

Core Francisco Park

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EDUCATION

Harvard University Ph.D. Candidate in Physics, GPA: 3.945/4.0 Advisors: Aravinthan Samuel, Hidenori Tanaka, Douglas Finkbeiner, Cecilia Garraffo	Cambridge, MA, U.S.A. 2019–Current
SNU Graduate Coursework	Seoul, South Korea 2019
KAIST B.S. in Physics, Advanced Major, GPA: 4.08/4.3, Summa Cum Laude – Thesis: “Real time DAQ setup and dead-time measurement for CAPP 18TDark Matter Axion Search and its first results”, Advisor: Prof. Jonghee Yoo – Focus: Astro-Particle Physics, Computational Physics, Biophysics	Daejeon, South Korea 2015–2019
Ecole Polytechnique Exchange Student – Data Structure, Numerical Analysis	Palaiseau, France 2017

EMPLOYMENT

NTT Research Research Intern Supervisor: Hidenori Tanaka – Project: Understanding Mechanisms and Capabilities of AI	Sunnyvale, CA, U.S.A. Jul. 2024–Sep. 2024
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CURRENT PROJECTS

Understanding Mechanisms and Capabilities of AI Advisor: Hidenori Tanaka, Ekdeep Singh Lubana – Understanding mechanisms and drivers of phase changes of In-Context Learning: Understanding how AI models transition between different mechanisms for in-context learning depending on the data distribution and design choices. – Understanding inference scaling: Understanding how in-context exemplars shape large language model’s representation and mechanisms. – Understanding Hidden Emergence of Capabilities: Understanding hidden emergence of capabilities in text-to-image generative models, showed a hidden phase transition of a compositional capability.	Harvard University Feb. 2024–Current
Deep Learning and Computer Vision for Neuroscience Advisor: Aravinthan Samuel, Jeff Lichtman	Harvard University Aug. 2020–Current

- **Few-Shot 3D Volumetric Tracking:** I implemented “targettrack”, enhancing modern CNN’s data efficiency by capture the global manifold structure of the data. This enabled the 3D tracking of individual neurons with minimal manual annotation.
- **Smart Electron Microscopy: Machine Learning Driven Accelerated Connectomics:** I used real-time, uncertainty aware machine learning to accelerate Electron Microscopy acquisition of brain sections for connectomics by actively allocating acquisition budget to sensitive areas. I achieved a 7x speedup of acquisition without loss of segmentation accuracy.

Machine Learning for Climate Change and Air Quality Monitoring

Harvard University

Advisor: Cecilia Garraffo, Douglas Finkbeiner

Sep. 2023–Current

- **MethaneSAT:** I am working on analyzing data efficiently using data driven spectral models to find clouds, shadows and methane plumes in hyperspectral image data.
- **TEMPO:** I am working on developping a convolutional VAE to jointly compress and segment hyperspectral data from TEMPO. The goal is to enhance prediction of NO densities, which is a major public health concern.

PAST PROJECTS

Emulating the structure of the universe using diffusion models

Harvard University

With: Carolina Cuesta-Lazaro

Aug. 2023–Aug. 2024

- **Large Scale Structure Emulation:** I am working on emulating the large scale structure of the universe using denoising diffusion probabilistic models.
- **Probabilistic Debiasing:** I am working on generating a probabilistic distribution over dark matter fields consistent with a given galaxy distribution.
- **Probabilistic Completion:** I am working on statistically motivated inpainting of fields for robust and unbiased astrophysical statistics.

Whole Brain Imaging

Harvard University

Advisor: Aravinthan Samuel

Apr 2021–May 2023

- **C. elegans Thermotaxis:** I worked on understanding the mechanism of the thermotactic behavior of *C. elegans*, revealing target neurons: AFD, BAG, RIA and revealing its connection to the gut’s calcium signaling via *pkc-2*.

Astro-statistics

Harvard University

Advisor: Douglas Finkbeiner

Sep. 2020–Oct. 2022

- **Fourier space sparse Wavelet Scattering Transform on the GPU:** Developped a high speed wavelet scattering transform on the GPU using sparse representations of wavelets in Fourier space.
- **Quantifying the validity of high-dimensional statistics:** High-dimensional Gaussianity tests have revealed that the constraints on cosmological parameters from Fisher forecast are sometimes under-estimated.
- **Estimating correlations of Large Scale structure and galactic dustmaps:** Developped an error estimation scheme of correlations of the large scale structure of the universe and galactic dustmaps using mock-rotated universes.

Experimental Particle Physics

KAIST

Advisor: Jonghee Yoo

Dec. 2018–Feb. 2019

- **Real-time DAQ system for the CAPP18T Axion Dark Matter Experiment:** I worked on developping a real time DAQ system with minimal dead-time for the CAPP18T Axion Dark Matter Experiment

PUBLICATIONS

First authors are marked with a *.

5.1 First Author or Significant Contribution

1. **C.F. Park***, E.S. Lubana, H. Tanaka; “Algorithmic Phases of In-Context Learning”; *under review*
2. **C.F. Park***, A. Lee*, E.S. Lubana*, Y. Yang, M. Okawa, K. Nishi, M. Wattenberg, H. Tanaka; “In-Context Learning of Representations”; *under review*
3. Y. Yang*, **C.F. Park**, E.S. Lubana, M. Okawa, W. Hu, H. Tanaka; “Dynamics of Concept Learning and Compositional Generalization”; *under review*
4. **C.F. Park***, A. Lee*, E.S. Lubana, Y. Yang, K. Nishi, M. Okawa, H. Tanaka; “Structured In-Context Task Representations”; *under review*
5. **C.F. Park***, E.S. Lubana, H. Tanaka; “Understanding the Transient Nature of In-Context Learning: The Window of Generalization”; *accepted to NeurIPS 2024 Workshop on Scientific Methods for Understanding Deep Learning*
6. **C.F. Park***, M. Okawa*, A. Lee, E.S. Lubana, H. Tanaka; “Emergence of Hidden Capabilities: Exploring Learning Dynamics in Concept Space”; [NeurIPS 2024 Spotlight](#)
7. **C.F. Park***, M. Okawa, A. Lee, E.S. Lubana, H. Tanaka; “Hidden Learning Dynamics: Capability Emerges Before Behavior in Compositional Generalization”; [ICML 2024 Workshop on High-dimensional Learning Dynamics](#), Jul 2024
8. **C.F. Park***, N. Mudur, C. Cuesta-Lazaro, Y. Ni, V. Ono, D.P. Finkbeiner; “3D Reconstruction of Dark Matter Fields with Diffusion Models: Towards Application to Galaxy Surveys”; [ICML 2024 Workshop: AI for Science](#), Jul 2024
9. V. Ono*, **C.F. Park**, N. Mudur, Y. Ni, C. Cuesta-Lazaro, F. Villaescusa-Navarro; “Debiasing with Diffusion: Probabilistic reconstruction of Dark Matter fields from galaxies with CAMELS”; [The Astrophysical Journal 970 \(2\), 174](#), Jul 2024
10. **C.F. Park***, M.B. Keshteli*, K. Korchagina, A. Delrocq, V. Susoy, C.L. Jones, A.D.T. Samuel, S.J. Rahi; “Automated neuron tracking inside moving and deforming animals using deep learning and targeted augmentation”; [Nature Methods](#), Jan 2024
11. **C.F. Park***, V. Ono, C. Cuesta-Lazaro, Y. Ni, N. Mudur; “Probabilistic reconstruction of Dark Matter fields from galaxies using diffusion models”; [NeurIPS 2023 Workshop on Machine Learning and the Physical Sciences](#), [arxiv](#), Oct 2023
12. **C.F. Park***, C. Garraffo; “Hyperspectral shadow removal with iterative logistic regression and latent Parametric Linear Combination of Gaussians”; [NeurIPS 2023 Workshop on Tackling Climate Change with Machine Learning](#), [arxiv](#), Oct 2023
13. Y. Meirovitch*, **C.F. Park***, L. Mi*, P. Potocek*, S. Sawmya, Y. Li, Y. Wu, R. Schalek, H. Pfister, R. Schoenmakers, M. Peemen, J.W. Lichtman, A.D.T. Samuel, N. Shavit; “SmartEM: machine-learning guided electron microscopy”; [Under Review at Nature Methods](#), Oct 2023
14. N. Mudur*, **C.F. Park**, D.P. Finkbeiner; “Stellar Reddening Based Extinction Maps for Cosmological Applications”; [The Astrophysical Journal 949 \(2\), 47](#), May 2023
15. **C.F. Park***, E. Allys, F.V. Navarro, D.P. Finkbeiner; “Quantification of high dimensional non-Gaussianities and its implication to Fisher analysis in cosmology”; [The Astrophysical Journal 946 \(2\), 107](#), Apr 2023
16. **C.F. Park***; “Real time DAQ setup and dead-time measurement for CAPP 18T Dark Matter Axion Search and its first results”; B.S. Thesis; Dec 2018

5.2 Contributing Authored Publications

1. Y. Li*, **C.F. Park**, D. Xenos, C. Bishop, D.R. Berger, A.D.T. Samuel, B. Wester, J.W. Lichtman, H. Pfister, W. Li, Y. Meirovitch; “EM-Compressor: Electron Microscopy Image Compression in Connectomics with Variational Autoencoders”; [bioarxiv](#), Jul 2024
2. E.C. Pavarino*, E. Yang*, N. Dhanyasi, M. Wang, F. Bidel, X. Lu, F. Yang, **C.F. Park**, M.B. Renuka, B. Drescher, A.D.T. Samuel, B. Hochner, P.S. Katz, M. Zhen, J.W. Lichtman, Y. Meirovitch; “mEMbrain: an interactive deep learning MATLAB tool for connectomic segmentation on commodity desktops”; [Front. Neural Circuits Vol 17](#), June 2023
3. L. Mi*, T. He*, **C.F. Park**, H. Wang, Y. Wang, N. Shavit; “Revisiting Latent-Space Interpolation via a Quantitative Evaluation Framework”; [arxiv](#), Oct 2021
4. V. Susoy*, W. Hung, D. Witvliet, J.E. Whitener, M. Wu, **C.F. Park**, B.J. Graham, M. Zhen, V. Venkatachalam, A.D.T. Samuel; Natural sensory context drives diverse brain-wide activity during *C. elegans* mating; [Cell](#), Sep 2021

TALKS & ORAL PRESENTATIONS

1. **C.F. Park**; “Scaling and In-Context Learning of Large Language Models”; *NTT Physics&Informatics Laboratory Journal Club*, [Slides](#), July 2024
2. **C.F. Park**; “Probabilistic Completion of Astrophysical Fields for Robust Statistics with Diffusion Models”; *EAS 2024, Padova*; Jul 2 2024; [Slides](#)
3. **C.F. Park**; “3D probabilistic reconstruction of the local dark matter from galaxies”, *Astro AI Workshop 2024, Center for Astrophysics*; Jun 20 2024; [Video](#); [Slides](#)
4. **C.F. Park**; “Debiasing with Diffusion: Probabilistic reconstruction of Dark Matter fields from galaxies”; *ITC Lucheon Talk, Center for Astrophysics*; Mar 7 2024; [Video](#); [Slides](#)
5. **C.F. Park**; “Reconstruction of the local dark matter using diffusion models”; *Workshop on AI-driven Discovery in Physics and Astrophysics at Kavli IPMU*; Jan 23 2024; [Slides](#)
6. **C.F. Park**; “Diffusion Models for Cosmology”; *AstroAI Lunch Talk, Center for Astrophysics*; Oct 30 2023; [Slides](#)
7. **C.F. Park**; “How is AI used in the Physical Sciences?”; *Hansung Science High School Mentoring Talk @ Harvard University*; Oct 13 2023; [Slides \(Korean\)](#)
8. **C.F. Park**; “Mstar2Mcdm using Diffusion Models: Generating Cold Dark Matter density fields conditioned on stellar mass fields using Denoising Diffusion Probabilistic Models”; *Camels Virtual Telecoms hosted by the Flatiron Institute*, Sep 20 2023; [Slides](#)
9. **C.F. Park**, S. Rahi, A.D.T. Samuel, M.B. Keshteli, K. Korchagina, A. Delrocq, V. Susoy, C. Jones; “Automated neuron tracking using deep learning and targeted augmentation allows fast collection of *C. elegans* whole brain calcium activity during behavior”, *American Physical Society March Meeting 2023*
10. **C.F. Park**, Erwan Allys, Francisco Villaescusa-Navarro, Douglas Finkbeiner; “On the Gaussianity of Non-Gaussian probes of Large Scale Structure”; *American Astronomical Society 240 (2022)*
11. **C.F. Park**; “Dark Matter Axion Search Experiment using 18T HTS Magnet”; *Stockholm International Youth Science Seminar 2018*; [Video](#)

POSTER PRESENTATIONS

1. **C.F. Park**, E.S. Lubana, H. Tanaka; “Emergence of In-Context Learning Beyond Bayesian retrieval: A mechanistic study”; [New England Mechanistic Interpretability Workshop 2024](#), Aug 2024

2. **C.F. Park**, M. Okawa, A. Lee, E.S. Lubana, H. Tanaka; “Hidden Learning Dynamics: Capability Emerges Before Behavior in Compositional Generalization”; *NeurIPS 2023 Workshop on Machine Learning and the Physical Sciences*, [ICML 2024 Workshop on High-Dimensional Learning Dynamics](#), Jul 2024
3. **C.F. Park**, N. Mudur, C. Cuesta-Lazaro, Y. Ni, V. Ono, D.P. Finkbeiner; “3D Reconstruction of Dark Matter Fields with Diffusion Models: Towards Application to Galaxy Surveys”; [ICML 2024 Workshop: AI for Science](#), Jul 2024
4. **C.F. Park**, V. Ono, C. Cuesta-Lazaro, Y. Ni, N. Mudur; “Probabilistic reconstruction of Dark Matter fields from galaxies using diffusion models”; *NeurIPS 2023 Workshop on Machine Learning and the Physical Sciences*, Dec 2023
5. **C.F. Park**, M. Nasr, M. Perez-Carrasco, E. Walker, D. Finkbeiner, C. Garraffo, “Hyperspectral shadow removal with iterative logistic regression and latent Parametric Linear Combination of Gaussians”, *NeurIPS 2023 Workshop on Tackling Climate Change with Machine Learning*, Dec 2023
6. **C.F. Park**, Y. Meirovitch, P. Potocek, S. Sawmya, Y. Li, R. Schalek, J.W. Lichtman, M. Peeman, A.D.T. Samuel, N. Shavit, “SmartEM: Faster Connectomics Using Deep Error Prediction Based Rescanning”; [ICML 2023 Workshop for Computational Biology](#), Jul 2023
7. **C.F. Park**, H. Casademunt, V. Susoy, A.D.T. Samuel, “Freely Moving Whole Brain Imaging of *C. elegans* under a thermal stimulus”, *International C.elegans conference 2023*, Jun 2023
8. **C.F. Park**, M.B. Keshteli, Vladislav Susoy, K. Korchagina, A. Delrocq, A.D.T. Samuel, S.J. Rahi, “Automated neuron tracking inside moving and deforming animals using deep learning and targeted augmentation”, *COSYNE 2023*, Mar 2023
9. **C.F. Park**, K. Kim, J. Yoo “Data acquisition system for dark matter Axion search experiment using 18 T HTS magnet at CAPP/IBS”, *Korean Physical Society Meeting 2018*, Oct 2018

REVIEWING

- NeurIPS 2024 Workshop on Scientific Methods for Understanding Deep Learning (4 papers) 2024
- ICML 2024 Workshop on Mechanistic Interpretability (3 papers) 2024
- ICLR 2024 Workshop on Tackling Climate Change with Machine Learning (4 papers) 2024

SCHOLARSHIPS

- Purcell Fellowship, Harvard University 2019–2020
- Doctoral Study Abroad Scholarship, KFAS 2019–Current
- Physics Department Honorary Scholarship, KAIST 2018
- Undergraduate Student Scholarship, KFAS 2017–2019
- Korea Presidential Science Scholarship, KOSAF 2015–2019
- Full Tuition Scholarship, KAIST 2015–2019

AWARDS

- Second Place in Citadel Datathon, Virtual 2023
- Best Machine Learning Project Award, KIAS 2019
- Summa Cum Laude, KAIST 2019
- Best Project Award Physics Winter Camp, KIAS 2018
- Dean’s List, KAIST Physics 2017
- Best Buddy Award, KAIST International Office 2016
- Fall Dean’s List, KAIST 2015
- Spring Dean’s List, KAIST 2015

EXTRACURRICULAR ACTIVITIES

- KITP Neurophysics of Locomotion School 2022
Summer Student
- APCTP-POSTECH Biophysics School 2019
Summer Student
- KIAS-SNU Physics Winter Camp 2018
Best Project Award: Accretion of Supermassive Black Holes
- Stockholm International Youth Science Seminar 2018
Korean Representative
- APCTP-NIMS-KISTI-KASI Summer School on Numerical Relativity, 2018
Summer Student
- APCTP-POSTECH Biophysics School 2018
Summer Student
- KAIST International Discovery Program 2017
Selected Team
- Asian Science Camp 2014
Korean Representative
- Molecular Frontiers Symposium 2013
School Representative

TEACHING

- **Teaching Fellow** at Harvard University Spring 2022
Physics as a Foundation for Science and Engineering
- **Teaching Fellow** at Harvard University Fall 2021
Physics of Sensory systems
- **Teaching Assistant** at Seoul National University Spring 2019
Physics Lab I
- **General Physics Tutor** at KAIST Fall 2018
General Physics 2
- **General Physics Tutor** at KAIST Spring 2018
General Physics 1
- **General Physics Tutor** at KAIST Spring 2017
General Physics 1
- **General Physics Tutor** at KAIST Fall 2016
General Physics 2
- **General Physics Tutor** at KAIST Spring 2016
General Physics 1

SKILLS& BACKGROUND

- **Experience with Diverse Working Environment:** Collaborative, Individual, Project Management, Code-Contributor, Software-Engineering
- **Computational Methods:** GPU and CUDA computation, Fourier Analysis, Time Series, Bayesian Inference, High Performance Computing, Data Structure, Human-Computer Interfacing

- **ML/AI Methods:** Probabilistic Deep Learning, Diffusion Models, Statistical Machine Learning, Uncertainty-Aware Machine learning.
- **Experimental:** DAQ, Hardware control, Automation, PID Control, Optics, Microscopy, Simple Genetics
- **Programming Languages:** Python (advanced), Julia (advanced), LabView (intermediate), Matlab (intermediate), Java (basic), C++ (basic), C (basic), HTML (basic)

LANGUAGES

- **Korean:** Native
- **English:** Native
 - **TOEFL:** 114/120
 - **TOEIC:** 985/990
- **French:** Semi-Native
 - **TCF:** 599 C1/C2/C1
- **Spanish:** Novice

REFERENCES

- Research Advisor: Hidenori Tanaka NTT Research at Harvard University, 2024–Current
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- Research Advisor: Cecilia Garraffo Center for Astrophysics, 2023–Current
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- Past Research Advisor: Aravinthan Samuel Harvard University, 2021–2023
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- Research Advisor: Douglas Finkbeiner Harvard University, 2020–Current
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- Past Research Advisor: Daniel Eisenstein Harvard University, 2019–2021
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- Past Research Advisor: Jonghee Yoo KAIST, 2018–2019
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- Past Academic Advisor: Hawoong Jeong KAIST, 2015–2019
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