarrow{q_2}\right)^2$ and we are seeing that they are dealt quantized *à la* Plank quantized in mode that it's possible to infer the

Conjecture 3 *the 4-momenta of coherent photons that in collision produce the dielectrons are*

$$\overleftrightarrow{q_1} \equiv (q_{01}, |\vec{q}_1|) = \left(\sqrt{\frac{n}{2}}\omega_1, \sqrt{\frac{n}{2}}\omega_1\right), \tag{6}$$

$$\overleftrightarrow{q_2} \equiv (q_{02}, |\vec{q}_2|) = \left(\sqrt{\frac{n}{2}}\omega_2, \sqrt{\frac{n}{2}}\omega_2\right), \tag{7}$$

in which n is found [5, 7] to be

$$n = 2\frac{q_{0tot}^2}{(\omega_1+\omega_2)^2} = 2\frac{\left(\frac{\sqrt{M_{e^+e^-}^2 + \vec{q}_{\perp tot}^{\,2}}}{\sqrt{1-\left(\frac{-1+\exp(2y_{lab})}{1+\exp(2y_{lab})}\right)^2}}\right)^2}{(\omega_1+\omega_2)^2}. \tag{8}$$

---

[8] Henceforward we shall indicate with $\overleftrightarrow{q}$ a 4-momentum, or $\overleftrightarrow{q} \equiv (q_0, q_1, q_2, q_3) = (q_0, \vec{q})$. Marking that the 4-momenta of the $e^\pm$ will be indicate with $\overleftrightarrow{q_\pm}$ while $\overleftrightarrow{q_{1,2}}$ are those photonics.

viz. they are rescalating[9] $\left(N^{1/2} \Leftrightarrow \sqrt{\frac{n}{2}}\right)$ *by* $\int\limits_{\vec{r},\alpha} \Psi^*(\vec{r},\alpha,t)\Psi(\vec{r},\alpha,t) = N$ *as foreseen by Preparata's theory and having the real form,* $\left(\overleftrightarrow{q_1}\right)^2 = \left(\overleftrightarrow{q_2}\right)^2 = 0.$

In the eq. (8), we've assumed that holds the relations for the variables of the *geometrical acceptance*[10] formed by the invariant mass of $(e^+e^-)_{tp}$, $M^2_{e^+e^-} = (\overleftrightarrow{q_+} + \overleftrightarrow{q_-})^2$, the transverse total momentum, $\vec{q}_{\perp tot} \equiv (\vec{q}_{\perp +} + \vec{q}_{\perp -})$ of *c.d.p.*, or in modulus $|\vec{q}_{\perp tot}| \equiv \sqrt{q^2_{+\perp} + q^2_{-\perp}}$, and by the dielectron laboratory rapidity

$$y_{lab} \equiv \frac{1}{2}\ln\left(\frac{q_{+0}+q_{-0}+q_{+3}+q_{-3}}{q_{+0}+q_{-0}-q_{+3}-q_{-3}}\right), \tag{9}$$

where the simulation of experimental data, by the DLS collaboration, has limited the measures of dielectrons cross section production. We are argueing that the relation between the invariant mass $M_{e^+e^-}$ of the dileptons and the "giant" coherent photons that are massive in the hadronic matter is

$$M^2_{e^+e^-} \equiv \left(\overleftrightarrow{q_-} + \overleftrightarrow{q_+}\right)^2 = q^2_{0tot} - \vec{q}^{\,2}_{\perp tot} - q^3_{3tot} = M^2_{\gamma\gamma} \equiv \left(\overleftrightarrow{q_1} + \overleftrightarrow{q_2}\right)^2 = 2\,\overleftrightarrow{q_1}\cdot\overleftrightarrow{q_2}. \tag{10}$$

A. The number and the density of (e^+e^-) or photon mass term

The experimental measures for the *lic* ^{12}C+^{nat}C at 1.0 A GeV conduct to the BEVALAC and presented in the Ref. [24, page 1230, Table I],

---

[9] We remember that the isonumber of $(e^+e^-)_{tp}$ is a measurable value[24, page 1230, Table I], like we may see $n_{DLS} = 4698 \pm 145$ as isonumber of $(e^+e^-)_{tp}$ for ^{40}Ca+^{nat}Ca at 1.0 A GeV.

[10] The experimental intervals of the *geometrical acceptance*, of the DLS, have the following ranges $0.05 \leq M_{e^+e^-} \leq 1.25\ \frac{GeV}{c^2}$, $0.0 \leq |\vec{q}_{\perp tot}| \leq 0.8\ \frac{GeV}{c}$, and $0.5 \leq y_{Lab} \leq 1.9$.

show for the number of $(e^+e^-)_{tp}$ the value of $n_{e^+e^-DLS} = 2841 \pm 82$. The theory of the QED coherent foresee a number of c.d.p equal to the measured value but it increases for high invariant mass and for raised values of the rapidity in the laboratory, as is seen in Fig. 4. A part of the $(e^{\pm}_{\uparrow\downarrow}e^{\pm}_{\uparrow\downarrow})$, for dissipative effect and interactions not local, not potential, not describable from a Hamiltonian convert in hadrons into the hadron horizon to form different particles secundum if the attraction is repulsive or attrative: for this reason the DLS collaboration [24] have detected π^0 and other mesons.

The density is an invariant value, stationary $\frac{\mathrm{d}}{\mathrm{d}t}\frac{N}{V_{CD}} = 0$ too, and is plotted in the Fig. 5, and its value in the acceptance's region launch from a value of the order of $\simeq 2.5 \cdot 10^{-5}$ GeV^{-3} at to $\simeq 1 \cdot 10^{-4}$ GeV^{-3}, having the same graphic behaviour that for n. Remember that the isodensity is important for the calculus of the value of $H^{(2)}_{rad}$ and it represents the contribution of the interactions not local and not potential that multiply the Hamiltonian part given from the sum $\sum_{\vec{k}\cdot\vec{r}} \frac{\lambda}{\omega_{\vec{k}\cdot\vec{r}}} \alpha^*_{\vec{k}\cdot\vec{r}} \alpha_{\vec{k}\cdot\vec{r}}$. The density is an invariant of the coherence of the medium with dielectric costant $\epsilon\omega = 1 - \lambda \left(\frac{e}{\omega}\right)^2 \left(\frac{N}{V_{CD}}\right)$, fruit of the dispersive interaction of the *e.m.* field with the hadronic matter and distinguishes the terms of the free space *e.m.* waves: is important for the "fluctuations" of the Lagrangian. Preparata called it "photon mass term". The quantum fluctuations taken account of the "external" field $\vec{A}_{QEDC-GDR}(\vec{r}, t, \phi)$,

coupled with the hadronic matter for this reason the description of the process becomes "perturbative" and the Lagrangian can be calculated as in [1, page 37, eq. (2.57).] in which the medium becomes *e.m.* "condensate", viz. the hadronic matter field $(\eta, \eta^\dagger)$ perform fluctuations with the *e.m.* field. We can conclude that the theory of Preparata is one that dinstinguishes the systems with exterior and interior dynamics.

IV. THEORETICAL CALCULATION FOR ^{12}C+^{nat}C A 1.0 A GEV

In this section we remember that the Lagrange function of the matter must be rewrited $\bar{L}_{matt} = L_{matt}[\Psi_o, \Psi^\dagger_o, a^o_{\vec{k}r}, a^{\dagger o}_{\vec{k}r}; e\sqrt{N}]$, in which we've rescaling the quantum wave field and the *e.m.* creation and the annihila-

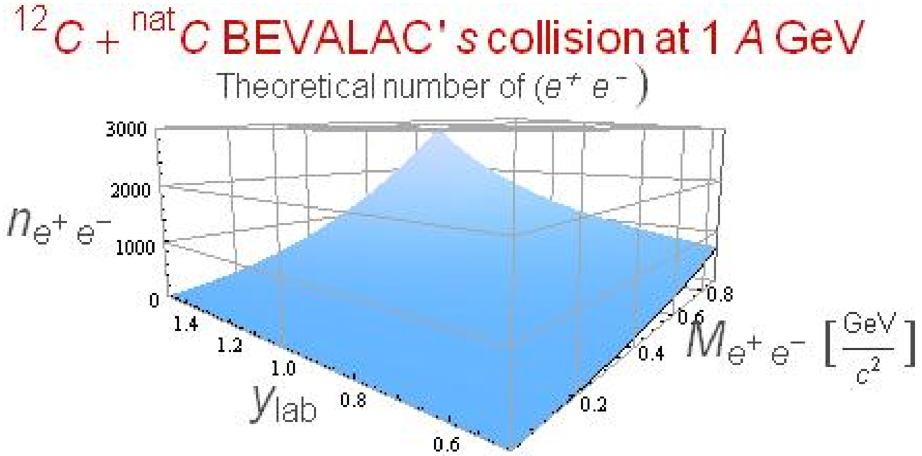

FIG. 4: The number of *c.d.p.* from the collision of the coherent photons, $(\gamma+\gamma)_{coherents} \longrightarrow (e^{+}+e^{-})_{coherents}$, plotted theoretically by us in function of $(M_{e^{+}e^{-}},\ y_{lab})$ in the region of geometric acceptance of the DLS spectrometer, for the collision ^{12}C+^{nat}C at 1.0 A GeV carried out at BEVALAC [24].

tion operators, dividing by $\sqrt{N}$ from the eq. (8), while $e\sqrt{N}$ represent the coupling of the electric charge with the coherent factor, that's the collettive behaviour of the interaction; the Langragian of *e.m.* filed is of the type $\bar{L}_{em}$ $=L_{em}[a^{o}_{\vec{k}r}, a^{\dagger\circ}_{\vec{k}r}]$; where we have written the rescalated amplitude: $\Psi_o(\vec{x},\alpha,t) = \frac{1}{\sqrt{N}}\Psi(\vec{x},\alpha,t)$ and $a^{o}_{\vec{k}r} = \frac{1}{\sqrt{N}}a_{\vec{k}r}$. In this way the amplitude of the transition between a general initial state i at the final state f is characterized of the integral of temporal path: $\langle f,t_f|i,t_i\rangle_N \propto$

$$\int \left[\mathrm{d}\Psi_o\right]\left[\mathrm{d}\Psi_o^{\dagger}\right]\left[\mathrm{d}a^{o}_{\vec{k}r}\right]\left[\mathrm{d}a^{o\dagger}_{\vec{k}r}\right]\exp\left\{\imath N\int_{t_f}^{t_i}\mathrm{d}t\left(\bar{L}_{matt}+\bar{L}_{em}\right)\right\}.$$

We've used this integral form the calculate the amplitude of $\gamma\gamma \longrightarrow (e^{+}e^{-})_{tp}$ scattering, as a matter of fact, the experimental measures are given in terms of $\frac{\mathrm{d}\sigma}{\mathrm{d}M_{e^{+}e^{-}}}\left[\frac{\mu\mathrm{barn}}{\mathrm{GeV}/c^{2}}\right]$, for this we have calculated the differential cross section in invariant mass in the form of

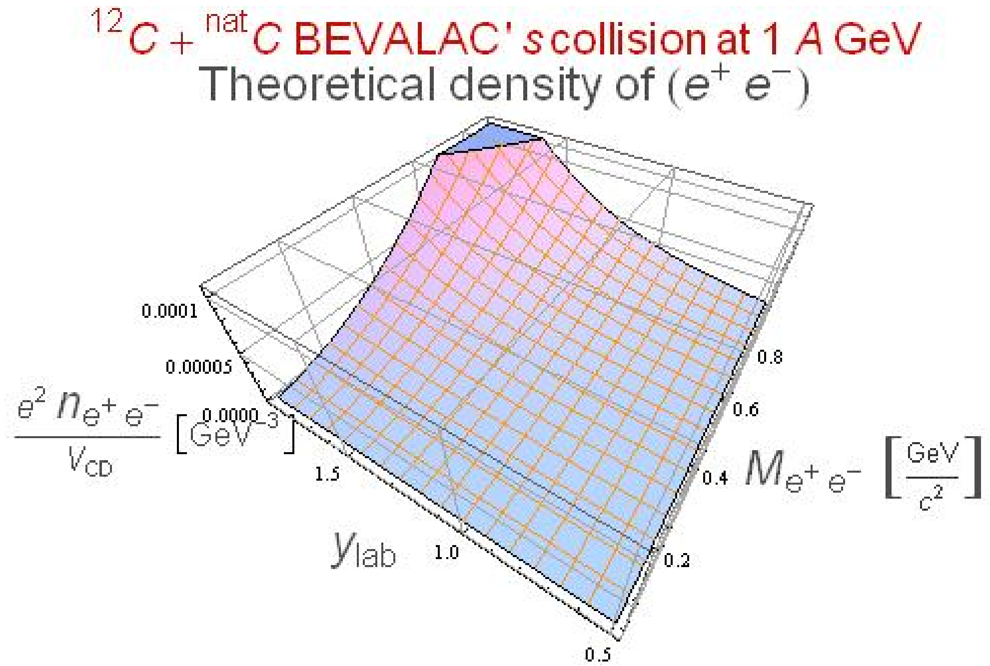

FIG. 5: The theoretical values of *c.d.p.* density that can be used to calculate the photon mass term, plotted theoretically by us in function of $(M_{e^+e^-},\ y_{lab})$ in the region of geometric acceptance of the DLS spectrometer, for the collision ^{12}C+^{nat}C at 1.0 A GeV carried out at BEVALAC [24].

$$\frac{\partial\sigma_{\gamma\gamma\longrightarrow(e^+e^-)_{tp}}(M_{e^+e^-},|\overrightarrow{q}_{\perp tot}|,y_{lab})}{\partial M_{e^+e^-}} = \Sigma(M_{e^+e^-})\Psi_{DileptonicSpace}(M_{e^+e^-},|\overrightarrow{q}_{\perp tot}|,y_{lab})\cdot$$
$$\cdot F_{CC}(M_{e^+e^-},|\overrightarrow{q}_{\perp tot}|,y_{lab}), \qquad (11)$$

where $\Sigma(M_{e^+e^-})$ is a function with unit of measure $\frac{\mu\text{barn}}{\text{GeV}/c^2}$ calculated in the Ref. [4, 7], being a familiar function of $M_{e^+e^-}$ regulated from the relative speed of the two nucleus that go into collision and from theirs energies, in function of ω_C the pulsation of GDR of the carbon being the energy of th e incoming coherent photons in the interaction scheme and of the energies of the outgoing *c.d.p.* as function of $M_{e^+e^-}$; whereas $\Psi_{DileptonicSpace}(M_{e^+e^-},|\overrightarrow{q}_{\perp tot}|,y_{lab})$ is the function, that we determined *one dileptonic space of the phases* for the *c.d.p.*, and finally $F(M_{e^+e^-}, |\overrightarrow{q}_{\perp tot}|, y_{lab})$ is the function that we determined a form factor of the coherent QED (to see the complete expressions of the three functions we send back the reader to the Ref. [4, 7], in which we've brought the resultes for the collision ^{40}Ca+^{nat}Ca at 1.0 A GeV). At this stage we are able to present the theoretical calculus for the collision ^{12}C+^{nat}C at 1.0 A GeV too.

A. The scattering angles in the reference frame of the DLS

As you can see from the Fig. 6 the photons have wide angles of opening in the reference frame of the laboratory. One photon pile up another with a given angle $\psi = \measuredangle(\vec{q}_1, \vec{q}_2)$. They are, however, coherent photons for this is definable between them a real angle in the region of the acceptance of the DLS spectrometer: the scattering that happens is of the type $(\gamma + \gamma)_{coherents} \longrightarrow (e^+ + e^-)_{coherents}$, we want to say that the *c.d.p.* that are formed and correlated. From the Fig. 6 is seen clearly that ψ has its maximum for the lowest value of the invariant mass but it's not influenced from the rapidity in the laboratory, as it's natural to imagine. While the lowest values of ψ are assumed in the values tallest for $M_{e^+e^-}$ (beyond 0.8 GeV/c^2), we will have that $\min\psi \simeq 0.74$ rad and $\max\psi \simeq 1.75$ rad (below 0.1 GeV/c^2). All the other photons with angle different from the values of ψ not produce measurable *c.d.p.* directly.

The other significant angle is $\theta = \measuredangle(\vec{q}_2, \vec{q}_{tot})$ and its given trend is in the Fig. 7. This is the angle between a photon and a *c.d.p.* in the DLS. Its maximum and minimum are $\min\theta \simeq 0$ rad and $\max\theta \simeq 2\ \pi$ rad, increasing then when increase $M_{e^+e^-}$ without the influence of y_{lab}, the c.d.p. comes spread everywhere in the plane of the DLS spectrometer, without favoured directions.

B. The signal and the density of energy of *c.d.p.* (e^+e^-)

From the Fig. 8 is evicted that the signal, $S_{e^+e^-}$, is not independent from di scatterig angle between the photons, incrementing with when its values increse. It vary, besides, in function of the invariant mass. This is a logical result from the physical point of view, since the *c.d.p.*'s

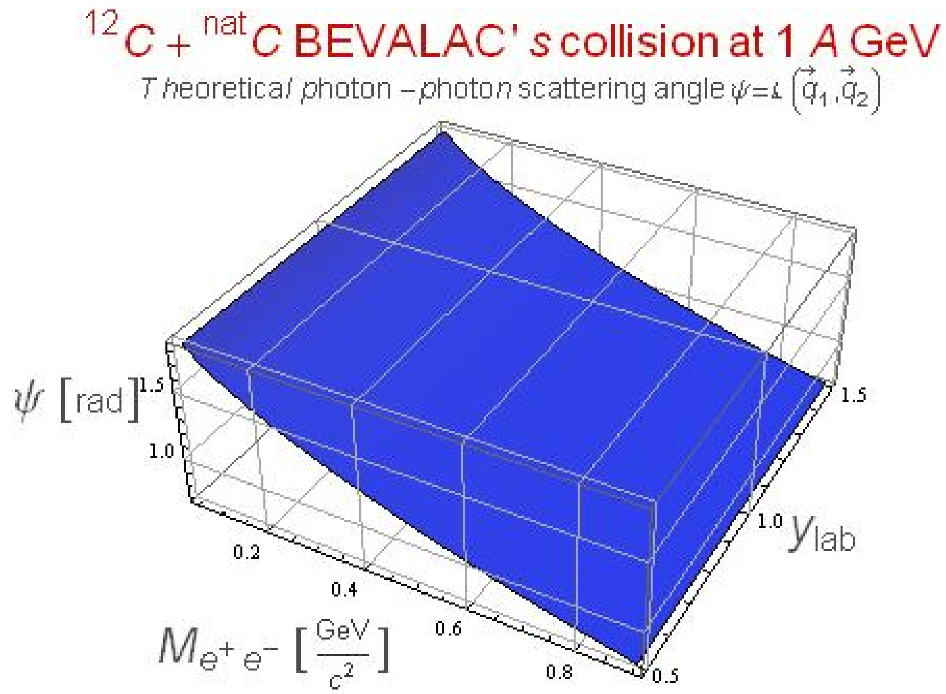

FIG. 6: The photonic scattering angle $\psi = \measuredangle(\vec{q}_1, \vec{q}_2)$ in $(\gamma + \gamma)_{coh} \longrightarrow (e^+ + e^-)_{coh}$; plotted theoretically by us in function of ($M_{e^+e^-}$, y_{lab}) in the region of geometric acceptance of the DLS spectrometer, for the collision ^{12}C+^{nat}C at 1.0 A GeV carried out at BEVALAC [24].

signal is a scalar function of the geometric variables in the acceptance's region of the spectrometer and from the imput variable of the transition amplitude that selects like coherent photons are possible to spread in *c.d.p.*. The prominent fact is that it varies from the values of $S_{e^+e^-} \simeq 2$ at 2.02, for two particlesin for one pair, the little variation reflects the Heisenberg's uncertaintly principle in the precise measurement of the number in the constituents of the single *c.d.p.* in the acceptance's region.

The volume of interaction, V_S of the dileptonic signal $S_{e^+e^-}$, is plotted in the Fig. 9, its trend is independent from the diffusion photonic angle ψ, but to the contrary vary significantly in function of $M_{e^+e^-}$ assuming values $\simeq 0$ for the high invariant mass and rising the top of 10^5 GeV^{-3}

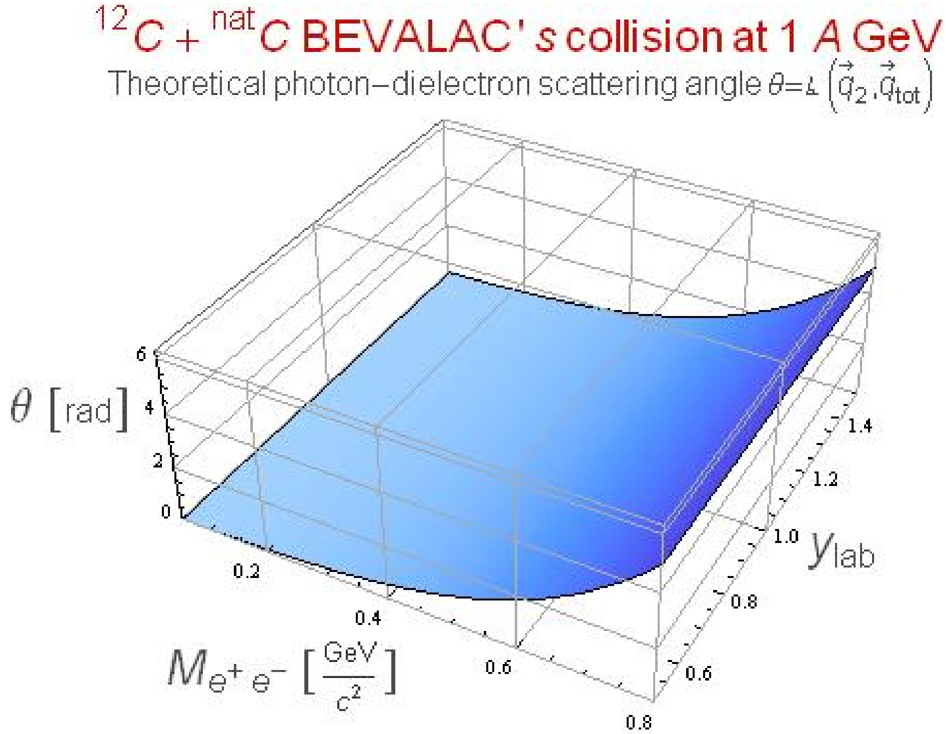

FIG. 7: The scattering angle $\theta = \measuredangle(\vec{q}_2, \vec{q}_{tot})$, between the photons and the *c.i.p.*, plotted theoretically by us in function of $(M_{e^+e^-},\ y_{lab})$ in the region of geometric acceptance of the DLS spectrometer, for the collision ^{12}C+^{nat}C at 1.0 A GeV carried out at BEVALAC [24].

for the low invariant mass, its trend is uniformly continuous.

C. The Dileptonic Coherent Form Factor and the Space of Phases of *c.d.p.*

As far as here, we have now noted uniformly continuous plots from the mathematic point of view. Passing, instead, to the analysis of the two structural components of the expression in eq. (11) for $\frac{\mathrm{d}\sigma_{\gamma\gamma\longrightarrow(e^+e^-)_{tp}}(M_{e^+e^-},|\overrightarrow{q}_{\perp tot}|,y_{lab})}{\mathrm{d}M_{e^+e^-}}$ we must analyse the Coherent Dilep-

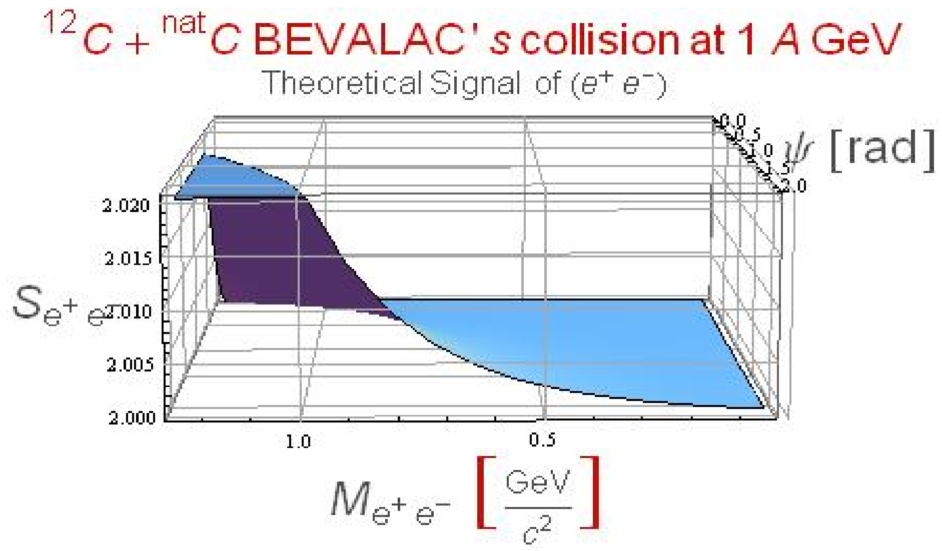

FIG. 8: The theoretical signal $S_{e^+e^-}$ of $c.d.p.$ plotted by us in function of $(M_{e^+e^-},\ \psi)$ in the region of geometric acceptance of the DLS spectrometer, for the collision ^{12}C+^{nat}C at 1.0 A GeV carried out at BEVALAC [24].

tonic factor of Form $F_{CC}(M_{e^+e^-}, |\overrightarrow{q}_{\perp tot}|, y_{lab})$, and the Coherent space of Phases $\Psi_{DileptonicSpace}(M_{e^+e^-}, |\overrightarrow{q}_{\perp tot}|, y_{lab})$. The former is plotted in Fig. 10 and points out characteristics of strong discontinuity in its points in function of the transverse momnetum of $c.d.p.$, $|\overrightarrow{q}_{\perp tot}|$, and than of the invariant mass $M_{e^+e^-}$. Its values (from 16, up to 17) are high for the low values fo $|\overrightarrow{q}_{\perp tot}|$ and for the invariant mass, for this we guess that the trend of dileptonic spetrum wait for a decreased with a discontinuity, significant, and resentful for low values of $M_{e^+e^-}$.

After such discontinuity we waiting that there is an uniform trend with increasing and decreasing values in function of the localization on the axes $(M_{e^+e^-}, |\overrightarrow{q}_{\perp tot}|)$, confluent to low values to the increase of the values of $(M_{e^+e^-}, |\overrightarrow{q}_{\perp tot}|)$. This conduct us to guess that the spectrum will have a trend as that experimental for the collision ^{12}C+^{nat}C at 1.0 A GeV carried out in BEVALAC [24].

The plot for $\Psi_{DileptonicSpace}(M_{e^+e^-}, |\overrightarrow{q}_{\perp tot}|, y_{lab})$ in Fig. 10 is, instead, continuous without discontinuity reflecting the coherence of the $c.d.p.$ in Coherent Space of the Phases and in the region of geometrical acceptance

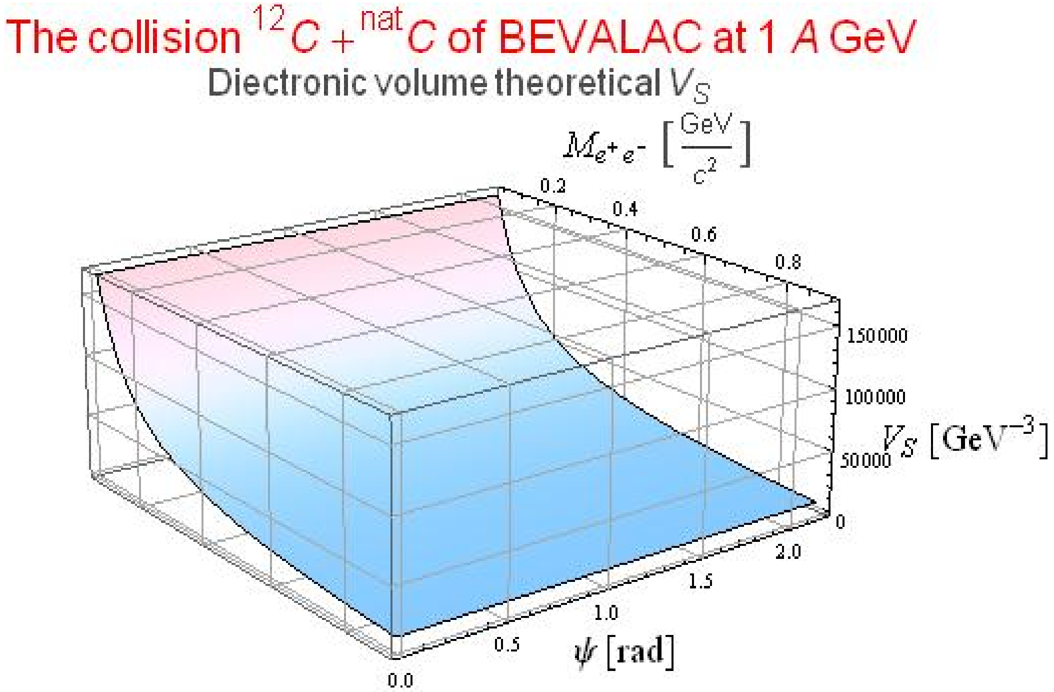

FIG. 9: The theoretical volume of interaction V_S of $S_{e^+e^-}$ plotted by us in function of $(M_{e^+e^-},\ \psi)$ in the region of geometric acceptance of the DLS spectrometer, for the collision ^{12}C+^{nat}C at 1.0 A GeV carried out at BEVALAC [24].

of the DLS spectrometer. Its values decrease uniformly in function of the rising of y_{lab} from to $\Psi_{DileptonicSpace}(M_{e^+e^-}, |\overrightarrow{q}_{\perp tot}|, y_{lab}) > 10$ at $\Psi_{DileptonicSpace}(M_{e^+e^-}, |\overrightarrow{q}_{\perp tot}|, y_{lab}) < 2$; also depending from the growth of $M_{e^+e^-}$ it drops and has its maximum in the region $y_{lab} < 1$ and $M_{e^+e^-} < 0.5\ \frac{\text{GeV}}{c^2}$. This trend will influence the spectrum, of the (e^+e^-), which assumes high and decreasing values floating from the low values of the invariant mass to that high.

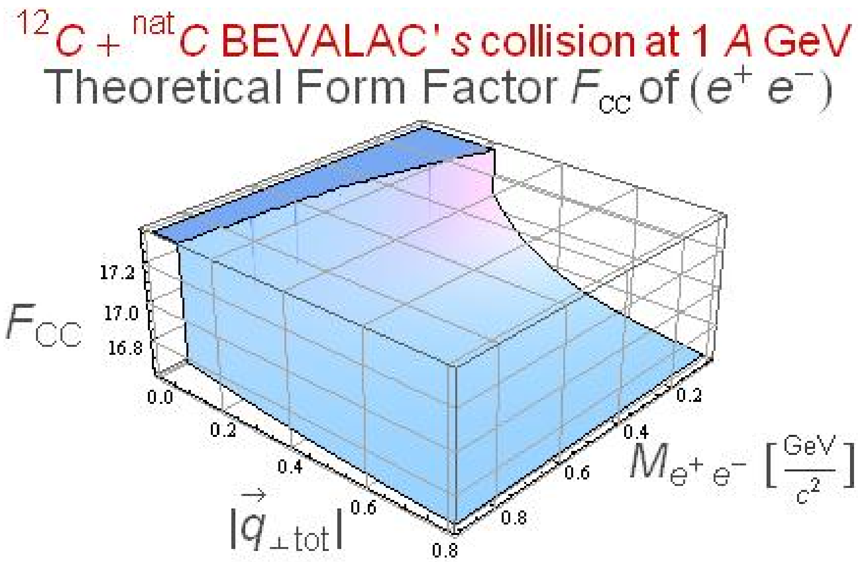

FIG. 10: The form factor F_{CC} for the collision of the coherent photons, plotted theoretically by us in function of invariant mass and transverse momentum of *c.d.p.* in the region of geometric acceptance of the DLS spectrometer, for the collision ^{12}C+^{nat}C at 1 A GeV carried out in BEVALAC [24].

V. CONCLUSIONS: THE DIFFERENTIAL SPECTRA IN INVARIANT MASS $\frac{\mathbf{d}\sigma_{\gamma\times\gamma\rightarrow e^+e^-}}{\mathbf{d}M_{e^+e^-}}$ OF *C.D.P.* (e^+e^-)

We are describing, now, the trend of our spectrum in function of the invariant mass being this the only variable with one the experimental measure are presented for the *l.i.c.* ^{12}C+^{nat}C at 1.0 A GeV carried out at BEVALAC [24]. The $\frac{\mathrm{d}\sigma_{\gamma\gamma\longrightarrow(e^+e^-)_{tp}}(M_{e^+e^-},|\vec{q}_{\perp tot}|,y_{lab})}{\mathrm{d}M_{e^+e^-}}$ spectrum, in lin-lin scale, in function of invariant mass calculated by our theory, represented comparatively to the HSD curve [31] and with the comparison with the experimental measures obtened in the BEVALAC [22], is plotted in the Fig. 12. In the HSD curve, in green, we note that it not have any discontinuity then is possible to unfold the effect of the exaltation measured of the (e^+e^-) pairs in the interval $M_{e^+e^-} \in (0.19, 0.4)\ \frac{\text{GeV}}{c^2}$. The iper-radiant effect is possible to be only explained in the QED coherence

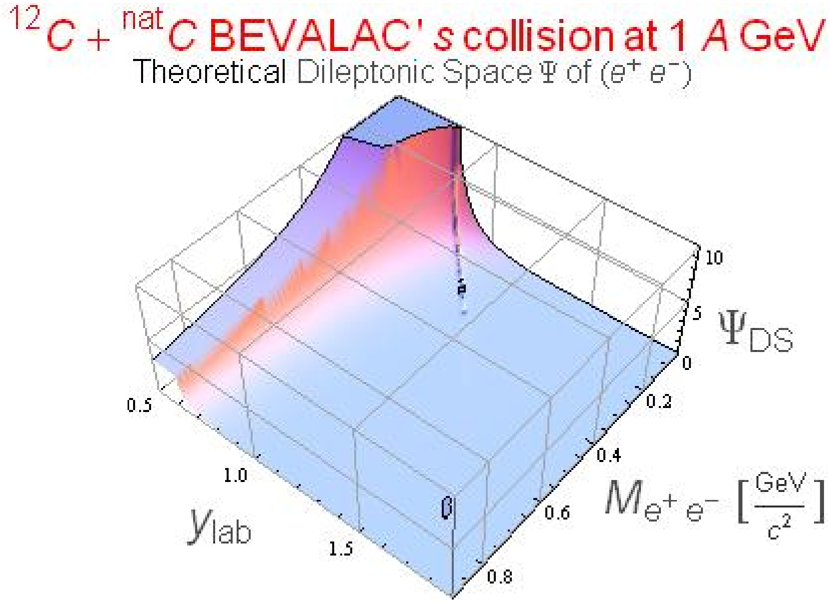

FIG. 11: The dileptonic space of phases $\Psi_{DileptonicSpace}$ for $(e^{+}e^{-})$, plotted theoretically by us in function of $(M_{e^{+}e^{-}},\ y_{lab})$ in the region of geometric acceptance of the DLS spectrometer, for the collision ^{12}C+^{nat}C at 1.0 A GeV carried out at BEVALAC [24].

in matter, as it is seen wonderfully from the trend of the calculated curve by our theory and presented in blue colour. The iper-radiant effect is dues by the coherence in the fusion of the electromagnetic and nuclear fields that vibrate at the pulsation of the GDR's resonance. Evidently, according to the necessary approximations, our presented spectrum has an asymptotic trend without maximum, below the local maximum in the region of enhancement and with a minimum for the high values of $M_{e^{+}e^{-}}$.

Its rounding should be executed in a later work. What interest us is its exceptional predictive of the iper-radiant phase justifiable by us, but become an open problem from the other theories. The HSD spectrum, as a matter of fact, for low values of the invariant mass seems represent the trend of the measured points in the DLS spectrum; but for us it doesn't seem so: it's evident that must be an iper-radiant effect due to the electro-hadronics dissipations that pervade the hadron condensate medium formed immediately after the collision: in the passage from the *p.g.s* to the *c.g.s.*. There is expected too, therefore, a first curve (not illustrated because cut from our kinematics cutting in the acceptance's region) explosively ascendant and asymptotic which precedes our curve reported in figure but that is not connected given the power of the electrohadronic radiance as the fusion of the electromagnetic and nuclear fields. This result there convinces us to say that any theory forecast on the quark is admissible or justified from the experiment, as the formation of the QGP phase is not the event responsable of the exaltation measured of the (e^+e^-) for the collision. This result there convinces us to say that *no one theoretical forecast on the quarks is admissible or justified from the experiments*, as the formation of the phase of QGP because the quarks aren't accountables of the measured exalting for the collision ^{12}C+^{nat}C at 1.0 A GeV and neither for the collision ^{40}Ca+^{nat}Ca at 1.0 A GeV carried out at BEVALAC how we've shown, already, in the Ref. [7]. The electro-hadronic coherent form factor, is the key of the iper-radiat phase as it points out its discontinuous trend (Fig. 10). The confirmation on the invariance of the measure of the number of the *c.d.p.* as waited from us as applying the theory is a fantastic scientific result that spurs us to lead further researches on the measures of the (e^+e^-) confirming magnificent predictive power of the relativistic generalization of QED coherence in the collisions between light and heavy ions at the BEVALAC's energy.

---

[1] G. Preparata, *QED Coherence in Matter*, World Scientific, 1995.

[2] G.Preparata, *An Introduction to realistic quantum physics*, Milano 1998

[3] Glauber R. J., *Quantum Optics*, Academic Press, London 1970

[4] G. Mileto, *QED Coerente e produzione esaltata di coppie e^+e^- nelle collisioni ioniche ultrarelativistiche*, Degree Thesis in University of Calabria (Italy) 1998

[5] G. Mileto, *Esaltazione della produzione di coppie dielettroniche nelle collisioni fra ioni pesanti relativistici*, PhD Thesis in University of Calabria (Italy) 2001

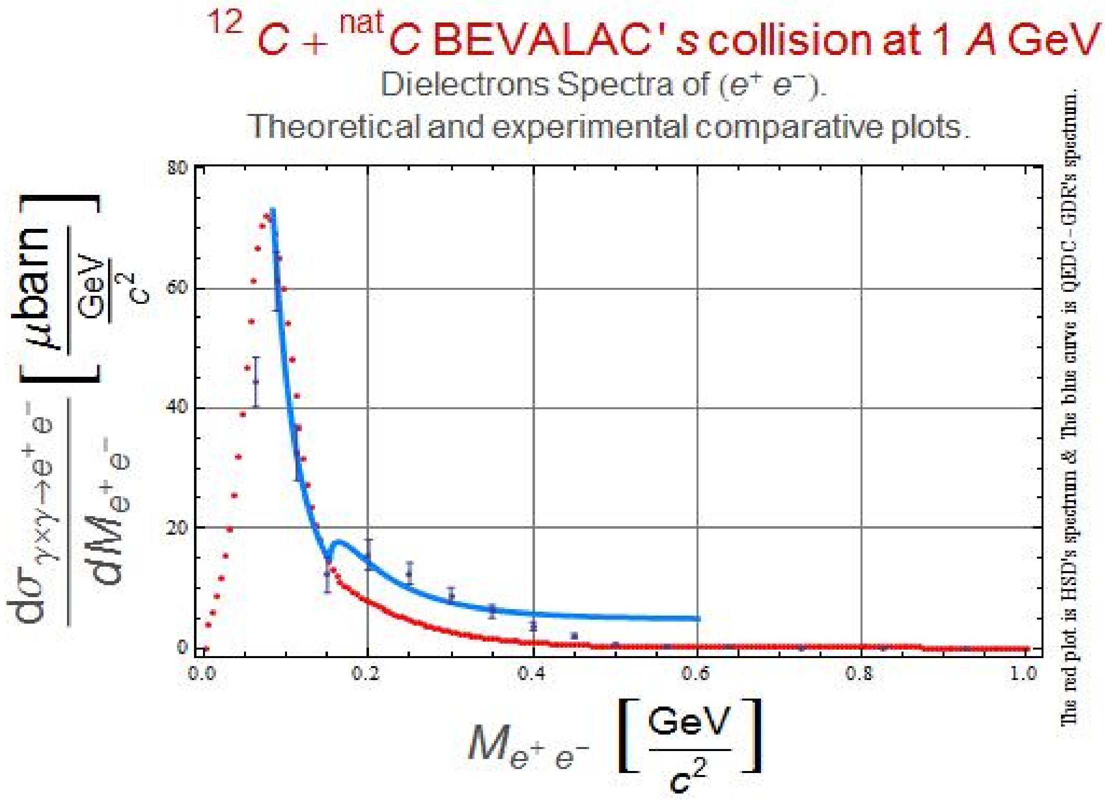

FIG. 12: The differential spectra in invariant mass in lin-lin scale, $\frac{d\sigma_{\gamma\times\gamma\to e^+e^-}}{dM_{e^+e^-}}$, in function $M_{e^+e^-}$ calculated through our theory, represented comparatively to the HSD curve [31]. It's, then, done the comparison with the experimental measures carried out at BEVALAC [22].

[6] G. Preparata, G. Mileto *et al.*, *Coherent QED Giant Resonances and e^+e^- Pairs in High Energy Nucleus-Nucleus Collisions*, Il Nuovo Cimento ,Vol. 112 A, N.7, July 1999

[7] G. Mileto, *Dielectrons e^+e^- signals from fusion of QED Coherent and Nuclear states in relativistic heavy ion collisions*, Hadronic Journal Volume 28, page 409-440, 2005, issue number 4 of September 2005

[8] F. A. Gareev *et al.*, *Mass trajectories of dihadronic and dileptonic reso-*

nances, Hadronic Journal Volume 20, 1997

[9] Fazal-E-Aleem, M. Ali, M Saleem, *Dilepton Production by Hadrons*, Hadronic Press, Jan. 1997

[10] Edited by T. Gill, *New Frontiers in Physics*, Proceedings of the International Workshop held at the IRB Vol. I, Part III, Hadronic Press Jan. 1996

[11] Edited by A. W. Khan et M. Saleem, *Proceedings of the International Workshop and Conference on Quark Matter and Heavy Ion Collisions*, Workshop held at Gomal University, Hadronic Press 1995

[12] Edited by B. I. Pustylnick, *Heavy Ion Physics*, Hadronic Press 1993

[13] Edited by Yu. Ts. Oganessian, *Proceedings of the School in Heavy Ion Physics*, Hadronic Press 1993

[14] Edited by R. Jolos *et al.*, *Nuclear Structure and Nuclear Reactions at Low and Intermediate Energies*, Proceed. of the International Conference held at the JINR, Hadronic Press, 1993

[15] G. Roche *et al. (The DLS Collaboration)*, *First Observation of Dielectron Production in Proton-Nucleus Collisions below 10 GeV*, Physical Review Letters, Vol. 61, Number 9, 29 August 1988

[16] A. Letessier-Selvon *et al. (The DLS Collaboration)*, *Mass and transverse momentum dependence of the dielectron yield in p-Be collisions at 4.9 GeV*, Physical Review C, Vol. 40, Num.3, Sept. 1989

[17] A. Yegneswaran et al., *The Dilepton Spectrometer*, Nuclear Instruments and Methods in Physics Research A290 (1990) 61-75

[18] S. Beedoe *et al.*, *Measurement of dielectron production in niobium-niobium collisions at 1.05 GeV/nucleon*, Physical Review C, Vol. 47, Num.6, June 1993

[19] R Koga *et al.*, *Bevalac ion beam characterizations for single event phenomena*, IEEE

[20] H. Z. Huang *et al. (The DLS Collaboration)*, *Mass and transverse momentum dependence of the dielectron production in p+d and p+p collisions at 4.9 GeV*, Physical Review C, Vol. 49, Num.1, Jen. 1994

[21] H. S. Matis *et al. (The DLS Collaboration)*, *Dilepton production from p-p to Ca-Ca at the Bevalac*, nucl-ex/9412001, 3 Nov 94

[22] http://macdls.lbl.gov/DLS_WWW_Files/DLS.html

[23] W. K. Wilson *et al. (The DLS Collaboration)*, *Inclusive Dielectron Cross Sections in p+p and p+d Interactions at Beam Energies from 1.04 to 4.88*

GeV, nucl-ex/9708002, 4 Aug 1997

[24] R. J. Porter *et al. (The DLS Collaboration)*, *Dielectron Cross Section Measurements in Nucleus-Nucleus Reactions at 1.0 A GeV*, Physical Review Letters, Vol. 79, Number 7, 18 August 1997

[25] E. L. Bratkovskaya *et al.*, *Dielectron production in proton-proton and proton-deuteron collisions at 1-2 GeV*, Physical Review C, Vol. 51, Num.1, Jan. 1995

[26] E. L. Bratkovskaya *et al.*, *Anisotropy of dilepton emission from nuclear collisions*, Physics Letters B, 348 (1995), 283-289

[27] E. L. Bratkovskaya *et al.*, *Anisotropy of dilepton emission from nucleon-nucleon interactions*, Physics Letters B, 348 (1995), 325-330

[28] E. L. Bratkovskaya *et al.*, *Decay anisotropy of e^+e^- sources from pN and pd collisions*, Physics Letters B, 362 (1995), 17-22

[29] E. L. Bratkovskaya *et al.*, *Dilepton anisotropy from p+Be and Ca+Ca collisions at BEVALAC energies*, Physical Letters B, Vol. 376 (1996), 12-18

[30] E. L. Bratkovskaya, W. Cassing, *Dilepton production from AGS to SPS energies within a relativistic transport approach*, Nuclear Physics A, 619 (1997), 413-446

[31] E. L. Bratkovskaya *et al.*, *Dilepton production and m_T-scaling at BEVALAC/SIS energies*, Nuclear Physics A, 634 (1998),168-189

[32] E. L. Bratkovskaya,W. Cassing, *Hadronic and electromagnetic probes of hot and dense nuclear matter*, Physics Reports, 308 (1999), 65-233

[33] E. L. Bratkovskaya *et al.*, *e^+e^- production from pp reactions at BEVALAC energies*, Nuclear Physics A, 653 (1999), 301-317

[34] E. L. Bratkovskaya, C. M. Ko, *Low-mass dileptons and dropping rho meson mass*, Physical Letters B, Vol. 445 (1999), 265-270

[35] W. Greiner *et al.*, *Intermediate mass excess of dilepton production in heavy ion collisions at BEVALAC energies*, Nucl-th/9712069, 12 Jan. 1998

[36] K. Haglin, C. Gale, *Dilepton production in nucleon-nucleon reactions with and without hadronic inelasticities,* Physical Review C, Vol. 49 Num., 1 Jan. 1994

[37] A. Grünschloß *et al.*, *Impact-parameter dependence of giant resonance excitations in relativistic heavy-ion collisions*, Physical Review C, Vol. 60, 051601-4

[38] C. Friberg , T. Sjöstrand, *Effects of longitudinal photons*, Physics Letters B, 492 (2000), 123–134
[39] Jan-e Alam, S. raha, B. Sinha, *Electromagnetic probes of quark gluon plasma*, Physics Reports, 273 (1996), 243-362
[40] Ph. Chomaz, N. Frascaria, *Multiple phonon excitation in nuclei: axperimental results and theoretical descriptions*, Physics Reports, 252 (1995), 275-405
[41] C. A. Bertulani, V. Yu. Ponomarev, *Microscopic studies on two-phonon giant resonances*, Physics Reports, 321 (1999), 139-251
[42] G. Baur *et al.*, *Coherent $\gamma\gamma$ and γA interactions in very peripheral collisions at relativistic ion colliders*, Physics Reports 364 (2002) 359–450
[43] C. Y. Wong and H. W. Crater, *Relativistic generalization of the post-prior equivalence for reaction of composite particles*, nucl-th/0105063
[44] L.G. Landsberg, *Electromagnetic decays of light mesons*, Phys. Rep. **128**, N. 6 (1985) 301-376
[45] N. S. Craigie, *Lepton and photon production in hadron collisions*, Phys. Rep. **47**, N. 1 (1978) 1-108
[46] S. T. Ali, J.-P. Antoine, J.-P. Gazeau, *Coherent States, Wavelets and their Generalization*, Springer-Verlag New York, Inc. 2000
[47] T. Brandes, *Coherent and collective quantum optical effects in mesoscopic systems*, Physics Reports 408 (2005) 315–474
[48] K. Shekhter *et al.*, *Dilepton production in heavy-ion collisions at intermediate energies*, Physical Review C, Vol. 68, 014904 (2003)
[49] R.L. Jaffe, *Exotica*, Physics Reports 409 (2005) 1–45
[50] C. Zeitlin *et al.*, *Heavy fragment production cross sections from 1.05 GeV/nucleon Fe_{56} in C, Al, Cu, Pb, and CH_2 targets*, Physical Review C, Vol. 56 N. 1, JULY 1997
[51] R. M. Santilli, *Elements of Hadronic Mechanics*, Vol. I, II (second edition 1995) and III (in preparation), Naukova Dumka Publishers, Kiev
[52] R. M. Santilli, *Inconsistencies of neutrino and quark conjectures and their negative environmental implications*, Proceedings of the XVIII Workshop on Hadronic Mechanics, University of Karlstad, Sweden, June 20-22, 2005
[53] R. M. Santilli, *Foundations of Hadronic Chemistry With applications to New Clean Energies and Fuels*, Naukova Dumka Publishers, Kiev
[54] The CMS Collaboration, *Search for exclusive or semi-exclusive $\gamma\gamma$ pro-*

duction and observation of exclusive and semi-exclusive e^+e^- production in pp collisions at $\sqrt{s}$= 7 TeV, arXiv:1209.1666v2 [hep-ex] 13 Mar 2013