The Resonant Nature of the Negative Z with a Mass of 4430 MeV

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Abstract: Here, applying the Scale-Symmetric Theory, we calculated mass (m = 4423 MeV), quantum numbers (unitary spin and positive parity) and estimated the full width (about 100 MeV; such mesons have the resonant character) of the negative resonance Z(4430). It is not a new form of matter called a tetraquark.

1. Introduction

The General Relativity leads to the non-gravitating Higgs field composed of tachyons [1A]. On the other hand, the Scale-Symmetric Theory (SST) shows that the succeeding phase transitions of such Higgs field lead to the different scales of sizes [1A]. 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 (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 (protoworlds) that evolution leads to the dark matter, dark energy and expanding universes [1A], [1B]. The non-gravitating tachyons have infinitesimal spin so all listed structures have internal helicity (helicities) which distinguishes particles from their antiparticles [1A].

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 for the nuclear strong interactions [1A].

A binary system of pions or other mesons of type $J^P = 0^-$ with non-zero angular velocity, due to interactions with real or virtual large loop (the mesons consist of the large loops), can have spin J equal to zero and negative parity P [1A]. For example, the neutral kaon is the binary system of relativistic neutral pions produced on the circular axis inside the core of baryons and such binary system interacts with electron-positron pair produced in the $d = 0$ state [1A]. Since spin of the core must be conserved so the binary system of the relativistic pions (its spin is unitary and parity is positive) must interact with virtual large loop (its spin is unitary and parity is negative). It causes that total spin of the neutral kaon is equal to zero whereas parity is negative. Such model leads to the exact masses of the kaons [1A].

Here within the lacking part of ultimate theory, i.e. the Scale-Symmetric Theory, we calculated mass, quantum numbers and estimated the full width of the negative resonance $Z(4430)^-$.

2. Calculations

SST shows that mass of the core of baryons (which is responsible for the strong, weak and electromagnetic interactions) is in approximation $f = 2.3$ times greater than the torus responsible for the nuclear strong and electromagnetic interactions [1A]. Inside the torus are produced pions, pairs of pions, and so on. There appear as well resonances/mesonic-nuclei composed of pions. It is because the pions in a nucleus composed of pions, exchange the large loops the pions consist of [1A]. Both the pions and the large loops are responsible for the nuclear strong interactions so the nuclei composed of pions and loops can decay due to the nuclear strong interactions. Notice that due to the internal structure of the core of baryons, a nucleus composed of two pions and two exchanged loops (its rest mass is in approximation 3 times greater than the rest mass of pion) can have mass about f times greater than the rest mass of the three pions i.e. a mass is about 970 MeV ($J^P = 0^+$). This mass is consistent with the mass of the $a_o(980)$ (its mass is $m = 980 \pm 20$, full width: 40 to 100 MeV [2]).

Within the Scale-Symmetric Theory, we described internal structure of the $B^o(5280)$ bottom meson [2] (calculated mass is 5281 MeV, $J^P = 0^-$ [1A]), of the $D_C(1865)^o$ charmed meson [2] (calculated mass is 1867 MeV, $J^P = 0^-$ [1A]), and of the $B_C(6275)^-$ bottom, charmed meson [2] (calculated mass is 6290 MeV, $J^P = 0^-$ [1A]; calculated lifetime is $0.19\cdot 10^{-12}$ s).

Notice that mass of the $Z(4430)^-$ resonance is close to the distance between the masses of the $B_C(6275)^-$ and the $D_C(1865)^o$ mesons ($\Delta m_{exp} \approx 4410$ MeV [2], $\Delta m_{th} \approx 4423$ MeV [1A]).

The quantum numbers of the $Z(4430)^-$ are determined to be $J^P = 1^+$ by ruling out $J^P = 0^-$, 1^-, 2^+ and 2^- [3]. The Scale-Symmetric Theory leads to such quantum numbers as well. We know that the $D_C(1865)^o$ can decay to $K^*(892)^+\pi^-$ or $K^+\pi^-$. On the other hand, the dominant fraction of decay of the $a_o(980)^-$ meson is for $a_o(980)^- \rightarrow \eta\ \pi^-$. The meson η ($J^P = 0^-$) can consist of 3 pions and two exchanged large loops – its lower limit for mass is about 540 MeV. It can decay to two resonances: one ($J^P = 1^+$) composed of the loop ψ' (it can decay to, for example, muon-antimuon pair) and pion and the second composed of two virtual pions exchanging virtual large loop ($J^P = 1^-$). We can see that there can appear $K\pi^-$ and $\psi'\pi^-$ (its relativistic mass can be about 4430 MeV) real resonances. We should see the resonant structures in $B^o a_o$ (not B^o only) to $\psi'\pi^- K^+$ decays. According to the Scale-Symmetric Theory, there are possible following transformations

$$B^o(5280, J^P = 0^-) + a_o(980, J^P = 0^+)^- \approx$$

$$\approx \{B_C(6275, J^P = 0^-)^-\} \approx$$

$$\approx D_C(1865, J^P = 0^-)^o + Z(4430, J^P = 1^+)^- + \text{virtual}(2\pi \text{ and loop}, J^P = 1^-). \quad (1)$$

We can see that the resonance $Z(4430)^-$ should have the full width close to $a_o(980)$ meson so we should observe the resonant character of this particle – its full width should be about 100 MeV and it is close to experimental data [3].

3. Summary

Here, within the lacking part of ultimate theory, i.e. the Scale-Symmetric Theory, we calculated mass (m = 4423 MeV), quantum numbers (unitary spin and positive parity) and estimated the full width (about 100 MeV; such mesons have the resonant character) of the negative resonance Z(4430). It is not a new form of matter called a tetraquark (within the Scale-Symmetric Theory, we described the reformulated quantum chromodynamics [1D] which leads to the masses of quarks).

References

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