Topological Phase Transitions as the Cause of Creation of High-Mass Narrow Resonances with Low Standard Deviation

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Abstract: Topology is the branch of mathematics that attempts to describe the properties changing stepwise as, for example, number of holes in objects or conductivity of thin layers. Topological phase transitions play an important role in the Scale-Symmetric Theory (SST). They describe the successive phase transitions of the Higgs field - there appear the spin-1 binary systems of closed strings responsible for the quantum entanglement and loops and tori composed of the spin-1 bosons built of fermions. The single loops or tori are the objects with one global hole whereas their components are the bi-holes. Surfaces of the tori are built of smaller binary systems of tori i.e. one-global-hole objects are built of bi-holes. But in SST, the topological phase transitions concern as well the transition from electromagnetic interactions (there is one Type of photons) to nuclear interactions (there are 8 Types of gluons). Such transition causes that there can appear composite resonances built of 8 or 8x8=64 vector bosons with total angular momentum equal to 0 or 2. The strictly defined numbers of the high-standard-deviation vector bosons (8 or 64) in the composite resonances cause that they must be the high-mass narrow resonances with low standard deviation! It leads to conclusion that we must change the statistical methods applied to the topological composite resonances. Here we described 3 groups of such resonances – the groups are associated with the mass distances between neutral and charged lightest baryons (i.e. nucleons), lightest strange mesons (i.e. kaons) and lightest mesons (i.e. pions). Obtained results are consistent with the LHC data. We predict existence of two low-standard-deviation neutral resonances (5.01 +- 0.13 TeV and 5.78 +- 0.15 TeV). There can be in existence a high-standard-deviation vector boson with a mass of 25.4 +- 0.7 GeV.

1. Topological phase transitions in the Scale-Symmetric Theory (SST)

The Scale-Symmetric Theory shows that the successive topological phase transitions of the superluminal non-gravitating Higgs field during its inflation (the initial big bang) lead to the different scales of sizes/energies [1A]. Due to a few new symmetries, there consequently appear the superluminal binary systems of closed strings (the spin-1 entanglons) responsible for the quantum entanglement (it is the quantum-entanglement scale), neutrinos and the spin-1 neutrino-antineutrino pairs moving with the speed of light in “vacuum” which are the components of the gravitating Einstein spacetime (it is the Planck scale), cores of baryons (it is the electric-charge scale), and the cosmic-structures/protoworlds (it is the cosmological scale) that evolution leads to the dark-matter (DM) structures (they are the loops and filaments composed of entangled non-rotating-spin neutrino-antineutrino pairs), dark energy (it consists of the additional non-rotating-spin neutrino-antineutrino pairs interacting gravitationally only) and the expanding Universe (the "soft" big bang due to the inflows of the dark energy into Protoworld) [1A], [1B]. The electric-charge scale leads to the atom-like structure of baryons [1A].

We can say that the Einstein spacetime consists of the neutrino-antineutrino pairs that are the structures composed of particles responsible for quantum entanglement (i.e. of entanglons). Such structures are very stable because they are sunk in the Higgs field. On the other hand, the neutrinos (i.e. the groups of entanglons) produce gradients in the Higgs field i.e. produce the gravitational fields.

Using other words, we can say that there is the dependence of gravity on neutrinos, built of the entanglons (which are responsible for quantum entanglement), placed in the Higgs field.

Topology is the branch of mathematics that attempts to describe the properties changing stepwise as, for example, number of holes in physical structures or conductivity of thin layers [2].

Topological phase transitions play an important role in the SST [1A], [1B]. They describe the successive phase transitions of the Higgs field – there appear the spin-1 binary systems of closed strings responsible for the quantum entanglement and loops and tori composed of the spin-1 bosons built of the spin-1/2 fermions. The single loops or tori are the objects with one global hole whereas their components are the bi-holes. Surfaces of the tori are built of smaller binary systems of tori i.e. one-global-hole objects are built of bi-holes.

Within SST we can describe the origin of the spin-1 bi-holes, calculate the distances between the bi-holes and distances between holes in bi-holes and shifts in phase for directions of spins of adjacent bi-holes. A few new symmetries [1A] show how changes number of holes in all scales.

The simultaneous exchanges of entanglons in the same state between adjacent bi-holes and between holes in the bi-holes cause that the semiclassical phenomena concerning the SST topological structures we can fully describe in a classical way [1A], [1B].

But in SST, the topological phase transitions concern as well the transition from electromagnetic interactions (there is one Type of photons) to nuclear interactions (there are 8 Types of gluons [1A]). Such transition causes that there can appear composite resonances built of 8 or $8 \cdot 8 = 64$ or $8 \cdot 8 \cdot 8 = 512$, and so on, entangled high-standard-deviation vector bosons (probability of creation decreases with increasing number of vector bosons).

The simultaneous exchanges of entanglons in the same state cause that mass of such composite resonances is an ordinary sum of masses of the entangled vector bosons. We will show that the vector bosons are the high-standard-deviation bosons (the $W^{+,-}$(80.4 GeV) and Z^o(91.2 GeV) bosons [3]) so due to the bell-shaped curve characteristic for particles with high standard deviation (such deviation indicates that the data points are spread out over a wider range of values), the 8 or 64 or 512, and so on, components can have different masses but their sum should be close to the mean i.e. close to the expected value. It leads to conclusion that a low standard deviation for composite resonances, with strictly defined number of "the same" components, does not mean that they do not exist. Just we must change statistical methods for such resonances. Generally, in science, effects should have standard deviation much higher than two sigma (2σ means that results are close to expected value) to be considered statistically significant. Can we change it? Yes. We should look for spin-0 and spin-2 narrow resonances belonging to the same group – their expected mass, $m_{X,n}$, is

$$m_{X,n} = 8^n M_o \,, \tag{1}$$

where $n = 1, 2, 3, \ldots$ whereas M_o is the expected mass of a spin-1 boson with high standard deviation. If such group contains at least one spin-1 boson and two spin-0 and spin-2 narrow resonances with low standard deviations (it is their characteristic feature (!)), i.e. $n = 0, 1, 2$, then there is very high probability that all three (or more) particles in the group are not statistical fluctuations.

Notice that global standard deviation of the composite resonances is lower than the local one because the decays of composite resonances for which n is $n + 1$ or more, increase number density of resonances defined by n in background. We can say that number density of sought-after composite resonances rises in other "places" of the phase space.

Here we described 3 groups of composite resonances defined by formula (1). The groups are associated with the mass distances between neutral and charged lightest baryons (i.e. nucleons), lightest strange mesons (i.e. kaons) and lightest mesons (i.e. pions).

The path of creation of a group is as follows. Due to the nucleon-nucleon collisions, an electromagnetic energy, ΔE, that is an absolute value of mass distance of charged and uncharged states of a particle, transforms, because of the transition from the electron-muon weak interactions (according to SST, the coupling constant is $\alpha_{w(electron\text{-}muon)} = 9.511082 \cdot 10^{-7}$ [1A]) to the nuclear weak interactions ((according to SST, the coupling constant is $\alpha_{w(proton)} = 0.01872286$ [1A]), into a high-standard-deviation vector boson with a mass of M_o

$$M_o = X \Delta E, \tag{2a}$$

where X is [1A]

$$X = \alpha_{w(proton)} / \alpha_{w(electron\text{-}muon)} = 19{,}685.3. \tag{2b}$$

Next, due to the photon→gluon transition, there appear the high-mass SST narrow composite resonances with low standard deviation – their masses are defined by formula (1). Notice that in SST, the gluons and photons are the rotational energies of the Einstein-spacetime components. The different properties of photons and gluons follow from the fact that the carriers of them, i.e. the rotating neutrino-antineutrino pairs, behave in a different way in fields without internal helicity (the gravitational and electromagnetic fields) and in fields with internal helicity (the nuclear strong fields) [1A]. The three different internal helicities of a rotating neutrino-antineutrino pair (i.e. they have three "colours") lead to the 8 Types of gluons.

The full width Γ of the narrow resonances and vector bosons is defined by following formula [4]

$$\Gamma = 2^{1/2} \alpha_{w(proton)} = 0.0265 \text{ i.e. is } 2.65\%. \tag{3}$$

What should be the total angular momentums, J, of the composite resonances? According to SST, in nuclear strong fields, due to their internal helicity, vector bosons behave as fermions in electromagnetic fields so we can apply to them the Hund law [1A]. The spin orientation of the vector bosons in the last shell of the composite resonance built of 8 vector bosons is

(up down) (up up up down)

i.e. the total angular momentum is $J = 2$.

The spin orientation of the vector bosons in the last shell of the composite resonance built of 64 vector bosons is

(up down) (up up)

i.e. the total angular momentum is $J = 2$.

But there can be the usual pairing of spins of the vector bosons as well so the total angular momentum of the composite resonances can be $J = 0$ also.

2. High-mass SST narrow resonances with low standard deviation

Notice that according to SST, standard deviation depends on number density of nucleon-nucleon collisions or on the integral luminosity. It follows from the fact that the mean distance between vector bosons in a composite resonance depends on strictly defined exchanged energy. For example, it can be the weak mass of the vector boson which is $\alpha_{w(proton)} M_o$ – on the other hand, the mean distance is inversely proportional to exchanged energy of the entanglons. In such a way we can explain, for example, the dependence of transition to superconductivity on temperature.

Table 1 *High-mass SST resonances*

Mass distance ΔE [MeV]	$n - p$ 1.29 [3], [1A]	$K^o - K^{+,-}$ SST+PDG mean: 3.98 "([3] + [1A]) / 2"	$\pi^{+,-} - \pi^o$ 4.59 [3], [1A]
J = 1 $X \cdot \Delta E$ [GeV] X = 19,685.3	25.4 ± 0.7 (?) **SST prediction**	78.3 ± 2.1 ≡ $W^{+,-}$ (80.4) SST and [3]	90.4 ± 2.4 ≡ Z^o (91.2) SST and [3]
J = 0, J = 2 8 $X \cdot \Delta E$ [GeV] 1σ – 2 σ	203 ± 5 (SST) Can overlap with $H + Z^o \approx 216$	627 ± 17 SST and [5], [6]*	723 ± 19 SST and [5], [6]*
J = 0, J = 2 64 $X \cdot \Delta E$ [TeV] 1σ – 2 σ	1.630 ± 0.043 SST and [5], [6]*	5.01 ± 0.13 **SST prediction**	5.78 ± 0.15 **SST prediction**

*The CMS and ATLAS combined results [5], [6]

Mass of a vector boson or composite resonance is defined as follows:

$$\text{Mass} = \text{expected mass (formulae (1) or (2a))} \pm \text{full width (formula (3))}. \quad (4)$$

The $W^{+,-}$ and Z^{o} bosons have charged states the same as the lighter kaons and pions.

The origin of the composite resonance with a mass of 1630 ± 43 GeV can be different.

The results calculated within SST are collected in Table 1.

3. Summary

To the high-mass narrow composite resonances with low standard deviation we should apply new statistical methods.

Here we described 3 groups of such resonances – the groups are associated with the mass distances between neutral and charged lightest baryons (i.e. nucleons), lightest strange mesons (i.e. kaons) and lightest mesons (i.e. pions). Obtained results are consistent with the LHC data.

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