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The Lensing Effect a Proof of Large Scale Entanglement in Holographic CFTs

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Abstract: *Many experimental works at small scale (photons, electrons, etc.) try to confirm the entanglement, in this work we will show that the Einstein ring could be a such proof of entanglement but at very large scale (cosmic objects), when, due of a QCD operation (Sc hwinger effect) inside nucleons is infused in quantum a flux of energy (pulse) that corresponds to stress-energy tensor onto attached nucleons either as of n-sheeted Riemann surfaces glued to the boundaries (CFT), or as by the magnetic flux lines (bit threads) of fluxoids type there producing a strain of space –the lensing effect. This approach is tested on light lensing around objects (Earth).*

1. The Holographic Screen at the Object Boundary

In the last time an important progress was done on the Ryu-Takayanagi (RT) formula generalization, especially by obtaining arguments about the nature of the transfer of bulk energy (Energy flux, the rate of transfer of energy through a unit area ($J \cdot m^{-2} \cdot s^{-1}$)) to the CFT horizon.

Thus, Bit threads provide an alternative description of holographic entanglement, replacing the Ryu-Takayanagi minimal surface with bulk curves connecting pairs of boundary points [11].

$$S_A = \frac{1}{4G_N} area(m(A))$$

Despite the fact that the RT formula has been a subject of intense research for over a decade, there are still many facets of it that are only now being discovered.

Indeed, only recently was it demonstrated that the geometric extremization problem underlying the RT formula can alternatively be interpreted as a flow extremization problem [5, 6]. By utilizing the Riemannian version of the max flow-min cut theorem, it was shown that the maximum flux out of a boundary region A, optimized over all divergenceless bounded vector fields in the bulk, is precisely the area of m(A).

In particular, for the minimal surface m(A),

$$N_{A\bar{A}} \leq \frac{1}{4G_N} area(m(A)) \tag{1}$$

The number of threads connecting A to $\bar{A}$ is at least as large as the flux of v on A:

$$N_{A\bar{A}} \geq \int_A v$$

The reason that don't necessarily have equality is that some of the integral curves may go from $\bar{A}$ to A, thereby contributing negatively to the flux but positively to $N_{A\bar{A}}$.

Given (1), however, for a max flow v(A) this bound must be saturated:

$$N_{A\bar{A}} = \int_A v(A) = S(A)$$

The bit threads connecting A to $\overline{A}$ are vivid manifestations of the entanglement between A and $\overline{A}$, as quantified by the entropy S(A).

Instead, in [2] they will invoke the notion of a flow, defined as a divergenceless vector field in the bulk with pointwise bounded norm; note that this is a global object, not localized anywhere in the bulk. Its flow lines can be thought of as a set of "threads" with a cross-sectional area of 4Planck areas. In the picture below, each thread leaving the region A carries one independent bit of information about the microstate of A; S(A) is thus the maximum possible number of threads emanating from A. The equivalence of this formulation to equation (1.1) arises from the fact that the minimal surface acts as a bottleneck limiting the number of threads emanating from A; this is formalized by the so-called max-flow min-cut (MFMC) principle, a theorem originally from network theory but which they use here in its Riemannian geometry version

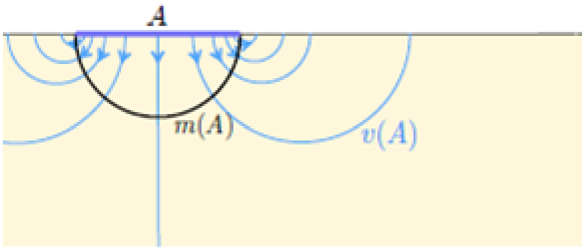

Figure 7 from [2]: According to eq. (1), the entanglement entropy of the region A is given by the maximum flux through A of any flow. A maximizing flow v(A) is illustrated by its flow lines in blue. This flux will equal the area of the RT minimal surface m(A) (divided by $4G_N$).

2. More about Bit threads

As with an electric, magnetic, or fluid velocity field, it is convenient to visualize the flow v by its field lines. These are defined as a set of integral curves of v chosen so that their transverse density equals $|v|$. In [11] they call these flow lines "bit threads", for a reason that will become clear soon. Please keep in mind that the threads are oriented.

The bit threads inherit two important properties from the definition of a flow. First, the bound $|v| = 1/4G_n$ means that they cannot be packed together more tightly than one per 4 Planck areas. Thus they have a microscopic but nonetheless finite thickness. In general, their density on macroscopic (i.e. AdS) scales will be of order N^2 (in the usual gauge/gravity terminology). Therefore, unless they are interested in 1=N effects (which will mostly ignore in this paper), it should not worry too much about the discrepancy between the continuous flow and the discrete threads. Second, the condition $\nabla \cdot v = 0$ means that the threads cannot begin, end, split, or join in the bulk; each thread can begin and end only on a boundary, which could be the conformal boundary where the field theory lives, or possibly a horizon (e.g. if are considering a single-sided black hole spacetime).

One of the most remarkable discoveries in fundamental physics was the realization that black hole horizons carry entropy. This entropy is manifest in the spacetime geometry, as expressed by the Bekenstein-Hawking formula:

$$S_{BH} = \frac{k_B c^3}{\hbar} \frac{A}{4G} \tag{2}$$

Where A is the area of the horizon.

Following [8a, b, c] of course, this expression (2) also reminds us that the physical constants in Nature can be combined to yield a fundamental length, the Planck scale:

$$l_P^{d-2} = 8\pi G\hbar / c^3$$

spacetime dimensions. Hence the geometric entropy (1) of the horizon is simply the horizon area measured in units of the Planck scale:

$$S_{geom} = 2\pi \frac{\mathrm{A}}{l_P^{d-2}}$$

Given a particular holographic framework, the entanglement entropy in the (d-1)-dimensional boundary theory between a spatial region A and its complement is calculated by extremizing the following expression

$$S(A) = \frac{2\pi}{l_P^{d-2}} \underset{v\sim A}{ext}\left[A(v)\right]$$

over (d-2)-dimensional surfaces v in the bulk spacetime which are homologous to the boundary region A.

In the following, we summarize here the main points of the derivation as given in Ref.[3]. Thus, the variation of the entanglement entropy obeys

$$\delta S_A = \delta\langle H_A\rangle \tag{3}$$

Where H_A is the modular Hamiltonian.

However, starting from the vacuum state of a CFT in flat space and taking A to be a ball-shaped spatial region of radius R centered at x_0, denoted $B(R, x_0)$, the modular Hamiltonian is given by a simple integral that takes the simple form

$$H_B = 2\pi \int_{B(R,x_0)} d^{d-1}x \frac{R^2 - |\vec{x} - \vec{x}_0|^2}{2R} T_{tt}$$

of the energy density over the interior of the sphere (weighted by a certain spatial profile).

Thus, given any perturbation to the CFT vacuum that have for any ball-shaped region

$$\delta S_B = 2\pi \int_{B(R,x_0)} d^{d-1}x \frac{R^2 - |\vec{x} - \vec{x}_0|^2}{2R} \delta\langle T_{tt}\rangle$$

where H_B and S_B denote the modular Hamiltonian and the entanglement entropy for a ball, respectively.

One example is when is to consider a conformal field theory in its vacuum state, $\rho_{total} = |0\rangle\langle 0|$ in d-dimensional Minkowski space, and choose the region A to be a ball $B(R, x_0)$ of radius R on a time slice $t = t_0$ and centered at $x^i = x_0^i$.

Hamiltonian takes the simple form

$$H_B = 2\pi \int_{B(R,x_0)} d^{d-1}x \frac{R^2 - |\vec{x} - \vec{x}_0|^2}{2R} T_{tt}(t_0, \vec{x}) \tag{4}$$

where $T_{\mu\nu}$ is the stress tensor.

In summary, starting from the vacuum state of any conformal field theory and considering a ball-shaped region B, the first law (3) simplifies to

$$\delta S_B = \delta E_B \tag{5}$$

where is defined

$$E_B = 2\pi \int_{B(R,x_0)} d^{d-1}x \frac{R^2 - |\vec{x} - \vec{x}_0|^2}{2R} T_{tt}(t_0, \vec{x}) \tag{6}$$

The gravitational version of EB is simply obtained by replacing the stress tensor expectation value in (4) or (6) with the holographic stress tensor

$$E_B^{grav} = \int_S d\,\Sigma^\mu\, T_{\mu\nu}^{grav} \zeta_B^\nu = 2\pi \int_{B(R,\vec{x}_0)} d^{d-1}x \frac{R^2 - |\vec{x} - \vec{x}_0|^2}{2R} T_{tt}(t_0, \vec{x})$$

giving E_B^{grav} an integral of a local functional of the asymptotic metric over the region $B(R, x_0)$ at the AdS boundary.

To convert the nonlocal integral equations into a local equation, the strategy is to make use of the machinery used by Iyer and Wald to derive the first law from the equations of motion.

The Iyer-Wald formalism is reviewed in detail in the next section, but for now is just need one fact: the crucial step in the derivation is the construction of a (d−1)-form χ that satisfies

$$\int_B \chi = \delta E_B^{grav}, \int_B \chi = \delta S_B^{grav} \tag{7}$$

and for which $d\chi = 0$ on shell (i.e. when the gravitational equations of motion are satisfied).

The first law follows immediately by writing

$\int_\Sigma d\chi = 0$ and applying Stokes theorem (i.e. integrating by parts).

To derive local equations from the gravitational first law, they show that there exists a form χ which satisfies the relations (7) off shell, and whose derivative is

$$d\chi = -2\xi_B^a \delta E_{ab}^g \varepsilon^b \tag{8}$$

Where the d-form ε^b is the natural volume form on co-dimension one surfaces in the bulk (defined in eq. (5.3) from [3]), ξ_B is the Killing vector that vanishes on $\tilde{B}(R, x_0)$, and δE_{ab}^g are the linearized gravitational equations of motion. In addition, they require that

$$d\chi|_{\partial M} = 0 \tag{9}$$

where ∂ M is the AdS boundary, assuming the tracelessness and conservation of the holographic stress tensor.

In detail in [3], by using the No ether identity (discussed in appendix B of [3]) linearized about the AdS background is obtained.

$$\nabla_a (\delta E^g)^{ab} = 0, \tag{10}$$

a divergenceless condition as the necessity mentioned before.

Using the vanishing of $E_{\mu\nu}^g$, the general solution to (10) can be written as:

$$\delta E_{z\mu}^g = z^{d-1} C_\mu, \ \delta E_{zz}^g = z^{d-2} C_z - \frac{1}{2} z^d \partial_\mu C^\mu \tag{11}$$

for unfixed C_μ, C_z which are functions of the boundary coordinates. It simply need to show that C_μ, C_z must vanish. This is achieved by the requirement (9) which (using eq. (8) and (11) gives:

$$0 = d\chi|_{\partial M} = -\left(\zeta_B^\mu C_\mu + \tilde{\zeta}_B^x C_z\right) dt \wedge dx^1 ... \wedge dx^{d-1} \tag{12}$$

Here, is defined $\tilde{\zeta}_B^z = \lim_{z\to 0}(z^{-1}\zeta_B^z) = -2\pi R^{-1}(t - t_0)$ which is related to the boundary conformal Killing vector via: $\partial_\mu(\zeta_B)_\nu + \partial_\nu(\zeta_B)_\mu = 2\eta_{\mu\nu}\tilde{\zeta}_B^z$. Since it is possible to construct _ for all possible boundary regions B and in all Lorentz frames, it follows that $C_\mu = C_z = 0$.

In summary, it can obtain the full set of linearized gravitational equations, if it can show that a form χ exists, which satisfies eqs. (7), (8) and (9), they in [3] found this. Thus, applying this discussion in an arbitrary frame, after a long way they have now established that, at the boundary, χ is equal to the conserved current that appears in the modular energy:

$$d\chi\big|_{\partial M} = d\sum\nolimits^{\mu} T_{\mu\nu}^{grav}\zeta^{\nu} \tag{13}$$

Conservation and traceless of the CFT stress tensor therefore imply $d\chi\big|_{\partial M} = 0$, completing the derivation requested.

Now, only the differential form for Gauss's law for magnetism is of this type:

$$\nabla \cdot B = 0 \tag{14}$$

The magnetic field **B**, like any vector field, can be depicted via field lines (also called *flux lines*) – that is, a set of curves whose direction corresponds to the direction of **B**, and whose areal density is proportional to the magnitude of **B**. Gauss's law for magnetism is equivalent to the statement that the field lines have neither a beginning nor an end: Each one either forms a closed loop, winds around forever without ever quite joining back up to itself exactly, or extends to infinity.

To note, that in case of electroweak and QCD epochs the magnetogenesis is analyzed for different mechanisms [12], [13], [14], [16], [5], [24], [25].

3. Magnetic field generation at the Confinement mechanism

At present, we have no analytic proof of the existence of the condensate of abelian magnetic monopoles in gluodynamics and in chromodynamics.

However, there are two large gaps between QCD and the dual-superconductor picture [12].

1. The dual-superconductor picture is based on the Abelian gauge theory subject to the Maxwell type equations, while QCD is a non-Abelian gauge theory.

2. The dual-superconductor picture requires color-magnetic monopole condensation as the key concept, while QCD does not have such a monopole as the elementary degrees of freedom.

In [31] is found another confinement mechanism. In this note, where is sown that the dual Meissner effect in an Abelian sense works good even when monopoles do not exist, performing Monte-Carlo simulations of quenched $SU(2)$ QCD with Landau gauge fixing. Instead of monopoles, time-dependent Abelian magnetic fields regarded as magnetic displacement currents are squeezing Abelian electric fields. The dual Meissner effect leads us to the dual London equation and the mass generation of the Abelian electric fields which suggests the existence of a dimension 2 gluon condensate. The present numerical results, hence, suggest the Abelian dual Meissner effect is the real universal mechanism of color confinement which has been sought for many years. Moreover the relation of the Abelian dual Meissner effect with the dimension 2 gluon condensate sheds new light on the importance of the gluon condensate, cited [13, 14, 15, 16, 17].

Hence, the Abelian fields satisfy kinematically the simple Abelian Bianchi identity

$$\vec{\nabla} \times \vec{E}_A^a = \partial_4 \vec{B}_A^a \qquad \vec{\nabla} \cdot \vec{B}_A^a = 0 \tag{15}$$

The dual Meissner effect says that the squeezing of the electric flux occurs due to cancellation of the Coulombic electric fields and those from solenoidal magnetic currents.

Now what happens in a smooth gauge like the Landau gauge where monopoles do not exist? From Eq.(15), only $\partial_4 \vec{B}_A$ regarded as a magnetic displacement current could play the role of the solenoidal current.

It is very interesting to see Fig.4 from [31], in which this happens actually in Landau gauge. Note that the solenoidal current has a direction squeezing the Coulombic electric field. Let us see also the detailed distributions shown in Fig.5 from [31]. The other components of the magnetic displacement current $\partial_4 B_{Ar}$ and $\partial_4 B_{Az}$ are not vanishing but they are much suppressed consistently with Fig.2 from [31]. In comparison, we show the case of MA gauge also in Fig.5 of [31].

Now they have shown that the magnetic displacement currents are important in the dual Meissner effect when there are no monopoles. Then how can we understand the origin of the dual Meissner effect without monopoles?. The Abelian dual Meissner effect indicates the massiveness of the Abelian electric field as an asymptotic field.

4. DIMENSION 2 GLUON CONDENSATE

Now in [31] is shown that the magnetic displacement currents are important in the dual Meissner effect when there are no monopoles. Then how can we understand the origin of the dualMeissner effect without monopoles? The Abelian dualMeissner effect indicates the massiveness of the Abelian electric field as an asymptotic field:

$$(\partial_\rho^2 - m^2)\vec{E}_A \approx 0 \tag{16}$$

This leads us to a dual London equation which is a key to the dual Meissner effect. Let us evaluate the curl of the magnetic displacement current. Using Eq.(15), we get

$$\vec{\nabla}\times\partial_4\vec{B}_A = \vec{\nabla}(\nabla\cdot\vec{E}_A) - \vec{\nabla}^2\vec{E}_A$$

From Eq.(16), we get the dual London equation:

$$\vec{\nabla}\times\partial_4\vec{B}_A \approx (\partial_4^2 - m^2)\vec{E}_A \tag{17}$$

Neglecting gauge-fixing and Fadeev-Popov terms, we have equations of motion $D_\mu^{ab}F_\mu^b = 0$ and the (non-Abelian) Bianchi identity $D_\mu^{ab} * F_\mu^{ab} = 0$. Applying D operator to the Bianchi identity and using the Jacobi identity and the equations of motion, we get

$$(D_\rho^2)^{ab}F_\mu^b = 2g\varepsilon^{abc}F_{\mu a}^b F_{va}^c$$

Notice $(D_\rho^2)^{ab} = \partial_\rho^2\delta^{ab} + g\varepsilon^{acb}(\partial_\rho A_\rho^c) + g^2(A_\rho^a A_\rho^b - \delta^{ab}(A_\rho^c)^2)$

Hence if $\langle A_\mu^a A_v^b\rangle\delta^{ab}\delta_{\mu v}v^2 \neq 0$ we see asymptotically that the electric fields become massive $(\partial_\rho^2 - m^2)E_k^a \approx 0$ with $m^2 = 8g^2v^2$ as in [30]. Now the Abelian electric field is also massive asymptotically $(\partial_\rho^2 - m^2)E_{Ak}^a \approx 0$. Hence the dual London equation (23) is obtained.

Most estimates in the literature refer to the gluon mass, related to the $m_A^2 = \frac{3}{32}g^2\langle A^2\rangle$ by the formula [30],

$$m_A = (625 \pm 33)MeV. \tag{18}$$

Finally, we have the above RT formula as expressed in the bit threads:

$$\frac{2\pi}{\hbar}\int d^2x\sqrt{g}T_\mu^\mu = \frac{2\pi}{\hbar}\rho = \frac{3H^2}{2\cdot 2\cdot G}n\frac{1}{\hbar} \tag{19}$$

$\frac{2\pi\cdot c^3\cdot\rho}{\hbar} = \frac{3H^2\cdot c^3}{4G}\frac{1}{\hbar}$ or $\frac{c^3\cdot\rho}{3\hbar} = \frac{H^2\cdot c^3}{8\pi G}\frac{1}{\hbar}$ or, $\frac{c^3\cdot\rho\cdot l_P^2}{3\hbar} = H^2[s^{-2}]$, or, $\frac{c^3\cdot\rho\cdot l_P^2}{3\hbar}\frac{1}{c^2} = H^2[m^{-2}]$ (20)

With data for the confinement epoch we have

$\rho = \frac{M_U}{n_{bubbles}\cdot\lambda_C^3} = 6.2\times10^{19}[kg/m^3]$; $n_{bubbles} = \frac{M_U c^2}{m_A} = 5.2\times10^{51}$; $l_P = 7.8\times10^{-35}$, that results from eq. (20) $H = 1878[m]$, which corresponds with the above value of $H = 1740[m]$, as given bellow eq. .

In the case of a homogeneous potential directed along the z-axis [12] eq. (2.2), the Einstein stress-energy tensor is:

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

$$\varepsilon = \frac{V_{vol}\varepsilon_0 c^2 B^2}{8\pi} = \rho V_{vol} = V[J],$$

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

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

With $V = \varepsilon_{gluons}$ as above is obtained $B = E_{q\bar{q}}/c$.

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

$V_{vol} = 2\pi\lambda_C \lambda_c (4\lambda_C) \cong 8\pi\lambda_C^3$, at Compton length $\lambda_C = \hbar/mc$

$E^2 = \dfrac{(V)}{\varepsilon_0 (\lambda_C^{e*})^3}$, also $E = Bc = \dfrac{\hbar c}{e\lambda_C^2}$

Here, the Hubble constant is defined as, see eq. (3.20, 3.21, 3.22) from [12].

$H^2 = \dfrac{8\pi G V^4}{3(\hbar c)^3 c^4}\ [m^{-2}]$, and by use of the Compton length as:

$$H^2 = \frac{1}{R^2} = \frac{8\pi G V^4}{3(\hbar c)^3 c^4} \to \frac{8\pi G V^4}{3\lambda_C^3 (mc^2)^3 c^4} \to \frac{8\pi G}{3}\frac{V}{\lambda_C^3 c^4}[m^{-2}] \tag{21}$$

Now, the rate per unit volume of quarks pair creation is given by using the Schwinger effect R inside the nucleon or EW bubbles, *when this electric field* E *is induced by* $e^+ - e^-$ *quarks pairs which decay in* $W^{\pm}$ *that explaining* β^- *decay,* of leading order behavior

$$R = (E/E_{cr})^2 (c/\lambda^4)(8\pi^3)^{-1} * \exp(-\pi E_{cr}/E) \tag{22}$$

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

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

the volume is given by:

$V_{matter} = (\lambda_C)^4 \dfrac{1}{c}[m^3 s]$; the mass of quarks.

The strain at Earth surface

5. STRAIN MODEL

From [36] we have:

$\lambda = \kappa^{-1} e^{kv}$; $\kappa^{-1} = 4M$; $v = t + r^*$; $C = 1 - 2M/r$; and $r^* = \int C^{-1} dr$; $C_{,r} = 2M/r^2$

We will assume that $T_{vv}(v)$ represents ingoing radiation which changes the black hole's mass by only a small fractional amount, $|\Delta M| << M$. We can then take κ to be constant to lowest order. If we change the independent variable from λ to v = t + r*, then

$$\frac{d}{d\lambda} = e^{-\kappa v}\frac{d}{dv};\ v = 1/\omega;\kappa = \frac{c^3}{4GM}$$

And

$$T_{\mu\nu}k^{\mu}k^{\nu} = e^{-2\kappa v}T_{vv}$$

For spherically symmetric pulses, the shear and vorticity vanish, and the Raychaudhuri equation, Eq. (36) from [36], becomes

$$\frac{d\theta}{dv} = -\frac{1}{2}e^{\kappa v}\theta^2 - 8\pi e^{-\kappa v}T_{vv}(v)$$

The equation for the horizon area can be expressed as

$$\frac{dA}{dv} = e^{\kappa v}A\theta$$

If we take $A_0 = 16M_0^2$ to be the initial area of the black hole in the distant past, where M_0 is its initial mass, then we have

$$\frac{\Delta A}{A_0} \cong \frac{a}{\kappa}e^{\kappa v_+} = 2\frac{\Delta M}{M_0}$$

In this approximation, the change in the mass of the black hole is

$$\Delta M = \frac{a}{2\kappa}M_0 e^{\kappa v_+} = \frac{aA_0}{8\pi}e^{\kappa v}$$

where we have used $\kappa = 1/(4M) \cong 1/(4M_0)$.

This agrees with the result obtained by calculating the change in mass directly from Eq. (23) as $\dot{M} = \frac{dM}{dt} = F = \int T_t^{\ r} r^2 d\Omega$

Here, it was defined an "effective magnetic field", B_{eff}, in terms of the total energy density in the magnetic field of MF Vortex,

$$\varepsilon_0 = \frac{\varepsilon_0 c^2 B_{eff}^2}{8\pi} \tag{23}$$

On the horizon, $T_t^{\ r} = T_{vv}$, $r = 2M + \varepsilon$

Since the quarks generated inside nucleons or in EW bubbles are generated by a pulsating process with frequency $v = \omega^{-1}$, a such pulse of stress-energy it could be $8\pi T_{\mu\nu}k^{\mu}k^{\nu} = a\delta(\lambda)$, a is a positive constant, and the surface gravity $\kappa = \frac{c^3}{GM}[s^{-1}]$.

We can observe that $\frac{\Delta A}{A} = \frac{8\pi GM}{c^2}\cdot\frac{1}{R} = \frac{r_{Schw}}{R}$, or, we have obtained the classical formula for deformation.

The build of spacetime is obtained by using well-known Inflation models [34a,b], which in our opinion is nothing else than a spreading of entanglement-energy source-horizon end, where 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 this gives $d\ln k = -dN(\varphi)$, 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 $k = k_{end}e^{N}[m^{-1}]$.

During Universe evolution, the horizon leave is when $a_{leave} = k_{leave}/H_{leave} = 1$, and $k_{leave}^{-1} = H_{leave}^{-1} = 10^{-18}[m]$.

From (18) we have at hologram site $\varepsilon_{QCD} \cong 0.7/a_{end} = 27\times10^{-2}GeV \to 4.4\times10^{-12}J$; $a_{end} = 25$; $k_{end}^{-1} = 2.5\times10^{5}[m]$, with eq. (20) ; $R = 7.1\times10^{6}m$, and $H_{end}^{-1} = 6.5\times10^{6}[m]$, $t_{end} = H_{end}^{-1}/c = 0.02s$, $\lambda_C = 6.7\times10^{-15}$; $H_{leave}^{-1} = k_{leave}^{-1} = 10^{-18}[m]$ we found $N = 53.9$

6. The strain at Earth surface-light bending

We use the above model

With $a = \frac{c}{R}[s^{-1}]$; where $R = 6.5\times10^{6}[m]$; $a = 45$; with $M = 1\times10^{24}[kg]$; $\kappa = 10^{-18}[s^{-1}]$; if we have the generation eq. (22) , $v = \omega^{-1} = (R/V\cdot V_{vol})^{-1}$; where

$$R/V\times V_{vol} \cong 2\times10^{57}\cdot\lambda_C^3 = 6.3\times10^{14}[s^{-1}],$$

$$v = 1.5\times10^{-15}[s];\ e^{\kappa v} \cong 1.0.$$

In other words the pulse is transferred from nucleons via electromagnetic field as bit threads to CFT viewed as a hologram, that it means the greater contribution to expansion.

So, the deformation is $\frac{\Delta A}{A} = 6.8\times10^{-10}$, or the expansion due of EW epoch since continue till today since $\Delta A = 6.8\times10^{-10}\bullet A = 4.4\times10^{-3}[m]$, that corresponds with well known Einstein ring, here $A = H^{-1} = R = 6.5\times10^{6}[m]$.

To note, that the gravitational potential for Earth is $U = \frac{GM_{Earth}^2}{R_{Earth}} = 3.6\times10^{32}J$; the stress-energy tensor is: $T_j \cong \varepsilon = U/1.44\times10^{-8}\times n_{nucleons} = 4.2\times10^{-12}J$; $n_{nucleons} = M_{Earth}/10^{-27} = 6\times10^{51}$

7. Conclusions

In this work are confirmed the following models:

-author' model of electromagnetic fields in nucleon,

-the origin of the gravitational potential,

-the Schwinger effect to create particles inside nucleons,

-the holographic derivation of entanglement for structured matter objects,

-the origin of the deformation of the horizon for structured matter objects,

-the lensing effect due of magnetic flux passing the hologram-CFT.

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