QGT Topical Collaboration
3D quark-gluon structure of hadrons

An Overview of Objectives and Accomplishments

Martha Constantinou

Temple University

QUARK-GLUON TOMOGRAPHY COLLABORATION

PHENOMENOLOGY · QCD · LATTICE · THEORY

DOE PIs Exchange Meeting

May 2, 2024

Scientific Questions →
What are the urgent open scientific questions to address in hadronic physics?

Approaches →
What novel methodologies are appropriate to address these fundamental questions?
How can these approaches work synergistically?

Main Goals →
What are the scientific priorities for the next 5 years? How will they contribute to the strategic plans of DOE Office of Science, Office of NP?

- How does the hadron mass emerges from interactions of quarks and gluons?

- How is the nucleon spin generated from quark/gluon spins and orbital angular momentum

- What are the internal distributions of physical quantities in hadrons (mass, momentum, forces, etc)

- How can the spatial structure of hadrons be characterized

- Change of quark-gluon structure of the nucleon change when it is bound in the nucleus?

- Theory:
  - effective field theories;
  - light-front quantization;
  - models of QCD;
  - QCD factorization (exclusive processes);
  - QCD vacuum structure;
  - Soft-collinear effective theory

- Lattice QCD:
  - Mellin moments of distribution functions;
  - Novel approaches to access distribution functions

- Phenomenology/global analysis:
  - Development of pixelation based ML workflow for CFF/GPD analysis;
  - Closure test for the extraction CFFs/GPDs from DVCS observables;
  - GUMP platform for analysis;
  - Inclusion of LQCD constraints as priors

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Overarching goal

The QGT Topical Collaboration has a main goal of spearheading understanding and discovery in the quark and gluon hadron tomography, and the origin of their mass and spin

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Scientific Questions

Approaches

Main Goals

Overarching goal

The QGT Topical Collaboration has a main goal of spearheading understanding and discovery in the quark and gluon hadron tomography, and the origin of their mass and spin

coherent and synergistic effort from three Working Groups

- Development of a comprehensive theoretical framework and toolkit for extracting hadron GPDs from data on exclusive processes using perturbative QCD calculations at NLO accuracy;

- Development of framework to perform first-principles Lattice QCD calculations of GPDs(valence & sea quarks, gluons);

- Extraction of nucleon GPDs via global analysis (JLab 12 GeV data and beyond) and theoretical constraints employing modern data science methods to solve the inverse problem (Bayesian inference, machine learning);

- Construction of data-based tomographic images of the spatial quark/gluon distributions in the nucleon and other hadrons;

- Evaluation the nucleon angular momentum sum rule and the energy-momentum tensor form factors (gravitational FFs) using GPD results and direct theoretical calculations. Interpretation of the findings in terms of mechanical structure and nonperturbative dynamics;

- Integrate efforts to constrain GPDs from theory, lattice QCD, and phenomenology and create a community of junior researchers fluent at this intersection.

Approaches

Main Goals

- Training and creating new opportunities for early career researchers (Partial support for 12 postdocs, 6 graduate students and 2 undergraduate summer students);

- Three bridge faculty positions will be created in nuclear theory.

Collaboration structure

★ **12 Universities**
- Duke University
- Hampton University
- Massachusetts Institute of Technology
- Penn State University Berks
- Stony Brook University
- Temple University
- University of Arizona
- University of Connecticut
- University of Kentucky
- University of Maryland
- University of Washington
- William & Mary

★ **3 National Labs**
- Argonne National Lab
- Jefferson Lab
- Lawrence Berkeley National Lab

★ **Senior Investigators**
- 29 Principal Investigators
- 4 Affiliated Members

★ **Early Career Members**
- 2 Undergraduate Students
- 22 Graduate Students
- 15 Postdoctoral Fellows/Research Associates

Principal Investigator:
Martha Constantinou (Temple University)

Additional Spokespersons:
Ian Cloët (Argonne National Lab)
David Richards (Jefferson Lab)
Feng Yuan (Lawrence Berkeley National Lab)

Executive committee:
Christopher Monahan (William&Mary)
Nobuo Sato ((Jefferson Lab))

Co-Investigators:
Yong Zhao (Argonne National Lab)
Thomas Mehen (Duke University)
Alberto Accardi, Jose Goity (Hampton University)
Wally Melnitchouk, Christian Weiss (Jefferson Lab)
William Detmold, John Negele, Phiala Shanahan, Iain Stewart (MIT)
Leonard Gamberg, Alexei Prokudin (Penn State University Berks)
Sergey Syritsyn, Edward Shuryak, Ismail Zahed (Stony Brook University)
Andreas Metz (Temple University)
Sean Fleming (University of Arizona)
Peter Schweitzer (University of Connecticut)
Keh-Fei Liu (University of Kentucky)
Xiangdong Ji, Kyle Shiells (University of Maryland)
Gerald Miller (University of Washington)
Konstantinos Orginos (William & Mary)

Affiliated Senior Investigators:
Luchang Jin (Connecticut)
Jianwei Qiu (Jefferson Lab)
Anatoly Radyushkin (ODU)
Chueng Ji (NCSU)

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Bridge Faculty positions

★ Temple University

Bridge Faculty positions

★ Temple University

Farid Salazar

- PhD from Stony Brook University (2021)
- postdoc at UCLA (2021-2023)
- LBNL (2023)
- INT Fellow at UW (2024)
- Temple University (January 2025)

Research:
- QCD at high energies
- perturbative calculations in EFT
- Gluon saturation
- multi-gluon correlations
- Nuclear tomography (collider experiments)

Focus Areas - Composition & Expertise

★ Specialization in designing and using effective field theories, chiral perturbation theory, perturbative QCD, and models of QCD

★ Hadron structure-related investigations, e.g., QCD factorization and breaking effects, lepton-nucleon interactions, light-front quantization, gauge topology

THEORY

➡ Quark & Gluon GPDs and TMDs

➡ Gravitational form factors

➡ Wigner functions

➡ Hadronic structure on the light front

➡ Spin physics

➡ Small-x physics

➡ Strangeness in exchange currents

➡ Large-N_c limit

Focus Areas - Composition & Expertise

★ Long-standing expertise in numerical methods in lattice gauge theories, simulations of QCD, non-perturbative methods for renormalization

★ Investigations of hadron structure via parton distribution functions and generalizations through: (a) Mellin moments method, (b) novel approaches

➡ Quark & Gluon PDFs

➡ Gravitational form factors

➡ Proton spin, momentum & angular momentum

➡ E/M form factors and charged radii

➡ Electric dipole moment

➡ x-dependence of PDFs, GPDs, TMDs

➡ neutrino-nucleon scattering cross-sections

➡ Nuclei structure

Focus Areas - Composition & Expertise

★ Broad expertise in developing frameworks for global analysis of experimental data sets, data science techniques, and analytical studies of aspects of QCD

★ Studies of non-perturbative bound-state problems, chiral effective theories, and the interface of lattice QCD and hadron phenomenology

PHENOMENOLOGY

➡ Quark & Gluon PDFs

➡ GPDs and TMDs

➡ Tensor charge and single-spin asymmetries

➡ Distributions of mass and spin in the nucleon

➡ radii and gravitational form factors

➡ perturbative corrections in DVMP

➡ Bayesian methods to tackle inverse problem

Synergy of focus areas

★ The efforts from the three focus areas are interdependent and connected at multiple levels.

★ Utilizing individual efforts from different focus areas and creating essential new synergies is a unique aspect of the topical collaboration
For instance:
- impose constraints in global analysis guided by theory
- impose constraints by incorporating lattice data in global analysis
- address challenges such as the inverse problem by combining lattice data and experimental data, as guided by theory.

Courtesy: C. Weiss
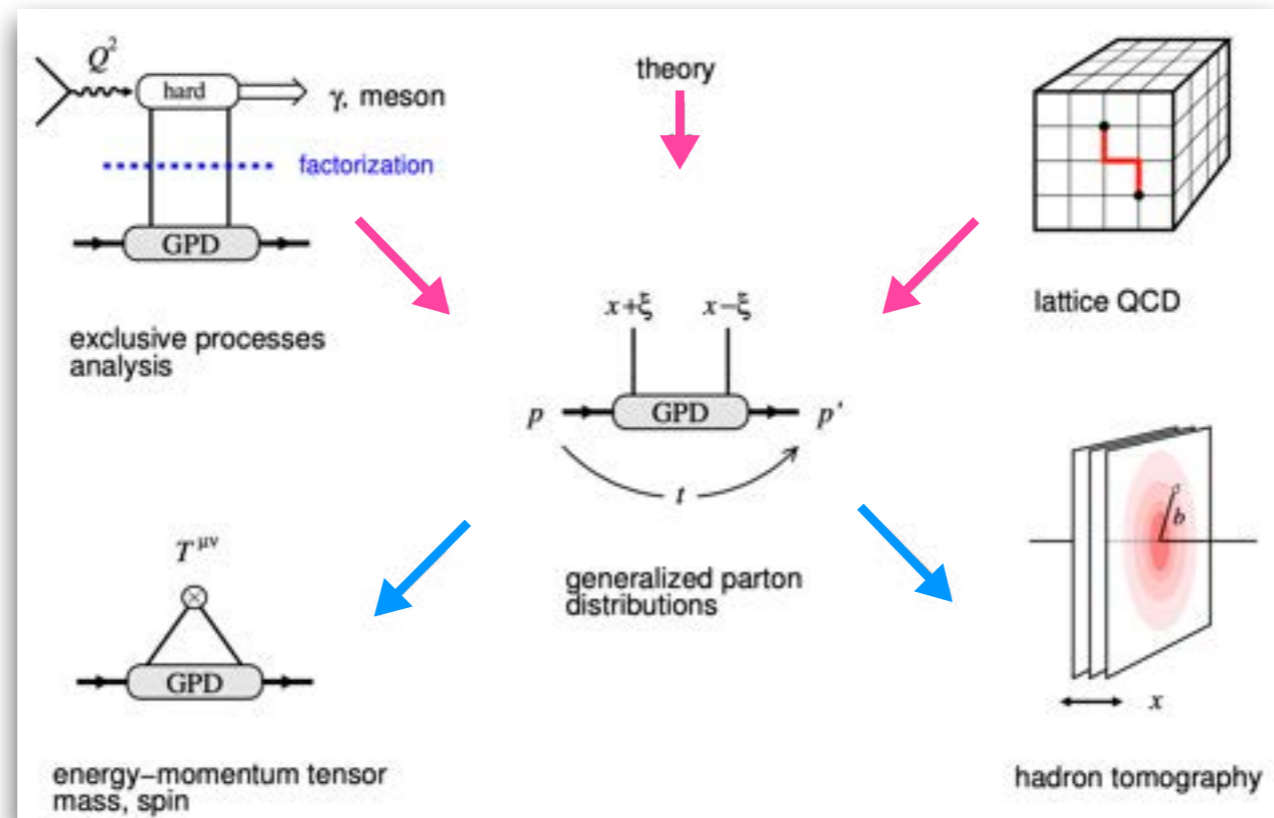
Public information for the scientific community

https://qgtcollab.github.io

★ also private webpages for the working groups

Milestone Progress

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QGT TC Publications

★ **24 publications**
(PRL, PRC, PRD,
PLB, JHEP,
Rev. Mod. Phys.)

★ **16 preprints**

★ **also proceedings**

- Fangcheng He, Ismail Zahed,
  Gravitational form factors of light nuclei: Impulse approximation,
  Phys.Rev.C 109 (Apr 2024)

- Florian Hechenberger, Kiminad A. Mamo, Ismail Zahed,
  Threshold photoproduction of η_c and η_b using holographic QCD,
  Phys.Rev.D 109 (Apr 2024)

- Kiminad A. Mamo, Ismail Zahed,
  String-based parametrization of nucleon GPDs at any skewness: a comparison to lattice QCD,
  Unpublished (Apr 2024)

- Kemal Tezgin, Brean Maynard, Peter Schweitzer,
  Chiral-odd GPDs in the bag model,
  Unpublished (Apr 2024)

- Sebastian Grieninger, Kazuki Ikeda, Ismail Zahed,
  Quasi-parton distributions in massive QED2: Towards quantum computation,
  Unpublished (Apr 2024)

- Wei-Yang Liu, Ismail Zahed,
  Photo-production of $\eta_{c,b}$ near Threshold,
  Unpublished (Apr 2024)

- Wei-Yang Liu, Edward Shuryak, Ismail Zahed,
  Glue in hadrons at medium resolution and the QCD instanton vacuum
  Unpublished (Apr 2024)

- H. Dutrieux, J. Karpie, C. Monahan, K. Orginos, S. Zafieropoulos,
  Evolution of Parton Distribution Functions in the Short-Distance Factorization Scheme,
  JHEP 04, 61 (Apr 2024)

- Peng-Xiang Ma, Xu Feng, Mikhail Gorchtein, Lu-Chang Jin, Keh-Fei Liu, Chien-Yeah Seng, Bi-Geng Wang, Zhao-Long Zhang,
  Lattice QCD Calculation of Electroweak Box Contributions to Superallowed Nuclear and Neutron Beta Decays,
  accepted in Phys. Rev. Lett. (Apr 2024)

- Xiang Gao, Wei-Yang Liu, Yong Zhao,
  Parton Distributions from Boosted Fields in the Coulomb Gauge,
  accepted in Phys. Rev. D (Apr 2024)

- X. Gao, A. D. Hanlon, S. Mukherjee, P. Petreczky, Q. Shi, S. Syritsyn and Y. Zhao,
  Transversity PDFs of the proton from lattice QCD with physical quark masses,
  Phys.Rev.D 109 (Mar 2024)

- Yoshitaka Hatta, Feng Yuan,
  Angular dependence in transverse momentum dependent diffractive parton distributions at small-x,
  Unpublished (Mar 2024)

- Mary Alberg, Gerald A. Miller,
  Quark Counting, Drell-Yan West, and the Pion Wave Function,
  Unpublished (Mar 2024)

- Nicholas Miesch, Edward Shuryak, Ismail Zahed,
  Bridging hadronic and vacuum structure by heavy quarkonia,
  Unpublished (Mar 2024)

- Joe Karpie, Richard Whitehill, Wally Melnitchouk, Chris Monahan, Kostas Orginos, Jian-Wei Qiu, David Richards, Nobuo Sato, Savvas Zafeiropoulos,
  Gluon helicity from global analysis of experimental data and lattice QCD Ioffe time distributions,
  Phys. Rev. D 109, 036031 (Feb 2024)

- Florian Hechenberger, Kiminad A. Mamo, Ismail Zahed,
  Holographic odderon at TOTEM?,
  Phys.Rev.D 109 (Feb 2024)

- Shohini Bhattacharya, Krzysztof Cichy, Martha Constantinou, Jack Dodson, Xiang Gao, Andreas Metz, Joshua Miller, Swagato Mukherjee, Peter Petreczky, Fernanda Steffens, Yong Zhao,
  Generalized parton distributions from lattice QCD with asymmetric momentum transfer: Axial-vector case,
  Phys.Rev.D 109 (Feb 2024)

- Fangcheng He, Ismail Zahed,
  Deuteron gravitational form factors: exchange currents,
  Unpublished (Jan 2024)

- Bigeng Wang, Fangcheng He, Gen Wang, Terrence Draper, Jian Liang, Keh-Fei Liu, Yi-Bo Yang,
  Trace anomaly form factors from lattice QCD,
  Accepted in Phys. Rev. D (Jan 2024)

- Yuxun Guo, Xiangdong Ji, Feng Yuan,
  Proton's gluon GPDs at large skewness and gravitational form factors from near threshold heavy quarkonium photo-production,
  Phys.Rev.D 109 (Jan 2024)

- F. Aslan, M. Boglione, J.O. Gonzalez-Hernandez, T. Rainaldi, T.C. Rogers, A. Simonelli,
  Phenomenology of TMD parton distributions in Drell-Yan and Z^0 boson production in a hadron structure oriented approach,
  Unpublished (Jan 2024)

- Yuxun Guo, Feng Yuan,
  Explore the Nucleon Tomography through Di-hadron Correlation in Opposite Hemisphere in Deep Inelastic Scattering,
  Unpublished (Dec 2023)

- Keh-Fei Liu,
  Hadrons, superconductor vortices, and cosmological constant,
  Phys. Lett. B 849, 138418 (Dec 2023)

- Daniel C. Hackett, Patrick R. Oare, Dimitra A. Pefkou, Phiala E. Shanahan,
  Gravitational form factors of the pion from lattice QCD,
  Phys. Rev. D 108 (Dec 2023)

- Yong Zhao,
  Transverse Momentum Distributions from Lattice QCD without Wilson Lines,
  Unpublished (Nov 2023)

- Jian Liang, Raza Sabbir Sufian, Bigeng Wang, Terrence Draper, Tanjib Khan, Keh-Fei Liu, Yi-Bo Yang,
  Elastic and resonance structures of the nucleon from hadronic tensor in lattice QCD: implications for neutrino-nucleon scattering and hadron physics,
  Unpublished (Nov 2023)

- Ho-Yeon Won, Hyun-Chul Kim, June-Young Kim,
  Role of strange quarks in the D-term and cosmological constant term of the proton,
  Phys. Rev. D 108 (Nov 2023)

- Tanjib Khan, Tianbo Liu, Raza Sabbir Sufian,
  Gluon helicity in the nucleon from lattice QCD and machine learning,
  Phys. Rev. D 108, 074502 (Oct 2023)

- V.D. Burkert, L. Elouadrhiri, F.X. Girod, C. Lorcé, P. Schweitzer, P.E. Shanahan,
  Colloquium: Gravitational Form Factors of the Proton,
  Rev. Mod. Phys. 95 (Oct 2023)

- Daniel C. Hackett, Dimitra A. Pefkou, Phiala E. Shanahan,
  Gravitational form factors of the proton from lattice QCD,
  Unpublished (Oct 2023)

- Shohini Bhattacharya, Krzysztof Cichy, Martha Constantinou, Jack Dodson, Andreas Metz, Aurora Scapellato, Fernanda Steffens,
  Chiral-even axial twist-3 GPDs of the proton from lattice QCD,
  Phys. Rev. D 108 (Sep 2023)

- Eric Moffat, Adam Freese, Ian Cloët, Thomas Donohoe, Leonard Gamberg, W. Melnitchouk, Andreas Metz, Alexei Prokudin, Nobuo Sato,
  Shedding light on shadow generalized parton distributions,
  Phys. Rev. D 108 (Aug 2023)

- June-Young Kim,
  Quark distribution functions and spin-flavor structures in N to Δ transitions,
  Phys.Rev.D 108 (Aug 2023)

- Shohini Bhattacharya Krzysztof Cichy, Martha Constantinou, Xiang Gao, Andreas Metz, Joshua Miller, Swagato Mukherjee, Peter Petreczky, Fernanda Steffens, Yong Zhao,
  Moments of proton GPDs from the OPE of nonlocal quark bilinears up to NNLO,
  Phy. Rev. D. 108, 014507 (Jul 2023)

- Adam Freese, Gerald Miller,
  Synchronization effects on rest frame energy and momentum densities in the proton,
  Phys Rev D 108 (Jul 2023)

- Xiang Gao, Wei-Yang Liu, Yong Zhao,
  Parton Distributions from Boosted Fields in the Coulomb Gauge,
  Unpublished (Jun 2023)

- Edward Shuryak, Ismail Zahed,
  Hadronic structure on the light-front VI. Generalized parton distributions of unpolarized hadrons,
  Phys. Rev. D 107 (May 2023)

- Tom Dodge, Peter Schweitzer,
  Exactly solvable models of nonlinear extensions of the Schrödinger equation,
  Unpublished (Apr 2023)

- X. Gao, A. D. Hanlon, J. Holligan, N. Karthik, S. Mukherjee, P. Petreczky, S. Syritsyn and Y. Zhao,
  Unpolarized proton PDF at NNLO from lattice QCD with physical quark masses,
  Phys. Rev. D 107 (Apr 2023)

- Yuxun Guo, Xiangdong Ji, M. Gabriel Santiago, Kyle Shiells, Jinghong Yang,
  Generalized parton distributions through universal moment parameterization: non-zero skewness case,
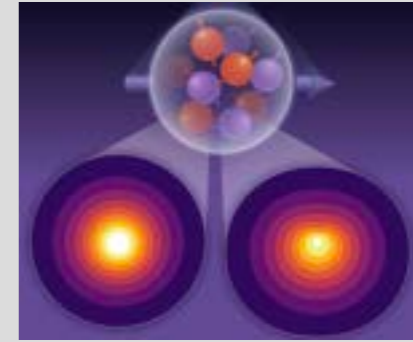 JHEP 05 150 (Feb 2023)

DOE Highlights

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Theory Offers a High-Resolution View of Quarks Inside Protons

NOVEMBER 29, 2023

[Bhattacharya et al. Phys. Rev. D 108, 014507 (2023)]

Novel approach to extract GPDs from lattice QCD with improved methodology that covers wide range of parameters

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Nuclear Physics

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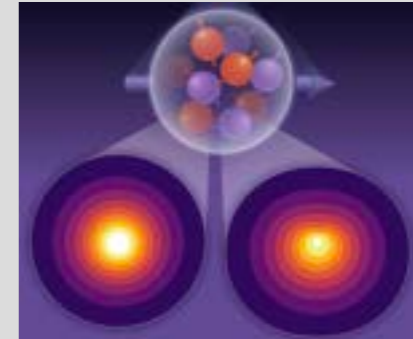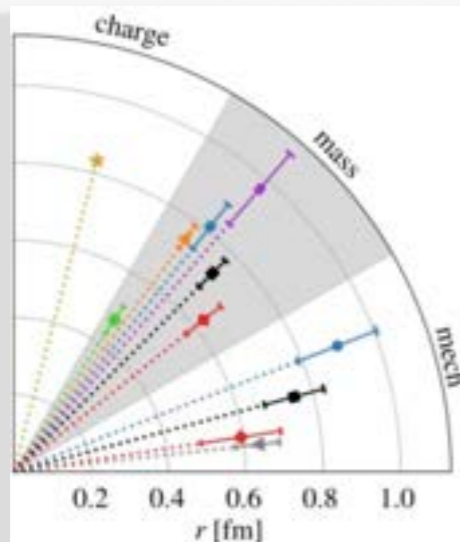Novel approach to extract GPDs from lattice QCD with improved methodology that covers wide range of parameters

Gravitational form factors of the proton revealed by theory and experiment

[Hackett, et al., Phys. Rev. D 108 (2023) 11, 114504]

Highlight in preparation

The u, d, s, g gravitational FFs of the proton reveal its mechanical radius, mass radius for the first time

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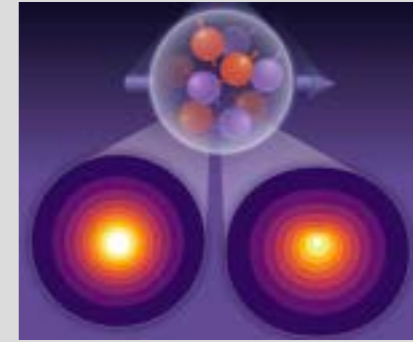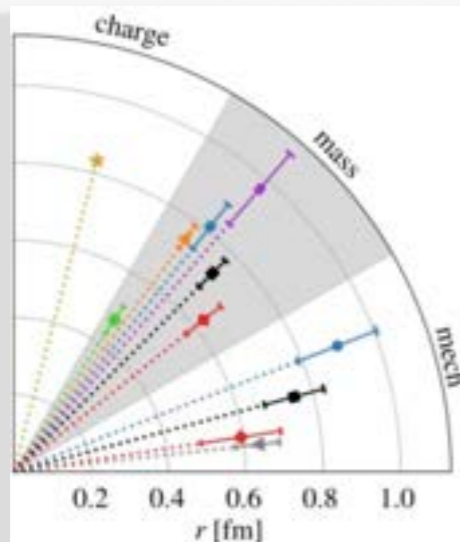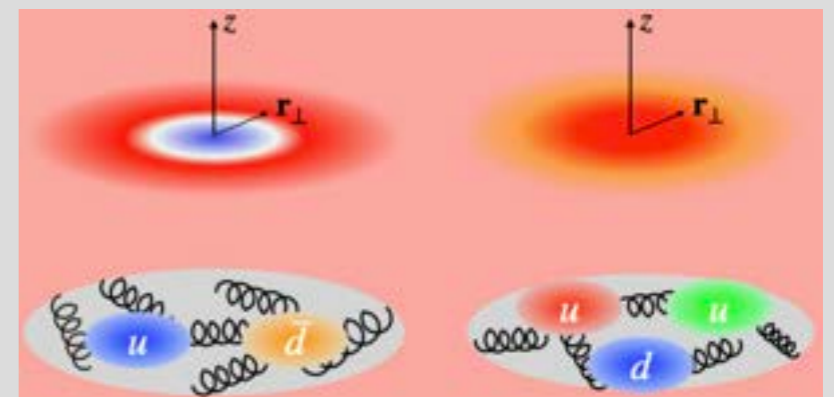The u, d, s, g gravitational FFs of the proton reveal its mechanical radius, mass radius for the first time

Visualization of mass distribution within hadrons

[Liu, Phys. Lett. B 849 (2024) 138418; Wang et al. arXiv:2401.05496]

Highlight in preparation

Nuclear theorists reveal mass distribution within the pion and the proton from Lattice QCD
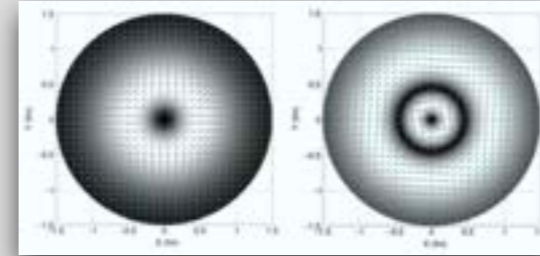
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QGT TC in the News

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Physicists Determine Distribution of Strong Force inside Proton

Jan 24, 2024 by News Staff **[Burkert et al. 2023. Rev. Mod. Phys 95 (4): 041002]**

quark contribution to the distribution of forces in the proton as a function of the distance from the proton's center.

Overview of progress in gravitational FFs
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EXPLORING THE FABRIC OF THE UNIVERSE: HADRONS TO COSMOLOGICAL CONSTANT

Apr 5, 2024 [Liu, Phys. Lett. B 849, 138418 (2024)]

Exploration of resemblance between the EMT trace anomaly and cosmological constant in general relativity, which are associated with the metric term that contributes to both energy and pressure.
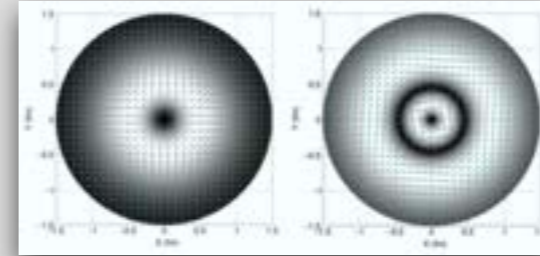
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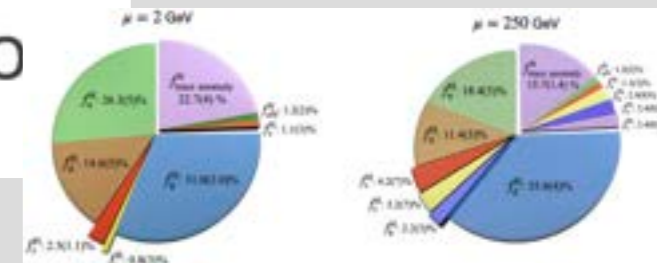

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SCIENCE FEATURED
THE LATEST RESEARCH SERIES
Apr 5, 2024

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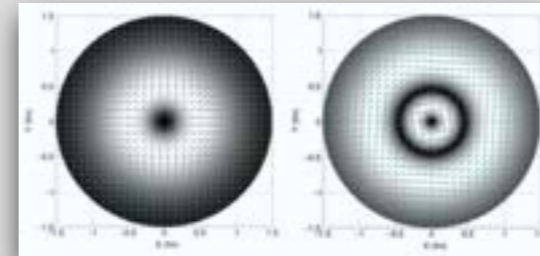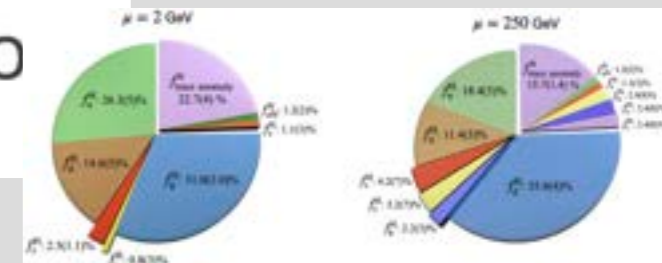
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list ENTERTAINMENT TECH SCIENCE LIFESTYLE

The discovery of Quark Secrets among supercomputers has been studied in a semi-structure and analysis BY WILLIAM ADAMS | SAT, 27 APR 2024 /

[Bhattacharya et al. Phys. Rev. D 108, 014507 (2023)]
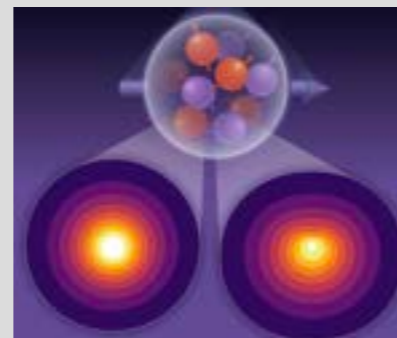
A new formalism leads to the prediction of the spatial distribution of charges, momentum, and other characteristics of *u* and *d* quarks within protons

QGT TC at Conferences

★ ~ 50 talks at International Conferences and Workshops
(~ 40% presented by early career members)

★ Plus seminars and colloquia

Mentoring/Training

★ Student and postdoc involvement in QGT TC research.

Partial support for:

Undergraduate students:
- Lillie Mohn (PSU Berks)
- Owen Page (PSU Berks)

Graduate students:
- Sarah Blask (U of Arizona)
- Ignacio Castelli (Temple)
- Rohit Gupta (U of Arizona)
- Joshua Miller (Temple)

Postdocs:
- Fatma Aslan (UConn)
- Xiang Gao (ANL)
- Yuxun Guo (LBNL)
- Eric Moffat (ANL)
- Jyotimir Roy (Duke)
- Bigeng Wang (U of Kentucky)
- Marco Zaccheddu (JLab)

★ Other students and postdocs involved in QGT TC activities

Mentoring/Training

★ **Co-mentoring and collaborative research for students & postdocs**

A. co-funded students/postdocs

- Fatma Aslan (Schweitzer and Qiu)
- Sarah Blask (Fleming, Mehen, and Stewart)
- Adam Freese (Miller, Qiu)
- Xiang Gao (Zhao, Constantinou, and Metz)
- Yuxun Guo (Yuan, Ji, and Shiells)
- Jyotimir Roy (Mehen, Fleming, and Stewart)
- Marco Zaccheddu (Sato, Cloët, and Gamberg)

B. Co-mentoring/advising also for other students and postdocs

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    B. **Co-mentoring/advising also for other students and postdocs**

★ **Provide training opportunities in summer schools and networking in workshops**

- Collaboration meeting 2023 (Temple)
- Advanced School 2024 (JLab)

Mentoring/Training

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    A. co-funded students/postdocs

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- Advanced School 2024 (JLab)

★ **Self-organized journal club for students and postdocs led by:**

- Joey Delmar   (graduate student at Temple)
- Herve Dutrieux (postdoc at W&M)

2023 QGT TC Meeting

September 8-9, 2023

https://sites.temple.edu/qgt2023/

★ 3 summary talks from each working group
★ 3 selected presentations on Milestones
★ 12 presentations by students and postdocs
★ Business Meeting
★ All-hands discussions for working groups

FRIDAY, SEPTEMBER 8

Room: Alter Hall 746 (except for parallel session at 17:00)

9:15 - 9:45   Opening (Martha Constantinou)

9:45 - 10:15   Overview/status of Theory Working Group (Feng Yuan)

10:15 - 10:45 Overview/status of Lattice Working Group
               (David Richards)

10:45 - 11:15 Overview/status of Global Analysis/Phenomenology
               Working Group (Ian Cloet)

11:15 - 11:45 Coffee Break

11:45 - 12:05 Milestone progress of Theory Working Group
               (Ismail Zahed)

12:05 - 12:25 Milestone progress of Lattice Working Group
               (Yong Zhao)

12:25 - 12:45 Milestone progress of Global Analysis/Phenomenology
               Working Group (Nobuo Sato, Yuxun Guo)

12:45 - 13:10 Discussion

13:10 - 14:30 Lunch Break

14:30 - 14:45 LaMET for GPDs (Xiangdong Ji)

14:45 - 15:00 Leading power accuracy in lattice calculations
               of parton distributions (Rui Zhang)

15:00 - 15:15 Progress in calculations of twist-3 GPDs from
               lattice QCD (Joshua Miller)

15:15 - 15:30 Quasi-PDFs in the Covariant Parton Model (Fatma Aslan)

15:30 - 16:30 Business Meeting

16:30 - 17:00 Coffee Break

17:00 - 18:30 Working groups parallel session (all hands discussion)

- 10:15 Parameterization and extraction of GPDs from small
         to larger skewness (Yuxun Guo)

- 10:30 The energy-momentum tensor and the D-term in a
         classical model of the neutron (Andrea Mejia)

- 10:45 Database for DVCS (Lillie Mohn)

- 11:00 Extraction of Compton form factors using a
         Generative Adversarial Network (Eric Moffat)

- 11:30 Coffee Break

- 11:45 Complementarity of lattice QCD and exclusive processes
         for GPDs (Herve Dutrieux)

- 12:00 Hadronic tensor in lattice QCD: applications
         to neutrino and hadronic physics (Raza Sufian)

12:00 - 12:15 Anomalies in GPDs (Shohini Bhattacharya)

12:15 - 12:30 Trace anomaly form factors of the pion and
               the nucleon from lattice QCD (Bigeng Wang)

12:30 - 13:00 Discussion and Closing

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2024 Advanced School
INTERNATIONAL SCHOOL OF HADRON FEMTOGRAPHY

Conference Date
September 16, 2024 to September 25, 2024

Conference Location
Jefferson Lab
12000 Jefferson Avenue
Newport News, VA 23606

Organizing Committee
Martha Constantinou | Temple U., Co-Chair
Latifa Elouadrhiri | Jefferson Lab, Co-Chair
Charles Hyde | ODU
Wally Melnitchouk | Jefferson Lab
David Richards | Jefferson Lab
Christian Weiss | Jefferson Lab

★ **In collaboration with CNF**

★ **Coupled to the 2024 QGT Collaboration meeting (Sept. 13 - 14, 2024)**

★ **School open to advanced graduate students/postdocs**

★ **Experiment and theory**

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Program

1. Introduction
— Overview of concepts, definitions
— Plan of lectures

2. Exclusive processes
— Basics of QCD factorization
— DVCS and light/heavy meson production
— Novel processes; Hadron/photon-induced

3. GPD analysis
— Analysis using GPD parametrizations
— Data science methods, inverse problem, ML
— Combined LQCD and experimental data analysis

4. Hadron structure with GPDs
— Hadron imaging
— EMT, AMO, mechanical properties
— EFT methods, dynamical models

5. Experimental methods
— Experimental methods: DVCS, meson production, SDHEPs
— Overview of results, esp. JLab12
— Future facilities EIC, JLab22

6. GPDs from lattice QCD
— Partonic structure from Euclidean correlators (quasi/pseudo)
— Specific challenges of GPDs
— Local operators and generalized form factors

Concluding remarks

The collective effort is greater than the sum of the individual parts

Concluding remarks

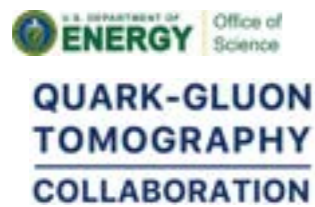*The collective effort is greater than the sum of the individual parts*

The QCT Topical Collaboration

★ Brings together world experts in the field of the partonic and spin structure of hadrons to address open scientific questions in nuclear theory

★ Covers all theoretical approaches in the field (theory, lattice QCD, phenomenology/global analysis)

★ Fosters scientific connections that might otherwise remain unexplored

★ Maximizes the potential of small research groups' resources

★ Provides training, mentoring and networking opportunities for the next generation of nuclear theorists

★ Enhances the nuclear theory workforce with bridge faculty positions

Thank you