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Upsilon Suppression in PbPb Collisions at sqrt(s_NN) = 2.76 TeV

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We suggest that gluon-induced dissociation and screening of the Y(nS) states together with feed-down explain the suppression of the Y(2S+3S) states relative to the Y(1S) ground state that has been observed by CMS in PbPb collisions at sqrt(s_NN) = 2.76 TeV at the CERN LHC.

The minimum-bias gluodissociation cross sections of the 1S-3S states are calculated using a screened Cornell potential and a thermal gluon distribution. The 3S state dissolves due to screening before sizeable gluodissociation occurs, but for the 2S and 1S states there is an interplay between screening, gluodissociation, and feed-down from the chi_b(2P) and chi_b(1P) states.

The calculated suppression of the Y(2S) and Y(3S) states relative to Y(1S) is consistent with the CMS result, but allows for additional suppression mechanisms. The Y(1S) suppression through gluodissociation is in excellent agreement with the CMS data.

Summary

We calculate the gluodissociation and screening of Y(1S), (2S), (3S) and χ_b states at LHC energies, plus the subsequent radiative feed-down via the χ_b states. The weakly bound 3S state dissolves due to screening already at temperatures T ≈ 200 MeV which are close to the critical value. For 2S + 3S relative to the 1S state we find a substantial
suppression due to screening, gluodissociation and feed-down that is consistent
with the value reported by CMS when the experimental error bars are considered, but allows for additional suppression mechanisms of the excited states.

We obtain reasonable results for the suppression of the excited states
relative to the ground state in PbPb collsions at LHC energies with an initial
central QGP temperature of 500 MeV < T_0 < 800 MeV, an effective gluon
mass of m_g ⊠ 0–1 GeV, and a central-collision interaction time of tau_int ⊠ 5–8
fm/c. Screening and gluodissociation are relevant suppression mechanisms
in particular for the higher bottomium states. The consideration of the
subsequent feed-down cascade via the χ_b states turns out to be an essential
ingredient in calculating the suppression of the excited states relative to the
ground state.

Although screening of the strongly bound 1S ground state is negligible,
we find that its gluodissociation is sizeable due to the strong overlap of the
1S gluodissociation cross section with the thermal gluon distribution. Its observed
suppression factor R_AA(1S) ⊠ 0.62 in minimum-bias PbPb collisions
is mainly due to both direct gluodissociation of the 1S state, and to the
melting and gluodissociation of the χ_b(1P) and χ_b(2P) states which partially
feed the 1S state in pp, pbarp and e+e− collisions.

For a detailed comparison, one needs data with better statistics that is expected
to become available from the 2011 PbPb run at the LHC. If it turned
out to be possible to measure the populations of the 2S and 3S states very
precisely, one could use this as a fairly accurate thermometer for the initial
temperature T_0 of the quark-gluon plasma. On the other hand, substantial
deviations from the experimental values might indicate that further mechanisms
contribute to the suppression. It may, however, also turn out that the
gluon distribution is not fully thermalized, in particular, in the longitudinal
direction.

References:
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