



Snowmass '21 Theory Frontier
Kick-Off Town Hall
TF05: Lattice Gauge Theory

Conveners:

Zohreh Davoudi, Taku Izubuchi,
Ethan Neil*

07/30/20



Overview

- Theory Frontier is new to Snowmass process this time around: emphasize vibrancy and importance of particle theory research
- Our topical group will summarize ongoing and future efforts in lattice gauge theory.
- Your involvement is crucial (thank you for coming to this meeting!) We want to make sure all of the exciting lattice research going on is represented in the Snowmass process.
- We have a channel on the Snowmass Slack, **#tf05-lattice** - feel free to join! (Instructions to join the Slack are on the Snowmass web page.)

Reminder: timeline of key events

- LOIs due: Aug 31, 2020
- Community planning meeting: Oct 5-9, 2020, virtual
- Theory frontier conference: Mar 17-19, 2021, KITP
- Community summer study: Jul 11-20, 2021, Seattle (~whitepapers due)

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TF05: Lattice gauge theory

Co-Conveners: Zohreh Davoudi (UMD), Taku Izubuchi (BNL), Ethan Neil (CU Boulder)

Description

Lattice gauge theory has long served as a reliable non-perturbative method to study the Standard Model in its strong regime, as well as models of new physics with strong dynamics from first principles. The formulation of quantum field theory on a discrete spacetime lattice was key to early understanding of renormalization, but modern applications most commonly involve the use of high-performance computing to calculate numerical results from first principles. Enjoying rapid developments in both theoretical methods and computing power, such studies, now available for a wealth of physical quantities of interest, provide essential inputs to experiments at the intensity, energy, and cosmic frontiers of research in high-energy physics. In particular, given the reliance of the experimental program on hadrons and nuclei as the medium to discover new physics, and with the introduction of new computing paradigms such as Artificial Intelligence and Quantum Computing, research in Lattice Gauge Theory in the U.S. will be more essential and more exciting than ever in the upcoming years. A number of research directions we envision the community of lattice gauge theorists to pursue vigorously over the next decade are enumerated in the following.

Subtopics to be explored:

- Quark and lepton flavor physics for searches of new physics in the intensity frontier
- Nucleon and nucleus response to external probes for long-baseline neutrino experiments and direct dark-matter detection
- Constraining Standard Model contributions in searches for the violation of fundamental symmetries such as in proton decay, in neutrinoless double-beta decay, and in electric dipole moment
- Physics of hadron and nucleus structure for intensity and energy frontiers such as studies of proton's structure functions
- Hot and dense state of matter for physics of early universe, astrophysics, and heavy ion collisions
- Exploration of strongly-coupled field theories not realized in the Standard Model, to probe fundamental quantum field theory questions, as well as for application to models of new physics such as composite Higgs or composite dark matter
- Development of the state-of-the-art simulation algorithms and frameworks such as Artificial Intelligence, Quantum Simulation, and Quantum Computing for finite density systems and real-time dynamics



<https://snowmass21.org/theory/lattice>

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(Any topics you think are missing?
Let us know/write an LOI!)

Opportunities for Lattice Gauge Theory in the Era of Exascale Computing

ISSN: 1434-6001 (Print) 1434-601X (Online)

In this topical collection (8 articles)

 Regular Article - Theoretical Physics	Status and future perspectives for lattice gauge theory calculations to the exascale and beyond Bálint Joó, Chulwoo Jung, Norman H. Christ...	Article:199
 Review	Lattice gauge theory for physics beyond the Standard Model Richard C. Brower, Anna Hasenfratz, Ethan T. Neil...	Article:198
 Review	The role of Lattice QCD in searches for violations of fundamental symmetries and signals for new physics Vincenzo Cirigliano, Zohreh Davoudi, Tanmoy Bhattacharya...	Article:197
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 Regular Article - Theoretical Physics	Hadrons and nuclei William Detmold, Robert G. Edwards, Jozef J. Dudek...	Article:193

- USQCD completed several whitepapers last year, giving a nice starting point as an overview of LGT research
 - https://link.springer.com/journal/10050/topicalCollection/AC_441c8f346e52ea575708850ad9629286
 - Or see the USQCD website: <https://www.usqcd.org/collaboration.html>
- Most important areas to expand upon for Snowmass *not* covered in detail by USQCD whitepapers are ***lattice + QIS/quantum computing*** and ***machine learning*** - LOIs/whitepapers in this area are strongly encouraged! (There is some starting info in the first whitepaper, “...exascale and beyond”.)
- Organization of topics for Snowmass TF05 otherwise roughly follows the set of topics in the whitepapers. (But important updates and specific topics not covered therein are good candidates for LOIs, too.)

Overlap with other frontiers/topical groups

- Other groups that you should be aware of with strong overlap w/certain lattice topics: (*USQCD members as conveners noted in parentheses*)

- Theory Frontier (*Aida El-Khadra*)
 - TF10 - Quantum Information Science (*Simon Catterall*)
- Computational Frontier (*Steve Gottlieb*)
 - CompF2 - Theoretical Calculations and Simulations (*Peter Boyle*)
 - CompF3 - Machine Learning (*Phiala Shanahan*)
 - CompF6 - Quantum Computing (*Martin Savage*)
- Energy Frontier
 - EF05 - Precision QCD
 - EF06 - Hadronic structure (*Huey-Wen Lin*)
 - EF07 - Heavy-ion physics (*Swagato Mukherjee*)
- Rare Processes and Precision Measurements
 - RF1 - Weak decays of b and c quarks (*Stefan Meinel*)
 - RF2 - Weak decays of strange and light quarks
 - RF3 - Fundamental physics + small experiments (*Tom Blum*)
 - RF7 - Hadron spectroscopy

Remember: LOIs can be “cross-listed”. Feel free to check with topical group leaders if unsure about fit!

Immediate goal: LOIs (due 8/31)

- Reminder: “**Letters of interest**”, not intent. Not a commitment to write a Snowmass whitepaper, but will help us plan and make sure important topics have whitepapers.
- For LGT in particular: are there topics you feel are not adequately represented in the USQCD whitepapers? Or important areas of overlap between LGT and other topics?
- Lots of natural overlap exists with other topical groups/frontiers: cross-listing is important to help with planning.
- Following the LOI process, we will look into organizing additional meetings and/or a short workshop to discuss the scope of topics and whitepaper coordination. Focused workshops on specific topics are also encouraged - we are willing to help organize!
- Join our Slack channel (**#tf05-lattice**) to discuss further with us and the community!