



Contribution ID: 52

Type: not specified

Mechanisms of fully heavy tetraquark production in proton-proton collisions

Sunday 25 September 2022 11:30 (20 minutes)

We discuss the production mechanism of a new state, a fully charm tetraquark, discovered two years ago by the LHCb at $M = 6.9$ GeV in the $J/\psi J/\psi$ channel.

Both single parton scattering (SPS) and double parton scattering (DPS) mechanisms are considered. We calculate the distribution in the invariant mass of the four-quark system M_{4c} for SPS and DPS production of $cc\bar{c}\bar{c}$ in the k_t -factorization approach with modern unintegrated gluon distribution functions (UGDFs).

The so-calculated contribution of DPS is almost two orders of magnitude larger than the SPS one, but the tetraquark formation mechanism is unknown at present.

We construct a simple coalescence model of the tetraquark out of $c\bar{c}c\bar{c}$ continuum.

Imposing a mass window around the resonance position we calculate the corresponding distribution in $p_{t,4c}$ – the potential tetraquark transverse momentum. The cross section for the $J/\psi J/\psi$ continuum is calculated in addition, again including SPS (box diagrams) and DPS contributions which are of similar size.

The formation probability is estimated trying to reproduce the LHCb signal-to-background ratio. The calculation of the SPS $gg \rightarrow T_{4c}(6900)$ fusion mechanism is performed in the k_T -factorization approach assuming different spin scenarios (0^+ , 0^- and 2^+). The 2^+ and 0^+ assignment is preferred over the 0^- one by a comparison of the transverse momentum distribution of signal and background with the LHCb preliminary data assuming the SPS mechanism dominance.

There is no microscopic approach for the DPS formation mechanism of tetraquarks at present as this is a complicated multi-body problem.

We do similar analysis for FCC energy $\sqrt{s} = 100$ TeV.

We predict the production cross section order of magnitude larger than its counterpart for the LHC.

We discuss also a possibility to observe the T_{4c} state in the $\gamma\gamma$ channel. The signal-to-background ratio is estimated.

We discuss also production of $c\bar{c}b\bar{b}$ tetraquarks and discuss how the results depend on the mass of such an object.

The presentation will be partially based on our paper [1].

[1] R. Maciula, W. Schaefer and A. Szczurek, “On the mechanism of $T_{4c}(6900)$ tetraquark production”, Phys. Lett. B812 (2021) 136010.

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Session Classification: Recent theoretical results on QCD and saturation

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