Report of Contributions

Contribution ID : **1** Type : **not specified**

Total Gluon Helicity from Lattice

We use the ensemble C24P29 provided by the CLQCD collaboration, insert the topological current using the proton external state of the momentum smear under the Coulomb gauge of the 5-HYP smear, extract the matrix elements to calculate the gluon helicity under lattice QCD, and the calculation proves that different components of the topological currents (and) can be used to give consistent results within the error range. In addition, we use the $\mathrm{RI/MOM}$ renormalization scheme, consider the mixing of gluon and quark helicity, and extract the renormalization constant to give the gluon helicity result under $\overline{\mathrm{MS}}$ scheme.

Primary author(s) : Dr ZHAO, Dian-Jun (CUHK(SZ)); Prof. YANG, Yi-Bo (ITP,CAS); Prof. ZHANG, Jianhui (CUHK(SZ)); Prof. SUN, Peng (IMP,CAS); Prof. LIU, Liuming (IMP,CAS); Dr PANG, Zhuo-Yi (CUHK(SZ)); Mr DONG, Hong-Xin (IMP,CAS); Ms ZHONG, Shi-Yi (CUHK(SZ))

Presenter(s) : Dr ZHAO, Dian-Jun (CUHK(SZ))

Contribution ID : **2** Type : **not specified**

Electromagnetic form factor of single charm baryons in lattice QCD

We report a latest lattice QCD study of the electromagnetic form factors of Σ_c^0, Σ_c^{++} and Ω_c^0. Relevant physical quantities such as electric and
magnetic charge radii and magnetic moment are extracted. We also investigate the individual quark sector contributions to the charge
radii and the magnetic moments. This work employs three gauge ensembles generated by CLQCD collaboration with lattice spacings ranging from a $\approx$ 0.051fm to 0.101fm, establishing a solid foundation for continuum extrapolation. Given the flexibility in phenomenological model selection for form factor fitting, we employed the model-independent Z-expansion method. When updating the results of the charge radii, we noticed that $r^{2,l}_{E,M}/r^{2,s}_{E,M} \approx 1.5$. The charge radii reflects its internal structure, which may be a good measure of the degree of $SU(3)_f$ symmetry breaking in the charm baryons sector.

Primary author(s) : Mr LAN, Xingyu (Hunan Normal University)

Co-author(s) : Mr HOU, Wenzhen; Mr GUI, Longcheng (Hunan Normal University); Mrs QIN, Wen (Hunan Normal University); Mr HUA, Jun (South China Normal University); Mr LIANG, Jian (South China Normal University); Mrs SHI, Jun (South China Normal University)

Presenter(s) : Mr LAN, Xingyu (Hunan Normal University)

Contribution ID : **3** Type : **not specified**

Contraining DVCS Compton Form Factors Using Lattice QCD calculations

The lattice QCD calculation of gravitational form factors (GFFs) are employed to determine the subtraction constant through dispersion relations of Deeply Virtual Compton Scattering (DVCS), thus constraining significantly the real part of the Compton Form Factors (CFFs) in a global analysis of proton data.This is realised by a synthesis of the dispersion relation and the neural networks, of which the architecture is carefully designed for a reliable extrapolation to unmeasured regime.Our framework allows for adding higher moments of generalized parton distributions (GPDs) from LQCD through dispersion relations beyond leading order into the extraction of CFFs from DVCS data.

Primary author(s) : [redacted]

Presenter(s) : [redacted]

Contribution ID : **4** Type : **not specified**

□□□□□sigma□□□□□□□□□□□□

The pion-nucleon sigma term, characterizing the mass component of Higgs origin related to u and d quarks inside the nucleon, is investigated within relativistic baryon chiral perturbation theory at leading two-loop order using the extended-on-mass-shell renormalization scheme. The two-loop representation of the sigma term is derived from the nucleon mass via the Feynman-Hellmann theorem and verified through a direct calculation of the forward isoscalar-scalar nucleon matrix element. We apply the derived chiral expression to extract the physical pion-nucleon sigma term by extrapolating $N_f = 2 + 1$ lattice quantum chromodynamics (QCD) data at unphysical quark masses. We find that, at the two-loop level, the long-standing tension between lattice QCD and dispersive determinations can be naturally resolved, owing to the incorporation of intermediate $\pi\pi$ rescattering effects that begin to contribute at two-loop order. Our final result for the nucleon sigma term based on recent lattice QCD calculations is $\sigma_{\pi N} = 55.9(2.5)$~MeV. It is compatible with the result of the Roy-Steiner equation analysis and thus provides a satisfactory resolution to the previous debate between lattice QCD and phenomenological determinations.

Primary author(s) : LIANG, Ze-Rui

Presenter(s) : LIANG, Ze-Rui

Contribution ID : **5** Type : **not specified**

Determination of Baryon LCDAs from Lattice QCD

The lattice QCD computation of parton distributions within the framework of large momentum effective theory (LaMET) constitutes a first-principles approach to studying hadron structures. Building upon preceding studies, we have developed and partly implemented lattice methodologies for calculating the leading twist LCDAs of light baryons under the LaMET formalism over the past few years. In this talk, we will introduce our series of works on the ab initio determination of baryon LCDAs and present preliminary numerical results for the leading-twist LCDAs of light baryons (Lambda and proton). We will also report some techniques developed recently to address the more complicated baryonic systems comparing to the mesons, including special operator selections, the hybrid renormalization scheme, and Fourier inversion strategies.

Primary author(s) : HUA, Jun (South China Normal University)

Presenter(s) : HUA, Jun (South China Normal University)

Contribution ID : **6** Type : **not specified**

Study of the $D_s \to \phi\ell\nu_\ell$ semileptonic decay with (2+1)-flavor lattice QCD

Semi-leptonic decays offer an ideal place to deeply understand hadronic transitions in the non-perturbative region of QCD and explore the weak and strong interactions in the charm sector. Combining with experimental data, the CKM matrix element can be extracted, and it helps to test unitarity of CKM matrix and searching for new physics beyond SM. In this talk, the full lattice QCD calculations of $D_s \to \phi\ell\nu_\ell$ decay form factors will be presented using CLQCD ensembles.

Primary author(s) : FAN, Gaofeng (IHEP); MENG, Yu (Zhengzhou University)

Presenter(s) : FAN, Gaofeng (IHEP)

Contribution ID : **7** Type : **not specified**

x-dependent Light Baryon LCDAs from Lattice QCD

We present the results of lattice QCD calculation of all leading-twist x-dependent Light-cone Distribution Amplitudes (LCDAs) for baryons in light octet, within the framework of Large-momentum Effective Theory (LaMET). We implement a novel Hybrid renormalization scheme for baryon nonlocal operators, and perform simulations at 4 different lattice spacings a = {0.052, 0.068, 0.077, 0.105} fm, achieving reliable and precise results of x-dependent baryon LCDA. To access the large momentum regime and facilitate matching to light-cone, we simulate the quasi-Distribution Amplitudes (quasi-DAs) with hadron momenta Pz of about 1~3 GeV. The numerical calculations employ CLQCD ensembles with stout smeared clover fermions and a Symanzik gauge action, and several new techniques are also developed to improve the extrapolation and inversion in matching procedure. We present the resulting momentum-fraction distributions for the two light quarks in the light baryon.

Primary author(s) : Mr ZHANG, Mu-Hua (Shanghai Jiao Tong University)

Co-author(s) : HUA, Jun (South China Normal University); Prof. WANG, Wei; Mr BAI, Haoyang; JI, Xiangdong

Presenter(s) : Mr ZHANG, Mu-Hua (Shanghai Jiao Tong University)

Contribution ID : **8** Type : **not specified**

Toward precise ξ gauge fixing for the lattice QCD

Lattice QCD provides a first-principles framework for solving Quantum Chromodynamics (QCD). However, its application to off-shell partons has been largely restricted to the Landau gauge, as achieving high-precision ξ-gauge fixing on the lattice poses significant challenges. Motivated by a universal power-law dependence of off-shell parton matrix elements on gauge-fixing precision in the Landau gauge, we propose an empirical precision extrapolation method to approximate high-precision ξ-gauge fixing. By properly defining the bare gauge coupling and then the effective ξ, we validate our ξ-gauge fixing procedure by successfully reproducing the ξ-dependent RI/MOM renormalization constants for local quark bilinear operators at 0.2\% level, up to $\xi \sim 1$.

Primary author(s) : Mr ZHOU, Li-Jun (Dalian University of Technology); Prof. YANG, Yi-Bo (ITP,CAS); FU, Wei-jie (Dalian University of Technology)

Presenter(s) : Mr ZHOU, Li-Jun (Dalian University of Technology)

Contribution ID : **10** Type : **not specified**

Chiral Extrapolation of Lattice QCD Nucleon Masses using Two-Loop Baryon Chiral Perturbation Theory

We calculate the nucleon mass in a manifestly relativistic baryon chiral perturbation theory up to the leading two-loop order. Through dimensional counting analysis, we perform the chiral expansion and verify the validity of the extended-on-mass-shell scheme at the two-loop level. As a result, we obtain the complete chiral representation of the nucleon mass up to $\mathcal{O}(p^5)$, which preserves the original analytic properties and satisfies the correct power counting. The obtained chiral result is well-suited for chiral extrapolation and provides an excellent description of lattice QCD data across a broad range of pion masses.

Primary author(s) : Prof. YAO, De-Liang (Hunan University)

Presenter(s) : Prof. YAO, De-Liang (Hunan University)

Contribution ID : **11** Type : **not specified**

Simulating Particle Scattering with Digital Quantum Computers

Particle scattering is a cornerstone of high-energy physics, providing deep insights into the structure and dynamics of matter. However, simulating this real-time, nonperturbative dynamic process remains a major challenge for classical methods: Monte Carlo techniques suffer from sign problems, while tensor network approaches are limited by rapid entanglement growth. Quantum computing offers a promising path to overcome these barriers.

In this talk, I will present our recent progress on simulating particle scattering using digital quantum computers. First, I will introduce a method we developed for constructing accurate meson wave packets in a (1+1)D lattice gauge theory, enabling high-accuracy simulations of meson scattering dynamics. Our classical simulations reveal rich nonperturbative phenomena, including new particle production, long string formation, and string breaking.

Second, I will present our recent hardware implementation of fermion scattering in the (1+1)D Thirring model using IBM quantum devices with 40 and 80 qubits. By combining tensor network-based circuit optimization with error mitigation techniques, we achieve experimental results that closely match ideal simulations, clearly capturing transmitted and reflected scattering phenomena.

Together, these results demonstrate the feasibility and scalability of quantum approaches to particle scattering, and point toward broader applications in lattice gauge theory and real-time quantum dynamics.

Primary author(s) : Dr CHAI, Yahui (DESY)

Presenter(s) : Dr CHAI, Yahui (DESY)

Contribution ID : **12** Type : **not specified**

First-Principle Calculation of Collins-Soper Kernel from Quasi-Transverse-Momentum-Dependent Wave Functions

We present a lattice QCD calculation of the Collins-Soper kernel, which governs the rapidity evolution of transverse-momentum-dependent (TMD) distributions, using Large Momentum Effective Theory (LaMET). Quasi-TMD wave functions are computed with three meson momenta on CLQCD configurations (multiple lattice spacings and pion masses) employing clover quarks and varied hadronic states. HYP smearing is applied to staple-shaped gauge links and Wilson loops to enhance signal-to-noise ratios. Divergences are systematically addressed: linear divergences via Wilson-line renormalization and logarithmic divergences through a self-renormalization-inspired scheme.

By systematically controlling the sources of systematic uncertainties, we determine the Collins–Soper kernel up to transverse separations of 1 fm, followed by extrapolations to the large-momentum limit, the continuum limit, and the physical pion mass. This study delivers essential inputs for soft functions and precision analyses of TMD physics, thereby advancing first-principles QCD in the domain of high-energy phenomenology.

Primary author(s) : TAN, Jin-Xin (Shanghai Jiao Tong University)

Co-author(s) : LIU, Hang (Shanghai Normal University); ZHANG, Qi-An (Beihang University); Prof. WANG, Wei; Mr GONG, Zhi-Chao (Shanghai Jiao Tong University)

Presenter(s) : TAN, Jin-Xin (Shanghai Jiao Tong University)

Contribution ID : **13** Type : **not specified**

Accurate B meson and Bottomonium masses and decay constants from the tadpole improved clover ensembles

Using the anisotropic relativistic fermion action on isotropic lattice, we present a systematic study of the masses and lepton decay constants of the mesons with the bottom quark based on the 2+1 flavor tadpole improved clover ensembles at different lattice spacings from 0.05 to 0.11 fm, various pion masses from 130 to 360 MeV, and several values of the strange quark mass. We also propose a systematic framework to renormalize the quark bi-linear operators with the bottom quark field, and verify it through the renormalized bottom quark mass and decay constants.

Primary author(s) : CAI, Mengchu (Institute of Theoretical Physics, Chinese Academy of Sciences); YANG, Yi-Bo (ITP/CAS); Mr DU, Hai-Yang (ITP,CAS)

Presenter(s) : CAI, Mengchu (Institute of Theoretical Physics, Chinese Academy of Sciences)

Contribution ID : **14** Type : **not specified**

Heavy meson light-cone distribution amplitudes from lattice QCD at the continuum Limit

Heavy meson light-cone distribution amplitudes (LCDAs) are essential nonperturbative quantities that characterize the internal dynamics of heavy mesons. They play a crucial role in the theoretical description of heavy meson (B or D) exclusive decays. However, due to the intrinsic challenges of nonperturbative QCD, first-principles calculations of heavy meson LCDAs have been notoriously difficult, with most studies relying on phenomenological models. We proposed a sequential effective theory approach to compute heavy meson LCDAs from first principles using lattice QCD. In this talk, we will present our latest results for heavy meson LCDAs obtained from lattice QCD calculations extrapolated to the continuum limit.

Primary author(s) : Mr GAO, Haofei (SJTU); ZHANG, Qi-An (Beihang University); Prof. WANG, Wei; Mrs HAN, xue-ying (IHEP)

Presenter(s) : Mr GAO, Haofei (SJTU)

Contribution ID : **15** Type : **not specified**

Charm baryon decay constants in Lattice QCD

We present the first calculation of charmed baryon decay constants using 2+1 flavor gauge ensembles with lattice spacings ranging from 0.05 to 0.1 fm and pion masses between 136 and 310 MeV. Under SU(3) flavor symmetry, we construct the charmed baryon interpolating operators and compute the corresponding hadronic matrix elements to extract the bare decay constants for each ensemble. The non-perturbative renormalization is performed using the symmetric momentum-subtraction scheme. After performing systematic chiral and continuum extrapolations, we obtain the decay constants with 10-20% precision.

Primary author(s) : Mr □, □□

Presenter(s) : Mr □, □□

Contribution ID : **16** Type : **not specified**

Scalar and tensor structures in $J/\psi J/\psi$ scattering from lattice QCD

The S-wave scattering amplitudes of $J/\psi J/\psi$ with quantum numbers $J^{PC} = 0^{++}$ and 2^{++} are determined up to 6600\,MeV via lattice QCD simulation.
The calculation is performed on two lattice volumes, L12 and L16, with a single lattice spacing of approximately 0.136\,fm, and at two unphysical pion masses, $m_\pi \approx 420$ and 250\,MeV.
The ${}^1S_0$ $J/\psi J/\psi$ system exhibits a near-threshold attractive interaction, resulting in a virtual scalar bound state with a binding energy of approximately 30-40\,MeV.
In contrast, the ${}^5S_2$ $J/\psi J/\psi$ system exhibits a repulsive interaction near threshold.
These behaviors are primarily dominated by the quark rearrangement effect.
A tenser resonance is observed in the ${}^5S_2$ $J/\psi J/\psi$ channel, with a mass around 6540\,MeV and a width of approximately 540\,MeV.
The extracted mass and width are consistent with the $X(6600)$ (or $X(6400)$) observed by the ATLAS and CMS collaborations, and show little dependence on the two sea pion masses.

Primary author(s) : Dr LI, Geng

Presenter(s) : Dr LI, Geng

Contribution ID : **17** Type : **not specified**

Charmed P → V semileptonic decay from lattice QCD

In this talk, I would introduce a lattice calculation on the charmed P → V semileptonic decay.

Primary author(s) : MENG, Yu (Zhengzhou University)

Co-author(s) : Mr FAN, Gaofeng; Prof. LIU, Zhaofeng

Presenter(s) : MENG, Yu (Zhengzhou University)

Contribution ID : **18** Type : **not specified**

Transverse Momentum Distributions from Lattice QCD

This talk provides a systematic overview of recent progress in lattice QCD studies of transverse momentum distributions within the framework of large-momentum effective theory. Particular attention is given to first-principles determination of the Collins–Soper kernel, intrinsic soft function, and TMDPDFs with different polarization, such as unpolarized TMDPDF, Boer-Mulders function and so on. The talk concludes with a perspective on future developments and open challenges in this direction.

Primary author(s) : Prof. QI-AN, Zhang (Beihang University)

Presenter(s) : Prof. QI-AN, Zhang (Beihang University)

Contribution ID : **19** Type : **not specified**

Finite Volume Hamiltonian method for two-particle system

We propose a systematic method to block-diagonalize the finite volume effective Hamiltonian for two-particle systems with arbitrary spin in both the rest and moving frame. The framework is convenient and efficient for addressing the left-hand cut issue arising from long-range potential, which are challenging in the framework of standard L\"uscher formula. Furthermore, the method provides a foundation for further extension to three-particle systems. We first benchmark our method by examining several toy models, demonstrating its consistency with standard L\"uscher formula in the absence of long-range potential. In the presence of long-range potential, we investigate and resolve the effects and issues of left-hand cut. As a realistic application, we calculate the finite volume spectra of isoscalar $D\bar{D}^*$ system, where the well-known exotic state $\chi_{c1}(3872)$ is observed. The results are qualitatively consistent
with the lattice QCD calculation, highlighting the reliability and potential application of our framework to the study of other exotic states in hadron physics.

Primary author(s) : Mr YU, Kang (UCAS)

Presenter(s) : Mr YU, Kang (UCAS)

Contribution ID : **20** Type : **not specified**

DD^* Spectrum in Lattice QCD from Coordinate-Space Two-Hadron Operators and Long-Range Force Analysis

The DD^* energy spectra are extracted from lattice QCD by utilzing the Coordinate-Space Two-Hadron Operators, named as dumbbell method. Finite-volume energies indicate an attractive interaction in $I = 0$ channel and a repulsive interaction in $I = 1$ channel. To investigate the contribution of the long-range potential, we perform fits using models with and without the long-range potential. We find that the long-range potential plays a crucial role in determining the nature of the pole for the $I = 0$ case.When the long-range potential is included, the pole below the threshold acquires an imaginary part. In contrast, for the $I = 1$ case, the behavior of $p \cot \delta$ with the long-range potential included only exhibits a cusp effect near the left-hand cut.

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Presenter(s) : Dr XIE, jiajun (School of Physical Sciences, University of Chinese Academy of Sciences, Beijing 100049, China)

Contribution ID : **21** Type : **not specified**

Spectral parameters of the ρ resonance from lattice QCD

We present a lattice QCD investigation of the ρ resonance using nine $N_f = 2 + 1$ Wilson-Clover ensembles with three lattice spacings and various pion masses ranging from 135 to 320 MeV. For each ensemble, a large number of finite volume energy levels are determined and the energy dependence of the phase shift obtained from L\"uscher's finite volume method. The mass and width of the ρ resonance are then extracted by assuming the Breit-Wigner form. The mass and width are extrapolated to the physical pion mass and continuum limit ($\mathcal{O}(a^2)$) using a linear function of a^2 and m_π^2. The extrapolated values for the mass and width in the Breit-Wigner form are $(m_\rho, \Gamma_\rho) = (781.6 \pm 10.0, 146.5 \pm 9.9)$ MeV, which are in good agreement with experiment. An alternative method of analysis, based on Hamiltonian effective field theory, involves directly fitting the lattice energy levels and accounting for the quark mass dependence of the hadronic loop diagrams which yield the leading and next-to-leading non-analytic behaviour. This approach also yields consistent ρ parameters at the physical point. This represents the most precise determination to date of the mass and width of a hadron which is unstable under strong decay, achieved through comprehensive lattice QCD calculations and methods of analysis.

Primary author(s) : Mr WANG, zhengli; Mr WU, jiajun; Mrs LIU, liuming; LIU, chuan; SUN, peng; YU, kang; XING, hanyang; LEINWEBER, Derek B.; THOMAS, Anthony W.

Presenter(s) : Mr WANG, zhengli

Contribution ID : **22** Type : **not specified**

Low-energy interactions of doubly charmed baryons and Goldstone bosons from lattice QCD

The S-wave interactions between doubly charmed baryons (Ξ_{cc}, Ω_{cc}) and Goldstone bosons (π, K, $\bar{K}$) are studied using lattice QCD on $N_f = 2+1$ CLQCD ensembles ($a = 0.07746$ fm, $M_\pi \simeq 210$ and 300 MeV). By applying Lüscher's method to the finite-volume spectra, we extract scattering lengths and effective ranges for four single-channel systems free of disconnected diagrams: $I = 1/2$ $\Omega_{cc}\bar{K}$, $I = 1$ $\Xi_{cc}K$, $I = 0$ $\Xi_{cc}K$, and $I = 3/2$ $\Xi_{cc}\pi$. These results show good agreement with baryon chiral perturbation theory.

Primary author(s) : YI, JingYu (Hunan University)

Presenter(s) : YI, JingYu (Hunan University)

Contribution ID : **23** Type : **not specified**

η and η' mesons from $N_f = 2 + 1$ lattice QCD at the physical point using topological charge operators

We present the first lattice QCD determination of both the eta and eta' masses as well as the mixing angle theta_1 by using topological charge operators. The calculation employs two state-of-the-art gauge ensembles both with physical quark masses. We obtain m_{\eta} = 0.546(43)(5) GeV, $m_{\eta'}$=0.941(54)(50) GeV, and $\theta_1 = -11.7(2.5)(1.6)^\circ$. Compared with conventional studies using quark bilinear operators, our mixing angle defined by the topological charge operators has remarkably high precision. These results provide critical inputs for understanding the flavor symmetry breaking and the $U_A(1)$ anomaly. It also demonstrates that the topological charge operators are well suited to study the η and η' mesons.

Primary author(s) : [redacted] (South China Normal University); Ms SU, Yue (Tianjin University); Mr LIANG, Jian (South China Normal University); GUI, Long-Cheng (Hunan Normal University)

Presenter(s) : [redacted] (South China Normal University)

Contribution ID : **24** Type : **not specified**

Unpolarized gluon parton distribution from lattice QCD in the continuum limit

We report a lattice QCD calculation of the nucleon gluon parton distribution function in the continuum-limit, employing large-momentum effective theory. The calculation is carried out on the 2+1 flavour CLQCD ensembles with three lattice spacings a = {0.105, 0.0897, 0.0775} fm and pion mass of approximately 300 MeV, covering nulceon momenta up to 1.97 GeV. Distillation technique is applied to improve the signal of two-point correlators. We then use the state-of-the-art hybrid renormalization and one-loop perturbative matching scheme, and extrapolate the results to continuum limit and infinite momentum limit.

Primary author(s) : [redacted]

Presenter(s) : [redacted]

Contribution ID : **25** Type : **not specified**

Accurate nucleon iso-vector scalar and tensor charge from tadpole improved clover ensembles

We report a new high precision calculation of the isospin vector charge $g_{S,T}$ of the nucleon using recently proposed "blending" method which provides a high-accuracy stochastic estimate of the all-to-all fermion propagator. By combining the current-inspired interpolation field, which can efficiently cancel the major excited state contamination, we found that both g_S and g_T have significant finite volume effects which are not suppressed in the chiral limit. Using 15 of the $N_f = 2+1$ lattice ensembles which covers 5 lattice spacing, 5 combinations with the same quark masses and lattice spacing but multiple volumes, and includes three at the physical pion mass, we report so far most accurate lattice QCD prediction $g_T^{\rm QCD} = 1.0253[94]_{\rm tot}(55)_{\rm stat}(46)_a(59)_{\rm FV}(13)_\chi(06)_{\rm ex}$ and $g_S^{\rm QCD} = 1.103[44]_{\rm tot}(32)_{\rm stat}(04)_a(26)_{\rm FV}(01)_\chi(15)_{\rm ex}$ at $\overline{\rm MS}$ 2~GeV, with the systematic uncertainty from infinite volume, continuum, and chiral extrapolations.

Primary author(s) : WANG, Ji-Hao (Institute of Theoretical Physics[redacted]Chinese Academy of Sciences); HU, Zhi-Cheng; JI, Xiangdong; JIANG, Xiangyu; SU, Yushan; SUN, Peng; YANG, Yi-Bo

Presenter(s) : WANG, Ji-Hao (Institute of Theoretical Physics[redacted]Chinese Academy of Sciences)

Contribution ID : **26** Type : **not specified**

Bottom baryon mass and trace anomaly contribution

Using anisotropic clover action for valence bottom quark on CLQCD ensembles with several different lattice spacing and various pion masses, we present the accurately prediction of ground state spin-1/2 and spin-3/2 baryon masses containing bottom quark, and extract sigma term contribution to bottom hadron masses using Feynman-Hellman method.

Primary author(s) : Mr DU, Hai-Yang (ITP,CAS); YANG, Yi-Bo (ITP/CAS)

Presenter(s) : Mr DU, Hai-Yang (ITP,CAS)

Contribution ID : **27** Type : **not specified**

Development on the precise control of systematic uncertainties on CLQCD ensembles

Obtaining hadron masses and matrix elements using Lattice QCD can suffer from kinds of systematic uncertainties. I will introduce the recent developments on CLQCD ensembles for better controls on systematic uncertainties from kinds of origins, and also preliminary investigation on the QED correction using the improved $\mathrm{QED_L}$ scheme.

Primary author(s) : Prof. YANG, Yi-Bo (ITP,CAS)

Presenter(s) : Prof. YANG, Yi-Bo (ITP,CAS)

Contribution ID : **28** Type : **not specified**

Lattice QCD towards TMDPDF: Boer-Mulders function

Transverse-momentum-dependent parton distribution functions (TMDPDFs) are important in revealing the 3D structure of hadrons. Among these distributions, the T-odd Boer-Mulders TMDPDF describes the transversely polarized quark distribution in an unpolarized hadron. Within large-momentum effective theory, I show a lattice calculation of both nucleon and pion Boer-Mulders functions. The calculation was done on the CLS collaboration with Clover fermion and HYP-smeared gauge links, with RG resummation applied to improve the perturbative matchings.

Primary author(s) : MA, Lingquan (Beijing Normal University)

Co-author(s) : Prof. ZHANG, Jianhui (CUHK(SZ))

Presenter(s) : MA, Lingquan (Beijing Normal University)

Contribution ID : **29** Type : **not specified**

Direct calculation of trace anomaly on CLQCD ensembles

In this work we present the direct calculation of trace anomaly matrix elements $\hat{\beta}\langle \mathrm{Tr}[g^2F^2]\rangle_H$ in kinds of baryons on the CLQCD ensembles, and compare with those from the sum rule. We also make a joint fit of 30 hadrons to extract the anomalous dimensions $\hat{\beta}$ and γ_m in the Wilson flow scheme at different energy scales.

Primary author(s) : ZHANG, Chenyu (ITP)

Co-author(s) : HU, Bolun; Mr MENG, Xiaolan (ITP/CAS); Prof. YANG, Yi-Bo (ITP/CAS)

Presenter(s) : ZHANG, Chenyu (ITP)

Contribution ID : **30** Type : **not specified**

Shear and bulk viscosities of gluon plasma across the transition temperature

Shear and bulk viscosities are two key transport coefficients that characterize the fundamental properties of quark-gluon plasma.They quantify the response of the energy-momentum tensor to shear flow and divergent flow,serving as crucial input parameters for the phenomenological and transport models that interpret experimental data, such as the elliptic flow v_2.
However, calculating these inherently non-perturbative viscosities within lattice QCD presents challenges due to strong ultraviolet fluctuations in the relevant operators. The traditional approach using the multi-level algorithm is highly effective in suppressing UV fluctuations but is limited to the quenched approximation. Recently, the gradient flow method was introduced to address this issue [1], opening the path to full QCD studies. However, Ref. [1] examined only a single temperature, $1.5T_c$.
This work extends the Ref. [1]'s results to a wide temperature range from $0.76T_c$ to $2.25T_c$, focusing on the high-temperature regime while also probing the system's behaviour across the phase transition. The former enables a fair comparison with the next-to-leading-order perturbative estimates which become more reliable at high temperatures, while the latter allows us to study the system's critical dynamics—a topic of wide community concern. The methodology developed in this work provides the foundation for future full QCD calculations.

Reference

[1] L. Altenkort, A.M. Eller, A. Francis, O. Kaczmarek, L. Mazur, G.D. Moore, and H.-T. Shu, Phys. Rev. D 108, 014503 (2023).

Primary author(s) : ZHANG, Cheng (Central China Normal University); Prof. SHU, Hai-Tao (Central China Normal University); Prof. DING, Heng-Tong (Central China Normal University)

Presenter(s) : ZHANG, Cheng (Central China Normal University)

Contribution ID : **31** Type : **not specified**

Radiative decay and electromagnetic radius of heavy-light mesons

On the five ensembles generated by the CLQCD collaboration, we computed decay width of D_s^ ⟶*D_s γ*D_ ^(+)⟶D_ ^+ γ and D_ ^(*0)⟶*D_ ^0 γ. Chiral extrapolation and lattice spacing extrapolation were performed, yielding significantly improved precission. The precision for D_ ^(+)⟶D_ ^+ γ was improved ten times compared to previous studies, while the precision for D_ ^(*0)⟶D_ ^0 γ was improved fivefold. Additionally, we computed g_{D^{\ast+}D^+\gamma}/g_{D^\ast_sD_s\gamma} by leveraging statistical correlations. Throughout these calculations, systematic uncertainties arising from variations in the fitting ranges, fitting methods, and extrapolation approaches were carefully considered.

Furthermore, on six ensembles including one physical pion mass ensemble, we computed the charge radius of D_s^*D_ ^*D_s^ *D_ ^*. For the first time, both lattice spacing effects and the influence of unphysical pion masses were simultaneously taken into account, leading to high-precision preliminary results.

Primary author(s) : HOU, wenzheng (south china normal university); Mr LIANG, Jian (South China Normal University)

Presenter(s) : HOU, wenzheng (south china normal university)

Contribution ID : **32** Type : **not specified**

Mixed-Action Effects on HISQ Ensembles

We are now generating and validating using eleven 2+1+1-flavor gauge ensembles at four lattice spacings a ∈ [0.04, 0.12] fm and several values of the strange quark mass tuned to near the physical value HISQ configurations that, relative to Clover ensembles, require fewer computational resources while exhibiting smaller discretization errors, facilitating chiral and continuum extrapolations. We also compute mixed-action effects for the unsmeared, Stout-smeared and HYP-smeared clover fermion on the HISQ action.

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Contribution ID : **33** Type : **not specified**

Quark masses and low energy constants on HISQ ensembles

We present the physical quark masses and low energy constants using gauge ensembles with 2+1+1 flavors Highly Improved Staggered Quark, using the clover valence fermion. The bare strange-quark mass is fixed from the ηs mass, and the bare charm-quark mass is obtained from the Ds meson mass.

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Contribution ID : **34** Type : **not specified**

LQCD Determination of Quark Spin in Octet Baryons and SU(3)-Flavor Symmetry

We employed a novel "blending method" to investigate the quark spin contributions in the octet baryons. Our lattice QCD calculations were performed on three ensembles, covering two pion masses and two lattice spacings. The sea quark contribution to the quark spin is found to observe SU(3) flavor symmetry to a good approximation within error. In contrast, the valence quark contribution exhibits a ~20% SU(3) flavor symmetry breaking effect. Furthermore, the symmetry is better preserved within specific diquark structures, as seen in the pairs like (n, Σ) and (Λ, Ξ).

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Contribution ID : **35** Type : **not specified**

Multi-hadron resonances

Understanding the interactions of multi-hadron systems directly from QCD is an essential step toward connecting the underlying theory of the strong interaction with the rich spectrum of hadronic states. Many open questions in hadron spectroscopy, such as the nature of the T_{cc} and the Roper resonance, are closely tied to the three-body problem. In this talk, I will review recent lattice studies of three-body resonances, including the $a_1(1260)$ and $\omega(782)$. I will also highlight progress in the two-body sector, with particular emphasis on the investigation of the two-pole structure of the $D_0^*(2300)$. These developments illustrate how lattice QCD is beginning to resolve longstanding puzzles in the hadronic spectrum and advance our understanding of multi-hadron dynamics.

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Contribution ID : **36** Type : **not specified**

SGEVP- A novel way to extend the power of GEVP

We introduce subtracted GEVP, a method which is designed to suppress the contamination of excited states and increase the SNR of conventional GEVP. We will show its mathematical mechanism and its detailed analysis on real lattice data, along with some novel applications.

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Contribution ID : **37** Type : **not specified**

Search for the QCD Critical Endpoint at a Temperature of 108 MeV

Determining the location of the Quantum Chromodynamics (QCD) critical endpoint (CEP) is a central goal in high-energy nuclear physics. Direct lattice QCD simulations are hindered by the sign problem at finite baryon chemical potential (μ_B), necessitating indirect approaches. Recent first-principles lattice investigations, particularly those analyzing Lee-Yang edge singularities from simulations at imaginary μ_B, suggest the CEP is located at a low temperature, around $T_c^{CEP} \approx 110$ MeV [1]. A significant caveat, however, is that these results are obtained by extrapolating from data generated at higher temperatures (T
$gtrsim$120 MeV). Intriguingly, predictions from independent theoretical frameworks, such as the Functional Renormalization Group (FRG) [2], Dyson-Schwinger Equations (DSE) [3], and AdS/CFT [4], also point towards a CEP in a similar low-temperature domain. While this broad agreement is encouraging, the reliance of current lattice predictions on extrapolation highlights the urgent need for direct simulations within the target critical region.

In our study, we present the first direct lattice QCD investigation of the QCD critical endpoint (CEP) at a low temperature of $T \approx 108$ MeV, using (2+1)-flavor HISQ ensembles at imaginary baryon chemical potential μ_B. Baryon-number fluctuations up to fourth order are excellently described by a hadron resonance gas (HRG), indicating negligible residual interactions. A model-independent search for Lee–Yang singularities via multi-point Padé approximants finds no evidence of criticality in the complex μ_B plane. Fits with a critical ansatz, used solely as a diagnostic, flag at most a marginal window around $\mu_B \simeq 420$–750 MeV—no stronger than the false-positive baseline calibrated on analytic HRG mock data. Moreover, this potential signal is not manifested in the higher-order susceptibility ratios (e.g., χ_6^B/χ_2^B), which serve as the most sensitive probes measurable with reasonable precision in current experiments. Together, these results demonstrate smooth, analytic thermodynamics at this temperature; consequently, at the beam energies corresponding to $T \approx 108$ MeV—i.e., $\sqrt{s_{NN}} \approx 5$ GeV—experimental observables should reflect HRG (hadronic-phase) thermodynamics rather than critical behavior.

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Presenter(s) : YE, Kai-Fan (Central China Normal University, Institute of Particle Physics)

Contribution ID : **38** Type : **not specified**

Extracting scattering phase shifts of KN scattering using lattice QCD

We present a lattice QCD calculation of the K^+n scattering length and effective range in the S-wave channel. This study employs the CLQCD gauge configurations (ensemble F24P29) with a pion mass of $M\pi \approx 300$ MeV and a lattice spacing of $a \approx 0.1053$ fm. By computing the finite-volume energy spectrum of the KN system—obtaining 5-6 distinct energy levels in both the center-of-mass frame and several moving frames—and applying the Lüscher finite-volume formalism, we extract the corresponding scattering phase shifts. From these phase shifts, the scattering length and effective range are determined.

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Contribution ID : **39** Type : **not specified**

Chiral Properties of (2+1)-Flavor QCD in Magnetic Fields at Zero Temperature

We present a lattice QCD study of the chiral properties of (2+1)-flavor QCD in background magnetic fields at zero temperature with physical pion masses. Simulations are performed using the highly improved staggered quark (HISQ) action across four different lattice spacings to enable a controlled continuum extrapolation. We compute the renormalized chiral condensates, pseudoscalar meson masses, and decay constants of pions, kaons, and the $\eta_{s\bar{s}}$ as functions of the magnetic field strength. Our results show that magnetic fields enhance the chiral condensates and lead to characteristic modifications in the meson spectrum: the masses of neutral mesons are reduced, while those of charged mesons exhibit a non-monotonic behavior. The decay constants of neutral pseudoscalar mesons are found to be suppressed with increasing magnetic field. To elucidate the origin of the non-monotonic behavior in charged meson masses, we separately analyze the sea and valence quark contributions. These results provide new insights into the interplay between QCD chiral symmetry breaking and strong magnetic fields.

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Contribution ID : **40** Type : **not specified**

Baryon electric charge correlation as a magnetometer of QCD

We present the first lattice QCD results of quadratic fluctuations and correlations of conserved charges in (2+1)-flavor lattice QCD in the presence of a background magnetic field. The simulations were performed using the Highly Improved Staggered Quarks with physical pion mass m_π = 135 MeV on $N_\tau = 8$ and 12 lattices. We find that the correlation between net baryon number and electric charge, denoted as χ_{11}^{BQ}, can serve as a magnetometer of QCD. At pseudocritical temperatures the χ_{11}^{BQ} starts to increase rapidly with magnetic field strength $eB2M_\pi^2$ and by a factor 2 at $eB \simeq 8M_\pi^2$.

By comparing with the hadron resonance gas model, we find that the eB dependence of χ_{11}^{BQ} is mainly due to the doubly charged $\Delta(1232)$ baryon. Although the doubly charged $\Delta(1232)$ could not be detected experimentally, the proxy constructed from its decay products, protons and pions, retain the eB dependence of $\Delta(1232)$'s contribution to χ_{11}^{BQ}. Additionally, under the same kinematic cuts as in the ALICE experiment, the proxy for χ_{11}^{BQ} still exhibits a strong dependence on the magnetic field.

Furthermore, the ratio of electric charge chemical potential to baryon chemical potential, $\mu_{\mathrm{Q}}/\mu_{\mathrm{B}}$, shows significant dependence on the magnetic field strength and varies with the ratio of electric charge to baryon number in the colliding nuclei in heavy ion collisions. These results provide baselines for effective theory and model studies, and both χ_{11}^{BQ} and $\mu_{\mathrm{Q}}/\mu_{\mathrm{B}}$ could be useful probes for the detection of magnetic fields in relativistic heavy ion collision experiments as compared with corresponding results from the hadron resonance gas model.

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Contribution ID : **41** Type : **not specified**

Hybrid Renormalization Scheme for the Lattice Calculation of Baryon LCDAs

Lattice QCD computations within the framework of large momentum effective theory (LaMET) provide a first-principles approach to studying hadron structure. However, LaMET matching requires a suitable perturbative scheme, which necessitates the development of appropriate renormalization methods connecting the lattice scheme to the perturbative scheme. Various renormalization schemes—such as RI-MOM and the ratio scheme—have been widely used in lattice calculations. In this talk, we present in detail the "hybrid renormalization" scheme implemented in our lattice calculation of the leading-twist lightcone distribution amplitudes (LCDAs) for light baryons. To address the greater complexity of baryonic systems compared to mesonic ones, we employ multiple types of region division to handle possible short-distance divergence structures. This hybrid approach combines self renormalization (which extracts the lattice-discretization-induced divergences from the zero-momentum matrix elements at different lattice spacings) at large separations with the ratio scheme at short distances, effectively avoiding singularities that are detrimental to numerical LaMET matching. Our results demonstrate that this scheme optimally subtracts lattice-discretization-induced divergences across the entire range of the nonlocal baryon matrix elements, while yielding smooth, continuum-like behavior suitable for further analysis.

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Presenter(s) : Mr BAI, Haoyang

Contribution ID : **42** Type : **not specified**

$\Lambda\Lambda - N\Xi$ interactions in $N_f = 2 + 1$ Lattice QCD

We present a lattice QCD study of two-baryon systems with strangeness $S = -2$, focusing on the $\Lambda\Lambda$ and ΞN interactions, which are essential for determining the existence of the H-dibaryon. Our calculations are performed on $N_f = 2+1$ CLQCD Wilson-Clover configurations, with lattice spacings range from $a \approx 0.05 - 0.105$ fm and pion masses from $M_\pi \approx 135 - 317$ MeV. Using Lüscher finite volume method, we extract the scattering phase shifts from the spectra of the two-baryon systems. The analysis is then complemented using effective range expansion to determine the scattering length and effective range. Our results indicate a consistently weak interaction in the $\Lambda\Lambda$ channel across all ensembles. In contrast, the ΞN channel exhibits a noticeable attraction, suggesting the possible presence of a virtual state.

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Contribution ID : **43** Type : **not specified**

Approaches to the Inverse Fourier Transformation with Limited and Discrete Data

W e have investigated various approaches to address the potential inverse problem involved in the limited inverse Fourier transform of quasi-distributions. The methods explored include the Tikhonov regularization method, the Backus–Gilbert method, the Bayesian approach, and genetic algorithms coupled with artificial neural networks. Using both simulated data and actual lattice data, we tested the effectiveness of these methods and compared them with the λ-extrapolation method. Our study shows that the limited inverse Fourier transform constitutes a relatively tractable inverse problem; except for the Backus–Gilbert method, all the approaches considered are capable of correctly reconstructing the quasi-distributions in momentum space. Depending on the specific behavior of the quasi-distribution data, adopting different strategies for processing and carefully estimating the associated systematic uncertainties is essential.

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