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Can Charmonium be a Probe for QGP in Small Collision Systems?

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Inspired by recent observations, we attempt to investigate the existence of a QGP-like medium in $p-p$ collisions. The $p-p$ being a small collision system implies comparable transverse and longitudinal dimensions, leading to rapid cooling of the medium. Consequently, it changes the dynamics of charmonium states, which is highly unlike the charmonium dynamics in heavy-ion collisions. We use second-order viscous hydrodynamics to obtain the medium evolution. As charmonium traverses through the medium, the relative velocity between charmonium and medium induces the relativistic Doppler shift, leading to an effective temperature for charmonium. The implicit temperature of the particle depends on its velocity and the medium's thermal velocity. Here, we show how particle velocity (v_Q) or transverse momentum (p_T) influences the suppression and regeneration of the charmonium in the medium. The present study incorporates the QGP-induced suppression effects, such as collisional damping, gluonic dissociation, and regeneration mechanisms. Additionally, we observe that the temperature evolution is fast enough in $p-p$ collisions to induce rapid changes in the Hamiltonian of the system, causing the transition from J/ψ to ψ(2S) state. This transition between charmonium states is obtained by considering the non-adiabatic framework for evolving charmonium states. These combined effects explore the charmonium yield modification in $p-p$ collisions at $\sqrt{s}$ = 13 TeV. The present study reexamines the validity of charmonium dynamics as a potential probe for QGP investigation in small collision systems.

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