

# Jinyeop Song

Ph.D. Candidate in Physics and Statistics ·

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## Education

### Massachusetts Institute of Technology (MIT)

Ph.D. Candidate in Physics and Statistics - GPA: 4.35/4.5

Supervisor: Jeff Gore

Cambridge, MA, USA

Aug 2020 - June 2026 (Expected)

### Korea Advanced Institute of Science and Technology (KAIST)

B.S. in Physics (Major) and Math (Minor) - GPA: 4.16/4.3 (Summa Cum Laude)

Daejeon, Korea

Mar 2014 - Jun 2020

## Research Interests

With a strong expertise in *ML* and *Physics*, I am interested in:

(1) **Multi-LLM Agent RL**: developing practical RL methods to jointly tune multiple models/agents with distinct roles (e.g., *solver* and *validator*), inspired by ecological and evolutionary dynamics.

(2) **LLM Agent Foundations**: extending my prior work on (1) novel evaluation frameworks for LLM agent [2, 4], and (2) tool-augmented reasoning with RL [1].

## Professional Experience

### MIT-IBM Watson AI Lab

Research Intern (Summer)

Cambridge, MA, USA

2025

- Developed a knowledge-graph-augmented RAG framework for LLMs using multi-turn reinforcement learning (RL), achieving state-of-the-art accuracy with 47% lower generation cost and 6% higher transferability compared with prior methods.

### Machine Learning Alignment and Theory Scholars

Research Fellow

Berkeley, CA, USA

2025

- Proposed a novel, goal-agnostic evaluation framework for LLM agents using the information-theoretic measure (i.e. empowerment: mutual information between actions and future states).

### MIT

Graduate Research Assistant (PI: Prof. Jeff Gore)

Cambridge, MA, USA

Feb 2021 - Present

- Explored emergent phenomena (e.g., neural scaling behaviors, in-context learning) in LLMs, linking theories with empirical results.
- Developed a foundation model for human methylation data that predicts patient aging and chronic disease.
- Explored how interspecies interaction strength shapes the merging of two microbial communities using experiments and simulations.

### Samsung Electronics Research

Research Intern (Summer)

Suwon, Korea

2020

- Investigated post-quantum cryptography (lattice-based encryption methods) for use in DRAM products.

### Harvard-MIT Health Sciences and Technology

Research Intern (Summer)

Boston, MA, USA

2019

- Developed a neural connectome reconstruction algorithm that maps brain images into 3D space.

### KAIST

Undergraduate Research Assistant

Daejeon, Korea

Jul 2014 - Aug 2020

- Biomedical Optics (PI: Prof. YongKeun Park): developed deep-learning algorithms for 3D time-lapse tracking of CAR-T cells; built classification models using 3D refractive-index maps for rapid pathogen identification.
- Chromatin/Protein Engineering (PI: Prof. Wonki Cho): implemented thermodynamic simulation code for multivalent antibody binding.
- Quantum & Nanophotonics (PI: Prof. YongHoon Cho): investigated exciton-polariton coupling in GaN nanoporous DBR cavities.

## Publications

\* indicates equal contributions.

### AI related

[1] **Song, J.**, Wang, S., Shun, J., & Zhu, Y. “Efficient and Transferable Agentic Knowledge Graph RAG via Reinforcement Learning.” *arXiv preprint* (2025). [\[PDF\]](#)

[2] **Song, J.**, Gore, J. & Kleiman, M. ‘Estimating Empowerment of Langague Model Agent” *arXiv preprint* (2025). [\[PDF\]](#)

[3] Akke, M., Yang, S., Ruža, J., **Song, J.**, Pan, E., & Gómez-Bombarelli, R. *When Do LLMs Improve Bayesian Optimization? A Systematic Comparison Across Molecular and Protein Design. NeurIPS 2025, AI4Science Workshops.* [\[PDF\]](#)

[4] Son, G., Hong, J., Fan, H., Nam, H., Ko, H., Lim, S., **Song, J.**, Choi, J., Paulo, G., Yu, Y., & Biderman, S. “When AI Co-Scientists Fail: SPOT - Benchmark for Automated Verification of Scientific Research.” *arXiv preprint* (2025) [\[PDF\]](#),

[5] **Song, J.\***, Han, S.\*, Argawal, P., & Gore, J. “Emergence and Effectiveness of Task Vectors in In-Context Learning : An Encoder Decoder Perspective” *ICML 2025, Spotlight* [\[Link\]](#),

[6] Yang, S., Nam, J., Perez, T., **Song, J.**, Du, X., & Gomez-Bombarelli, R. “Probing the Embedding Space of Protein Foundation Models through Intrinsic Dimension Analysis” *Neurips 2025, AIDrugX Workshop*[\[Link\]](#),

[7] Ying, A.\*, **Song, J.\***, Cui. H.\* ... et al. “MethylGPT - Foundational GPT-like model for human methylation data” 2024. submitted for Nature Methods [\[Link\]](#)

[8] Pearce, T., & **Song, J** “Reconciling Kaplan and Chinchilla Scaling Laws” *TMLR*, 2024. [\[Link\]](#)

[9] **Song, J.\***, Liu, Z.\*, Tegmark, M., & Gore, J. “Resource model for neural scaling law,” 2024 *ICRL, BGPT Workshop*, 2024. [\[Link\]](#)

### Biophysics related

[1] **Song, J.**, Hu, J. & Gore, J. “Interspecies Interaction Shapes Community-level Selection in Microbial Coalescence,” *In Preparation*, 2025.

[2] **Song, J.\***, Jeong, B.S.\*, ..., & Oh, B.H. “Noncovalent antibody catenation on a target surface greatly increases the antigen-binding avidity,” *Elife*, 9: e81646, 2023. [\[Link\]](#)

[3] Lee, M.\*, Lee, Y. H.\*, **Song, J.\***, ..., & Park, Y. “Deep-learning-based three-dimensional label-free tracking and analysis of immunological synapses of CAR-T cells,” *Elife*, 9, 2020. [\[Link\]](#)

[4] Kim, G., Ahn, D., Kang, M., Jo, Y., Ryu, D., Kim, H., **Song, J.**, ..., & Kim, K. “Rapid species identification of pathogenic bacteria from a minute quantity exploiting three-dimensional quantitative phase imaging and artificial neural network,” *Light, Science & Applications.* [\[Link\]](#)

## Awards and Honors

|             |   |
|-------------|---|
| 2025        | <b>Scholarship:</b> “Machine Learning and Theory Scholarship(MATS)” |
| 2023        | <b>Scholarship:</b> “Mokam Research Scholarship”                    |
| 2016        | <b>Fellowship:</b> “KAIST Presidential Fellowship (KPF)”            |
| 2023        | <b>Award:</b> “2020 KPS Best Oral Presentation Award”               |
| 2020        | <b>Honorary Title:</b> “Excellent Graduate of KAIST”                |
| 2014 - 2020 | <b>Scholarship:</b> “Korea Presidential Science Scholarship”        |

## Teaching & Extracurricular Experiences

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|-------------|---|-------|
| 2024 - 2025 | <b>Organizer:</b> AI Weekly Journal Club in Physics of Living Systems | MIT   |
| 2023        | <b>Teaching Assistant:</b> “Complex Systems Biology”                  | MIT   |
| 2015 - 2018 | <b>Freshmen Tutoring Program</b>                                      | KAIST |

## Skills

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|--------------------|--|
| <b>Programming</b> | Python, Matlab, R, Github, Torch, and Cuda           |
| <b>Languages</b>   | English(Fluent), Korean(Native), Chinese(Elementary) |

## References

- Prof. Max Kleiman @ UW
- Prof. Jeff Gore @ MIT
- Prof. Oh, Byung-Ha @ KAIST