Masses of the Upsilon Mesons

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Abstract: Here, applying the Scale-Symmetric Theory (SST), we described composition and calculated masses of the Upsilon mesons. This follows from the atom-like structure of baryons. Applying the modified quantum chromodynamics, within the SST, we can calculate the masses of quarks. This leads to conclusion that SST is the superior theory to the Standard Model in initial conditions. Calculated mass of b quark is 4190 MeV. Here, we showed that the Type 1S Upsilon meson is both a structure containing b-b(anti) quark pair (theoretical mass of such structure is 9460.1 MeV), or mesonic nucleus (theoretical mass of such nucleus is 9465.1 MeV). Due to the oscillations between these two different structures having practically the same mass and spin and parity, the full width of the Type 1S Upsilon meson is very small. Calculated masses of Types 1S, 2S, 3S, 4S, 10860 and 11020 Upsilon mesons are very close to experimental data. They all have unitary spin and negative parity.

1. Introduction and calculations

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/energies [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 (it is the quantum-entanglement scale), stable neutrinos and luminal neutrino-antineutrino pairs which are the components of the luminal Einstein spacetime (it is the Planck scale), cores of baryons (it is the electric-charges scale), and the cosmic structures (protoworlds; it is the cosmological scale) that evolution leads to the dark matter, dark energy and expanding universes (the "soft" big bangs) [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].

Due to the atom-like structure, there appears the particle zoo [1A]. For the strong interactions are responsible the large loops composed of entangled gluons – mass of the loops is m_{LL} = 67.54 MeV [1A]. This mass is very close to the half of the mass of neutral pion, $m_{pion(o)}$ = 134.97 MeV [1A]. Outside the strong fields, the gluons transform into photons

[1A]. Mass of the charged pion calculated within SST is $m_{pion(+,-)}$ = 139.57 MeV [1A]. Inside the strong fields, due to the atom-like structure of baryons, most numerous are the gluon loops carrying energy 67.54 MeV and gluons that energy follows from the transitions between the baryonic shells: m_B = 25.21 MeV [1A].

Gluon loops in strong fields behave as electrons in electromagnetic fields – it is not true that in the strong fields can be more than one boson loop in the same mass and spin-orientation state [1A].

Because electrically neutral mesonic nuclei may consist of three different electrically neutral types of objects whereas only one of them contains the charged pions, the charged pions should, therefore, be two times less than the neutral pions. It is also obvious that there should be some analogy for mesonic and atomic nuclei. We will demonstrate this for the Upsilon meson and the Gallion. The Gal is composed of 31 protons and has an atomic mass equal to 69.72. To try to build a meson having a mesonic mass equal to 69.5, we can use the following equation:

$$Y(1S) = {}^{69.5}Upsilon = 8\boldsymbol{a} + 14\boldsymbol{b} + 9\boldsymbol{b'} = 9465.1 \text{ MeV } (J^P = 1^-), \quad (1)$$

where $\boldsymbol{a} = m_{pion(o)} + m_{LL}$ = 202.5 MeV, $\boldsymbol{b} = m_{pion(o)} + (m_{pion(o)} + m_{LL})$ = 337.5 MeV and $\boldsymbol{b'} = m_{pion(+)} + (m_{pion(-)} + m_{LL})$ = 346.7 MeV. The Type ***a*** objects have unitary angular momentum, J, and positive parity, P, i.e. $J^P = 1^+$, whereas for the Type ***b*** and ***b'*** objects is $J^P = 1^-$.

Such a mesonic nucleus contains 18 charged pions, 36 neutral pions (there indeed number of charged pions is two times smaller than neutral ones) and contains 31 objects. Applying the Hund law to *Y(1S)* (i.e. 31 = (2) + (2 + 6) + (2 + 6 + 10) + (2 + **1**)), we obtain that total angular momentum is unitary. On the other hand, there are 14 + 9 = 23 objects with negative parity so the total parity is negative as well. Notice as well that total number of loops is 139 i.e. 69 pions plus loop (i.e. about a half of a pion) so the mass signature is 69.5.

Table 1 *Unstable neutral objects,* $J^P = 0^+$

Symbol	Composition	Mass [MeV]
A	$m_{pion(+)} + (m_{pion(-)} + m_{LL}) + (m_{pion(o)} + m_{LL}) + 4g^*$	549.2
B	$m_{pion(+)} + (m_{pion(-)} + m_{LL}) + 3g^*$	346.7
C	$(m_{pion(o)} + m_{LL}) + 1g^*$	202.5
D	$m_{pion(+)} + (m_{pion(-)} + m_B) + 3g^*$	304.4
E	$(m_{pion(o)} + m_B) + 1g^*$	160.2

In Table 1 are collected the Type $J^P = 0^+$ unstable neutral objects composed of the carriers of strong interactions i.e. of the pions (134.97 MeV, 139.57 MeV), gluon/large-loop (67.54 MeV) or the characteristic gluon (25.21 MeV), and virtual gluons $g*$.

Number of virtual gluons in an unstable neutral object we can calculate applying following rule. With each pion should be associated one virtual gluon plus one just exchanged virtual gluon. For example, the unstable neutral object, A, contains 3 pions so there should be 4 virtual gluons. But notice that if there is one pion then the additional just exchanged gluon is useless so there should be only one virtual gluon.

By the way, notice that the sum of the mass of η meson and its full width Γ is 549.2 MeV ($\Gamma << \eta$; $J^P = 0^-$) [2]. On the other hand, it is as well the mass of the unstable neutral object, A, but to obtain the same spin and parity, the A should emit two virtual gluons

$$\eta + \Gamma = A - 2\, g* = 549.2 \text{ MeV},\ J^P = 0^-. \quad (2)$$

Assume that there are preferred unstable neutral objects containing gluon loop or gluon carrying greater energy. If two objects contain the same gluon loop or gluon then there is preferred object carrying greater mass.

Assume that the $Y(1S)$ is the ground state of the Upsilon mesons. Composition and masses of the excited states of this meson are collected in Table 2.

Table 2 *Composition and theoretical masses of Upsilon mesons,* $J^P = 1^-$

Particle	Composition	PDG [2]	SST Theoretical Mass [MeV]
$Y(1S)$	$Y(1S)$	9460.30 ± 0.26	9465.1
$Y(2S)$	$Y(1S) + A$	10023.26 ± 0.31	10014.3
$Y(3S)$	$Y(1S) + A + B$	10355.2 ± 0.5	10361.0
$Y(4S)$	$Y(1S) + A + B + C$	10579.4 ± 1.2	10563.5
$Y(10860)$	$Y(1S) + A + B + C + D$	10876 ± 11	10867.9
$Y(11020)$	$Y(1S) + A + B + C + D + E$	11019 ± 8	11028.1

Notice that there is not in existence some analog to A containing instead m_{LL} the m_B. It follows from the fact that neutral pion can decay to $2m_{LL}$ whereas there is not in existence a particle which can decay to $2m_B$. Notice as well that D is an analog to B whereas E is an analog to C.

We can see that the calculated masses of Types $1S$, $2S$, $3S$, $4S$, 10860 and 11020 Upsilon mesons are very close to experimental data. They all have unitary spin and negative parity.

Applying the modified quantum chromodynamics, within the SST, we can calculate the masses of quarks [1A], [1D]. This leads to conclusion that SST is the superior theory to the Standard Model in initial conditions. Calculated mass of b quark is 4190 MeV. Composition of the Type $1S$ Upsilon meson containing the b-b_{anti} quark pair is as follows

$$Y(1S) = (b + b_{anti}) + (K^+ + m_{LL}) + (K^- + m_B) \rightarrow g\, g\, g = 9460.1 \text{ MeV},\ J^P = 1^-. \quad (3)$$

We can see that $Y(1S)$ can decay to three gluons.

So we have the two different structures of the $Y(1S)$ i.e. one containing b-b_{anti} quark pair (theoretical mass of such structure is 9460 MeV) and the second that is the mesonic nucleus (theoretical mass of such nucleus is 9465.1 MeV). Due to the oscillations between these two different structures having practically the same mass and spin and parity, the full width of the Type $1S$ Upsilon meson is very small.

2. Summary

Here, applying the Scale-Symmetric Theory (SST), we described composition and calculated masses of the Upsilon mesons. This follows from the atom-like structure of baryons.

Applying the modified quantum chromodynamics, within the SST, we can calculate the masses of quarks. This leads to conclusion that SST is the superior theory to the Standard Model in initial conditions. Calculated mass of b quark is 4190 MeV.

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Calculated masses of Types $1S$, $2S$, $3S$, $4S$, 10860 and 11020 Upsilon mesons are very close to experimental data. They all have unitary spin and negative parity.

References

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[1B]: http://vixra.org/abs/1511.0223 (Cosmology)
[1C]: http://vixra.org/abs/1511.0284 (Chaos Theory)
[1D]: http://vixra.org/abs/1512.0020 (Reformulated QCD)

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