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Estimation of diffusion coefficients of heavy quarks under Gribov-Zwanziger action.

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Over the last few decades, there has been extensive research going on on a few of the most sophisticated experimental setups which have ever been established in human history. Large Hadron Collider(LHC) at CERN and Relativistic Heavy Ion Collider(RHIC), located at Brookhaven National Laboratory(BNL), in New York, two serves as the benchmark to study the primordial form of matter that existed in the universe shortly after the Big Bang and to mimic conditions that existed at the birth of the universe. As a result of the collision of a subatomic particle moving at ultra-relativistic velocity, the constituent of those, namely Quarks and Gluons deconfined for a short amount of time, and its internal(color) degrees of freedom governs its dynamics.
To our surprise, the properties of QGP are opposite to what was expected(as a result of perturbative QCD calculations) long before its very existence. This has attracted the long-lasting curiosity of physicists all across. Strongly interacting and correlated QGP gives us a green signal to incorporate dissipative hydrodynamics as a tool to extract the properties of this extremely dense matter, QGP, in the form of various transport coefficients. Heavy quarks(HQ), on the other hand, play an important role to dig for the properties of QGP due to several factors. With a huge mass of the order of a few GeV, heavy quarks are produced in the pre-equilibrium phase i.e. before the formation of QGP. The long relaxation time of heavy quark gives it an upper hand for using it as a tool to describe the properties of QGP. Also due to larger mass, the production of heavy quarks as a result of the interaction of QGP medium particles is very unlikely to occur, hence heavy quarks, to a good extent, remain constant in terms of numbers. Therefore, because of these factors, heavy quark acts as a good candidate to probe in QGP.
The QGP is a highly correlated system with large coupling strength hence the perturbative treatment is plagued with large inconsistencies when matched with lattice results. This factor signals toward consideration of the non-perturbative effect in the calculation. One of the non-perturbative approaches that seem quite promising in the non-perturbative scale is given by Gribov, which later was updated by Zwanziger by formulating renormalizable action, termed as Gribov-Zwanziger(GZ) action. Within the GZ action, the gluon propagator in the covariant gauge is expressed as:
D$^{\mu\nu}(Q) = \left[\delta^{\mu\nu} - (1-\xi)\frac{Q^\mu Q^\nu}{Q^2}\right]\left(\frac{Q^2}{Q^4+\gamma_G^4}\right)$ $,where \xi$ is the gauge parameter and γ_G is termed as the Gribov parameter, which is fixed either by matching the thermodynamic quantities with lattice equation of state or by solving one loop gap equation. The Gribov-Zwanziger prescription leads to infrared-improved dispersion relations for gluons. I tried to calculate the diffusion coefficient of heavy quark under Gribov prescription and match it with lattice data available in the range $1 \leq T/T_c \leq 5$. In the end, we compare our calculation with the Leading Order(LO) and Next to Leading Order(NLO) calculation of the diffusion coefficients, κ and $\mathcal{D}$. We saw a better agreement of our calculation with the lattice data in comparison to LO and NLO calculation of the same, in the given range of T/T_c .

Session

Heavy Ions and QCD

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