Masses of the Upsilon Mesons

Sylwester Kornowski

Abstract: Here, applying the Scale-Symmetric Everlasting Theory (S-SET), I described composition and calculated masses of the Upsilon mesons. This follows from the atom-like structure of baryons. Obtained results are very close to experimental data.

1. Introduction and calculations

The Scale-Symmetric Everlasting Theory (S-SET) shows that the succeeding phase transitions of the modified Higgs field lead to the atom-like structure of baryons [1]. Within S-SET, we obtained hundreds theoretical results consistent with experimental data. They concern as well the physical constants. Mass of proton, its spin and radii are consistent with experimental results. Due to the atom-like structure, there appears the particle zoo [1]. For the strong interactions are responsible the large loops composed of entangled gluons – their mass is m_{LL} = 67.54 MeV ([1]: see the explanation below formula (8)). This mass is very close to the half of the mass of neutral pion, $m_{pion(o)}$ = 134.97 MeV [1]. Outside the strong fields, the gluons transform into photons [1]. Mass of the charged pion calculated within S-SET is $m_{pion(+,-)}$ = 139.57 MeV. 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 which energy follows from the transitions between the baryonic shells and relativistic effects: m_B = 25.21 MeV ([1]: formula (127)).

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 [1].

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. I 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:

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

where a = $m_{pion(o)} + m_{LL}$ = 202.5 MeV, b = $m_{pion(o)} + (m_{pion(o)} + m_{LL})$ = 337.5 MeV and 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 is two times less charged pions 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.

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*.

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

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]	S-SET 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 theoretical results obtained within S-SET are very close to experimental data.

2. Summary

Here, applying the Scale-Symmetric Everlasting Theory (S-SET), I described composition and calculated masses of the Upsilon mesons. This follows from the atom-like structure of baryons. Obtained results are very close to experimental data.

References

[1] Sylwester Kornowski (14 March 2014). “The Everlasting Theory and Special Number Theory”.
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