The Diphoton Mass Spectrum for Proton-Proton Collisions from the Scale-Symmetric Theory

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Abstract: Theory of the condensates produced due to the confinement of the Einstein-spacetime components (i.e. of the neutrino-antineutrino pairs), described within the Scale-Symmetric Theory (SST), shows that some of the spectral lines in the diphoton mass spectrum with invariant mass larger than 200 GeV up to 2000 GeV for proton-proton collisions obtained in the LHC experiments are not due to statistical fluctuation but due to strictly defined phenomena - a new phenomenon needs more than 2-standard deviations and the width/invariant-mass ratio about 0.0265 for two-sigma. Here we described such phenomena within a coherent model for lines with invariant mass about 209 GeV, 742 GeV and 1579 GeV (in previous papers we showed that such model leads to the Higgs boson with a mass of 125 GeV). To explain the spectrum, most important are the atom-like structure of baryons, density of the Einstein spacetime, the quadrupole symmetry and masses of nucleons, pions and the two lightest quarks.

1. Introduction

On Tuesday, 15 December 2015, physicists from CERN published the results from Run 2 [1]. There is an excess of pairs of photons for a few spectral lines in the diphoton mass spectrum.

Here, applying the Scale-Symmetric Theory (SST) [2], we show that condensates composed of confined Einstein-spacetime components with local standard deviations higher than 2σ and the ratio of width to invariant mass about 0.0265 for 2σ, are produced due to strictly defined phenomena characteristic for nuclear plasma. We calculated the invariant masses, $m_{x,n}$, and the decay widths, $\Gamma_{x,n}$, - the obtained theoretical results are consistent with the LHC data [1]. In previous papers we showed that presented here model leads to the Higgs boson with a mass of 125 GeV [3], [2A].

The General Relativity leads to the non-gravitating Higgs field composed of tachyons [2A]. On the other hand, SST shows that the succeeding phase transitions of such Higgs field (of the inflation field) lead to the different scales of sizes/energies [2A]. Due to the saturation of interactions via the Higgs field and due to the law of conservation of the half-integral spin that is obligatory for all scales, there consequently appear the superluminal binary systems of closed strings (the entanglons) responsible for the quantum entanglement, stable neutrinos and luminal neutrino-antineutrino pairs which are the components of the luminal Einstein spacetime (it is the Planck scale), cores of baryons, and the cosmic structures that evolution leads to the dark matter, dark energy and expanding universes [2A], [2B]. The non-gravitating tachyons have infinitesimal spin so all listed structures have internal helicity (helicities) which distinguish particles from their antiparticles [2A].

During the inflation, the liquid-like inflation field transformed partially into the luminal Einstein spacetime. In our Cosmos, the two-component spacetime is surrounded by timeless wall – it causes that the fundamental constants are invariant [2A], [2B].

Due to the symmetrical decays of bosons on the equator of the core of baryons, there appears the atom-like structure of baryons described by the Titius-Bode orbits/tunnels/loops for the nuclear strong interactions [2A]. But the loops and their interactions with leptons cause that the interactions concern the electrically charged leptons as well.

The coupling constant for the two shortest-distance quantum entanglement is very big (about $3 \cdot 10^{92}$) so the core of the baryons is practically indestructible [2A]. It causes that the liquid-like nuclear plasma consists of the cores [2A]. In such plasma, there are produced first of all pions, kaons and relativistic electrons in the $d = 0$ ground state which is tangent to the equator of the cores [2A]. Relativistic mass of the $d = 0$ electrons is about $F = 9.00362$ times higher than their bare mass ($m_{bare(electron)} = 0.510407011$ MeV) [2A].

Fermions have spin and internal helicity. To obtain objects with total spin and helicity simultaneously equal to zero, there must be obligatory the four-fermion symmetry (the quadrupole symmetry) but this symmetry concerns as well other objects because of the quantum entanglement [2B], [2A]. For example, according to the SST, the quadrupole image of a quasar follows from the quadrupole symmetry for the dark-matter structures. When fermions are created as groups of four particles then in the Einstein spacetime do not appear turbulences. It leads to conclusion that in the nuclear plasma, in the $d = 0$ state are produced relativistic quadrupoles composed of two electrons and two positrons.

Mass of the Einstein spacetime corresponding to energy equal to E is $f = 40{,}362.942$ times higher [2A].

The above remarks lead to conclusion that there can be produced scalar condensates with following mass [4], [3]

$$M = 4\, m_{bare(electron)}\, F\, f = 741.95 \text{ GeV}. \tag{1}$$

Such a scalar condensate can decay into two photons. It is the new LHC scalar resonance.

2. Calculations

Most important in the theory of the Einstein-spacetime condensates are the quadrupole symmetry for invariant entangled energies, $E_{x,n}$, that can appear in the nuclear plasma produced in the pp collisions, and the factor $f = 40{,}362.942$ that is the ratio of the mass densities of the Einstein spacetime and the Einstein-spacetime condensates [2A]. When energy of collision is sufficiently high, then an invariant entangled energy can produce a condensate from the "underlying" region of the Einstein spacetime – it causes that the invariant energy $E_{x,n}$ increases f times. The above remarks lead to following formula for the diphoton invariant mass $m_{x,n}$

$$m_{x,n} = 4\, f\, E_{x,n}. \tag{2}$$

Theory of the Einstein-spacetime condensates shows that their decay width, $\Gamma_{x,n}$, we can calculate from following formula [5]

$$\Gamma_{x,n} / m_{x,n} = sqrt(2)\ \alpha_{w(proton)} = 0.026478, \tag{3}$$

where $\alpha_{w(proton)} = 0.0187229$ is the coupling constant for the weak interactions of nucleons [2A].

Consider a spectrum line for a condensate with central invariant mass $m_{x,n}$ and decay width $\Gamma_{x,n}$. We know that the standard to report a discovery of a particle is $P\text{-}value < 0.00000027$ (i.e. the statistical significance must be equal or higher than 5σ). Because we know value of the decay width of the Einstein-spacetime condensates that can decay to pairs of photons (formula (3)), we can reduce the lower limit for the statistical significance to report a discovery of Higgs like scalar boson. To report a discovery, number of events for $m_{x,n}$ must be able to define the decay width $\Gamma_{x,n}$. When formula (3) is satisfied and there appear diphotons then we can say that we discovered an Einstein-spacetime condensate (a Higgs like boson). For all condensates, the ratio $\Gamma_{x,n} / m_{x,n} = 0.026478$ is invariant so we can assume that if for such P-value the width/invariant-mass ratio is about 0.0265 then we can claim that we discovered a Higgs like scalar boson

$$P\text{-}value = \Gamma_{x,n} / m_{x,n} = 0.026478 \rightarrow 2\ \sigma. \tag{4}$$

For the interval [200, 2000] GeV of the invariant mass $m_{x,n}$ there are three spectral lines (~200 GeV, ~750 GeV and ~1600 GeV) corresponding to a local significance higher than 2σ [1]. It means that in the pp collisions must be produced invariant entangled energies, $E_{x,n}$, defined by formula (2), that should lead to the listed invariant masses. Moreover, for P-value defined by formula (4), i.e. for 2σ, the width/invariant-mass ratio for the spectral lines must be ~0.0265.

Assume that $E_{x,n=1}$ is the mass distance between neutron and proton

$$E_{x,n=1,theory(SST)} = (m_{neutron} - m_{proton})_{theory(SST)} = 1.2923\ \text{MeV [2A]}. \tag{5a}$$

Within SST, applying formulae (2) and (3), we obtain $m_{x,n=1,theory(SST)} = \underline{208.64\ \text{GeV}}$ and $\Gamma_{x,n=1,theory(SST)} = \underline{5.52\ \text{GeV}}$ for 2σ.

For experimental data [6]

$$E_{x,n=1,experiment} = (m_{neutron} - m_{proton})_{experiment} = 1.2933322 \pm 0.0000005\ \text{MeV} \tag{5b}$$

the SST gives $m_{x,n=1,experiment} = \underline{208.81\ \text{GeV}}$ and $\Gamma_{x,n=1,experiment} = \underline{5.53\ \text{GeV}}$ for 2σ.

The interior of the nuclear plasma consists of the indestructible cores of baryons whereas the outer shell consists of baryons. It means that the phenomena characteristic for the cores take place in whole volume of the plasma whereas the orbital phenomena concern the surface processes only so the signal from the volumetric processes (core processes) should be stronger than from the surface processes (orbital processes).

It means that the ~209 GeV line should be a relatively weak spectral line.

Assume that $E_{x,n=2}$ is the mass distance between charged and neutral pion

$$E_{x,n=2,theory(SST)} = (m_{pion(+,-)} - m_{pion(o)})_{theory(SST)} = 4.59367 \text{ MeV [2A]}. \quad (6a)$$

We obtain $m_{x,n=2,theory(SST)}$ = 741.66 GeV and $\Gamma_{x,n=2,theory(SST)}$ = 19.64 GeV for 2σ.
For experimental data [6]

$$E_{x,n=2,experiment} = (m_{pion(+,-)} - m_{pion(o)})_{experiment} = 4.5936 \pm 0.0005 \text{ MeV} \quad (6b)$$

the SST gives $m_{x,n=2,experiment}$ = 741.64 GeV and $\Gamma_{x,n=2,experiment}$ = 19.64 GeV for 2σ.

SST shows that the pions are produced inside the core of baryons so phenomena defined by both formula (1) and formulae (6a) and (6b) are the volumetric processes so the ~742 ± 10 GeV line should be relatively strong. But notice that the decay width for this condensate (i.e. about 20 GeV) is lower than the experimental value for 2σ [1]. It suggests that there is in existence some additional process. Assume that $E_{x,n=3}$ is the mass of pair of the up quarks

$$E_{x,n=3,theory(SST)} = (2\, m_{up\text{-}quark})_{theory(SST)} = 4.454 \text{ MeV [2A]}. \quad (7)$$

Within SST we obtain $m_{x,n=3,theory(SST)}$ = 719.0 GeV and $\Gamma_{x,n=3,theory(SST)}$ = 19.0 GeV for 2σ. According to SST, this process is the surface/orbital process, [2A], so is relatively weak. It leads to conclusion that for the ~750 GeV line there should be the maximum for about 742 GeV whereas for 2σ, the width of the line should be from about 709 GeV to 752 GeV i.e. about 43 GeV.

Assume that $E_{x,n=4}$ is the mass of pair of the down quarks

$$E_{x,n=4,theory(SST)} = (2\, m_{down\text{-}quark})_{theory(SST)} = 9.780 \text{ MeV [2A]}. \quad (8)$$

Within SST we obtain $m_{x,n=4,theory(SST)}$ = 1579 GeV and $\Gamma_{x,n=4,theory(SST)}$ = 41.8 GeV for 2σ. According to SST, this process is the surface/orbital process, [2A], so signal should be relatively weak.

Obtained results are consistent with the LHC data [1].

3. Summary

Here, applying the Scale-Symmetric Theory, we showed that the local significance higher than 2σ and the width/invariant-mass ratio about 0.0265 for 2σ is enough for reporting a discovery of Higgs like resonances decaying to two photons. For the invariant mass lager than 200 GeV up to 2000 GeV, we found three condensates, composed of the confined Einstein-spacetime components, decaying to two photons. Their invariant masses and the widths for 2σ are respectively as follows: 209 GeV and 6 GeV, 742 GeV and 43 GeV (in reality there are two lines but a maximum should be for 742 GeV whereas width for 2σ should be from 709 GeV to 752 GeV i.e. the width should be asymmetrical in relation to the maximum), and 1579 GeV with width 42 GeV. The three invariant masses are the real masses distinguished from statistical fluctuation.

Theory of the nuclear plasma described within the SST shows that the most significant deviation in the diphoton invariant mass spectrum should be for about 742 GeV (SST shows that there are the two different relatively strong processes).

Obtained results are consistent with the LHC data [1].

References

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Chin. Phys. C, **38**, 090001 (2014) and 2015 update