Welcome to MIT Physics!

Interdisciplinary Studies at MIT:

Institute for Artificial Intelligence and Fundamental Interactions (IAIFI)

Interdisciplinary PhD in Physics, Statistics, and Data Science (PhysSDS)

Jesse Thaler | Mike Williams | Marisa LaFleur

IAIFI Director | IAIFI Deputy Director | IAIFI Project Manager

MIT Physics Open House — April 3, 2024

NSF Institute for Artificial Intelligence and Fundamental Interactions (IAIFI)

Jesse Thaler | Mike Williams | Marisa LaFleur
IAIFI Director | IAIFI Deputy Director | IAIFI Project Manager

April 3, 2024

Deep Learning (AI)

+

Deep Thinking (Physics)

=

Deeper Understanding

Generated using Adobe Firefly:
drawing of a brain on a chalkboard with physics equations written inside of it; chalkboard is surrounded by neural networks being injected into the brain; use purple and teal

Pioneering interdisciplinary

RESEARCH

Empowering the next generation of

TALENT

Building a dynamic

COMMUNITY

IAIFI Resources & Opportunities

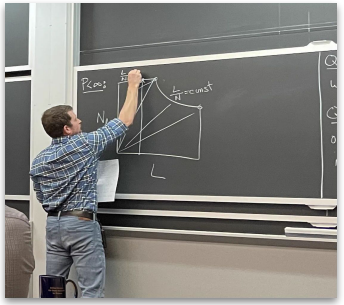
Computing Resources
IAIFI hosts its own set of NVIDIA A100 nodes at the Harvard Cannon cluster, available to IAIFI Investigators

IAIFI Journal Club
Led by junior members, opportunity for junior members to present and discuss research

IAIFI Friday Afternoons
Discussion Seminars, Public Colloquia, Industry Lunches, and Lightning Talks/Thematic Discussions, followed by networking receptions

Early Career and Equity Committee
IAIFI members at all careers stages advise IAIFI on matters related to well being of the community and the interests of junior members

IAIFI Community
Regular networking events bring together IAIFI researchers across institutions and departments and the IAIFI Penthouse offers a communal workspace



IAIFI Summer School and IAIFI Summer Workshop
- IAIFI Summer School: August 5–9, 2024 at MIT!
- IAIFI Summer Workshop: August 12–16, 2024 at MIT, pre-registration open!

IAIFI Partner Organizations

Critical mass of AI + Physics expertise in Boston area!

Senior Investigators: 19 Physicists + 8 AI Experts + 21 IAIFI Affiliates

Junior Investigators: ≈31 FTE PhD Students, ≈7 IAIFI Fellows in steady state

Pulkit Agrawal
Lisa Barsotti
Isaac Chuang
William Detmold
Bill Freeman
Liang Fu
Philip Harris
Erik Katsavounidis
Lina Necib
Alexander Rakhlin
Dan Roberts
Phiala Shanahan
Tracy Slatyer
Tess Smidt
Marin Soljacic
Washington Taylor
Max Tegmark
Jesse Thaler
Mark Vogelsberger
Mike Williams

Carlos Argüelles-Delgado
Demba Ba
Edo Berger
Mike Douglas
Cora Dvorkin
Daniel Eisenstein
Doug Finkbeiner
Cecilia Garraffo
Cengiz Pehlevan
Artan Sheshmani
Haim Sompolinsky
Matthew Schwartz
Hidenori Tanaka
Ashley Villar
Susanne Yelin
Todd Zickler

Olga Goulko
Rahul Kulkarni
Akira Sone

Ning Bao
James Halverson
Brent Nelson
Fabian Ruehle

Aram Apyan
An Huang
Tyler Maunu

Shuchin Aeron
Abiy Tasissa
Taritree Wongjirad

NSF ExpandAI Partner!

Sudhir Malik
Vidya Manian

MIT Physics Involvement in IAIFI

Faculty: 15 IAIFI Postdoctoral Fellows: 8 Junior Investigators (Postdocs, Graduate Students): 51

Physics

Faculty Senior Investigators

Jesse Thaler
Director

High Energy Theory

Mike Williams
Deputy Director

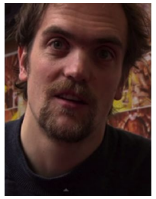
High Energy Experiment

Tracy Slatyer
Communications Committee

Astroparticle Theory

Phiala Shanahan
Physics Theory Research Lead

Nuclear Theory

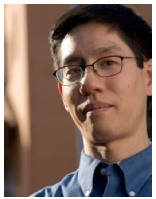


Phil Harris
Physics Experiment Research Lead

High Energy Experiment

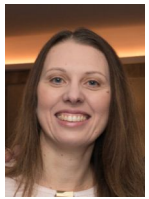
Will Detmold
Computing Committee Chair

Nuclear Theory



Ike Chuang
MITx Coordinator

Quantum Physics



Lisa Barsotti
Fellowship Committee Chair

Gravitational Waves

Lina Necib
Public Engagement Committee Chair

Astrophysics

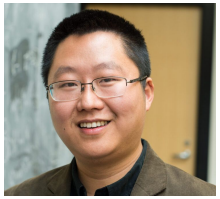
Marin Soljacic
Industry Partnership Committee Chair

Physics for AI

Max Tegmark

Physics for AI

Affiliates



Liang Fu

Condensed Matter Physics

Erik Katsavounidis

Gravitational Waves

Wati Taylor

String Theory

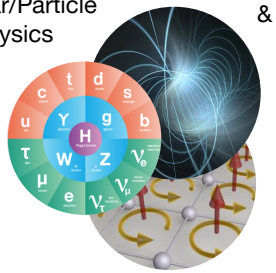
Mark Vogelsberger

Astrophysics

IAIFI Research Impact

Nuclear/Particle Physics

Quantum Field Theory & String Theory



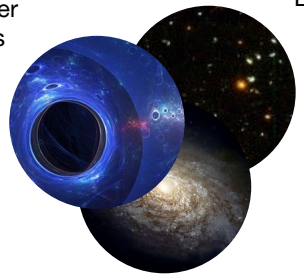
Quantum Many-Body Physics

Theoretical Physics

Leveraging AI to understand the theoretical underpinning of fundamental physics

Dark Matter Searches

Large-Scale Structure



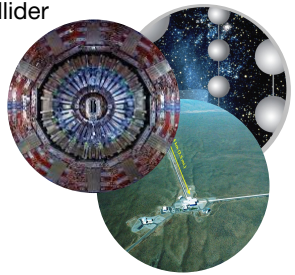
Galaxy Formation

Astrophysics

Using AI techniques to understand the universe on cosmological scales

Large Hadron Collider

IceCube Neutrino Observatory



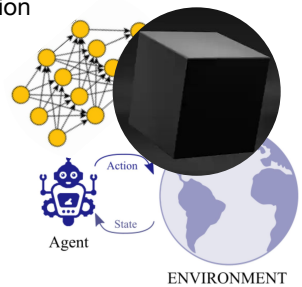
LIGO Gravitational Waves

Experimental Physics

Enhancing the operations and analysis of flagship NSF experiments through AI

Representation Learning

Robust/ Interpretable AI



Reinforcement Learning

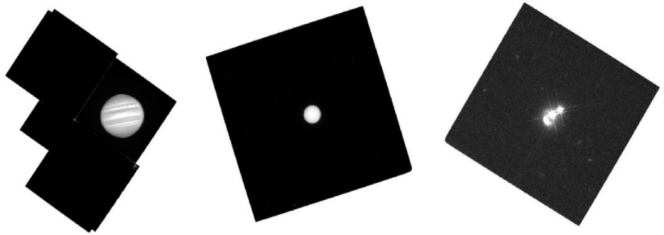
Foundational AI

Infusing physics principles into AI to create state-of-the-art AI innovations

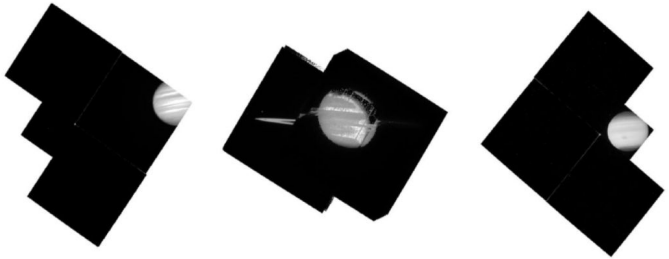
LLMs for Scientific Discovery


The next generation of AI, developed by the next generation of talent:
With Siddharth Mishra-Sharma (IAIFI Fellow), Yiding Song (RSI Intern)

"Show me Hubble images of Jupiter" (CLIP-ViT-B/16):



After Fine-Tuning with Hubble Proposal Abstracts:



"What is this a picture of?"


SN1987A

CLIP-ViT-B/16: "gravitational lens"
Fine-Tuned: "supernova remnant"

Combining power of AI technologies with insights from physics

Get Involved with IAIFI

(whether or not you come to MIT…)

Follow IAIFI

Join our Mailing List
http://mailman.mit.edu/mailman/listinfo/iaifi-news

Follow on X (Twitter)
@iaifi_news

Follow on LinkedIn
https://www.linkedin.com/company/iaifi/

Watch on YouTube
https://www.youtube.com/IAIFIInstituteforAIFundamentalInteractions

https://iaifi.org

Upcoming Talks

2:00–3:00 pm
MIT 26-414 and on Zoom

Jennifer Ngadiuba
Associate Scientist, Fermilab
Friday, April 12, 2024

Gaia Grosso
IAIFI Fellow
Friday, April 26, 2024

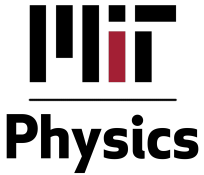
IAIFI Summer Workshop 2024
August 12–August 16

https://iaifi.org/summer-workshop.html

Pre-registration now open!

Learn more about how to become a "Friend of IAIFI" or Junior Investigator:
https://iaifi.org/junior-researchers.html

PhD in Physics, Statistics, and Data Science



Physics, Statistics, and Data Science (PhysSDS) PhD program open to **all MIT Physics PhD students**

PhD in Physics, Statistics, and Data Science

Interdisciplinary PhysSDS PhD is a collaboration between
MIT Physics Department, MIT Statistics and Data Science Center (SDSC), and IAIFI

- Open to **current MIT Physics PhD students**
- Establishes a **verifiable credential** that helps Physics students pursue careers in the fields of data science and artificial intelligence
- Provides **essential training** for students working with these techniques
- **Facilitates mentoring** relationships with SDSC experts outside of Physics
- Utilizes existing structure of MIT's Interdisciplinary Doctoral Program in Statistics

PhysSDS Committee

- Jesse Thaler (co-chair)
- Mike Williams (co-chair)

Advisors:

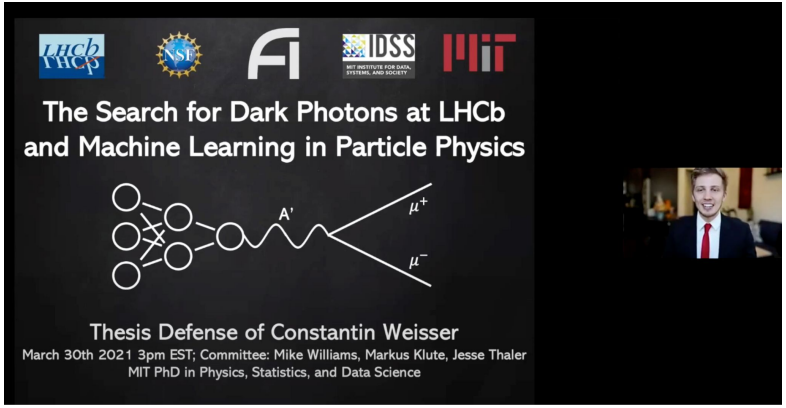
- Isaac Chuang
- Janet Conrad
- William Detmold
- Philip Harris
- Jacqueline Hewitt
- Kiyoshi Masui
- Leonid Mirny
- Christoph Paus
- Phiala Shanahan
- Marin Soljačić
- Washington Taylor
- Max Tegmark

Twelve members of the Physics Department, three from each division, are serving as advisors on the PhysSDS Committee. Our preference is that at least one member of this committee is on a candidate's PhD Thesis Committee.

PhD in Physics, Statistics, and Data Science

What kind of students should do this Interdisciplinary program? You!

- Students come from a **variety of fields**: nuclear physics, biophysics, neutrino physics, plasma physics, astrophysics, particle physics, quantum physics
- Students have been **hired for internships** at Microsoft Research, Meta AI, Amazon Alexa, NASA Frontier Development Lab, Jump Trading, TikTok
- **9 PhysSDS PhDs awarded**; jobs after graduation include:
  - Consultant Data Scientist, QuantumBlack
  - Quantitative Strategist, Virtu Financial
  - Associate Research Scholar, Princeton
  - Postdoctoral Researcher, MIT Plasma Science and Fusion Center
- **6 current students enrolled** (many more planning to join)



- First recipient in May 2021: IAIFI member Constantin Weisser: *"The Search for Dark Photons at LHCb and Machine Learning in Particle Physics"*
- Currently Data Science Consultant at QuantumBlack

PhD in Physics, Statistics, and Data Science

Requirements

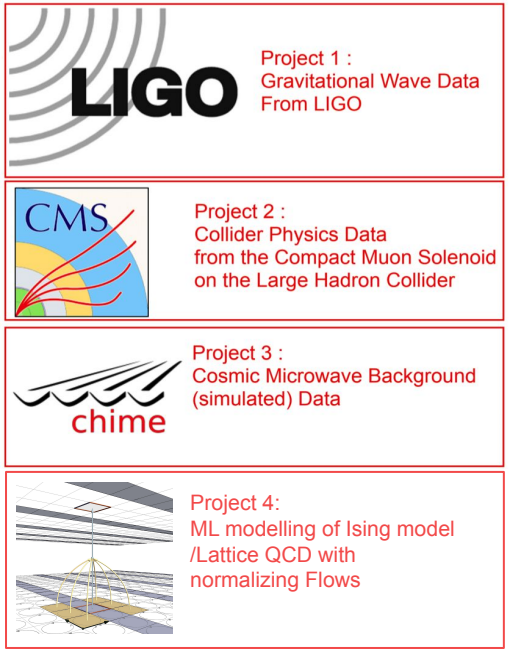
- Participate in the **Doctoral Seminar in Statistics**
- Take four classes, one each in the areas of **Probability**, **Statistics**, **Computation & Statistics**, and **Data Analysis**.
- Submit and defend a **PhD thesis that involves the utilization of statistical methods** in a substantial way
- Satisfy all **requirements of MIT Physics PhD** (you are allowed to double count courses)

Course Options

- **SEMINAR**
  - IDS.190 – Doctoral Seminar in Statistics and Data Science (*may be substituted by IDS.955 Practical Experience in Data, Systems and Society*)
- **PROBABILITY**
  - 6.7700[J] Fundamentals of Probability *or*
  - 18.675 – Theory of Probability
- **STATISTICS**
  - 18.655 – Mathematical Statistics *or*
  - 18.6501 – Fundamentals of Statistics *or*
  - IDS.160[J] – Mathematical Statistics: A Non-Asymptotic Approach
- **COMP & STAT**
  - 6.C01/6.C51 – Modeling with Machine Learning: From Algorithms to Applications *or*
  - 6.7810 Algorithms for Inference *or*
  - 6.8610 (6.864) Advanced Natural Language Processing *or*
  - 6.7900 (6.867) Machine Learning *or*
  - 6.8710 (6.874) Computational Systems Biology: Deep Learning in the Life Sciences *or*
  - 9.520[J] – Statistical Learning Theory and Applications *or*
  - 16.940 – Numerical Methods for Stochastic Modeling and Inference *or*
  - 18.337 – Numerical Computing and Interactive Software
- **DATA ANALYSIS**
  - 8.316 – Data Science in Physics *or*
  - 6.8300 (6.869) Advances in Computer Vision *or*
  - 8.334 – Statistical Mechanics II *or*
  - 8.371[J] – Quantum Information Science *or*
  - 8.591[J] – Systems Biology *or*
  - 8.592[J] – Statistical Physics in Biology *or*
  - 8.942 – Cosmology *or*
  - 9.583 – Functional MRI: Data Acquisition and Analysis *or*
  - 16.456[J] – Biomedical Signal and Image Processing *or*
  - 18.367 – Waves and Imaging *or*
  - IDS.131[J] – Statistics, Computation, and Applications

AI + Physics Courses @ MIT

8.316: Computational Data Science in Physics

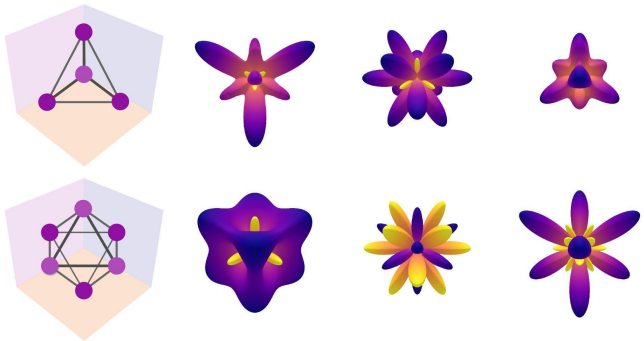


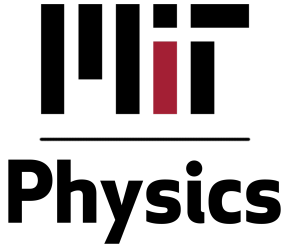
- **Prof. Phil Harris (Physics)**
- Spring 2023: Full course in the Physics department
- MITx modules developed with Alex Shvonski (Digital Learning Fellow) and Ike Chuang (Physics/EECS)
- Provides realistic, contemporary examples of how **computational and statistical methods** apply to physics research

MITx

6.S966 / 8.S301: Symmetry for Machine Learning

- **Prof. Tess Smidt (EECS)**
- Spring 2023: Cross-listed in EECS & Physics
- Introduces use of **group representation theory** to construct symmetry-preserving ML algorithms





If you are interested in rich data sets involving deep physics principles and exciting discovery opportunities, come to MIT Physics and collaborate with IAIFI!

Want to deepen your knowledge of the statistical foundations of AI and position yourself for exciting AI career opportunities? Join the Interdisciplinary PhD in Physics, Statistics, and Data Science!

Snapshot of IAIFI Activities

RESEARCH

Theoretical Physics
- Nuclear/Particle Physics
- QFT and String Theory
- Quantum Many-Body Physics

Experimental Physics
- Large Hadron Collider
- IceCube Neutrino Observatory
- LIGO

Astrophysics
- Dark Matter Searches
- Large-Scale Structure
- Galaxy Formation

Foundational AI
- Representation Learning
- Robust/Interpretable AI
- Reinforcement Learning

TALENT

Interdisciplinary PhD at MIT

MITx Course

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Early Career & Equity Committee

Journal Club

IAIFI Summer School

K-12 Engagement

COMMUNITY

IAIFI Penthouse

IAIFI Seminars

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IAIFI Summer Workshop

Computing Resources

IAIFI Affiliate Program

Industry Partnerships

Community Building Events