

Taiwan-Korea Joint Workshop on Nuclear Physics 2026:
**Synergies in Hadron Structure, Heavy Ion Collisions and
Nuclear Astrophysics**

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Opening presentation

Academia Sinica, Taipei, Taiwan, 16. Sep. 2026

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Welcome to Taiwan

大家好, 歡迎來到台灣

好久不見! Very happy to see you all!



Illustrations generated using ChatGPT. Photos by me.

How do quarks and gluons give rise to the structure and evolution of matter across vastly different scales?



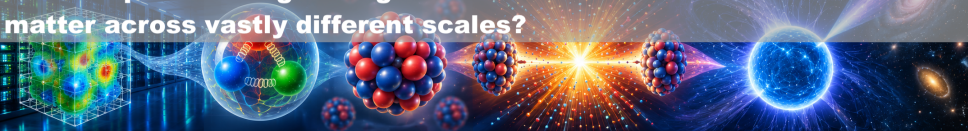
What we know about the microscopic theory:

$$\mathcal{L}_{\text{QCD}} = -\frac{1}{4} G_{\mu\nu}^a G^{a\mu\nu} + \sum_f \bar{\psi}_f (i\gamma^\mu D_\mu - m_f) \psi_f$$

$$G_{\mu\nu}^a = \partial_\mu A_\nu^a - \partial_\nu A_\mu^a + g f^{abc} A_\mu^b A_\nu^c, \quad D_\mu = \partial_\mu - ig A_\mu^a T^a.$$

- **QCD is asymptotically free**, at scales $\simeq 0.001 fm$ quarks are not bound into hadrons. Perturbative QCD correctly describes the dynamics.
- **QCD shows confinement**, at scales $\simeq 1 fm$ quarks are bound into hadrons. Dynamics is non-perturbative and requires full QCD description.
- **Nuclei and HIC**, at scales $\simeq 1 - 10 fm$, we have a (non-)equilibrium few-body quantum system. Dynamics needs effective theory description.
- **Compact objects**, at larger scales the system is cosmic. Dynamics describes the process of supernovae and cosmic evolution in the early universe.

How do quarks and gluons give rise to the structure and evolution of matter across vastly different scales?



The core questions to understand are in nuclear physics:

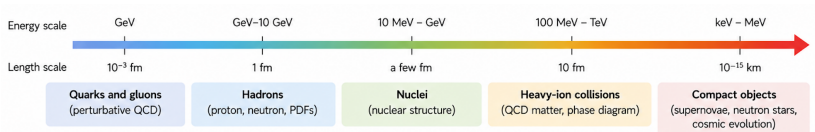
- Proton tomography = hadron structure and spectroscopy from QCD
- Creation of matter in the early universe = high-density, high-temperature QCD, connection to neutrinos and nuclei
- Explosion mechanism of supernovae = neutrinos and astrophysics

Large scale experimental facilities need support and guidance from physics theory to have their intended impact.

- Electron-Ion-Collider (EIC)
- Deep Underground Neutrino Experiment (DUNE)
- Astronomy surveys

A timely opportunity to join forces:

- Experimental milestones are coming soon.
 - Increasing focus on multi-messenger astrophysics and the QCD phase diagram
- ⇒ Need consolidation of regional theoretical expertise in nuclear physics.



A call to action:

- This workshop is about building bridges and forming collaborative networks to address the entire evolution chain across all scales.
- The bigger goal is to get theory ready for upcoming experimental milestones.

Taiwan and Korea have complementary strengths in the research of nuclear physics.

- Expertise in hadron structure, neutrino astrophysics, lattice QCD, and dense matter theory.
- Common basis and strategic alignment for sustained bilateral collaboration.
- Heavily invested in key areas:
 - Proton tomography through distribution functions at the parton level.
 - Conditions and process of supernova explosions.
 - Study of heavy-ion collisions and early universe physics through modeling and non-perturbative calculations.

This workshop

Three topical areas:

Hadron Structure

Momentum and flavor structure of hadrons and nuclei.

Heavy-Ion Collisions

Creating and probing QCD matter under extreme conditions.

Nuclear Astrophysics

From nuclei to stars, supernovae, neutrinos and the elements.

Four types of talk:

- **Keynote speech:** Taiwan and South Korea based experts. High-level reviews and overviews.
- **Emerging leader:** Promising young and rising experts. Topical, cutting-edge, research presentations.
- **Panel discussion:** Community introductions, discussions for future opportunities.
- **Invited and contributed talks:** Experts at all stages. Topical, cutting-edge, research presentations.

Timetable

Day 1 Wednesday, 16 September 2026	Day 2 Thursday, 17 September 2026	Day 3 Friday, 18 September 2026
09:30-10:00 Morning coffee and Registration	09:30-10:15 Taiwan's QCD Program and Heavy Quarkonium Physics at STAR <i>Yi Yang</i>	09:30-10:15 Hadrons in Nuclear Matter
10:00-10:15 Welcome introduction	10:15-11:00 Modeling QCD at Low Resolution with an Instanton Liquid: Applications to Hadron Structure <i>Wei-Tang Liu</i>	10:15-11:00 Neutron-star oscillations as a spectroscopic probe of dense nuclear physics with... <i>Haoyu Kuang</i>
10:15-11:00 Parton physics on the lattice: past, present and future <i>C.-J. David Lin</i>	11:00-11:30 Break: Coffee break	11:00-11:30 Recent progress on the in-medium heavy quark potential from lattice QCD <i>Alexander Rothkopf</i>
11:00-11:45 Nucleon structure and multi-hadron dynamics from lattice QCD <i>Sungwoo Park</i>	11:30-12:00 Nonperturbative effects on quark orbital angular momentum in the nucleon <i>June-Young Kim</i>	12:00-12:30 Chiral and Nuclear Transitions beyond the... <i>Jangho Kim</i>
11:45-14:00 Break: Lunch and discussions	12:00-12:30 Probing the phi meson in nuclear matter through proton-nucleus collisions <i>Philipp Gubler</i>	12:30-14:00 Break: Lunch
14:00-14:30 Hadron mass spectra in extreme conditions -from Lattice Monte Carlo to Tensor Network <i>Etsuko Ito</i>	12:30-12:50 Effective QCD model with consistent quasi-gluon treatment <i>Pracheta Singha</i>	14:00-14:20 Quark-hadron phase transition in the early... <i>Kim-Wang Ng</i>
14:30-14:50 The Collins-Soper kernel from a vacuum soft... <i>Wayne Morris</i>	12:50-18:50 Lunch and free afternoon (self-organized excursion)	14:20-14:40 From Tidal Deformability to the Neutron-Star Equation of State with Cosmic Explorer <i>Hung Tan</i>
14:50-15:10 Hadron structure functions from Hamiltonian lattice gauge theory with tensor networks <i>Manuel Schneider</i>		14:40-15:00 Vorticity-induced effects from Wess-Zumino-... <i>Geraint Evans</i>
15:10-15:30 Moments of pion and kaon light-cone distribution amplitudes from dynamical lattice QCD using the heavy-quark operat... <i>Alex Chang</i>		15:00-15:20 Anomalous dynamical screening of relativistic... <i>Sota Hanai</i>
15:30-16:00 Break: Coffee break		15:20-15:50 Break: Coffee break
16:00-16:30 Exploring Exotic Nuclei at the Center for Exotic Nuclear Studies <i>Sunghoon (Tony) Ahn</i>		15:50-16:20 Charmed hadron production in relativistic... <i>Sungtae Cho</i>
16:30-16:50 Pion/Kaon PDFs and the measurements at EIC <i>Wen-Chen Chang</i>		16:20-16:40 Local spin polarization by color-field... <i>Hansom Sung</i>
16:50-17:10 TMDPDFs of protons and pions <i>Valentin Moos</i>		16:40-17:00 Local Thermalization of SU(2) Lattice Gauge... <i>Ghanashyam Rether</i>
17:10-17:40 Panel discussions: Panel discussions		17:00-17:30 Panel discussions: Panel discussions
		17:30-17:45 Closing remarks
		18:30-21:00 Banquet

A fascinating program — with plenty of opportunities for synergies, and time to explore them!

In a nutshell

- NP research in the local regional area:

Complementary expertise offers large potential for knowledge exchange, opening and extending the dialogue between all participants.

- With our workshop we want to build and encourage:

Dialogue + Knowledge transfer + Collaboration

Opportunities for combined growth in fundamental nuclear physics, particle physics, computational methods, HPC and AI.

- **Organising Team:**

→ Seung-Il Nam, Meng-Ru Wu, Di-Lun Yang and Anthony Francis

→ Welcome active participation, extensions and new ideas.



We wish you a fantastic time in Taipei!