The Resonant Substructure of Strange B to Charmed D, Kaon and Pion Decays within the Scale-Symmetric Physics

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Abstract: Here, the resonant substructure of strange B to charmed D, kaon and pion decays is studied. The study is based on the Scale-Symmetric Everlasting Theory (S-SET) i.e. the lacking part of ultimate theory that main part leads to the structures of bare objects and to the origin of physical constants. The Kasner solutions to the vacuum Einstein equations lead to the structure of the core of baryons and next to their atom-like structure. Here, within the phenomena characteristic for the core of baryons, we calculated the masses of the spin-1 and spin-3 charmed, strange D resonances with a mass of 2860 MeV. The calculated masses are respectively 2858.5 MeV and 2860.8 MeV (they are very close to the experimental central values (!)) whereas to obtain the exact spins equal to 1 and 3 we need a broadening of masses respectively about ± 5.3 MeV and 0.9 MeV and it is as well consistent with experimental data.

1. Introduction

The Scale-Symmetric Everlasting Theory (S-SET) [1], [2], [3] starts from expanding liquid composed of the non-gravitating, non-relativistic, superluminal pieces of space (tachyons) – it is the big bang. The gas composed of the tachyons is the modified Higgs field.

To the modified Higgs field we can apply the Kasner metric [4] that is a solution to the vacuum Einstein equations. The Kasner solutions we interpret as the virtual tori/cyclones and one-dimensional virtual oscillations which lead to virtual loops in the modified Higgs field [1], [2].

To quantize the sizes of the virtual Higgs cyclones we need additional conditions (the three additional laws of conservation) that lead as well to the four succeeding phase transitions of the modified Higgs field [2].

Due to the four succeeding phase transitions, there are in existence the four scales i.e. the superluminal-quantum-entanglement scale, luminal Planck scale concerning the Einstein-spacetime components, observed-particles scale and cosmological scale [2]. The main part of S-SET leads to internal structures of bare objects [2] and to the origin of the physical constants [5].

The phenomena characteristic for the observed-particles scale lead to the structure of the core of baryons and next to the atom-like structure of baryons [2].

At high-energy resonance production in electron-positron or pp collisions, the atom-like structure of baryons outside the core is destroyed so most important are phenomena which take place inside the core and on its surface. The core is composed of entangled and confined Einstein-spacetime components which are the carriers of gluons [2]. The equatorial radius of the core is A = 0.6974425 fm [2] and we say that relativistic particles on the equator are in the d = 0 state. Relativistic speed in the d = 0 state is v = 0.993813c i.e. rest mass increases f = 9.003632 times [2]. In distance 2A/3 are produced from the Einstein-spacetime components the large loops with mass m_{LL} = 67.5444 MeV [2]. Interaction of two such loops gives the mass of neutral pion [2].

Using the Uncertainty Principle, energy of a loop having a circumference equal to 2π·2A/3 is 67.5444 MeV, therefore, for a length equal to A the energy/mass is approximately m_A = 282.93 MeV ([2], Chapter "Liquid-like plasma").

We apply the data from Particle Data Group [6].

2. Calculations

Consider following two structures of strange B mesons

$$B^o_S \rightarrow D^+ K^- \pi^+ + D^*_{s1}(2860)^-, \quad (1)$$

$$B^o_S \rightarrow D^+ K^- \pi^+ + D^*_{s3}(2860)^-. \quad (2)$$

Define the structures of the spin-1 and spin-3 charmed, strange D resonances with a mass of 2860 MeV as follows

$$D^*_{s1}(2860)^- \equiv D^- \pi^+ + S^-_1, \quad (3)$$

$$D^*_{s3}(2860)^- \equiv D^- \pi^+ + S^-_3. \quad (4)$$

There is possible following structure of S^-_1

$$S^-_1 \equiv m_{A,equator} + m_A + m_A e^- \nu_e = 849.30 \text{ MeV}. \quad (5)$$

The mass $m_{A,equator}$ = 282.93 MeV is moving along the equator of the core and it is the relativistic mass. There are two additional masses m_A and one is interacting with electron and electron-antineutrino – its mass is $m_A e^- \nu_{e,anti}$ = 283.44 MeV, both are in the rest. The three m_A masses are the product of decay of the structure which appears in spin-3 strange, charmed meson (see formula (9); the mass of such structure is 851.61 MeV; in such decay the spin decreases from 3 to 1).

The spin of S^-_1 is the spin of $m_{A,equator}$ – we can calculate it from following formula

$$Spin_1 = m_{A,equator} \, A \, v = 1.048 \cdot 10^{-34} \text{ Js} = 0.9938 \, [\hbar]. \quad (6)$$

To obtain the unitary spin and because there are the three identical masses 283.93 MeV, the mass of $D^*_{s1}(2860)^-$ must be broadened by

$$\Delta D^*_{s1}(2860)^- = 3 \, m_A \, (1 - Spin_1) \approx 5.3 \text{ MeV}. \quad (7)$$

From formulae (3), (5) and (7) we obtain that the mass of the spin-1 charmed, strange D resonance is

$$M \, (D^*_{s1}(2860)^-) = 2858.5 \pm 5.3 \text{ MeV}. \quad (8)$$

This mass is consistent with experimental data [7]. The obtained mass is very close to the central value (2859.0) obtained in LHCb experiment. From formula (1) results that the right side is 5361.4 MeV i.e. it is about 5.4 MeV less than the mass of the strange B meson i.e. such decay is possible.

There is possible following structure of S^-_3

$$S^-_3 \equiv (2\pi^o / 3 + e^-_{d=0}\nu_{e,anti})_{d=0} = 851.61 \text{ MeV}. \qquad (9)$$

The pion appears as two circles with radius 2A/3. The transition of these two large loops to d = 0 state (the radius is A) causes that mass of the pion is 2/3 of the rest mass. Next, it interacts with electron and electron-antineutrino in d = 0 state i.e. the mass of electron increases f = 9.003632 times. The total rest mass is **m** = 94.5852 MeV. In the d = 0 state its mass increases f times so it leads to 851.61 MeV.

The spin of S^-_3 is

$$Spin_3 = S^-_3 \, A \, v = 3.1544 \cdot 10^{-34} \text{ Js} = 2.991 \, [\hbar]. \qquad (10)$$

To obtain the spin equal to 3 the mass of $D^*_{s3}(2860)^-$ must be broadened by (the broadening concerns the rest mass **m** = 94.5852 MeV only so the broadening for the spin-3 resonance is lower)

$$\Delta D^*_{s3}(2860)^- = m \, (3 - Spin_3) \approx 0.9 \text{ MeV}. \qquad (11)$$

From formulae (4), (9) and (11) we obtain that the mass of the spin-3 charmed, strange D resonance is

$$M \, (D^*_{s3}(2860)^-) = 2860.8 \pm 0.9 \text{ MeV}. \qquad (12)$$

This mass is consistent with experimental data as well [7]. The obtained mass is very close to the central value (2860.5) obtained in LHCb experiment. From formula (2) results that the right side is 5363.7 MeV i.e. it is about 3.1 MeV less than the mass of the strange B meson i.e. such decay is possible.

3. Summary

Here, the resonant substructure of strange B to charmed D, kaon and pion decays is studied. The study is based on the Scale-Symmetric Everlasting Theory (S-SET) i.e. the lacking part of ultimate theory that main part leads to the structures of bare objects and to the origin of physical constants.

The Kasner solutions to the vacuum Einstein equations lead to the structure of the core of baryons and next to their atom-like structure.

Here, within the phenomena characteristic for the core of baryons, we calculated the masses of the spin-1 and spin-3 charmed, strange D resonances with a mass of 2860 MeV. The calculated masses are respectively 2858.5 MeV and 2860.8 MeV (they are very close to the experimental central values (!)) whereas to obtain the exact spins equal to 1 and 3 we need a broadening of masses respectively about ±5.3 MeV and ±0.9 MeV and it is as well consistent with experimental data. As it follows from experimental data, the broadening of mass for the spin-3 resonance should be lower and the presented here model leads to the same conclusion.

References

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