CHEN SUN

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RESEARCH EXPERIENCE

Los Alamos National Laboratory 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

Effective field theory
· dark matter direct detection *v.s.* EFT of stellar cooling
· 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*) 2019-2021

· China Postdoctoral Science Foundation
International Travel Research Award (*top 5% awarded*) 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. Up-to-date list can be found here

Novel astrophysical probes of axions

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," arXiv:2111.03070 [hep-ph]. accepted by Phys.Rev.D
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

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

OUTREACH AND COMMUNITY

Skype A Scientist 2021-present
Volunteer at Skype-A-Scientist, a nonprofit organization that connects scientists to classrooms in the world. The nearest event on my agenda is a meeting with two year-6 classes (48 students) in the UK on March 13, 2023.

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

CMB Machine Learning (on-going) 2022
- simulate CMB maps (gaussian and non-gaussian) at the pixel level
- process with noise maps from Planck FFP10
- apply neural network for anomaly hunting that gives well-defined statistics

Ultralight Dark Matter from Galaxy Dispersion 2021
- 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
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