HAW14-2014-000061

Abstract for an Invited Paper
for the HAW14 Meeting of
the American Physical Society

Heavy quarkonium potential from lattice QCD

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We have recently proposed a novel method for the determination of the interaquark potential together with quark "kinetic mass" from the equal-time $Q\bar{Q}$ Bethe-Salpeter (BS) amplitude in lattice QCD. Our approach allows us to calculate spin-dependent $Q\bar{Q}$ potentials, spin-spin, spin-orbit and tensor potentials, as well. In this talk, we will give a short review of the BS amplitude method on the lattice and present results for both spin-independent and -dependent parts of charmonium potential, which is calculated in 2+1 flavor dynamical lattice QCD using the PACS-CS gauge configurations with a lattice cutoff of $a^{-1} \approx 2.2$ GeV. Our simulations are performed with a relativistic heavy-quark action for the charm quark at the lightest pion mass, $M_\pi = 156(7)$ MeV, in a spatial volume of $(3\ \mathrm{fm})^3$. We observe that the spin-independent charmonium potential obtained from lattice QCD with almost physical quark masses is quite similar to the Cornell potential used in nonrelativistic potential models. We also present preliminary results for a full set of spin-dependent potentials (spin-spin, spin-orbit and tensor potentials), which is calculated in full lattice QCD for the first time. From the viewpoint of phenomenology, greater knowledge of the r-dependence of the spin-dependent potentials paves way for making more accurate theoretical predictions about the higher-mass quarkonium states, where nonrelativistic potential models fail to reproduce properties of newly discovered charmonium-like XYZ states.