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Section 7 / **27**

S-wave scattering length of the $J/\psi J/\psi$ system from lattice QCD in coordinate space

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The $J/\psi J/\psi$ 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 total spin $S = 0$ channel and a repulsive interaction in total spin $S = 1$ channel and total spin $S = 2$ channel.

The scattering lengths of three different total spin are also extracted from the lattice energy levels.

Section 13 / **40**

A new approach to the flowed quark field renormalization constant Z_χ using quark bilinears

[1]

[1]

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The field renormalization constant of flowed quark fields, denoted as Z_χ, is a critical component in the non-perturbative renormalization of fermion operators within the gradient flow framework. While the conventional "ringed" scheme based on the fermion kinetic term provides a theoretically robust definition, its practical implementation on the lattice is hampered by significant statistical noise arising from disconnected contributions. In this work, we propose a novel approach to determine Z_χ using quark bilinears. To validate our approach, we use the extracted Z_χ to reconstruct the renormalized bilinear matrix elements O^R for the pseudoscalar, scalar, axial-vector, and tensor channels in the continuum limit.Our results demonstrate excellent consistency between the gradient flow and RI/MOM frameworks, confirming that the bilinear-based Z_χ provides a reliable and computationally efficient alternative for high-precision lattice QCD calculations.

Section 11 / **36**

Algorithms and Softwares for Lattice Gauge Theory

[1]

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I will review recent developments in algorithms and softwares for lattice gauge thoery, including AI/ML algorithms and agentic workflows.

Section 4 / **4**

An Infrared Topological Approach to Baryon Structure

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This report investigates the infrared structure of QCD through the lens of the Cho–Faddeev–Niemi decomposition and Faddeev–Niemi effective theory. We argue that gluon knots, as topological solitons characterized by the Hopf invariant, constitute the relevant infrared ground-state degrees of freedom of Yang–Mills fields. Within this framework, we present a unified mechanism for monopole condensation and center-vortex confinement. Crucially, we introduce a picture of baryons as quarks embedded in a gluon-knot background, where dual superconductivity naturally gives rise to the characteristic Y-shaped flux-tube geometry. We further delineate how the strong local color-magnetic fields drive chiral symmetry breaking through magnetic catalysis. The talk will also highlight the topological connection between the Hopf invariant, Yang–Mills vacua, and the axial anomaly, demonstrating that the topological current of gluon knots offers a viable carrier for the missing proton spin. Ultimately, we offer a cohesive, topology-driven perspective uniting confinement, chiral symmetry breaking, and baryon structure.

Section 10 / **6**

BESIII□□□□□□□□□□□

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BESIII□□□2011□2024□□□□□□□□□□□□□□□□□□

Section 13 / **60**

Bottom baryon mass and sigma term contribution

□□ □[1]

[1] *ITP, CAS*

Using anisotropic clover action for valence bottom quark on CLQCD 2+1 flavor ensembles,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.

Section 3 / **72**

CMS□□□□□□□□QCD□□□□

Section 9 / **46**

Chiral and $U(1)_A$ symmetries in background magnetic fields from lattice QCD

□ □[1] ; Heng-Tong Ding[1] ; José Javier Hernández Hernández[1]

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Understanding how external magnetic fields affect chiral and singlet $U(1)_A$ symmetry breaking is an important question in QCD under extreme conditions. In a pure magnetic background, the unequal electric charges of the light quarks explicitly reduce the non-singlet flavor symmetry, making it necessary to identify the appropriate neutral mesonic partner channels. We clarify the neutral-sector symmetry structure and identify $\chi_{\pi^0} - \chi_\sigma$ as the chiral-partner splitting associated with the surviving neutral non-singlet axial symmetry, and $\chi_{\pi^0} - \chi_{\delta^0}$ as the singlet $U(1)_A$ partner splitting. Using fixed-scale $(2+1)$-flavor HISQ ensembles with $m_\pi \simeq 220\,\mathrm{MeV}$ at vanishing magnetic field, we study these observables over a broad range of temperatures and magnetic fields. At low temperatures, both splittings increase with eB. At intermediate temperatures, both splittings decrease with increasing eB once the field is sufficiently strong. The decrease of the singlet $U(1)_A$ partner splitting sets in at larger eB and is milder than in the chiral channel. These results provide fixed-scale lattice-QCD evidence for distinct magnetic responses of the neutral chiral and singlet $U(1)_A$ partner susceptibility splittings.

Section 9 / **51**

Chiral anomaly, neutral pion lifetime and axion-photon coupling

□ □[1] ; Xu Feng[1] ; Lu-Chang Jin[2] ; Qi-Yuan Luo[1] ; Hao-Yang Cheng[1] ; Chuan Liu[1]

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The chiral anomaly underlies many processes, including the two-photon decay of the neutral pion and the axion-photon coupling, and fixes their leading-order contributions to a constant independent of QCD dynamics. However, traditional lattice QCD methods compute the complete amplitude, making percent-level precision demanding. We show that, by applying the anomalous Ward identity (AWI), the anomalous contribution can be isolated directly, leaving only a finite-quark-mass correction that lattice QCD evaluates reliably.Employing this strategy, we present the first lattice determination of the neutral pion lifetime with isospin-breaking effects, and determine the axion-photon coupling to 1.8% precision, furnishing a first-principles benchmark and reconciling the discrepancies among published ChPT determinations.

Section 9 / **8**

Chiral gauge theories on a disk and a slab

[1]

[1]

The Standard model as a chiral gauge theory is the core foundation of particle physics. Yet, no consensus has been reached on non-perturbative formulations of chiral gauge theories although a few number of promising theoretical models have been constructed. In this work, we exam the extra dimension or domain wall fermion approach. Firstly, we numerically tested the slab (Grabowska-Kaplan) proposal in 2+1 dimensional lattice with a background gauge field and showed anomaly inflow, anomaly cancellation, and the behaviour of the boundary chiral model under different flow of the gauge field. Secondly, we tested a recently proposed proposal with a disk shape defect with a boundary under annealing flow of the background gauge field. Similarly, we demonstrate the mechanism of anomaly inflow and anomaly cancellation.

Section 10 / **30**

Collins-Soper Kernel and Intrinsic Soft Funtion

[None]

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TMDTMDPDFSIDIS
Drell–YanPDFTMD Wilson
TMD Collins–Soperintrinsic soft function
TMD

Collins–Soper TMD LaMET
QCDNLO pion
1fm

Section 8 / **10**

Complete Leading-twist Baryon Light-cone Distribution Amplitudes from LQCD

[1]

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Baryon light-cone distribution amplitudes (LCDAs) encode the longitudinal momentum distributions of valence quarks and provide important nonperturbative inputs for hard exclusive processes involving baryons. In this talk, I will present the first lattice determination of the three leading-twist Λ-baryon LCDAs, V, A, and T, as full two-dimensional functions of the valence-quark momentum fractions.

This work establishes a systematic large-momentum effective theory (LaMET) framework for determining leading-twist baryon LCDAs from lattice QCD, covering the complete procedure from equal-time three-quark correlators to the momentum-fraction dependence of physical light-cone amplitudes. Key ingredients include a two-dimensional hybrid renormalization prescription in coordinate space, an HQET-motivated large-λ extrapolation strategy for controlling the long-distance behavior of Euclidean correlators, one-loop perturbative matching to the light-cone amplitudes in the $\overline{\mathrm{MS}}$ scheme, and controlled extrapolations to the continuum, physical-pion-mass, and infinite-momentum limits.

As a phenomenological illustration, replacing the asymptotic LCDA with the lattice-determined distributions leads to an $\mathcal{O}(10\%)$ shift in the Λ electromagnetic form factor at perturbative scales. These results provide the first complete multidimensional, x-dependent baryon LCDAs from first principles and establish a framework for future lattice studies of baryon light-cone structure.

Section 14 / **63**

Computing hadron structure with ancilla-free quantum circuits

[None]

Computing hadron structure with ancilla-free quantum circuits

Section 14 / **44**

Constraining DVCS Compton Form Factors Using Lattice QCD informed Neural Network

[1]

[1]

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The lattice QCD calculation of generalized form factors are exploited to determine the subtraction constants through all order dispersion relations of Deeply Virtual Compton Scattering (DVCS). The leading order relation is found to constrain significantly the real part of the Compton Form Factors (CFFs), and the higher order one reduces considerably both the real and imaginary part of CFFs in a global analysis of proton data. This is realized by a synthesis of the DVCS data and LQCD calculations within a neural network framework, whose architecture is specifically designed for a reliable extrapolation to unmeasured kinematic regime. By leveraging dispersion relations beyond leading order, our framework allows for adding higher moments of generalized parton distributions from LQCD into the extraction of CFFs from DVCS data.

Section 13 / **50**

Continuous Renormalization Group Beta Function in Four-Flavor QCD

[1]

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The renormalization group beta function encodes how the strength of the strong interaction changes with energy scale, connecting asymptotic freedom at high energies to the onset of nonperturbative dynamics at low energies. We study the beta function of four-flavor QCD using the continuous gradient-flow approach, which provides a nonperturbative definition of the running coupling and its scale evolution. Our calculation follows the running from the perturbative regime toward stronger coupling, with controlled continuum and infinite-volume extrapolations. This provides a first-principles view of the transition between perturbative and nonperturbative QCD dynamics in a theory with four dynamical sea-quark flavors.

Section 10 / **33**

Continuum-Limit Heavy-Meson LCDAs from Lattice QCD

[1]

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Heavy-meson light-cone distribution amplitudes are essential nonperturbative inputs for precision heavy-flavor phenomenology. We present a first-principles lattice-QCD determination of heavy-meson LCDAs in both QCD and HQET using the HQLaMET framework. Simulations on multiple ensembles enable controlled continuum, chiral, and infinite-momentum extrapolations. Improved lattice techniques significantly enhance the quality of nonlocal correlators. For the HQET LCDA, we combine the nonperturbative peak region with the perturbative tail and determine key inverse moments, obtaining (\lambda_B = 0.340(20)) GeV at (\mu = 1) GeV.

Section 8 / **98**

Continuum-Limit Heavy-Meson LCDAs from Lattice QCD

Section 13 / **61**

Contributions of Electromagnetic Interaction to Hadron Masses

[1]

[1] *ITP, CAS*

Electromagnetic effects are increasingly relevant to precision hadron spectroscopy, yet their evolution across the light, strange, charm, and bottom sectors remains poorly mapped. We calculate the leading QED corrections to meson and baryon masses using electroquenched photons on nine 2+1-flavor, tadpole-improved clover ensembles at three lattice spacings, with pion masses from 135 to 316 MeV and spatial extents from approximately 2.5 to 6.7 fm. The quark masses are matched in the Dashen scheme, and the results are extrapolated jointly to the physical pion mass, continuum limit, and infinite volume. Resolving each mass shift into quark self-energy and pairwise interaction terms, we find that attractive electromagnetic interactions lower hadron masses, whereas repulsive interactions raise them. Most neutral hadrons receive corrections below 1 MeV, while singly charged states receive corrections of at most about 5 MeV.

Section 10 / **38**

Control of Excited-State Contamination in Nucleon Matrix Elements Using All-to-All Fermion Propagators

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We present a method to decompose and control excited-state contamination in nucleon matrix elements using all-to-all fermion propagators. By constructing a variational basis of nucleon and nucleon–meson interpolating operators, we resolve the contributions of the nucleon ground state and low-lying multi-hadron states. In particular, we investigate excited states containing $(N\pi)$, $(N\pi\pi)$, and meson-related scattering components such as (Nf_1). The generalized eigenvalue problem is applied to the two-point correlation matrix to determine optimized operators, which are then used to rotate the three-point functions and reduce transitions involving excited states. This framework allows the excited-state contributions to be studied separately instead of being absorbed into an uncontrolled systematic uncertainty. We focus on the scalar and axial charges, (g_S), (g_A), for which excited-state effects can have different magnitudes and time dependence. The method provides a systematic approach to improving the reliability of nucleon structure calculations and to quantifying the residual excited-state contamination.

Section 7 / **20**

DbarN meson-baryon scatter in Lattice QCD

□ □[1] ; Liuming Liu[2] ; peng sun[3]

[1] □□□□□□□□□□□□□□

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This project studies the low-energy $\bar{D}N$ scattering in lattice QCD, focusing on the S-wave channels $I(J^P) = 0\left(\frac{1}{2}^-\right), 1\left(\frac{1}{2}^-\right)$.

Finite-volume $\bar{D}N$ correlation functions are analyzed using the generalized eigenvalue problem (GEVP) to extract the two-body energy spectrum. The Lüscher formalism is then used to relate the finite-volume energy levels to infinite-volume scattering amplitudes. Near threshold, the effective range expansion (ERE) is employed to extract low-energy scattering parameters, including the

scattering length and effective range. Possible effects from higher channel $\bar{D}^*N$, is also considered.

The overall aim is to obtain a first-principles understanding of the low-energy $\bar{D}N$ interaction and to clarify whether it supports any near-threshold structures.

Section 13 / **35**

Determination of Standard Model Parameters From CLQCD Ensembles

[1]

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Lattice QCD provides a first-principles framework for studying the strong interactions and plays an important role in the precision determination of Standard Model parameters. This talk will review the determination of renormalized light and heavy quark masses, and discuss how lattice QCD calculations of hadronic decay matrix elements enable precise extractions of CKM matrix elements. Particular emphasis will be placed on recent results obtained with the CLQCD clover ensembles, illustrating their contributions to precision flavor physics and tests of the Standard Model.

Section 14 / **3**

Diffusion Sampler For Lattice Field Theory

[1]

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Sampling algorithms for lattice field theories face persistent efficiency challenges near the continuum limit, including critical slowing down and, in certain fermionic theories, poor ergodicity across degenerate vacua. Generative diffusion models, recently shown to correspond to stochastic quantization, offer a promising alternative and have been demonstrated for scalar and pure gauge theories; their extension to fermionic systems, central to full QCD with dynamical quarks, has remained largely unexplored.

We present a diffusion-based sampler for the two-dimensional Gross-Neveu model, a four-fermion lattice theory. The sampler is combined with an exact Monte Carlo correction step, guaranteeing unbiased sampling from the target distribution. We validate the method in the asymptotically free regime and across the finite-volume crossover, with observables cross-checked against an independent reference implementation. This work extends diffusion-based sampling to the fermionic sector and suggests a possible route toward accelerating simulations with dynamical fermions.

Section 14 / **21**

Electromagnetic form factors and radii of charmed mesons from lattice QCD

[1]

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Using $N_f = 2+1$ clover fermions across six gauge ensembles generated by the CLQCD collaboration, this work performs simultaneous chiral and continuum extrapolations to determine the electromagnetic properties of charmed mesons, providing the first lattice QCD calculations for the magnetic moments and radii of D^{*+} and D_s^*, and filling the gap for the D_s^* charge radius. The preliminary numerical results yield the charge radii squared as $(r_c)^2_D = 0.208(26)$ fm^2, $(r_c)^2_{D^{*+}} = 0.258(25)$ fm^2, $(r_c)^2_{D_s} = 0.083(17)$ fm^2, and $(r_c)^2_{D_s^*} = 0.101(15)$ fm^2; the magnetic dipole moments as $(G_M)_{D^{*+}} = 2.21(17)$ and $(G_M)_{D_s^{*+}} = 2.19(12)$; and the magnetic radii squared as $(r_m)^2_{D^{*+}} = 103(84)$ fm^2 and $(r_m)^2_{D_s^*} = 0.088(54)$ fm^2.

Section 8 / **82**

Enhanced Signal and Excited-State Control in Nonlocal Lattice Correlators

Section 9 / **48**

Entanglement Entropy of the Infinitely-Heavy Quark-Antiquark System from Lattice QCD

[1]

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An infinite-heavy quark system can clearly be divided into two subsystems: one consisting of two infinitely heavy quarks and the other being the sea gluon and sea quark subsystem, allowing us to define the reduced density matrix and entanglement entropy. We calculate the reduced density matrix defined in color space under the Coulomb gauge condition on lattice dynamical configurations and find the relationship between the proportion of different color components and the distance between quarks.

Section 13 / **54**

Finite-Volume Gluon Trace-Anomaly Matrix Elements in the \(\rho\)-Resonant \(\pi\pi\) Channel

Author(s): [1]

Co-author(s): Yi-Bo Yang [2]

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Understanding how gluonic dynamics manifests itself in unstable hadrons remains an important challenge in studies of hadron mass generation. We investigate the gluon trace anomaly in the isovector \(P\)-wave \(\pi\pi\) channel containing the \(\rho\) resonance using lattice QCD. A variational basis composed of quark-antiquark \(\rho\) operators and two-pion operators projected onto the appropriate finite-volume irreducible representations is employed. Solving the generalized eigenvalue problem isolates a tower of interacting finite-volume energy eigenstates. For each optimized state, we calculate a vacuum-subtracted gluonic insertion proportional to \(\beta(g)F_{\mu\nu}F_{\mu\nu}/(2g)\) and extract the corresponding diagonal matrix element using the summed-ratio method. Away from the resonance region, the matrix elements approximately follow the behavior expected for weakly interacting two-pion states. Near the \(\rho\) resonance, however, we observe a pronounced peak in the gluon trace-anomaly contribution, correlated with the resonant behavior of the finite-volume spectrum and the changing \(\rho\)- and \(\pi\pi\)-operator overlaps. The enhancement indicates that the gluonic response of the interacting two-pion system is significantly stronger in the resonance region than the approximate sum of the individual-pion contributions. Our results demonstrate that gluonic trace operators provide a sensitive probe of resonance formation and establish a framework for studying the gluonic structure of unstable hadrons through finite-volume matrix elements.

Section 6 / **34**

From Longitudinal to Transverse Structure: Hadron Tomography from Lattice QCD

□ □[1]

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Understanding the partonic structure of hadrons from first principles is a major goal of lattice QCD. In this talk, I will review recent progress by the Lattice Parton Collaboration using large-momentum effective theory (LaMET). I will first discuss lattice determinations of longitudinal parton structure, including parton distribution functions and light-cone distribution amplitudes of mesons and baryons, together with recent developments in renormalization, perturbative matching, and large-momentum extrapolation. I will then turn to transverse-momentum-dependent distributions, where lattice calculations have progressed from the soft function and Collins–Soper kernel to TMD wave functions, unpolarized TMDPDFs, and spin-dependent distributions. These developments illustrate the emerging capability of lattice QCD to quantitatively resolve the multidimensional partonic structure of hadrons.

Section 8 / **24**

From Spin Structure to Transverse Momentum Distributions: A Lattice View of the Nucleon

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Understanding how the spin, flavor, and intrinsic transverse motion of quarks emerge from QCD is essential for building a complete picture of nucleon structure. Recent developments in large-momentum effective theory have made it possible to access increasingly detailed partonic information directly from lattice QCD.

In this talk, I will present two complementary lattice studies of nucleon structure. The first focuses on the spin-flavor structure encoded in ratios of helicity and unpolarized parton distribution functions, with particular emphasis on $\Delta d(x)/d(x)$. This ratio directly probes the polarization of the down quark inside a longitudinally polarized nucleon, especially in the valence region, while benefiting from partial cancellation of common systematic uncertainties between the helicity and unpolarized distributions.

The second study extends this picture from longitudinal spin structure to the transverse-momentum structure of the nucleon through calculations of isovector unpolarized and helicity TMD PDFs, $f_1^{u-d}(x, b_T)$ and $g_{1L}^{u-d}(x, b_T)$. Using ensembles with multiple lattice spacings, pion masses, and nucleon momenta, together with nonperturbative Collins–Soper evolution and LaMET matching, we investigate their dependence on both the longitudinal momentum fraction x and the transverse separation b_T, as well as the associated systematic uncertainties.

Together, these studies illustrate how lattice QCD can connect the spin structure of the nucleon with its transverse-momentum structure, providing increasingly detailed first-principles information on nucleon partonic dynamics and complementary input for phenomenology and future Electron-Ion Collider measurements.

Section 3 / **74**

Future High-Energy Nuclear Physics Experiments at HIAF: Hyperon-Nucleon Spectrometer

Section 12 / **86**

Generative AI meets Physics

Section 10 / **31**

Gluon Helicity Distribution of the Nucleon from Lattice QCD in Continuum Limit

[redacted][1]

[1] *CUHK(SZ)*

We report a state-of-the-art lattice QCD calculation of the gluon helicity parton distribution function of the proton within the large-momentum effective theory framework. The calculation employs 2+1-flavor CLQCD gauge ensembles at three lattice spacings $a = \{0.105, 0.0897, 0.0775\}$ fm and pion mass of approximately 300 MeV/c^2, with nucleon momenta up to 3.0 GeV/c. Distillation with momentum smearing is applied to improve the signal of two-point gluon-field correlation functions. We renormalize the results in the hybrid scheme, applying self-renormalization to purely imaginary and antisymmetric matrix elements.
After one-loop perturbative matching, the gluon helicity distribution

is extrapolated to the continuum and infinite-momentum limits. The final result is consistent with global fitting within errors.

Section 2 / **69**

Gradient flow in perturbative QCD and lattice QCD

Section 13 / **57**

Gradient-Flow Renormalization of Nonlocal Quasi Operators in Lattice QCD

□□ □[None] ; Hao-Yang Bai[None] ; Jun Hua[None] ; Jia-Lu Zhang[None]

Large-momentum effective theory (LaMET) enables first-principles studies of hadron structure from spatially nonlocal quasi observables, for which renormalization is essential to connect lattice calculations to continuum perturbative schemes. While the renormalization of local operators has been extensively studied using methods such as RI/MOM and gradient flow, nonlocal quasi operators containing space-like Wilson lines involve additional linear divergences and require dedicated renormalization strategies. Conventional self-renormalization can properly remove these divergences, but in practice the extraction of lattice-spacing-dependent renormalization factors is entangled with discretization effects and typically relies on simultaneous analyses at multiple lattice spacings. In this work, we develop a gradient-flow-based renormalization strategy for nonlocal quasi operators. The flow-dependent Wilson-line self energy is extracted from gauge-fixed Wilson lines and then applied as a common long-distance renormalization factor for different quasi matrix elements. After subtracting the linear divergence, the flowed operators are perturbatively matched to the \(\overline{\mathrm{MS}}\) scheme, thereby separating the Wilson-line self-energy subtraction from the remaining lattice-spacing dependence. Gradient flow also improves the long-distance signal of Wilson-line observables while retaining a controlled field-theoretic interpretation. We implement the procedure on two CLQCD ensembles with different lattice spacings. The extracted self-energy correction shows mild lattice-spacing dependence and yields well-behaved renormalized quasi matrix elements at large separations.

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Group photo & Tea break

Section 14 / **43**

High-Performance Implementation of Multigrid Solver for Lattice QCD

□ □[1]

[1] □□□□□□□□□□□□□

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We have independently implemented a multigrid solver for propagator calculation for Lattice QCD. Compared to existing implementations from abroad, this project features a flatter structure and lower

complexity, while offering greater autonomy and control. At the current stage, performance in common application scenarios is approaching the level of advanced international implementations, with the potential for further performance enhancements and the addition of unique features. The project is hosted at “https://github.com/ZhangXin8069/PyQCU”.

Section 3 / **12**

Highlights from the ATLAS Experiment

[1]

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This report highlights the latest ATLAS physics results based on proton-proton collision data collected during LHC Run 2 and Run 3. High precision measurements of Higgs boson properties validate Standard Model predictions for production cross sections and couplings. Evidence is obtained for rare Higgs decays such as H->mumu and H->Zgamma, while constraints are set on Higgs CP-violating interactions and self-couplings from di-Higgs and tri-Higgs searches. Differential top quark spectra and the toponium quasi bound state measurement offer stringent tests of pQCD. Studies of vector boson scattering yield evidence for longitudinally polarized W bosons, and several triboson processes are observed. Searches for physics beyond the Standard Model cover exotic Higgs signatures, dark matter, LLP and effective field theory interpretations, with no statistically significant excess identified. Complementary results from heavy ion and light ion collision data are also briefly reported.

Section 10 / **13**

Hyperons Gluon Helicity from Lattice QCD

[1]

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We present the first lattice QCD calculation of the total gluon helicity contribution ΔG_H to the spin of Λ, Σ, and Ξ hyperons.
The calculation employs the Coulomb-gauge fixed topological current K^μ, whose forward matrix element in the infinite momentum frame yields ΔG_H without non-trivial perturbative matching.
Using a single $N_f = 2 + 1$ flavor dynamical ensemble with lattice spacing $a \approx 0.105$ fm and pion mass $m_\pi \approx 292$ MeV, we extract the bare matrix elements via the Feynman-Hellmann method, with distillation and momentum smearing to control excited-state contamination.
The bare matrix elements are non-perturbatively renormalized in the RI/MOM scheme and subsequently converted to the $\overline{\mathrm{MS}}$ scheme; the renormalization factor $\bar{Z}_{11}^{\mathrm{lat}}$ is employed, whose state-independence is guaranteed by the intrinsic nature of operator ultraviolet divergences.
After infinite-momentum extrapolation and renormalization, we obtain
$\Delta G_\Lambda = 0.165(19)_{\mathrm{stat}}(19)_{\mathrm{ren}}$,
$\Delta G_\Xi = 0.160(14)_{\mathrm{stat}}(19)_{\mathrm{ren}}$, and
$\Delta G_\Sigma = 0.232(24)_{\mathrm{stat}}(28)_{\mathrm{ren}}$
at the $\overline{\mathrm{MS}}$ scale $\mu^2 = 10\ \mathrm{GeV}^2$, corresponding to approximately
$37(5)_{\mathrm{stat}}(4)_{\mathrm{ren}}\%$,
$33(3)_{\mathrm{stat}}(4)_{\mathrm{ren}}\%$, and
$48(5)_{\mathrm{stat}}(6)_{\mathrm{ren}}\%$ of the hyperon total spin, respectively.
The temporal and spatial components of K^μ yield consistent results, confirming Lorentz covariance of the approach beyond the nucleon sector.

These first-principles results reveal the impact of flavor-symmetry breaking on gluon polarization across the baryon octet.

Section 9 / **41**

Isospin-Driven Splitting of Chemical Potentials in Isobar Collisions from Lattice QCD

Heng-Tong Ding[1] ; [1] ; Jin-Biao Gu[1] ; Arpith Kumar[None]

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Strong magnetic fields produced in relativistic heavy-ion collisions can modify conserved-charge fluctuations and their associated chemical potentials. The Ru and Zr isobars share the same mass number, $A = 96$, but have different charge-to-baryon ratios, making Ru+Ru and Zr+Zr collisions a controlled setting for isolating isospin effects. In this talk, we will present first-principles, continuum-estimated $(2 + 1)$-flavor lattice-QCD results for isospin-driven splittings of conserved-charge chemical potentials near the QCD crossover, at both vanishing and nonzero external magnetic fields along the pseudocritical line $T_{\rm pc}(eB)$. Under strangeness neutrality and the charge-to-baryon constraint $r \equiv n_Q/n_B$, the difference in nuclear isospin composition is mapped onto the splitting ratios $\Delta\mu_Q/\Delta\mu_B$, $\Delta\mu_S/\Delta\mu_B$, and $\Delta\mu_S/\Delta\mu_Q$. At vanishing magnetic field, the lattice results yield $\Delta\mu_Q < 0$ and $\Delta\mu_S > 0$, with the electric-charge sector dominating, and the splitting ratios are similar in magnitude to recent Bayesian extractions from STAR isobar data. At nonzero magnetic fields, the splitting ratios themselves vary only moderately with eB. A clearer field signal emerges from the Ru-Zr difference in the normalized magnetic-field response: in lattice QCD, the relative response of μ_Q/μ_B is substantially stronger in Ru+Ru than in Zr+Zr. We also present hadron resonance gas (HRG) results and experimentally motivated proxy observables with kinematic cuts to facilitate contact with experiment. These results provide first-principles benchmarks for the conserved-charge response to isospin and magnetic fields in isobar collisions.
This talk is based on our recent work: H.-T. Ding, J.-B. Gu, A. Kumar, and J. Ni, arXiv:2606.30164 [hep-lat] (2026).

Section 14 / **2**

LaMET-Agent: Agentic Workflow for Large-Momentum Effective Theory Analysis

[1] ; Jinchen He[2] ; Xiangyu Jiang[3] ; Fei Yao[4]

[1] *CUHK(SZ)*

[2] *University of Maryland*

[3] *ITP, CAS*

[4] *BNL*

Extracting light-cone parton distributions from lattice QCD within Large-Momentum Effective Theory (LaMET) requires a multi-stage data-reduction pipeline: fitting Euclidean correlators for hadronic matrix elements, renormalizing the resulting matrix elements, extending and Fourier-transforming them to momentum space, matching to light-cone distributions in perturbation theory, and extrapolating to the continuum, infinite-volume, and physical-mass limits. Several of these stages are procedurally fixed once a scheme is chosen, but others require a physicist to judge fit windows, ansatz choices, and model-averaging strategies from the data itself, which makes the full pipeline slow to execute and difficult to reproduce across practitioners. We present \lamet, an open-source large

language model (LLM) agent framework that formalizes this pipeline as a declarative, job-based manifest and exposes each analysis stage as a registry of typed numerical tools. A tool-calling LLM loop drives the stages that require strategy selection, guided by stage-local "skill" prompts that encode the underlying physics heuristics, while stages that are procedurally fixed run as deterministic tool pipelines. We describe the resulting architecture, validate the agent-in-the-loop correlator-fitting stage on synthetic two-point-function data, and outline its application to an end-to-end pion quasi-parton-distribution-function (quasi-PDF) workflow in the Coulomb-gauge formulation of LaMET. This paper documents the design and first release, \lamet\ v1.0, of the framework.

Section 5 / **78**

LaMET□□□□

Section 2 / **28**

Lattice QCD Studies of Glueballs

□□ □[None]

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Glueballs provide a direct setting for studying how nonperturbative gauge dynamics generates massive hadronic excitations. While lattice calculations in pure Yang–Mills theory have established a well-defined glueball spectrum, identifying the corresponding states in full QCD is considerably more challenging. In the scalar channel, gluonic, quark–antiquark, and multihadron operators couple to the same finite-volume eigenstates, so mixing and strong-decay effects must be treated explicitly.

In this talk, I will briefly review lattice-QCD studies of the glueball spectrum and radiative processes relevant to experimental searches. I will then present our recent study of scalar glueball–\(s\bar{s}\) mixing in \(N_f=1\) lattice QCD with a dynamical strange quark, where we find sizable mixing between the gluonic and \(s\bar{s}\) sectors. Finally, I will discuss our ongoing extension toward a larger variational basis including flavor-singlet two-meson operators, with the longer-term goal of studying scalar scattering and resonance properties.

Section 6 / **56**

Lattice QCD study of the $K^*(892)$ resonance at the physical point

□□ □[1]

[1] *Sichuan University*

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We present a lattice QCD study of the $K^*(892)$ resonance using eight $N_f = 2 + 1$ Wilson-Clover ensembles with three lattice spacings and six pion masses ranging from 135 to 320 MeV. For each ensemble, a large number of finite volume energy levels in the P-wave $K\pi$ channel are determined. The energy dependence of the scattering phase shift is then obtained from L\"uscher's finite-volume method. To systematically assess parametrization dependence, the amplitude is described using three different models, which yield

consistent results. The resulting phase shifts show a clear resonant behavior for all ensembles, and the corresponding $K^*(892)$ resonance pole is identified on the second Riemann sheet in the complex energy plane. The pole positions are extrapolated to the physical pion mass and the continuum limit, yielding a $K^*(892)$ resonance located at $\sqrt{s_0} = [883.0(6.9) - i20.1(2.2)]\mathrm{MeV}$, which is in excellent agreement with the experimental value. This study provides a first-principles QCD determination of the $K^*(892)$ mass and width with estimated systematic uncertainties.

Section 4 / **96**

Lattice QCD study of the K*(892) resonance at the physical point

Section 12 / **17**

Lattice QCD: From Precision Tests to New-Physics Searches

; Zhaofeng Liu[None] ; Chuan Liu[None]

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Lattice QCD has made key breakthroughs in precision calculations for charmonium radiative decays and charm-meson semileptonic decays in recent years. This talk will first review these developments. Apart from precision tests, searching for possible dark-matter candidates with high-precision experimental data constitutes another frontier of modern physics. We will introduce recent lattice advances in axion-like-particle studies and neutrino-background calculations, and outlook its growing significance for dark-matter studies in the future.

Section 9 / **5**

Leading-order dynamical QED corrections to the thermodynamics of isospin-asymmetric QCD

; Gergely Endrodi[1] ; Gergely Marko[1] ; Ádám Fischer[1]

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At large isospin chemical potential μ_I and low temperature, QCD undergoes a second-order transition to a Bose-Einstein condensate of charged pions, whose order is encoded in the non-analytic μ_I-dependence of the pressure and of the isospin density derived from it. Including dynamical photons is expected, on general grounds, to drive this transition first order. Since unequal quark charges render the QCD+QED action complex, we avoid the sign problem by expanding the pressure to $\mathcal{O}(e^2)$ around $e = 0$, with the leading contribution governed by the second charge-derivative of the free energy density, $\partial^2 f/\partial e^2|_{e=0}$. We evaluate it directly on existing isospin-asymmetric pure-QCD ensembles as a spacetime convolution of the Feynman-gauge photon propagator with the vector current-current correlator at nonzero μ_I and pion source λ. The full correlator is computed using a point source and a newly proposed two-dimensional planar source. We report progress toward the

first lattice determination of $\partial^2 f/\partial e^2|_{e=0}$ as a function of μ_I, which captures, at leading order, the imprint of dynamical photons on the thermodynamics across the transition.

88

Lunch break

80

Lunch break

71

Lunch break

Section 5 / **1**

Matching Singlet Axial-Vector and Topological Currents from (S)MOM to MS to Four Loops

Author(s): [1]

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The singlet axial-vector and topological current operators play central roles in determining the quark and gluon spin contributions to the proton spin. As a consequence of the Adler–Bell–Jackiw anomaly, the axial-vector current J_A^μ acquires a non-trivial renormalization starting at two loops in perturbation theory, which is closely related to the renormalization of the topological current. The determination of the renormalization constant for J_A^μ at high orders is complicated by the notorious difficulty of treating γ_5 in dimensional regularization. Employing an newly proposed efficient variant of Larin's renormalization condition for J_A^μ in dimensionally regularized QCD, we compute the finite matching coefficients from (S)MOM to $\overline{\rm MS}$ schemes up to unprecedented (3)4 loops. These results provide essential theoretical input for accurately converting (S)MOM-renormalized currents computed in lattice QCD to their $\overline{\rm MS}$-renormalized counterparts.

Section 14 / **62**

N-point correlation functions on ancilla-free quantum circuits and neural networks

[None]

The n-point real-time correlation function is pivotal for establishing connections between experimental observations and theoretical predictions using field theories. Conventional methods for computing n-point correlation functions on quantum computers generally require an ancilla qubit that controls the entire system – an approach that poses challenges for digital quantum devices with limited qubit connectivity, as well as for analog quantum platforms lacking controlled operations. Here, we introduce a method to compute n-point correlation functions using only unitary evolutions on the system of interest, thereby eliminating the need for ancillas and the control operations. We demonstrate our protocol on IBM quantum hardware up to 12 qubits to measure the single-particle spectrum of the Schwinger model and the out-of-time-order correlator (OTOC) in the transverse-field Ising model, where the noiseless simulation results are successfully reproduced from the noisy hardware. Additionally, I will talk about our recent work on predicting the long-time dynamics of the correlation function from short-time quantum data using NeuralODE.

Section 8 / **15**

Neural-network extraction of collinear transversity distributions and tensor charges with distribution level lattice-QCD input

[1] ; peng sun[2] ; Xiaonu Xiong[None] ; Jianhui Zhang[None] ; Tianbo Liu[None] ; Yuxiang Zhao[None]

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[2] *IMP*

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We present a neural-network global analysis of transversity parton distributions and dihadron fragmentation functions using Belle, HERMES, COMPASS, and STAR measurements. The main new ingredient is an x-dependent lattice-QCD determination of isovector transversity, included directly at positive and negative x. It complements the limited experimental coverage and favors a larger positive up-quark and a more negative down-quark transversity while retaining an acceptable description of the world data.

Section 1 / **67**

Neutrino-nucleon scattering with lattice QCD

37

Neutrino-nucleon scattering with lattice QCD

Keh-Fei Liu[None]

I will give a report 'Neutrino UCLeon scattering with lattice QCD'.

Section 7 / **81**

Non Perturbative Hamiltonian Framework for Finite Volume Energies of N-body System

Section 8 / **9**

Parton Distribution Functions from Large Momentum Expansion of Current-Current Correlators

□□ □[1] ; Xiangdong Ji[2] ; Andreas Schäfer[3] ; Rui Zhang[4] ; Christian Zimmermann[5]

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The universality of the large momentum expansion allows computing parton distribution functions (PDFs) starting from any Euclidean correlator with appropriate large momentum Fourier Components. Here we consider current-current correlators which have been used in short-distance expansion to obtain moments of PDFs. The advantage of such correlators is that they have simple renormalization properties and do not have linear power divergences as in quasi-PDF. However, in lattice calculations, four-point functions are needed. Here we present an expansion formula with current-current correlators up to the next-to-leading order, and preliminary numerical calculations with four-point functions.

Section 14 / **16**

Pion Transition Form Factor in Lattice QCD

peng sun[1] ; □□ □[2] ; Liuming Liu[3]

[1] *IMP*

[2] □□□□□□□□□□□□□

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We investigate the neutral pion transition form factor $F_{\pi^0\gamma^*\gamma^*}(q_1^2, q_2^2)$ in lattice QCD and confirm that the connected and disconnected contributions, in the short-distance regime with a fixed time integration, have the same sign. We employ the recently proposed blending method, which supplies an unbiased and cheap estimators for the required all-to-all propagators.
The external pion states are treated within the distillation framework, while the electromagnetic currents are evaluated via blending method.
Numerical tests are performed on an $N_f = 2 + 1$ lattice ensemble. Our result shows that the contribution of the disconnected part is approximately 1% of that of the connected part and enables constructive interference of probability amplitudes.

Section 7 / **11**

Portraits of Charmoniumlike States

□□ □[1] ; Xiangyu Jiang[None] ; Ying Chen[None] ; Geng Li[None] ; Chunjiang Shi[None] ; Wei Sun[None]

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The charm quark density-density correlation is calculated for 1S and 1P conventional charmonia and $J^{PC} = 1^{-+}, 0^{+-}$ charmoniumlike states from lattice QCD and are interpreted as spatial wave functions of these states with some approximations. The angular distributions of $c\bar{c}$ in conventional charmonia are found to be in accordance with the expectation of two-body systems, while that of the 1^{-+} state exhibits an S-wave feature. However, the $c\bar{c}$ radial distributions turn out to be strikingly different from the non-relativistic quark model and can be understood by the Dirac theory of two-body bound states. These results provide the first gauge invariant and model-independent three-dimensional portraits of charmonium(like) states.

Section 8 / **55**

Precision determination of nucleon iso-vector scalar and tensor charges at the physical point

□□ □[1] ; Zhi-Cheng Hu[None] ; Xiangdong Ji[None] ; Xiangyu Jiang[None] ; Yushan Su[None] ; Peng Sun[None] ; Yi-Bo Yang[None]

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We report a high precision calculation of the isospin vector charge $g_{S,T}$ of the nucleon using recently proposed "blending" method which provides a high-precision stochastic estimate of the all-to-all fermion propagator. A spin-$1/2$, isospin-$1/2$ projected current-involved basis element is utilized to reduce a particular nucleon-meson type excited state contamination whose coupling to the current operator is enhanced by the lattice spatial volume. Using 16 $N_f = 2 + 1$ lattice ensembles which cover 5 lattice spacing, 5 combinations with the same quark masses and lattice spacing but multiple volumes, including three at the physical pion mass, we report so far most precise lattice QCD prediction with the systematic uncertainties from continuum, infinite volume, chiral extrapolations, excited state contamination and also renormalization.

Section 5 / **14**

Progress and Challenges in Phenomenological Determination of PDFs

□□ □[1]

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We present new parton distribution functions (PDFs) at next-to-next-to-leading order (NNLO) from the CTEQ-TEA global analysis of quantum chromodynamics. The CT25 PDFs incorporate new data from the LHC and employ a more flexible parametrization, enabling improved fits to the various quark flavor combinations. The CT25 PDFs include a central set and Hessian error sets. Instead of the combined global + dynamic tolerance used in CT18, the main CT25 PDF set uses only a dynamic tolerance. We also present CT25 PDFs at leading order (LO) and next-to-leading order (NLO), along with (N)NLO sets for different α_s values, and PDF4LHC-like sets. Phenomenological implications are discussed, with emphasis on Higgs production at the 13 TeV LHC.

Section 12 / **53**

Progress on LQCDMaster

[1]

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Section 9 / **42**

QCD Chiral Crossover Line from Lee–Yang Edge Singularities

Heng-Tong Ding[1] ; Swagato Mukherjee[2] ; Peter Petreczky[2] ; [3]

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We propose a universality-based reconstruction of the QCD chiral crossover line from Lee–Yang edge singularities in the complex baryon chemical potential plane[1]. The framework maps lattice-extracted complex Lee–Yang-zero estimates, treated as proxies for edge singularities, to the universal chiral Lee–Yang edge and thereby determines the μ_B dependence of both the chiral critical line in the light-quark chiral limit and the pseudo-critical crossover line at physical quark masses. As an illustration, we apply the framework to Lee–Yang-zero estimates recently obtained by the Wuppertal–Budapest collaboration from high-statistics lattice QCD simulations. Without imposing the previously determined small-μ_B expansion of the crossover line as input, the reconstructed curvature is consistent with existing continuum lattice-QCD results at small μ_B. The fitted chiral-limit transition temperature is also compatible with existing chiral-scaling analyses. These results demonstrate that lattice information on Lee–Yang singularities, combined with universal chiral scaling, provides a quantitatively consistent constraint on the QCD crossover line within the present temperature window and establishes a framework that can be systematically improved with future Lee–Yang-zero determinations.

[1] H.-T. Ding, S. Mukherjee, P. Petreczky, and K.-F. Ye, QCD Chiral Crossover Line from Lee-Yang Edge Singularities, arXiv:2608.05752 [hep-lat] (2026).

Section 2 / **70**

Quantum computing for lattice QCD

Section 13 / **45**

Quark-Gluon Vertex under Complete Tensor Basis

Yi-Bo Yang[1] ; Wei-jie Fu[2] ; [2]

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The quark gluon vertex is a fundamental quantity in unquenched QCD, where as the "classical" channel, i.e. the spinor structure of γ_μ is related to strong coupling constants α_s. Higher order loop correlation would introduce other non-perturbative non-classical structures to the 3-pt correlation function of $\langle \psi\bar{\psi}A \rangle$. In this work, we carried out computation under the complete tensor basis to see whether they are non-negligible or not.

Section 4 / **47**

Rotating QCD matter in strong coupling limit in lattice QCD approach

[1] ; Xu-Guang Huang[2]

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[2] *Fudan University*

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Analytic strong-coupling calculations and previous rotating-lattice simulations appear to predict opposite responses of deconfinement to rotation. We investigate this tension in pure $SU(3)$ gauge theory on anisotropic lattices at imaginary angular velocity over $1.5 \leq \beta \leq 4.5$. At strong coupling we find a reentrant deconfined–confined–deconfined sequence near the zero-rotation transition, in qualitative agreement with analytic strong-coupling theory. The corresponding nonmonotonic phase boundary locally continues to a decreasing transition temperature at real rotation. As β increases, the reentrant interval closes between $\beta = 2.75$ and 3.0; at larger β and moderate temperatures above T_c^0, the Polyakov loop instead initially increases with imaginary angular velocity, recovering the response observed in earlier lattice studies. We further show that quadratic and quartic fits to the same imaginary-rotation boundary yield opposite trends after analytic continuation. The results reconcile the strong-coupling and previous lattice observations as distinct coupling–temperature regimes and expose the cutoff and ansatz dependence that must be controlled when extrapolating to real rotation.

Section 6 / **97**

Static Quark-Antiquark Interactions in Rotating SU(3) Gluodynamics

Section 4 / **39**

Static Quark-Antiquark Interactions in Rotating SU(3) Gluodynamics

Heng-Tong Ding[None] ; Olaf Kaczmarek[None] ; Ran Luo[None] ; [None]

In this talk, I will present a study of static quark–antiquark interactions in rotating SU(3) gluodynamics using quenched lattice simulations at imaginary angular velocity.

Section 1 / **32**

Strong interaction origin of hadron masses

[1]

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I will present the progress and outlook on the strong interaction origin of hadron masses based on the CLQCD ensembles.

83

Tea Break

89

Tea break

85

Tea break

79

Tea break

75

Tea break

Section 6 / **7**

Understand Hadron structure from Wick Contraction

[1]

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□□□□□□□□□□□□□□□□□□

amplitude, taking into account mixing among the relevant local operators. By comparing results at different flow times, we will investigate the flow-time dependence of the extracted moment. This talk will present the computational setup, analysis strategy, and progress towards determining the second moment of the φ-meson light-cone distribution amplitude.

Section 14 / **29**

\Xi to \Lambda form factor

[1]

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We present a first-principles lattice QCD calculation of $\Xi^- \to \Lambda$ form factors using $2+1$ flavor gauge ensembles with lattice spacings ranging from 0.06 to 0.1 fm and pion masses between 230 and 340 MeV. This decay provides an independent avenue for determining the Cabibbo–Kobayashi–Maskawa matrix element $|V_{us}|$ in the baryon sector. We determine the full set of vector and axial-vector transition form factors and their q^2 dependence, followed by a combined chiral and continuum extrapolation to the physical point. Our preliminary prediction for the electron-channel branching fraction is consistent with the recent BESIII measurement, which lies 3.9 standard deviations below the previous world average.

Section 7 / **19**

calculate Λ → pℓ⁻νℓ semileptonic decay in lattice QCD

[1] ; Shihao Su[1] ; peng sun[2]

[1]

[2] *IMP*

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This work presents a non-perturbative lattice-QCD study of the semileptonic decay \(\Lambda \to p\ell\bar{\nu}_{\ell}\), where \(\ell=e,\mu\). The main objective is to calculate the hadronic transition matrix element

$\langle p|\bar{u}\gamma^{\mu}(1-\gamma_5)s|\Lambda\rangle$

and extract the corresponding vector and axial-vector form factors.

Two-point and three-point correlation functions are constructed on the lattice. Excited-state contamination is reduced using the summation method, correlated global fits, and jackknife resampling. The momentum-transfer dependence of the form factors is described using a model-independent z-expansion with the appropriate kinematic constraints.

The extracted form factors are then used to calculate the differential and total decay rates,

$\Gamma_\ell = \int_{m_\ell^2}^{(m_\Lambda - m_N)^2} dq^2 \, \frac{d\Gamma_\ell}{dq^2}$,

and to determine the CKM matrix element
$lvertV_{us}$
$rvert$. Using experimental baryon masses, the resulting muon-to-electron decay-rate ratio is

$\mathrm{R}_{\mu/e} = 0.16464(18)$,

while the extracted values of
$lvert V_{us}$
$rvert$ are

$$\mathrm{V}_{us,e} = 0.2438(21), V_{us,\mu} = 0.2557(161).$$

The study demonstrates the feasibility of determining \(\Lambda\)-baryon semileptonic form factors from lattice QCD. Further calculations with multiple lattice spacings, improved mass tuning, and continuum extrapolation are required for a precision determination of \(\lvert V_{us}\rvert\).
\langle p|\bar{u}\gamma^\mu(1-\gamma_5)s|\Lambda\rangle
\]

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η and η' mesons from lattice QCD

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Understanding the masses of η and η' mesons as well as the mixing between the original flavor singlet state and the neutral octet state is an important topic in low-energy strong-interaction physics. We determine masses and mixing angle of the η and η' mesons in lattice QCD. The calculations are carried out on a set of 13 CLQCD gauge ensembles with N_f = 2 + 1 Wilson-Clover quarks. These ensembles cover three values of the lattice spacing a = 0.105, 0.077, 0.052fm and pion masses from 136 to 317MeV, including two ensembles at physical pion mass. In all ensembles, we used all-to-all quark propagators, named perambulators, generated via a distillation smearing algorithm to improve signal quality. The fitting results indicate that the perambulators perform well for both connected and disconnected diagrams of the correlation function, without requiring too many configurations. This provides a solid foundation for accurately calculating the masses of the η and η' mesons, especially the η'.

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