論文の内容の要旨

論文題目　:　Heavy Quark Potential from the thermal Wilson Loop in Lattice QCD
（有限温度ウィルソン・ループに基づく格子 QCD からの重クォークポテンシャルの研究）

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Bound states of heavy quarks play a central role in the investigation of hadronic matter in and possibly beyond the standard model. From the viewpoint of the matter phase diagram they are of particular interest in the transition to the Quark-Gluon Plasma observed in relativistic heavy-ion collisions. Their theoretical description based on non-relativistic potentials with input from Lattice QCD has been successful in vacuum but generalizations to finite temperature using potential models are plagued with ambiguities related to gauge invariance and the correct treatment of entropy contributions. The most fundamental limitation to these approaches however is that no Schrödinger equation has been derived for the model potentials to date. A promising approach based on high temperature resummed perturbation theory has been put forward but the phenomenological region of interest, the sQGP, is not captured by the employed Hard Thermal Loop approximation.

This thesis offers a solution through a gauge-invariant and non-perturbative definition of the in-medium heavy quark potential based on the thermal Wilson Loop and its spectral function from Lattice QCD. We show how to relate the peak structure of the spectral function to the existence of a Schrödinger equation for the forward correlator of the heavy quark system and are naturally lead to a complex static potential if the peaks can be described by a simple Breit-Wigner or Gaussian form.

The basis of this work is a combination of an effective field theory description for the heavy quarks in Minkowski time using a quantum mechanical path-integral picture, supplemented with non-perturbative information from lattice QCD in the form of the spectral function from the thermal Wilson loop. For the extraction of dynamical information from Wick-rotated Euclidean Lattice QCD simulations we utilize a form of Bayesian inference christened Maximum Entropy Method. Our particular implementation with an extended search space allows us to obtain meaningful results for small datasets previously inaccessible.

The proper potential is found to be qualitatively distinct from the color singlet free energies at finite temperature, since it exhibits a small but finite imaginary part at all $T>0$. Below the confinement phase transition its real part agrees with the singlet potential but it exhibits a non-vanishing string tension even at temperatures above 290 MeV, where a non-vanishing linearly rising imaginary part is also present.