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Quarkonia as an Open-Quantum-System

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Quarkonia suppression has been long predicted \cite{satz19861} and explored as a defining signature of formation of quark-gluon-plasma (QGP). Various physical processes \cite{satz19861,laine20071,brambilla20081} have been understood to contribute to the dynamics of a Q-$\bar{Q}$ traversing through the QGP. The proper framework to implement a Schr\"{o}dinger equation, which takes into account the dynamical nature of the above problem, is treating the system as an open quantum system \cite{akamatsu20121,akamatsu20151}.

In our calculation, we implement a stochastic Schr\"{o}dinger equation which describes the evolution of the Q-$\bar{Q}$ pair starting from a pure state.
In the first part, we start with an extension of the results obtained in \cite{akamatsu20181} by extending the calculation to three-dimensional case and including the full-color structure of a Q-$\bar{Q}$ pair (including color-octet states as well). We do so by expanding the equations obtained in \cite{akamatsu20151} in small $\vec{r}$ limit. This is not an ad hoc approximation but is rather motivated by the idea of effective-field-theory (EFT) methods, such as pNRQCD \cite{brambilla20081}. Further, in a simple calculation, we check how much of an error small '$\vec{r}$' expansion brings. This is an example of a Markovian process as shown in \cite{akamatsu20151}. This formalism does not include on-shell gluon emission or absorption.

The second part of the calculation is a dynamical implementation of the physical process called gluo-dissociation \cite{brambilla20081} by the means of stochastic evolution. This necessarily involves kernels which remember correlation in time as the process occurs at a finite frequency. This is an example of a non-Markovian process. If one wants to use results from lattice (since the QGP formed at RHIC and LHC is an example of a strongly coupled system), one would like to understand the relative importance of these physical processes. We suggest that this can be done by comparing correlation functions of color electric-fields at zero and non-zero frequencies. It appears that non-Markovian dynamics will play an important role when higher-excited states are considered.

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Primary author: Mr TIWARI, Anurag (Tata Institute of Fundamental Research)

Co-author: Mr SHARMA, Rishi (Tata Institute of Fundamental Research)

Presenter: Mr TIWARI, Anurag (Tata Institute of Fundamental Research)

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