The Origin of the Two New Baryon Resonances with a Mass of 5935 and 5955 MeV Observed in LHCb Experiment

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Abstract: Here, within the Scale-Symmetric Theory, the origin of the two new baryon resonances with a mass of 5935 and 5955 MeV observed in LHCb experiment is presented.

1. Introduction and motivation

The Scale-Symmetric Theory (SST) [1] leads to the atom-like structure of baryons. There is the core and the quantum states of pions outside it [1]. In the high-energy collisions, the states of pions are destroyed and there dominate the phenomena characteristic for the core of baryons. The mass distance between the charged and neutral core of baryons is $\Delta m^+ \approx 2.66$ MeV [1]. The cores of baryons can be neutral or charged positively. They produce pairs in such a way that the component charged positively is real whereas the charged negatively is virtual – it leads to the positron fraction in the cosmic rays [2]. On the surface of the core can appear the pions [1]. The mass distance between the charged and neutral pion is $\Delta M^+ \approx 4.60$ MeV [1]. The mean energy of such condensates is $E_L^+ = (\Delta m^+ + \Delta M^+) / 2 \approx 3.63$ MeV. The condensates (with energy E_L^+ as well) can transform into circular loops [1]. The energy of a wave with the length equal to the radius of the loop is $E_U^+ = 2 \pi E_L = 22.81$ MeV.

In the outer shell of the baryonic plasma can be produced the charged bottom baryons with a mass of $m(\Xi_b)^- = 5791.1 \pm 2.2$ MeV [3].

The calculated mass of the charged pion is $m(\pi)^- = 139.57041$ MeV [1].

Now we can calculate the masses and define charges of the two new baryon resonances

$$m(\Xi_b')^- = m(\Xi_b)^- + m(\pi)^- + E_L^+ = 5934.30 \pm 2.2 \text{ MeV}, \quad (1)$$

$$m(\Xi_b^*)^- = m(\Xi_b)^- + m(\pi)^- + E_U^+ = 5953.48 \pm 2.2 \text{ MeV}. \quad (2)$$

The obtained theoretical results are consistent with experimental data obtained in the LHCb experiment [4]. Notice that the natural width is measured to be $\Gamma(\Xi_b^{*-}) = 1.65 \pm 0.41$ MeV [4].

Within SST we can calculate the mass of the charged bottom baryon $m(\Xi_b(5791)^-)$. To calculate the masses of D and B mesons, there appears the factor $F_x = 3.688$ that is the ratio of the masses of charged kaon and neutral pion [1]. The mass of the torus/electric-charge in the core of baryons is $X = 318.2955$ MeV [1]. Calculate the mass $m(\Xi_b(5791)^-)$ from following formula

$$m(\Xi_b(5791)^-) = m_X(\Xi_b)^o + m(\pi)^- = 5791.0 \pm 0.2 \text{ MeV}, \qquad (3)$$

where

$$m_X(\Xi_b)^o = \{ X^+ + X^- + m(K^*(892)^o \} F_x = 5651.5 \pm 0.2 \text{ MeV}, \qquad (4)$$

where $m(K^*(892)^o) = 895.81 \pm 0.19$ MeV [5].

Emphasize as well that the symmetrical decays (as the decay of energy $2E_L^+ = \Delta m^+ + \Delta M^+$) are characteristic for the nuclear strong interactions, for example, they lead to the atom-like structure of baryons [1]. Emphasize as well that the ratio $E_U^+ / E_L = 2\pi$ is characteristic for the core of baryons. In centre of the core, there is the condensate with a mass of $Y \approx 424$ MeV, [1], whereas inside the torus are produced the loops composed of gluons with a mass of $m_{LL} \approx 67.5$ MeV (the neutral pion is the binary system of such loops) [1]. Notice that the ratio $Y / m_{LL} \approx 2\pi$ is very close to the $E_U^+ / E_L = 2\pi$. It suggests that presented here phenomena mimic the internal structure of the core of baryons.

References

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