A T-matrix calculation for heavy-quark gluon scattering

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Heavy quarks are invaluable probes of the Quark-Gluon Plasma (QGP) as created in ultrarelativistic heavy-ion collisions at RHIC and LHC. Their large mass, $m_Q >> T$ (T: temperature), renders a diffusion approach applicable so that their transport coefficients can be evaluated in controlled approximations; in particular, the predominantly space-like momentum exchange for on-shell scattering enables the use of potential approaches. In this way heavy-flavor observables can be connected to the properties of the fundamental QCD force in the medium [1]. In Ref. [2] we have constructed a potential-based thermodynamic ***T***-matrix approach to describe heavy-quark (HQ) diffusion and quarkonia in the QGP in a common framework. For the transport properties of charm and bottom quarks, we have focused on interactions with light quarks and anti-quarks of the medium, leading to a factor of 3-5 stronger interaction than obtained in perturbation theory.

In the present work [3], we extend the nonperturbative treatment to the gluon sector by evaluating ***T***-matrices for HQ interactions with thermal gluons. The input potential is again motivated by lattice-QCD computations of the HQ free energy, implemented via a field-theoretic ansatz for color-Coulomb and (remnants of) confining interactions [4]. This enables to evaluate corrections to the potential approach, specifically hard-thermal-loop corrections to the vertices, relativistic corrections deduced from pertinent Feynman diagrams, and a suitable projection on transverse thermal gluons. The resulting potentials are applied to compute scattering amplitudes in the three color channels of the HQ-gluon system. In the attractive triplet and sextet channel the resummations in the ***T***-matrix generate an appreciable enhancement of its imaginary part in the S-wave, especially close to the 2-particle threshold; in the repulsive 15-plet channel and for higher partial waves the nonperturbative enhancement is less pronounced. The pertinent ***T***-matrices are subsequently utilized to compute the HQ drag and friction coefficients in the QGP, see Fig. 1 for charm (left panel) and bottom quarks (right panel). When

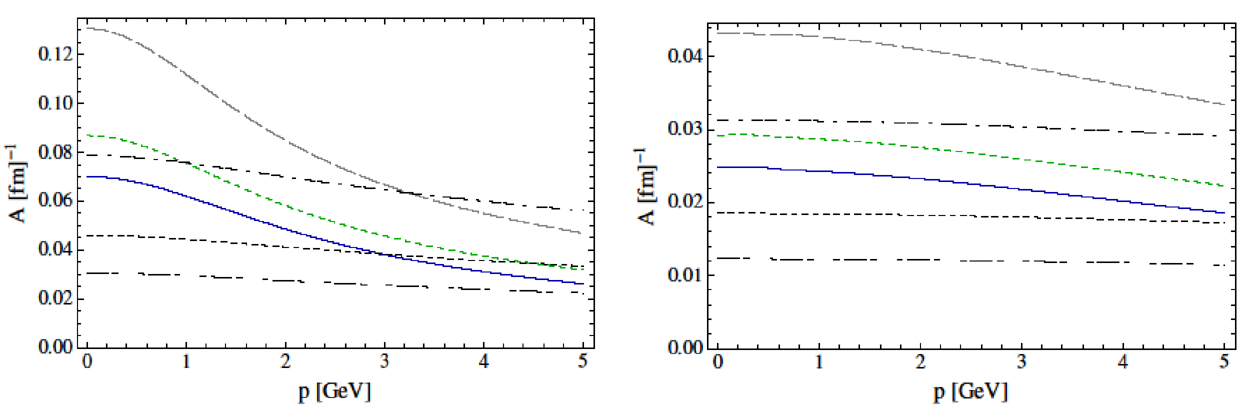

FIG. 1. Thermal relaxation rates of charm (left) and bottom quarks (right) in a hot gluon plasma evaluated from nonperturbative ***T***-matrix interactions at temperatures 1.2 T_c (solid), 1.5 T_c (green-dotted) and 2 T_c (dashed lines), compared to perturbative results at the same temperature (dash-double-dotted, dotted and dash-dotted lines).

approximating the input potential with the internal energy, the low-momentum friction coefficient (relaxation rate) is augmented by a factor of ~2.5(2) for charm (bottom) quarks at temperatures close to T_c. The enhancement is smaller at higher T, larger momentum, and when using the free energy as potential. The increased relaxation rate is expected to aid in the understanding of heavy-flavor data at RHIC and LHC.

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