Constraining the transport coefficient in cold nuclear matter with the Drell-Yan process

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By means of the Salgado-Wiedemann (SW) quenching weights and the analytic parametrizations of quenching weights based on the Baier-Dokshitzer-Mueller-Peigné-Schiff (BDMPS) formalism, the leading-order computations for nuclear Drell-Yan differential cross section ratios as a function of the quark momentum fraction are performed with the nuclear geometry effect in Drell-Yan dimuon production and the HKM nuclear parton distribution functions, avoiding overestimation of the nuclear modification in the sea quark distribution. By a global analysis of the Drell-Yan experimental data from NA3 and E866 Collaborations, the extracted transport coefficient with the SW quenching weights is $\hat{q} = 0.32 \pm 0.04$ GeV^2/fm, which is approximately equal to the value $\hat{q} = 0.37 \pm 0.05$ GeV^2/fm determined with the analytic parametrizations of BDMPS quenching weights. It is found that the theoretical results are in good agrement with the experimental measurements, and especially the agreement of calculations with NA3 experimental data has a significant improvement. We have also given the predictions for the forthcoming Sea Quest experiment. It is hoped that the obtained value of the transport coefficient in cold nuclear matter can provide a useful reference for determining the precise values of the transport properties of the quark-gluon plasma.

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I. INTRODUCTION

A new state of matter, the so called quark-gluon plasma (QGP), is expected to be formed in ultrarelativistic heavy-ion collisions, where nuclear matter reaches high temperatures and pressures. The energy loss suffered by quarks of different flavors and gluons as they traverse the QGP, undergoing collisions and radiating gluons, is a subject matter of considerable topical interest. In order to determine the precise values of the transport properties of the QGP, a solid understanding of the nuclear modification of particle spectra in cold nuclear matter is fundamentally important.

The nuclear Drell-Yan process can be considered a very clean probe for the energy loss effect of an incoming quark in cold nuclear matter; since the lepton pair in the final state does not interact strongly with partons in the nuclei, only initial-state interactions are important. A series of experimental data on the Drell-Yan differential cross section ratios were presented by NA3 [1] and NA10 [2] Collaborations from CERN and by the E772 [3] and E866 [4] Collaborations from Fermilab. The data on the differential cross section ratio as a function of the quark momentum fraction can cancel most uncertainties regarding the lepton pair production, and avoid the influence of the QCD next-to-leading order correction [5].

Many theoretical phenomenological models were proposed to describe the incoming quark energy loss in the nuclear Drell-Yan process [6–11]. The best value of energy loss obtained by their independent analysis of the Drell-Yan experimental data was strongly dependent on the nuclear parton distribution functions used and on the assumption for the average path length of the incident quark. For example, the energy loss value obtained by Johnson *et al.* [7] is significantly higher (2.73 ± 0.37 GeV/fm), since their method depends entirely on the validity of a theoretical light-cone formulation of nuclear shadowing and Drell-Yan process in the rest frame. The smaller value obtained by Arleo *et al.* [9] from a fit to E866 and NA3 data sets is 0.20 ± 0.15 GeV/fm with the EKS98 nuclear parton distributions [12]. As mentioned in Ref. [9], the large uncertainties in the nuclear sea quark distributions prohibit constraints on the quark energy loss from the E866 experimental data.

The parton distribution functions inside a nucleus have been found to differ notably from the corresponding ones in a free nucleon. However, there is as yet no consensus about the origin of the modification of the nuclear parton distribution functions. The four sets of nuclear parton distribution functions—HKM [13], HKN07 [14], nDS [15], and EPS09 [16] (EKS98 [12])—employed the existing experimental data on nuclear structure functions from the electron and muon deep inelastic scattering. Unfortunately, the nuclear structure functions are composed of nuclear sea- and valence-quark distributions, which results in that the nuclear valence quark distributions being relatively well determined except for the small-x region, and nuclear antiquark distributions are reasonably well determined at small x in addition to the medium- and large-x regions. The nuclear Drell-Yan experimental data at low energy from π-A collisions can probe valence quark distributions at rather large x in the nucleus, and higher energy Drell-Yan p-A data can probe the sea quark distribution in the smaller x region in the nucleus. Therefore, HKN07 and EPS09 (EKS98) included Fermilab E772 and E866 nuclear Drell-Yan data, and nDS added E772 experimental data. The nuclear parton distribution parametrization employing the Drell-Yan experimental data consequently overestimates the nuclear modification in the sea quark distribution by reason of leaving the quark energy loss effect out of the Fermilab Drell-Yan data. It is noticeable that HKM nuclear parton distributions were determined only by fitting the experimental data from l-A deep inelastic scattering (DIS) without the data from the Drell-Yan reaction.

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In our preceding papers [17–20], the effect of energy loss in the Drell-Yan process is discussed and models are given to incorporate them in the calculation of Drell-Yan yields. It is found that the energy loss effect of incoming quark can suppress evidently the differential cross sections versus the quark momentum fraction, and the mean value of quark energy loss obtained by HKM nuclear parton distribution functions [13] ($dE/dL = 1.21 \pm 0.09$ GeV/fm) is larger than that by using HKN07 [14] ($dE/dL = 0.64 \pm 0.09$ GeV/fm), nDS [15] ($dE/dL = 0.73 \pm 0.09$ GeV/fm), and EPS09 [16] ($dE/dL = 0.23 \pm 0.07$ GeV/fm) parametrizations, which directly reflects the deviation between HKM nuclear corrections to the sea quark distribution and other sets.

It is worthwhile to mention that the mean energy loss employed in our preceding calculations wold be considered very simplistic in hot and dense matter, and the fluctuations of the path that a quark takes through the medium have not yet been considered. It is accepted that at least the probability $D(\varepsilon,L)$ of energy loss ε given a path L, with averaging over geometry, is a relevant quantity. In this paper, by means of the Salgado-Wiedemann (SW) quenching weights [21], and the analytic parametrizations of quenching weights [22] based on the Baier-Dokshitzer-Mueller-Peigné-Schiff (BDMPS) formalism [23], the leading-order computations for the nuclear Drell-Yan differential cross section ratio as a function of the quark momentum fraction are performed with the nuclear geometry effect in Drell-Yan dimuon production. The transport coefficient $\hat{q}$ of the incoming quark energy loss in cold nuclear matter is extracted with a global analysis of the NA3 [1] (incident proton energy $E_{\rm beam} = 150$ GeV and target-quark momentum fraction x_2 from 0.074 to 0.366) and E866 [4] ($E_{\rm beam} = 800$ GeV and $0.0179 < x_2 < 0.1022$) nuclear Drell-Yan experimental data. We desire that our results and discussion in this work can constrain the transport coefficient in cold nuclear matter.

The remainder of this paper is organized as follows. In Sec. II, the theoretical framework of our study is introduced. Section III is devoted to the results and discussion. Finally, a summary is presented.

II. DRELL-YAN REACTION IN HADRON-NUCLEUS COLLISIONS

As expressed in Ref. [20], the lepton pair production differential cross section in hadron-nucleus collisions for the leading order in perturbation theory can be obtained from the convolution of differential partonic cross section $q\bar{q} \to l^+l^-$ with the quark distributions in the beam and in the target:

$$\frac{d^2\sigma}{dx_1 dx_2} = \frac{4\pi\alpha_{em}^2}{9sx_1x_2}\sum_f e_f^2\big[q_f^h(x_1,Q^2)\bar{q}_f^A(x_2,Q^2) + \bar{q}_f^h(x_1,Q^2)q_f^A(x_2,Q^2)\big], \tag{1}$$

where x_1 (x_2) is the momentum fraction carried by the projectile (respectively target) parton, α_{em} is the fine structure constant, $\sqrt{s}$ is the center-of-mass energy of the hadronic collision, e_f is the charge of the quark with flavor f, Q^2 is the invariant mass of a lepton pair, the sum is carried out over the light flavors ($f = u,d,s$), and $q_f^{h(A)}(x,Q^2)$ and $\bar{q}_f^{h(A)}(x,Q^2)$ are respectively the quark and antiquark distribution functions in the hadron (nucleon in the nucleus A).

In the hadron-induced Drell-Yan reaction on the nucleus, when the incoming quark propagates through the nuclear medium, it suffers multiple scattering on the surrounding nucleon and gluon radiation. The induced gluon bremsstrahlung effectively reduces the incoming quark energy. The energy loss (ε) of the incoming quark results in a change in its momentum fraction prior to the collision, $\Delta x_1 = \varepsilon/E_{\rm beam}$, where $E_{\rm beam}$ is the incident hadron energy. As a consequence, the projectile parton distribution function should be evaluated at $x_1' = x_1 + \Delta x_1$.

Considering the incoming quark energy loss in the nuclear medium, the Drell-Yan differential cross section in hadron-nucleus collisions can be expressed as

$$\frac{d^2\sigma}{dx_1 dx_2} = \frac{4\pi\alpha_{em}^2}{9sx_1x_2}\sum_f e_f^2\int_0^{\varepsilon_{\max}} d\varepsilon D(\varepsilon,\omega_c,L) \times\big[q_f^h(x_1',Q^2)\bar{q}_f^A(x_2,Q^2) + \bar{q}_f^h(x_1',Q^2)q_f^A(x_2,Q^2)\big]. \tag{2}$$

Here $\varepsilon_{\max} = (1-x_1)E_{\rm beam}$, the characteristic gluon frequency $\omega_c = \frac{1}{2}\hat{q}L^2$, and $D(\varepsilon,\omega_c,L)$ denotes the probability that an incoming quark suffers an energy loss ε from the quark radiating gluons. In the calculation, the energy scale ω_c depends on the path length L covered by the incoming quark in the nuclear medium, and is determined by the transport coefficient $\hat{q}$ adjusted to the data.

Considering the fluctuations of the path L traveled by the incoming quark across the target, the energy loss probability distribution $D(\varepsilon,\omega_c,L)$ needs to be averaged over the geometry. The nuclear geometry is described by the nuclear density distribution $\rho_A(\vec{b},y)$, where y is the coordinate along the direction of the incoming quark and $\vec{b}$ is the impact parameter. The center of the target nucleus lies at $(\vec{0},0)$. With the assumption that the annihilation of a quark-antiquark pair into a virtual photon is located at $(\vec{b},y)$, the incident quark at y will travel the path length $L = \sqrt{R_A^2 - b^2} + y$, along a direction with impact parameter $\vec{b}$. Then with the nuclear geometry effect in Drell-Yan dimuon production, the nuclear Drell-Yan differential cross section should be written as

$$\frac{d^2\sigma^{h-A}}{dx_1 dx_2} = \frac{4\pi\alpha_{em}^2}{9sx_1x_2}\sum_f e_f^2\int d^2b dy \rho_A(\vec{b},y) \times\int_0^{\varepsilon_{\max}} d\varepsilon D(\varepsilon,\omega_c,L)\big[q_f^h(x_1',Q^2)\bar{q}_f^A(x_2,Q^2) + \bar{q}_f^h(x_1',Q^2)q_f^A(x_2,Q^2)\big]. \tag{3}$$

Here the nuclear density profile $\rho_A(\vec{b},y)$ is normalized to unity. In our calculation, we use the uniform hard-sphere nuclear density normalized to unity,

$$\rho_A(\sqrt{b^2+y^2}) = (\rho_0/A)\Theta(R_A - \sqrt{b^2+y^2}), \tag{4}$$

where ρ_0 is the nuclear density, $R_A = r_0A^{1/3}$, and $r_0 = 1.12$ fm.

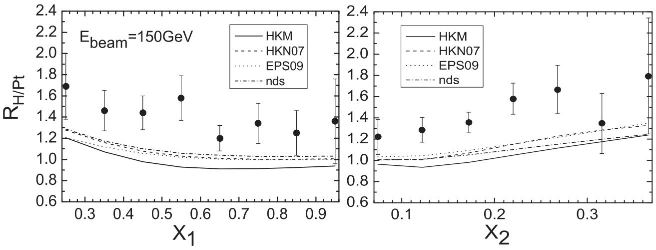

FIG. 1. The Drell-Yan cross section ratio $R_{\mathrm{H/Pt}}$ obtained by means of HKM (solid lines), HKN07 (dashed lines), EPS09 (dotted lines), and nDS (dash-dotted lines) without the quark energy loss effect. The experimental data are taken from the NA3 Collaboration [1].

III. RESULTS AND DISCUSSION

In this paper, the experimental data for constraining the transport coefficient in cold nuclear matter are taken from the NA3 [1] Collaboration at CERN and the E866 [4] Collaboration at Fermilab. To constrain the quark energy loss in cold nuclear matter by a global analysis of the Drell-Yan experimental results, we give a phenomenological analysis at leading order for the nuclear Drell-Yan differential cross section ratio:

$$R_{A_1/A_2}(x_{1(2)}) = \int dx_{2(1)} \frac{d^2\sigma^{h-A_1}}{dx_1 dx_2} \Bigg/ \int dx_{2(1)} \frac{d^2\sigma^{h-A_2}}{dx_1 dx_2}. \quad (5)$$

We emphasize that the NA3 [1] data used cover the momentum fraction of the target parton from 0.074 to 0.366. In this intermediate x_2 range, the Drell-Yan process should only be slightly affected by quark (antiquark) shadowing [9], which helps us to set tight constraints on the quark energy loss in the nuclear target. Meanwhile, the negative pion incident Drell-Yan cross section is dominated by the fusion of a valence antiquark (in the pion) and a valence quark (in the nucleus), which induces this reaction to be sensitive to the valence quark distribution in the nucleus and not to the sea quark distribution.

A quantitative comparison of the theoretical results on the Drell-Yan cross section ratio $R_{\mathrm{H/Pt}}$ obtained separately by means of HKM (solid lines), HKN07 (dashed lines), EPS09 (dotted lines), and nDS (dash-dotted lines) nuclear parton distribution functions and without the quark energy loss effect is shown in Fig. 1. In our calculation, we use the CTEQ6L parton density in the proton [24] and parton density in the negative pion [25]. From Fig. 1, we can see that deviation from different sets of nuclear parton distribution is not obvious for NA3 data. However, HKN07 and EPS09 added Fermilab E772 and E866 nuclear Drell-Yan data, and nDS included E772 experimental data. As discussed in Ref. [9], quark energy loss in Fermilab Drell-Yan data was not constrained by means of the nuclear parton distributions obtained by fitting the Fermilab Drell-Yan data to the constrained sea quark shadowing in the $0.01 < x < 0.3$ region. Therefore, in order to extract the value of the transport coefficient $\hat{q}$ precisely by fitting the NA3 [1] and E866 [4] experimental data (87 points), in our calculation (as follows) we use the HKM nuclear corrections determined only by fitting the world data on the nuclear structure function.

By means of the CERN subroutine MINUIT [26], the transport coefficient $\hat{q}$ is obtained by minimizing χ^2. One standard deviation of the optimum parameter corresponds to an increase of χ^2 by 1 unit from its minimum χ^2_{min}. Table I summarizes the calculated results corresponding to the transport coefficient $\hat{q}$ and χ^2 per number of degrees of freedom (χ^2/ndf) by means of the SW quenching weights [21]:

TABLE I. The values of $\hat{q}$ and χ^2/ndf extracted from the experimental data by means of the SW quenching weights [21].

Expt. data	$\hat{q}$ (GeV^2/fm)	χ^2/ndf
E866x_1	0.29 ± 0.05	0.86
E866x_2	0.41 ± 0.08	1.18
NA3x_1	0.42 ± 0.11	0.54
NA3x_2	0.50 ± 0.09	1.28
Global fit	0.32 ± 0.04	0.90

$$D(\varepsilon,\omega_c,L) = p_0(\omega_c,L)\delta(\varepsilon) + p(\varepsilon,\omega_c,L). \quad (6)$$

Here the discrete weight $p_0(\omega_c,L)$ is the probability for no medium-induced energy loss, and $p(\varepsilon,\omega_c,L)$ is the continuous part, and the results of these quenching weights are available as a FORTRAN routine [21]. It is shown that the global fit of all data gives $\hat{q} = 0.32 \pm 0.04$ GeV^2/fm with $\chi^2/\mathrm{ndf} = 0.90$. As can be seen from Table I, considering the incoming quark energy loss effect and the nuclear geometry effect in Drell-Yan dimuon production, the theoretical results are in good agreement with the experimental data, and especially the agreement of calculations with NA3 [1] experimental data has a significant improvement (with $\chi^2/\mathrm{ndf} = 0.54$ for NA3x_1 data and $\chi^2/\mathrm{ndf} = 1.28$ for NA3x_2 data). In our previous study [20], χ^2/ndf extracted from the NA3x_1 (NA3x_2) data is 1.69 (respectively 2.53) by means of the mean energy loss model and without the fluctuations of the path.

To demonstrate intuitively the energy loss effect of an incoming quark on the nuclear Drell-Yan cross section ratio, the solid curves in Fig. 2 are our numerical results calculated with SW quenching weights [21] and HKM nuclear parton distributions, which are compared with the corresponding NA3 experimental data. It is necessary to note that the NA3 Collaboration provided the negative pion incident Drell-Yan cross section ratio $R_{\mathrm{H/Pt}}$ as a function of parton momentum fraction. As can be seen from the solid lines in Fig. 2, the theoretical results with the incoming quark energy loss effect and the nuclear geometry effect in Drell-Yan dimuon

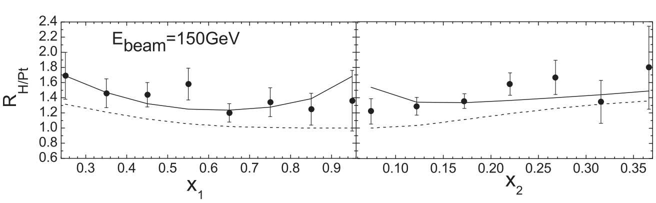

FIG. 2. The nuclear Drell-Yan cross section ratios $R_{\mathrm{H/Pt}}(x_{1(2)})$. The solid lines denote the results calculated with SW quenching weights [21] and HKM nuclear parton distributions, and the dashed lines denote the calculations without quark energy loss and without the nuclear parton distribution corrections. The experimental data are taken from the NA3 Collaboration [1].

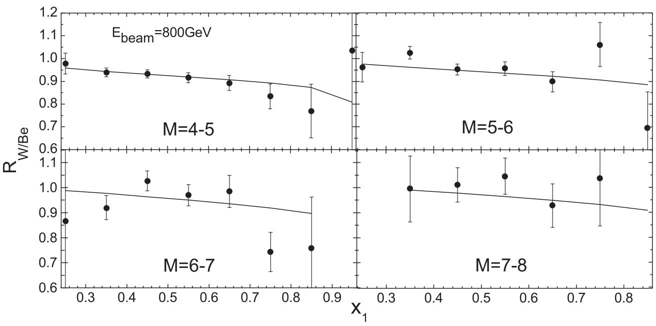

FIG. 3. The nuclear Drell-Yan cross section ratios $R_{\mathrm{W/Be}}(x_1)$ calculated with SW quenching weights [21] and HKM nuclear parton distributions. The experimental data are taken from the E866 Collaboration [4].

production have good agreement with the experimental data. The dashed lines in Fig. 2 denote the calculations without quark energy loss and without the nuclear parton distribution corrections, which display the role of isospin effects on the negative pion incident Drell-Yan cross section ratio. The role of isospin effects is evident in the small-x_1 region and the large-x_2 range. Excluding the influence of isospin effects, the solid line in Fig. 2 (left) shows that the influence due to the incoming quark energy loss on the NA3 nuclear Drell-Yan different cross section ratio $[R_{\mathrm{H/Pt}}(x_1)]$ decreases with the increase of x_1 (approximately from 39% to 24% in the range $0.25 < x_1 < 0.65$) and then becomes greater (approximately from 24% to 68% in the range $0.65 < x_1 < 0.95$). For the ratio $R_{\mathrm{H/Pt}}(x_2)$, the influence induced by the quark energy loss first decreases sharply with the increase of x_2 (approximately from 54% to 30% in the range $0.07 < x_2 < 0.12$), and then decreases gradually (approximately from 30% to 13% in the range $0.12 < x_2 < 0.37$).

In Figs. 3, 4, and 5 we present the calculated results for the nuclear Drell-Yan cross section ratio for E866 experimental data with the incoming quark energy loss effect, the nuclear geometry effect, and the HKM nuclear parton distributions. From Figs. 3, 4, and 5 it is found that the incoming quark energy loss effect on the Fermilab E866 nuclear Drell-Yan differential cross section ratio becomes greater with the increase of quark

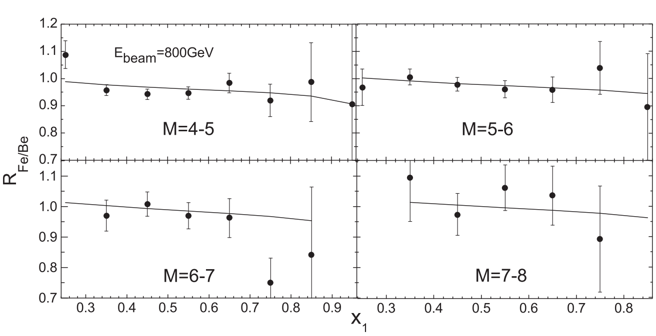

FIG. 4. The nuclear Drell-Yan cross section ratios $R_{\mathrm{Fe/Be}}(x_1)$ calculated with SW quenching weights [21]and HKM nuclear parton distributions. The experimental data are taken from the E866 Collaboration [4].

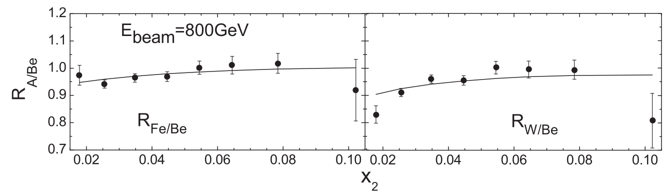

FIG. 5. The nuclear Drell-Yan cross section ratios $R_{A/\mathrm{Be}}(x_2)$ calculated with SW quenching weights [21] and HKM nuclear parton distributions. The experimental data are taken from the E866 Collaboration [4].

momentum fraction (x_1) in the beam hadron [for example, the suppression of $R_{\mathrm{W/Be}}(x_1)$ for $M = 4$–5 is approximately from 4% to 19% in the range $0.25 < x_1 < 0.95$], and decreases gradually with the increase of quark momentum fraction (x_2) in the target nucleus [such that the suppression of $R_{\mathrm{W/Be}}(x_2)$ is approximately from 10% to 3% in the range $0.018 < x_2 < 0.102$]. It is obvious that the energy loss effect of the incoming quark is particularly significant at lower incident proton energies. High statistics, high precision data on the nuclear Drell-Yan different cross section ratio from lower incident proton energies in the larger x_2 region will help to pin down the energy loss effect of an incoming quark in cold nuclear matter.

In Table II, we presents the results obtained by means of the analytic parametrizations of BDMPS quenching weights [22]:

$$D(\varepsilon,\omega_c,L) = \frac{1}{\sqrt{2\pi}\,\sigma(\varepsilon/\omega_c)} \exp\left[-\frac{[\ln(\varepsilon/\omega_c)-\mu]^2}{2\sigma^2}\right], \quad (7)$$

where $\mu = -2.55$ and $\sigma = 0.57$. As can be seen from Table II, the global fit of all data gives $\hat{q} = 0.37 \pm 0.05\ \mathrm{GeV}^2/\mathrm{fm}$ with $\chi^2/\mathrm{ndf} = 0.96$, which is approximately equal to the above result ($\hat{q} = 0.32 \pm 0.04\ \mathrm{GeV}^2/\mathrm{fm}$ with $\chi^2/\mathrm{ndf} = 0.90$) given by the SW quenching weights [21]. This indicates that the finite-length effects which lie in the SW quenching weights have little influence on extracting the transport coefficient $\hat{q}$ from E866 and NA3 Drell-Yan experimental data due to the large-R_A target. In addition, the value of the transport coefficient ($\hat{q} = 0.37 \pm 0.05\ \mathrm{GeV}^2/\mathrm{fm}$) obtained in this work for the incoming quark by means of the analytic parametrizations of BDMPS quenching weights is bigger than that ($\hat{q} = 0.14 \pm 0.11\ \mathrm{GeV}^2/\mathrm{fm}$) extracted by Arleo *et al.* [27], which originates from overestimating the nuclear modification in the sea quark distribution by using EKS98 parametrizations.

TABLE II. The values of $\hat{q}$ and χ^2/ndf extracted from the experimental data by means of the analytic parametrizations of BDMPS quenching weights [22].

Expt. data	$\hat{q}$ (GeV^2/fm)	χ^2/ndf
E866x_1	0.37 ± 0.05	0.92
E866x_2	0.36 ± 0.12	1.08
NA3x_1	0.40 ± 0.07	1.49
NA3x_2	0.41 ± 0.09	1.08
Global fit	0.37 ± 0.05	0.96

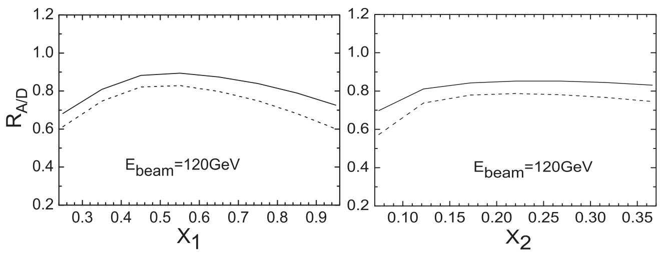

FIG. 6. The nuclear Drell-Yan cross section ratios $R_{A/D}(x_{1,(2)})$ for the forthcoming E906 Sea Quest experiment calculated with SW quenching weights [21] and the HKM nuclear parton distributions. The solid lines correspond to $R_{Fe/D}(x_{1,(2)})$ and the dashed lines correspond to $R_{W/D}(x_{1,(2)})$

High statistics, high precision data from E906 Sea Quest experiment [28] on the nuclear Drell-Yan different cross section ratio at $E_{beam} = 120$ GeV in various regions of x_1 and x_2 will provide important information about the modification of quark parton distribution functions (PDFs) and nucleon structure function in the nucleus, and further constrain the transport coefficient in cold nuclear medium. In Fig. 6, we have provided the predictions for the nuclear Drell-Yan cross section ratios $R_{Fe(W)/D}(x_{1(2)})$ at $\sqrt{s} = 15$ GeV corresponding to the energy of the incident proton $E = 120$ GeV by means of SW quenching weights [21] and the HKM nuclear parton distributions. The solid lines correspond to $R_{Fe/D}(x_{1,(2)})$ and the dashed lines correspond to $R_{W/D}(x_{1,(2)})$. Comparing with the theoretical results for the nuclear Drell-Yan cross section ratios at Fermilab energy in Figs. 3, 4, and 5, we find that there is large reduction, mainly induced by the quark energy loss effect at low energy ($\sqrt{s} = 15$ GeV), and the reduction increases considerably with the increase in the mass number of the target nucleus.

IV. SUMMARY

The Drell-Yan reaction in hadron-nucleus collision is an ideal tool to determine and constrain the transport coefficient in cold nuclear medium. By means of the SW quenching weights and the analytic parametrizations of quenching weights based on BDMPS formalism, the NA3 and E866 experimental data on the nuclear Drell-Yan differential cross section ratio as a function of the quark momentum fraction have been analyzed with the HKM nuclear parton distribution functions together with the CTEQ6L parton density in the proton and parton density in the negative pion. Considering the fluctuations of the path L traveled by the incoming quark across the target, the energy loss probability distribution $D(\varepsilon,\omega_c,L)$ has been averaged over the geometry. The extracted transport coefficient from the global fit is shown to be $\hat{q} = 0.32 \pm 0.04$ GeV^2/fm (χ^2/ndf $= 0.90$) for the SW quenching weights, which is approximately equal to the value $\hat{q} = 0.37 \pm 0.05$ GeV^2/fm (χ^2/ndf $= 0.96$) determined with the analytic parametrizations of BDMPS quenching weights. This indicates that the finite-length effects which lie in the SW quenching weights and result in the large value of the transport coefficient $\hat{q}$ for a small-R_A target have little influence on extracting the transport coefficient $\hat{q}$ from E866 and NA3 Drell-Yan experimental data due to the large-R_A target. The value of the transport coefficient ($\hat{q} = 0.37 \pm 0.05$ GeV^2/fm) obtained by means of the analytic parametrizations of BDMPS quenching weights and HKM nuclear parton distribution functions in this work is bigger than that ($\hat{q} = 0.14 \pm 0.11$ GeV^2/fm) extracted by Arleo *et al.* [27] using EKS98 parametrizations, since the EKS98 parametrization employed E772 data that consequently overestimated the nuclear modification in the sea quark distribution by reason of leaving out the quark energy loss effect. It is found that our predictions are in good agreement with the experimental measurements, and especially the agreement of calculations with NA3 experimental data has a significant improvement. The comparison with the corresponding experimental data demonstrates intuitively that the energy loss effect of the incoming quark is particularly significant at lower incident proton energies. We have also given the predictions for the forthcoming Sea Quest experiment. High statistics, high precision data from the E906 Sea Quest experiment [28] on the nuclear Drell-Yan different cross section ratio at $E_{beam} = 120$ GeV in various regions of x_1 and x_2 will provide important information about the modification of quark PDFs and nucleon structure function in the nucleus, and further constrain the transport coefficient in cold nuclear medium. A series of experimental studies on jet-quenching from the BNL Relativistic Heavy Ion Collider [29–34] and the CERN Large Hadron Collider [35] reflect the energy loss of fast partons while traversing the hot and dense medium. We hope that the value of the transport coefficient in cold nuclear matter constrained with the Drell-Yan process in this paper can provide a useful reference for a deeper understanding of the microscopic dynamics of medium-induced parton energy loss in cold nuclear matter and disentangling the QGP formation related effects from the cold nuclear matter effects.

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