

# Snowmass LOIs: Lattice QCD and Neutrino-Nucleus Scattering

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Andreas S. Kronfeld  
Fermilab

NuSTEC Board Meeting  
December 10–11, 2020



# Pre-history

- Lattice QCD and **Neutrino-Nucleus Scattering** (A.S.K., D.G. Richards, W. Detmold, R. Gupta, **H.-W. Lin**, K.-F. Liu, **A.S. Meyer**, R. Sufian, **S. Syritsyn**) [[arXiv:1904.09931](https://arxiv.org/abs/1904.09931)]

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Hadrons and Nuclei

Inside: Topical Issue on Opportunities for Lattice Gauge Theory in the Era of Exascale Computing  
edited by William Detmold, Andreas Kronfeld, Ulf-G. Meißner

From: Lattice QCD and neutrino-nucleus scattering by USQCD Collaboration

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194	Alexei Bazavov et al., USQCD Collaboration	Hot-dense Lattice QCD	Review
195	Christoph Lehner et al., USQCD Collaboration	Opportunities for Lattice QCD in quark and lepton flavor physics	Review
196	Andreas S. Kronfeld et al.	Lattice QCD and neutrino-nucleus scattering	Regular Article - Theoretical Physics
197	Vincenzo Cirigliano et al., USQCD Collaboration	The role of Lattice QCD in searches for violations of fundamental symmetries and signals for new physics	Review
198	Richard C. Brower et al., USQCD Collaboration	Lattice gauge theory for physics beyond the Standard Model	Review
199	Bálint Jóni et al.	Status and future perspectives for lattice gauge theory calculations to the exascale and beyond	Regular Article - Theoretical Physics
200	T. Wright et al.	Measurement of the $^{13}\text{C}(n,\gamma)$ thermal cross section via neutron irradiation and AMS	Regular Article - Experimental Physics
201	P. Belli et al.	First direct search for $2\nu$ and $\epsilon\beta^+$ decay of $^{144}\text{Sm}$ and $2\nu$ decay of $^{147}\text{Sm}$	Regular Article - Experimental Physics
202	C.S. Akondi et al.	Experimental study of the $\gamma p \rightarrow K^0 \Sigma^+$ , $\gamma n \rightarrow K^0 \Lambda$ , and $\gamma n \rightarrow K^0 \Sigma^0$ reactions at the Mainz Microtron	Regular Article - Experimental Physics
203	Daniel M. Siegel	GW170817 — the first observed neutron star merger and its kilonova: Implications for the astrophysical site of the r-process	Regular Article - Topical Issue: First Joint Gravitational Wave and Electromagnetic Observations: Implications for Nuclear and Particle Physics
204	Georgy Kornukov and Tetyana Galatyuk	An iterative method to estimate the combinatorial background	Regular Article - Experimental Physics
205	Lilin Zhu et al.	Centrality and transverse momentum dependencies of hadrons in Pb+Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV and Xe+Xe collisions at $\sqrt{s_{NN}} = 5.44$ TeV from a multi-phase transport model	Regular Article - Theoretical Physics

junior faculty  
postdoc

# USQCD Whitepaper

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- Put forth the idea that lattice-QCD calculations of nucleon matrix elements could work together with nuclear many-body theory:
  - a **wish** rather than a **framework**.
- Explained the challenges of lattice-QCD calculations of properties of small nuclei ( $A \leq 4$  now,  $\leq 6$  or  $8$  in five years?):
  - interplay with chiral effective theory.
- Makes a Snowmass WP solely on lattice QCD not very interesting.
- Makes **the work** needed to turn the wish into a framework a very interesting prospect for a Snowmass WP.

# DPF Snowmass Study

# Lattice QCD is Everywhere

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- Computational Frontier: Steve Gottlieb
  - Theoretical Calculations and Simulations: Peter Boyle
  - Machine Learning: [Phiala Shanahan](#)
  - Quantum Computing: Martin Savage
- Theory Frontier: Aida El-Khadra
  - Lattice Gauge Theory: [Zohreh Davoudi](#), Taku Izubuchi, Ethan Neil
  - QIS: Simon Catterall
- Frontier: Convener
  - Topical Group: Leader
- Energy Frontier:
  - QCD—Hadronic Structure: [Huey-Wen Lin](#)
  - QCD—Heavy Ions: Swagato Mukherjee
- Rare Processes and Precision Frontier:
  - Weak Decays of  $b$  and  $c$  Quarks: [Stefan Meinel](#)
  - Fundamental Physics in Small Experiments: Tom Blum
  - Hadronic Spectroscopy: Sasa Prelovsek (Ljubljana)
- [Nearly 50 LOIs w/ USQCD authors.](#)

Almost

junior faculty

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# Lattice QCD for Neutrino-Nucleon Scattering

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- CompF2/040 [Lattice Calculation of Neutrino-Nucleon Cross Section](#) ( $\chi$ QCD; POC = Liu); Keh-Fei Liu, Terrence Draper, Jian Liang, G. Wang, Yi-Bo Yang, Yong Zhao
- NF6/111 [Nucleon Form Factors for Neutrino Physics](#) (RBC, POC = Meyer); Taku Izubuchi, Christoph Lehner, Aaron S. Meyer, Shigemi Ohta, Sergey Syritsyn
- NF6/193 [Lattice-QCD Calculations Supporting Neutrino-Oscillation Experiments](#) (Fermilab Lattice, MILC; POC = Kronfeld); A. Bazavov, C. DeTar, A.X. El-Khadra, E. Gámiz, Z. Gelzer, Steven Gottlieb, U.M. Heller, R.J. Hill, C. Hughes, W.I. Jay, A.S. Kronfeld, S. Lahert, J. Laiho, Yin Lin (林胤), P.B. Mackenzie, A.S. Meyer, E.T. Neil, J. Osborn, J.N. Simone, A. Strelchenko, R.L. Sugar, D. Toussaint, R.S. Van de Water, A. Vaquero Avilés-Casco

# Towards a Framework

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- NF6/167 [Theoretical Predictions of Neutrino-nucleus Interactions](#) (POC = Gupta, Gandolfi); Tanmoy Bhattacharya, Joseph A. Carlson, Vincenzo Cirigliano, Stefano Gandolfi, Rajan Gupta, Yong-Chull Jang, Huey-Wen Lin, Santanu Mondal, Sungwoo Park, Saori Pastore, Boram Yoon
- NF6/177 [Connecting QCD to Neutrino-nucleus Scattering](#) (POC = Rocco, Wagman); Joseph Carlson, Chia Cheng Chang (張家丞), William Detmold, Joshua Isaacson, William Jay, Gurtej Kanwar, Andreas Kronfeld, Huey-Wen Lin, Yin Lin (林胤), Keh-Fei Liu, Alessandro Lovato, Pedro Machado, Aaron S. Meyer, Saori Pastore, Noemi Rocco, Phiala Shanahan, and Michael Wagman
- NF6/144 [Event Generators for Accelerator-Based Neutrino Experiments](#) (POC = Jay, Machado); Joshua Isaacson, William I. Jay, Alessandro Lovato, Pedro A. N. Machado, Noemi Rocco; Joseph A. Carlson, Alexander Friedland, Rajan Gupta, Deborah Harris, Or Hen, Kevin J. Kelly, Andreas S. Kronfeld, Ivan J. Martinez-Soler, Ornella Palamara, Saori Pastore, Yuber F. Perez-Gonzalez, David Schmitz, Hirohisa A. Tanaka, Jessica Turner, Yu-Dai Tsai, Michael Wagman
- NF6/094 [Neutrino-induced Shallow- and Deep-Inelastic Scattering](#) (POC = Katori); L. Alvarez-Ruso, A. M. Ankowski, M. Sajjad Athar, C. Bronner, L. Cremonesi, K. Duffy, S. Dytman, A. Friedland, A.P. Furmanski, K. Gallmeister, S. Gardiner, W.T. Giele, N. Jachowicz, H. Haider, M. Kabirnezhad, T. Katori, A.S. Kronfeld, S. W. Li, J.G. Morfín, U. Mosel, M. Muether, A. Norrick, J. Paley, V. Pandey, R. Petti, L. Pickering, B.J. Ramson, M. H. Reno, T. Sato, J.T. Sobczyk, J. Wolcott, C. Wret, and T. Yang



Possible Snowmass-USQCD Workshop

# Lattice Meets Experiment: Neutrino Scattering

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- In September, A.S.K. contacted topical-group leaders André de Gouvea (TF11), Kendall Mahn (NF06), Saori Pastore (TF11).
- Positive response; post-CPM timeframe considered; other TGLs of TF11 & NF06 in loop.
- Time to get back to this:
  - any volunteers to help organize?