Zhonghao Sun
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EDUCATIONS

2007-2011 B.S. Nuclear Physics, Lanzhou University
Lanzhou, China

2011-2016 Ph.D. School of Physics, Peking University
University
Beijing, China

ACADEMIC AND PROFESSIONAL APPOINTMENTS

2016-2021 Research Associate
University of Tennessee, Knoxville, TN, U.S

2021-2024 Research Associate
Oak Ridge National Laboratory, Oak Ridge, TN, U.S

2024-2025 Senior Postdoc
Louisiana State University, Baton Rouge, LA, U.S

2025- Assistant Research Professor
University of Notre Dame, Notre Dame, IN, U.S

RESEARCH INTERESTS

My research focuses on advancing our understanding of nuclear structures and decays by developing accurate and reliable quantum many-body methods. The primary goal is to make accurate predictions about nuclear properties to answer the following questions: How do low-energy phenomena such as nuclear deformation and rotation emerge from a quantum many-body system dominated by strong nuclear forces? Where are the limits of nuclear stability? This study helps to explain exotic nuclear phenomena observed at rare isotope facilities and may contribute to ongoing experiments searching for new physics beyond the Standard Model.

A significant part of my work involves quantifying uncertainties in theoretical calculations, a major challenge in nuclear physics. By using advanced quantum many-body methods (primarily coupled cluster theory) and their efficient emulators based on eigenvector continuation, as well as modern statistical tools and supercomputing resources, we can reliably predict nuclear properties and transitions derived from chiral effective field theory (Chiral EFT) while accounting for various sources of uncertainty.

RESEARCH EXPERIENCE

Senior Postdoctoral Research Associate
Department of Physics & Astronomy, Louisiana State University, Baton Rouge, LA, U.S
Jul-2024- May.2025
-Develop classical and quantum algorithms to accurately simulate the collective state of nuclei, on their deformation, rotation, and decays.
-Collaboration on developing algorithms to simulate many-body problems on the Photonic Quantum Simulator

Postdoctoral Research Associate
Quantum Science Center / Physics, Oak Ridge National Laboratory, Oak Ridge, TN, U.S
Jul. 2021 – Jul. 2024

- Ab initio calculation of deformed nuclei, development of the projected coupled cluster method to describe the rotation spectrum of atomic nuclei. Compute their structure and decays using supercomputer.
- Investigation of static correlations and strong entanglement in nuclei. Development of the quantum-classical hybrid algorithm for nuclear symmetry breaking using the active space coupled cluster method.

Postdoctoral Research Associate
University of Tennessee, Department of Physics and Astronomy, Knoxville, TN, U.S
Sep. 2016 – Jul. 2021

- Developed the shell model coupled cluster method to compute the structure of heavy-mass open-shell nuclei.
- Collaborated in the development of the projected coupled cluster method to compute the deformation and rotational states of atomic nuclei from the ab-initio approach
- Develop the emulator for coupled cluster calculations, to perform uncertainty quantification and sensitivity analysis in the ab-initio calculations and to make reliable predictions on structure and decays of nuclei.

Graduate Research
Peking University, School of Physics, Beijing, China
Sep. 2011-Jul. 2016

- Research on the structure of dripline nuclei using realistic nuclear forces. Established the method to build the effective interaction for Gamow shell model calculations from realistic nuclear forces.
- Development and optimization of large-scale shell model program, developed an optimized basis to reduce the dimension of shell model calculations.

RECENT PRESENTATIONS AND WORKSHOPS

- "Ab-initio computation of exotic nuclei," Invited talk, Jan 2023, Theories-Seminar, TU Darmstadt
- "Structure of odd-mass Ne, Na, and Mg nuclei in the "island of inversion," "2023 NUCLEI Collaboration Meeting, Knoxville, TN
- "Active space coupled cluster calculation of open-shell nuclei," APS April meeting 2022
- "Coupled cluster calculation of deformed nuclei," APS April Meeting, April 17 - 20, 2021

PUBLICATIONS

Publications:

1. Z. H. Sun, Andreas Ekström, Christian Forssén, G. Hagen, G. R. Jansen, T. Papenbrock., Multiscale physics of atomic nuclei from first principles, Phys. Rev. X 15, 011028 , 2023
2. Z. H. Sun, G. Hagen, T. Papenbrock., Structure of odd-mass Ne, Na, and Mg nuclei in the ``island of inversion", Phys. Rev. C 111, 044304, 2023
3. Chenyi Gu, Z. H. Sun, G. Hagen, and T. Papenbrock. Entanglement entropy of nuclear systems, Phys. Rev. C 108, 054309 ,2023
4. Y. Kondo., …, Z.H. Sun et al. First observation of ^{28}O. Nature, 620(7976):965–970, August 2023
5. Sun, Z. H., G. Hagen, and T. Papenbrock. Coupled-cluster theory for strong entanglement in nuclei. Phys. Rev. C, 108:014307, Jul 2023
6. Sun, Z. H., C. A. Bell, G. Hagen, and T. Papenbrock. How to renormalize coupled cluster theory. Phys. Rev. C, 106: L061302, Dec 2022
7. G. Hagen, S. J. Novario, Sun, Z. H., T. Papenbrock, G. R. Jansen, J. G. Lietz, T. Duguet, and A. Tichai. Angular-momentum projection in coupled-cluster theory: Structure of ^{34}Mg. Phys. Rev. C, 105:064311, Jun 2022
8. Q. Yuan, S. Q. Fan, B. S. Hu, J. G. Li, S. Zhang, S. M. Wang, Sun, Z. H., Y. Z. Ma, and F. R. Xu. Deformed in-medium similarity renormalization group. Phys. Rev. C, 105: L061303, Jun 2022
9. Y. F. Geng, J. G. Li, Y. Z. Ma, B. S. Hu, Q. Wu, Sun, Z. H., S. Zhang, and F. R. Xu. Excitation spectra of the heaviest carbon isotopes investigated within the cd-bonn gamow shell model. Phys. Rev. C, 106:024304, Aug 2022
10. Baishan Hu, Weiguang Jiang, Takayuki Miyagi, Sun, Zhonghao, Andreas Ekström, Christian Forssén, Gaute Hagen, Jason D. Holt, Thomas Papenbrock, S. Ragnar Stroberg, and Ian Vernon. Ab initio predictions link the neutron skin of ^{208}Pb to nuclear forces. Nature Physics, August 2022
11. B. Ohayon, R. F. Garcia Ruiz, Sun, Z. H., G. Hagen, T. Papenbrock, and B. K. Sahoo. Nuclear charge radii of Na isotopes: Interplay of atomic and nuclear theory. Phys. Rev. C, 105: L031305, Mar 2022
12. Markus Kortelainen, Sun, Zhonghao, Gaute Hagen, Witold Nazarewicz, Thomas Papenbrock, and Paul-Gerhard Reinhard. Universal trend of charge radii of even-even Ca-Zn nuclei. Phys. Rev. C, 105: L021303, Feb 2022
13. Sun, Z. H., G. Hagen, G. R. Jansen, and T. Papenbrock. Effective shell-model interaction for nuclei "southeast" of ^{100}Sn. Phys. Rev. C, 104:064310, Dec 2021

14. M. Mougeot, D. Atanasov, J. Karthein, R. N. Wolf, P. Ascher, K. Blaum, K. Chrysalidis, G. Hagen, J. D. Holt, W. J. Huang, G. R. Jansen, I. Kulikov, Yu. A. Litvinov, D. Lunney, V. Manea, T. Miyagi, T. Papenbrock, L. Schweikhard, A. Schwenk, T. Steinsberger, S. R. Stroberg, Sun, Z. H., A. Welker, F. Wienholtz, S. G. Wilkins, and K. Zuber. Mass measurements of $^{99–101}$In challenge ab initio nuclear theory of the nuclide ^{100}Sn. Nature Physics, 17(10):1099–1103, October 2021
15. M. Holl, R. Kanungo, Z.H. Sun, G. Hagen, J.A. Lay, A.M. Moro, P. Navrátil, T. Papenbrock, M. Alcorta, D. Connolly, B. Davids, A. Diaz Varela, M. Gennari, G. Hackman, J. Henderson, S. Ishimoto, A.I. Kilic, R. Krücken, A. Lennarz, J. Liang, J. Measures, W. Mittig, O. Paetkau, A. Psaltis, S. Quaglioni, J.S. Randhawa, J. Smallcombe, I.J. Thompson, M. Vorabbi, and M. Williams. Proton inelastic scattering reveals deformation in ^{8}He. Physics Letters B, 822:136710, 2021
16. B.S. Hu, Q. Wu, J.G. Li, Y.Z. Ma, Z.H. Sun, N. Michel, and F.R. Xu. An ab-initio gamow shell model approach with a core. Physics Letters B, 802:135206, 2020
17. B. S. Hu, Q. Wu, Sun, Z. H., and F. R. Xu. Ab initio gamow in-medium similarity renormalization group with resonance and continuum. Phys. Rev. C, 99:061302, Jun 2019
18. Sun, Z. H., T. D. Morris, G. Hagen, G. R. Jansen, and T. Papenbrock. Shell-model coupled-cluster method for open-shell nuclei. Phys. Rev. C, 98:054320, Nov 2018
19. Q. Wu, B. S. Hu, F. R. Xu, Y. Z. Ma, S. J. Dai, Sun, Z. H., and G. R. Jansen. Chiral NNLOsat descriptions of nuclear multipole resonances within the random-phase approximation. Phys. Rev. C, 97:054306, May 2018
20. W. G. Jiang, B. S. Hu, Sun, Z. H., and F. R. Xu. Gogny-force-derived effective shell-model Hamiltonian. Phys. Rev. C, 98:044320, Oct 2018
21. B. S. Hu, F. R. Xu, Q. Wu, Y. Z. Ma, and Sun, Z. H. Brueckner-hartree-fock calculations for finite nuclei with renormalized realistic forces. Phys. Rev. C, 95:034321, Mar 2017
22. Z.H. Sun, Q. Wu, Z.H. Zhao, B.S. Hu, S.J. Dai, and F.R. Xu. Resonance and continuum gamow shell model with realistic nuclear forces. Physics Letters B, 769:227–232, 2017
23. B. S. Hu, F. R. Xu, Sun, Z. H., J. P. Vary, and T. Li. Ab initio nuclear many-body perturbation calculations in the Hartree-Fock basis. Phys. Rev. C, 94:014303, Jul 2016
24. Sun, ZhongHao, Qiang Wu, and FuRong Xu. Green's function calculations of light nuclei. Science China Physics, Mechanics & Astronomy, 59(9):692013, July 2016
25. L. F. Jiao, Sun, Z. H., Z. X. Xu, F. R. Xu, and Chong Qi. Correlated-basis method for shell-model calculations. Phys. Rev. C, 90:024306, Aug 2014