Quarkonium polarization at the LHC energies with ALICE

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Quarkonium polarization studies in hadronic collisions are robust tests for QCD. Nonrelativistic QCD (NRQCD) can explain quarkonium production reasonably well; however, it fails to predict measurements of quarkonium polarization. The NRQCD calculations with dominant contributions from the color-octet component predict transverse polarization of charmonia at high transverse momentum (pT) at the LHC energies. On the other hand, the next-to-leading order (NLO) calculations of the color-singlet model show a strong longitudinal polarization. These opposite theoretical predictions are not supported by recent quarkonium polarization results released at the LHC energies, which tend to favour zero or very small polarization scenarios. Additional quarkonium polarization measurements, in particular for less abundantly produced states such as excited charmonia and bottomonia, are therefore mandatory to better understand quarkonium production mechanisms, both in proton-proton and nucleus-nucleus collisions. Considering heavy-ion collisions, quarkonium polarization can also be used to investigate the characteristics of the hot and dense medium created at the LHC energies. ALICE measures inclusive quarkonium production at both mid-rapidity ($|y| < 0.9$) and forward rapidity ($2.5 < y < 4.0$) down to zero pT. In this contribution, we report on the recent ALICE results on Υ(1S) polarization and the status of ongoing J/ψ, ψ(2S) polarization analyses at forward rapidity in pp collision at $\sqrt{s}$ = 13 TeV. In addition, the latest published result of J/ψ polarization in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV will be presented.

In near future, studying quarkonia in ALICE 3 will be crucial. The Muon Identifier (MID) in ALICE 3 is designed to efficiently identify muons by matching tracklets from its detector layers with tracks from the inner tracker. It will ensure high-muon efficiency while providing strong hadron rejection, which will enable precise measurements of quarkonium states via the dimuon channel, even at low transverse momentum. This will help us to probe the quark-gluon plasma properties and understand heavy-quark interactions in extreme QCD conditions.

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