CHEN SUN

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RESEARCH EXPERIENCE

Los Alamos National Laboratory (Theoretical Division) 2022 - Present
Postdoctoral Researcher *Los Alamos, USA*

Tel Aviv University 2019 - 2022
Postdoctoral Researcher (IASH Postdoctoral Fellow) *Tel Aviv, Israel*

VISITING EXPERIENCE

Weizmann Institute of Science 2022
Short-term visitor (two months), host: Kfir Blum *Rehovot, Israel*

Brown University 2018 - 2019
Long-term visitor (KITPC Travel Award), host: JiJi Fan *Providence, USA*

Boston University 2018
Short-term visitor (three months), host: Martin Schmaltz *Boston, USA*

Dartmouth College 2017 - 2018
Long-term visitor (KITPC Travel Award), host: Marcelo Gleiser, Devin Walker *Hanover, USA*

EDUCATION

Virginia Tech 2013 - 2017
Ph.D. in Theoretical Physics, Advisor: Tatsu Takeuchi *Blacksburg, USA*
· GPA: 3.8/4 · Degree date: May 13, 2017

RESEARCH AREAS

Astrophysical constraints of axion and dark matter
· supernova remnant echo *v.s.* axion dark matter stimulated decay
· cosmic distance measurement *v.s.* axion-photon coupling
· galaxy velocity dispersion *v.s.* ultralight dark matter

Lab searches of axions
· axion-magnetic resonance *v.s.* axion-photon conversion
· muon g-2 *v.s.* axion EFT and completion

Gravitational wave from BSM sources
· neutron star binary mergers *v.s.* long range force
· gravitational wave of boson stars *v.s.* axion potential

Neutrino phenomenology
· solar neutrino *v.s.* monopole
· solar neutrino *v.s.* large non-standard interaction
· DUNE *v.s.* supernova neutrino

BSM Theory
· Pati-Salam extension from noncommutative geometry

GRANTS

· Israel Academy of Sciences and Humanities (IASH)
Foreign Postdoctoral Fellowship (*top 25% awarded*) USD 100,000 2019-2021

· China Postdoctoral Science Foundation
International Travel Research Award (*top 5% awarded*) USD 46,000 2017-2019

HONORS AND AWARDS

· Clayton Williams Graduate Fellowship (*2 in 50 awarded per year*) 2015-2016

· Sigma Xi Outstanding Ph.D. Research Award (*1 in 30 awarded per year*) 2015

PUBLICATIONS

*Authorship is in **alphabetical** order following HEP standard unless noted otherwise.*

H-index: 17, citation: 26.2 per paper. Up-to-date list can be found here

** : CS as the leading contributor equivalent to a "first author"*

† : CS as first author following astrophysics convention

Novel lab probes of axions

25. * H. Seong, **CS**, and S. Yun, "Axion Magnetic Resonance: A Novel Enhancement in Axion-Photon Conversion," arXiv:2308.10925 [hep-ph]

Novel astrophysical probes of axions

24. † **CS**, M. Buen-Abad, and J. Fan, "Probing New Physics with High-Redshift Quasars: Axions and Non-standard Cosmology," arXiv:2309.07212 [astro-ph.CO]
23. C. Antel *et al.*, "Feebly Interacting Particles: FIPs 2022 workshop report," in *Workshop on Feebly-Interacting Particles*. 5, 2023. arXiv:2305.01715 [hep-ph]
22. D. Antypas *et al.*, "New Horizons: Scalar and Vector Ultralight Dark Matter," arXiv:2203.14915 [hep-ex]. Contribution to Snowmass 2021 – CF3. Dark Matter: Cosmic Probes
21. E. Berti *et al.*, "Dark Matter In Extreme Astrophysical Environments," in *2022 Snowmass Summer Study*. 3, 2022. arXiv:2203.07984 [hep-ph]. Snowmass 2021 White Paper
20. * N. Bar, K. Blum, and **CS**, "Galactic rotation curves versus ultralight dark matter: A systematic comparison with SPARC data," *Phys. Rev. D* **105** no. 8, (2022) 083015, arXiv:2111.03070 [hep-ph]
19. * M. A. Buen-Abad, J. Fan, and **CS**, "Axion echoes from the supernova graveyard," *Phys. Rev. D* **105** no. 7, (2022) 075006, arXiv:2110.13916 [hep-ph]
18. J.-F. Fortin, H.-K. Guo, S. P. Harris, D. Kim, K. Sinha, and **CS**, "Axions: From magnetars and neutron star mergers to beam dumps and BECs," *Int. J. Mod. Phys. D* **30** no. 07, (2021) 2130002, arXiv:2102.12503 [hep-ph]. published, editor invited review
17. * M. A. Buen-Abad, J. Fan, and **CS**, "Constraints on Axions from Cosmic Distance Measurements," *JHEP* **02** (2022) 103, arXiv:2011.05993 [hep-ph]
16. * H.-K. Guo, K. Sinha, **CS**, J. Swaim, and D. Vagie, "Two-Scalar Bose-Einstein Condensates: From Stars to Galaxies," *JCAP* **10** (2021) 028, arXiv:2010.15977 [astro-ph.CO]

Gravitational wave probe of dark sector

15. J. Barir, M. Geller, **CS**, and T. Volansky, "Gravitational Waves from Incomplete Inflationary Phase Transitions," arXiv:2203.00693 [hep-ph]. submitted to Physical Review Letters
14. * H.-K. Guo, K. Sinha, and **CS**, "Probing Boson Stars with Extreme Mass Ratio Inspirals," *JCAP* **09** (2019) 032, arXiv:1904.07871 [hep-ph]
13. * D. Croon, J. Fan, and **CS**, "Boson Star from Repulsive Light Scalars and Gravitational Waves," *JCAP* **04** (2019) 008, arXiv:1810.01420 [hep-ph]
12. * D. Croon, M. Gleiser, S. Mohapatra, and **CS**, "Gravitational Radiation Background from Boson Star Binaries," *Phys. Lett. B* **783** (2018) 158–162, arXiv:1802.08259 [hep-ph]
11. * D. Croon, A. E. Nelson, **CS**, D. G. E. Walker, and Z.-Z. Xianyu, "Hidden-Sector Spectroscopy with Gravitational Waves from Binary Neutron Stars," *Astrophys. J. Lett.* **858** no. 1, (2018) L2, arXiv:1711.02096 [hep-ph]

Neutrino probe of BSM

10. S. K. Agarwalla *et al.*, "Constraints on flavor-diagonal non-standard neutrino interactions from Borexino Phase-II," *JHEP* **02** (2020) 038, arXiv:1905.03512 [hep-ph]
9. * N. Houston, T. Li, and **CS**, "A new solar neutrino channel for grand-unification monopole searches," *JCAP* **10** (2018) 034, arXiv:1803.02835 [hep-ph]
8. A. Ankowski *et al.*, "Supernova Physics at DUNE," in *Supernova Physics at DUNE*. 8, 2016. arXiv:1608.07853 [hep-ex]. Conference Proceedings

Particle physics and model building

7. * M. A. Buen-Abad, J. Fan, M. Reece, and **CS**, "Challenges for an axion explanation of the muon g − 2 measurement," *JHEP* **09** (2021) 101, arXiv:2104.03267 [hep-ph]
6. U. Aydemir, D. Minic, **CS**, and T. Takeuchi, "B-decay anomalies and scalar leptoquarks in unified Pati-Salam models from noncommutative geometry," *JHEP* **09** (2018) 117, arXiv:1804.05844 [hep-ph]
5. * U. Aydemir, D. Minic, **CS**, and T. Takeuchi, "Pati–Salam unification from noncommutative geometry and the TeV-scale W_R boson," *Int. J. Mod. Phys. A* **31** no. 01, (2016) 1550223, arXiv:1509.01606 [hep-ph]
4. L. N. Chang, D. Minic, A. Roman, **CS**, and T. Takeuchi, "On the Physics of the Minimal Length: The Question of Gauge Invariance," *Int. J. Mod. Phys. A* **31** (2016) 1630012, arXiv:1602.07752 [hep-th]
3. * U. Aydemir, D. Minic, **CS**, and T. Takeuchi, "The 750 GeV diphoton excess in unified $SU(2)_L \times SU(2)_R \times SU(4)$ models from noncommutative geometry," *Mod. Phys. Lett. A* **31** no. 18, (2016) 1650101, arXiv:1603.01756 [hep-ph]
2. L. N. Chang, D. Minic, **CS**, and T. Takeuchi, "Observable Effects of Quantum Gravity," arXiv:1605.04361 [gr-qc]. for Gravity Research Foundation 2016 Awards
1. * U. Aydemir, D. Minic, **CS**, and T. Takeuchi, "Higgs mass, superconnections, and the TeV-scale left-right symmetric model," *Phys. Rev. D* **91** (2015) 045020, arXiv:1409.7574 [hep-ph]

INVITED TALKS

LANL P Division 2023/09
· Axion Magnetic Resonance: A Novel Enhancement in Non-accelerator Axion Searches

LANL Plasma Group 2023/09
· New Fundamental Interactions and Plasma Physics

U. Chicago 2023/04
· Distinguish Axion Models with SPARC

U. Notre Dame 2023/04
· Distinguish Axion Models with SPARC

CERN 2022/10
· Novel Astronomical Probes of Axions – with photon "baselines" of kpc, Mpc, and Gpc

IBS-CTPU 2022/05
· Novel Astronomical Probes of Axions – with baselines from kpc, Mpc, to Gpc

Ben-Gurion University 2022/05
· Searching for Axion-Photon Coupling with Baselines of kpc to Gpc

Beijing Normal University (Zhuhai) 2022/01
· Astrophysical Probes of Light Dark Sector

CAS-ITP 2021/12
· Galactic Rotation Curves vs. Ultralight Dark Matter

LBNL Theory 4D Seminar 2021/12
· Galactic Rotation Curves vs. Ultralight Dark Matter

UC Irvine 2021/12
· Axion Archaeology – Echos from Ancient Supernova Remnants

Fermilab Theory Seminar 2021/11
· Axion Archaeology – Echos from Ancient Supernova Remnants

University of Amsterdam 2021/11
· Axion Archaeology – Echos from Ancient Supernova Remnants

University of Chicago KCTP 2021/11
· Axion Archaeology – Echos from Ancient Supernova Remnants

University of Maryland 2021/11
· Novel Astrophysical Probes of Axion Dark Matter

UC Santa Cruz 2021/11
· Axion Echoes from Supernova Remnants

Hebrew University 2021/05
· Constraints on Axions from Cosmic Distance Measurements

Notre Dame 2021/02
· Constraints on Axions from Cosmic Distance Measurements

U. Oklahoma 2019/05
· Gravitational Wave Signatures of Beyond Standard Model Physics

Neutrino-Electron Scattering at Low Energies Workshop 2019/04
UMass, Amherst
· Constraints on Non-Standard Neutrino Interactions from Borexino Phase-II

Signals of Dark Matter in its Natural Habitat Workshop 2019/02
TRIUMF
· Boson Star from Repulsive Scalars, at LIGO and LISA

Carleton 2018/10
· Particle Phenomenology in the Era of Gravitational Wave Astronomy

Perimeter Institute 2018/10
· Particle Phenomenology in the Era of Gravitational Wave Astronomy

Joint Tufts/MIT Cosmology Seminars 2018/10
MIT
· Boson Star from Repulsive Light Scalars and Gravitational Waves

Queen's University 2018/10
· Particle Phenomenology in the Era of Gravitational Wave Astronomy

McGill 2018/10
· Particle Phenomenology in the Era of Gravitational Wave Astronomy

Stanford 2018/11
· Boson Star from Repulsive Light Scalars and Gravitational Waves

UC Irvine 2018/11
· Boson Star from Repulsive Light Scalars and Gravitational Waves

U. Utah 2018/11
· Boson Star from Repulsive Light Scalars and Gravitational Waves

North-East Cosmology Workshop 2018, McGill University 2018/03
McGill
· New Astrophysical Probes of Beyond SM Physics

Brown University 2017/12

· Gravitational Wave Cosmology & Particle Physics

New England Theoretical Cosmology and Gravity Workshop 2017/10
MIT
· The Limits of Dark Matter from Electroweak Symmetry Breaking

Duke Regional String Meeting 2015/10
Duke University
· Rethinking Gauge Theory through Connes' Noncommutative Geometry

SPOCK meeting 2015/08
University of Cincinnati
· Rethinking Gauge Theory through Connes' Noncommutative Geometry

TEACHING EXPERIENCE

Electromagnetism 2016
I was an external project consultant of the project "Modeling of Eddy Current Separation" in the Mining Engineering, Virginia Tech. I tutored the Ph.D. candidate, Selahattin Baris Yazgan, for the magnetic response and Eddy current during the Summer (April to September) of 2016.

Electromagnetism 2016
I performed independent recitation sessions for Prof. Leo Piilonen's undergraduate course Electromagnetism. I also worked as a lecturer to cover Prof. Piilonen's work travel for Belle II experiment.

Mathematical Methods 2015
I performed independent recitation sessions for Prof. Tatsu Takeuchi for the course of Mathematical Methods, intended for physics major undergraduate students. I also worked as a grader for the homework and exams for the course.

Modern Physics Laboratory 2014
I guided non-physics major undergraduates through modern physics laboratory. I also rated the laboratory reports.

OUTREACH AND COMMUNITY

LANL 2023 Student Symposium 2023
I participated the student summer program at Los Alamos National Laboratory. I was in charge of the mathematics project session at the final presentation and served as a judge to determine the final student award.

Summer STEM Circles @ Santa Fe Community College 2023
Guest speaker at the summer camp "Patterns: The Intersection of Art and Math" for middle school and high school students. The title of my presentation is "What I Learn from STEM Education".

LANL-Utah-Rice Joint Journal Club 2023-present
I have initiated LANL-Utah joint journal club. I have been the organizer of the joint journal club where the groups at both institutes join remotely to discuss latest arXiv paper and form new projects.

Cosmicdicord.net 2019-present
A blog that features background of my research, fun facts of astroparticle physics, as well as tutorials of simple coding projects.

Women in Science Project (WISP) 2018
Introduction of physics research to female starting undergraduates. Co-mentoring short term interns from selected groups.

Dartmouth-TRIUMF HEP Tools Bootcamp 2017
One of the three organizers. Invited authors of computational programs in both high energy physics and cosmology to give online lectures series through the Vidyo platform. The workshop had nearly 200 participants from six continents and received very positive feedback.

SCIENTIFIC PROGRAMMING

Languages	`Python, C, bash, MATLAB, C++, Mathematica`
ODE Solving	Shooting and relaxation for Singular Boundary Value problems
Boltzmann Solver	`CLASS`
MCMC	`emcee`, `MontePython`, `GENIE`, `MadGraph`
Parallel Computation	`mpi4py`, `multiprocessing`, `ipyparallel`, `TensorFlow-GPU`
Machine Learning	`TensorFlow`, `Keras`
CMB Analysis	`healpy`
Data Acquisition	`Scrapy` web scraping, `Regex` parsing
Data Simulation	CMB pixel level local non-Gaussian map simulation
Data Sets	BOSS DR12 (real/k space), Pantheon SNIa, SPARC, Bonamente galaxy clusters, Green's Catalog of SN Remnants, Planck 2018 likelihood, Borexino Phase II

SAMPLE CODE

BΛCDM and BSM in Quasars 2023

· Compute the cosmic distance inference with quasar data set
· MCMC test of axion, wCDM, and cosmographic model

Numerical Solver for Axion Magnetic Resonance 2023

· Solving the axion-photon oscillation in a spatially varying magnetic profile
· Test it in the monochromatic (laser) and extended energy spectrum (solar)

Ultralight Dark Matter from Galaxy Dispersion 2022

· load and parse SPARC data set
· construct χ^2 estimator and perform Frequentist analysis using `emcee` as a smart grid

Axion Echo from Supernova Remnant 2021

· regex parse SNR catalog (Green 2019), scrapy crawler of SN data, process of Haslam 408 MHz map
· construct supernova remnant light curve, compute echo signal from stimulated decay

Constraining Axions from Cosmic Distance Measurement 2020

· construct axion-photon conversion model inside IGM and ICM
· load and process Pantheon, Bonamente galaxy clusters, BOSS DR12
· perform Bayesian and Frequentist analysis with `emcee` sampler

Self-gravitating Bose-Einstein Condensate Solver 2019

· relaxation solver of Bose-Einstein condensate system with two axions
· shooting solver of Bose-Einstein condensate system with one axion, stiffness detection and switch

REFERENCES

Kfir Blum	Department of Particle Physics and Astrophysics, Weizmann Institute of Science Phone: +972-8-934-3181 Email: kfir.blum@weizmann.ac.il
JiJi Fan	Department of Physics, Brown University, Providence, RI 02912 Phone: +1-401-863-2641 Email: jiji_fan@brown.edu
Michael Graesser	Theoretical Division, Los Alamos National Laboratory, Los Alamos, NM 87545, USA Phone: N/A Email: graesser@lanl.gov
Tatsu Takeuchi	Department of Physics, Virginia Tech, Blacksburg, VA 24061-0435 Phone: +1-540-231-5333 Email: takeuchi@vt.edu
Tomer Volansky	School of Physics and Astronomy, Tel-Aviv University, Tel-Aviv 69978 Phone: +972-3-6407026 Email: tomerv@post.tau.ac.il