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Heavy Quark Potential in QGP: Deep Neural Network meets Lattice QCD

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Bottomonium states are key probes for experimental studies of the quark-gluon plasma (QGP) created in high-energy nuclear collisions. Theoretical models of bottomonium productions in high-energy nuclear collisions rely on the in-medium interactions between the bottom and antibottom quarks. The latter can be characterized by the temperature (T) dependent potential, with real ($V_R(T,r)$) and imaginary ($V_I(T,r)$) parts, as a function of the spatial separation (r). Recently, the masses and thermal widths of up to $3S$ and $2P$ bottomonium states in QGP were calculated using lattice quantum chromodynamics (LQCD) [Phys.Lett.B 800, 135119 (2020)]. We find that the HTL complex potential is disfavored by the lattice result, which motives us to employ a model-independent parameterization — the Deep Neural Network (DNN) — to represent the Bottomonium potential, extract the potential allowed by the lattice data. Starting from these LQCD results and through a novel application of DNN, here, we obtain $V_R(T,r)$ and $V_I(T,r)$ in a model-independent fashion. The temperature dependence of $V_R(T,r)$ was found to be very mild between $T \approx 0 - 330$˜MeV. For $T = 150 - 330$˜MeV, $V_I(T,r)$ shows rapid increase with T and r, which is much larger than the perturbation theory based expectations.

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