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Holographic equation of state matched with hadron gas EoS as a tool for the study of the QGP evolution

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At the beginning of the 21st century, a new phase state of strongly interacting matter was established, known as the quark-gluon plasma (QGP) [1]. To study the formation of the QGP in collisions of heavy nuclei, the solution of a system of equations of relativistic hydrodynamics with a specific equation of state (EoS) is typically employed. In light of difficulties for non-zero baryonic potentials within Lattice QCD, various holographic models based on the well-known AdS/CFT duality have been proposed to obtain EoS for the QGP using the thermodynamic properties of the corresponding black brane in AdS_5.

In the present work, a calibration method is proposed for the holographic EoS developed by I. Ya. Aref'eva's theoretical group [2] to study QGP properties within the framework of relativistic hydrodynamics. Machine learning methods were applied to address the regression and optimization issues during the calibration of the relevant parameters using the LQCD results for quark masses that approximate the physical values [3]. Special attention is paid to the matching of the equation of state with the hadron gas EoS for low temperatures, which is common for lattice instruments [4]. The advantage of holography in this context is the possibility of matching at almost any baryonic potentials. For practical applications in studying heavy-ion collisions, the corresponding holographic EoS was incorporated into the relativistic hydrodynamics packages MUSIC [5] and vHLLE [6].

To obtain the final hadron spectra, numerical simulations were conducted using the iEBE-MUSIC and SMASH-vHLLE frameworks, which additionally include a set of packages for initial conditions, freeze-out and hadronic afterburner. Consequently, the transverse mass distributions of produced hadrons were calculated at the energies of NA49 experiment. The effect of matching holographic EoS with the HRG equation on the above results is discussed.

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