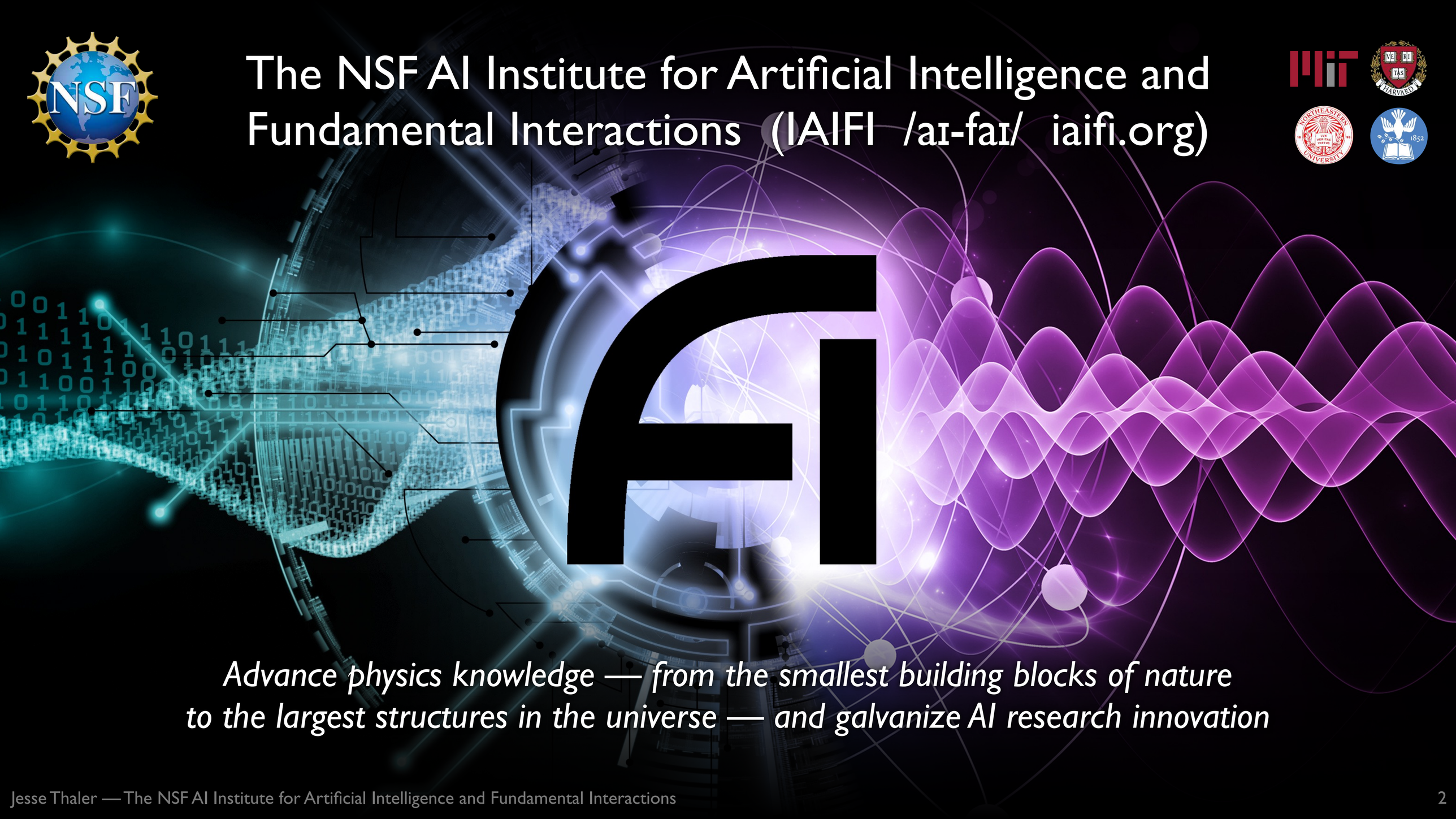
The NSF AI Institute for Artificial Intelligence and Fundamental Interactions

Jesse Thaler

Director, IAIFI

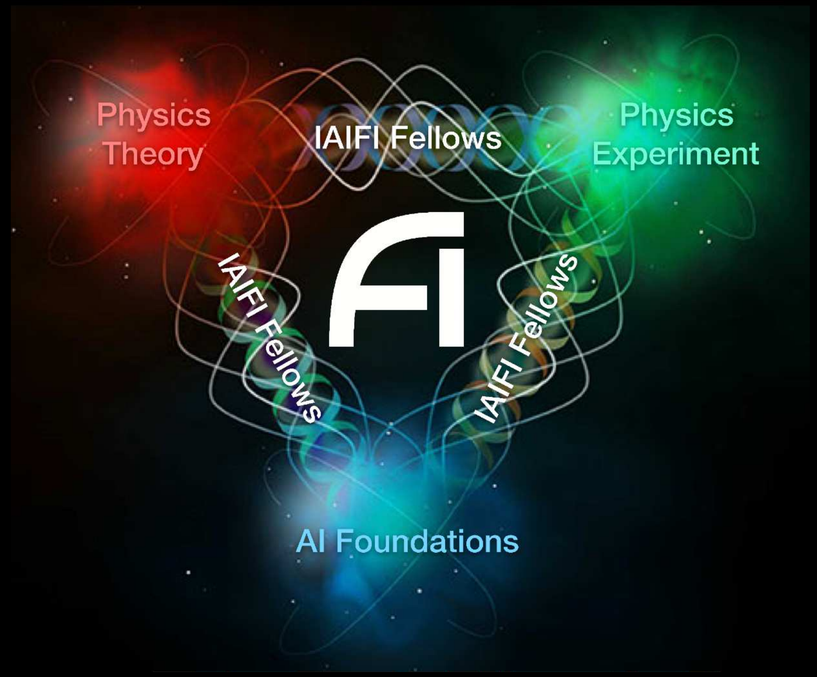
CACM Digital Event on AI and Science — February 1, 2022

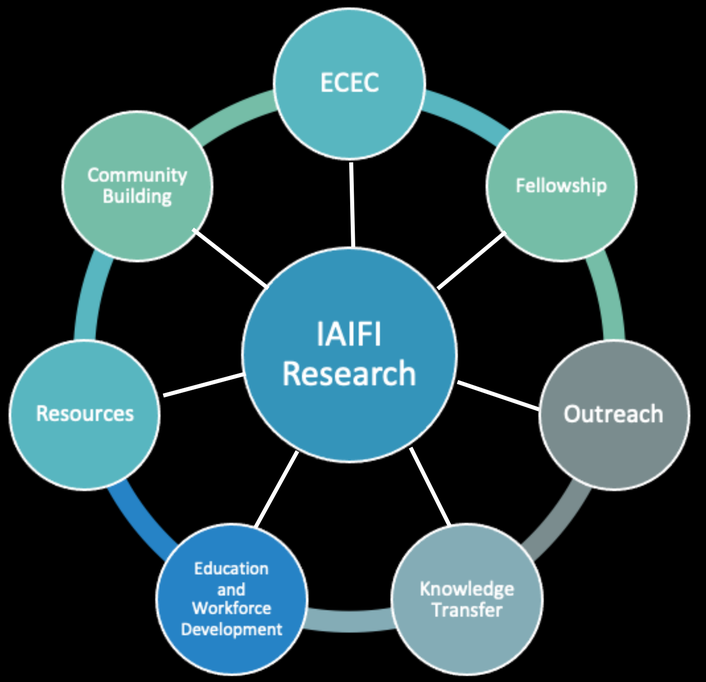
The NSF AI Institute for Artificial Intelligence and Fundamental Interactions (IAIFI /aɪ-faɪ/ iaifi.org)



Advance physics knowledge — from the smallest building blocks of nature to the largest structures in the universe — and galvanize AI research innovation

IAIFI at a Glance:





IAIFI Postdoctoral Fellows:

2021-2024


Anna Golubeva


Di Luo


Siddharth Mishra-Sharma


Ge Yang

2022-2025


Denis Boyda


Carolina Cuesta


Jessie Micallef

The NSF AI Institute for Artificial Intelligence & Fundamental Interactions

AI Foundations:

Power of machine learning to process large, rich data sets

Physics Theory & Experiment:

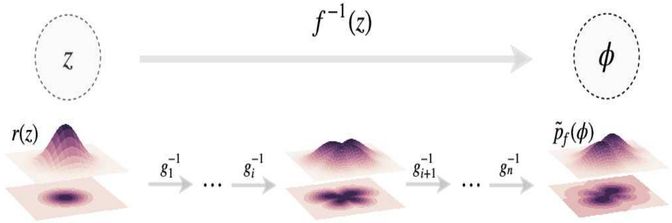
First principles and best practices from fundamental interactions

Enable physics discoveries by developing and deploying the next generation of AI technologies

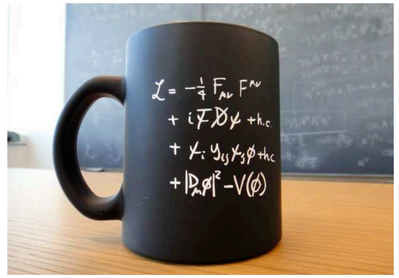
Galvanize AI research innovation by **incorporating physics intelligence** into artificial intelligence

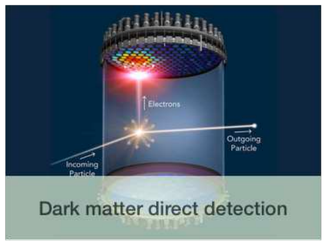
The NSF AI Institute for Artificial Intelligence & Fundamental Interactions

Generative Models from Normalizing Flows

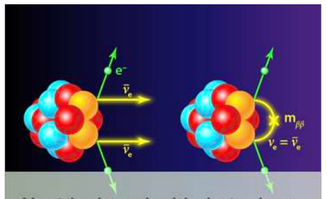


Symmetries of Standard Model of Particle Physics

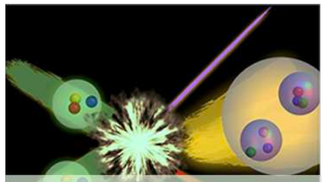




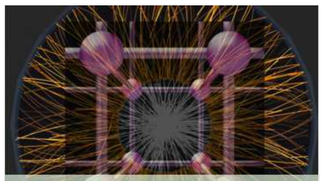
Dark matter direct detection



Neutrinoless double-beta decay



Proton-proton fusion



QCD phase structure and heavy ion dynamics

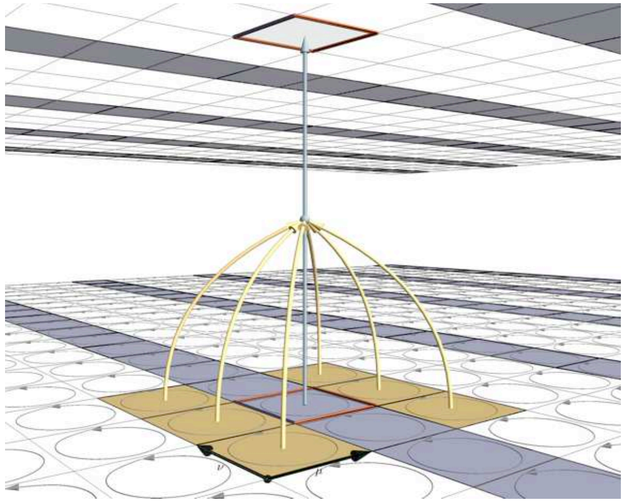
Efficient Computations in Lattice Field Theory

Currently: >10% of open supercomputing in US

Industry collaboration for 1000-fold speedup: Google DeepMind Massachusetts Institute of Technology

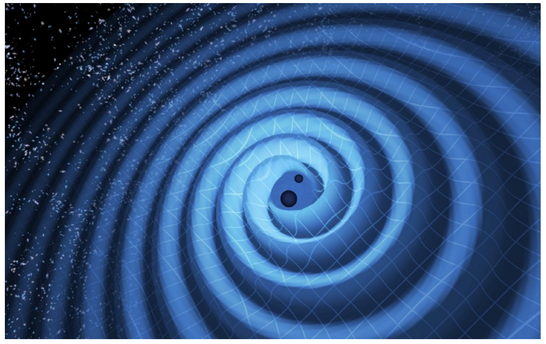
Tools designed for physics find interdisciplinary applications:

Shanahan Group: PRD 103, 074504 (2020), PRL 125, 121601 (2020), ICML, PMLR 8083-8092 (2020), 2107.00734 (2021) 2106.05934 (2021), 2101.08176 (2021)

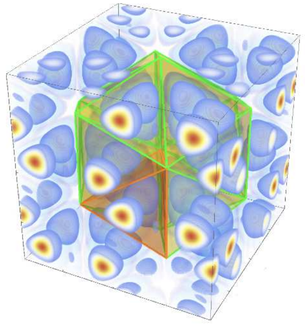


Artificial Intelligence ⇔ Fundamental Physics

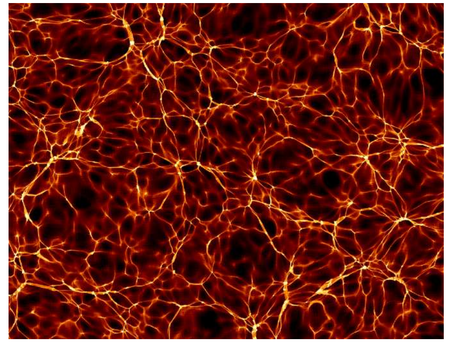
Gravitational Waves



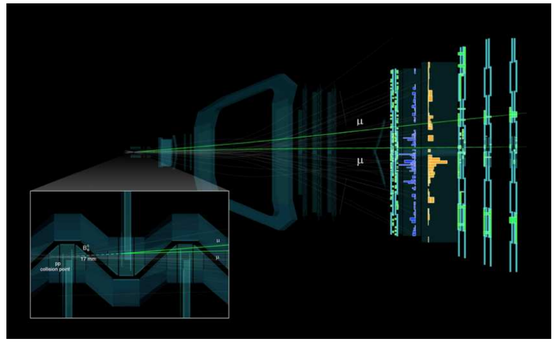
Nuclear Physics



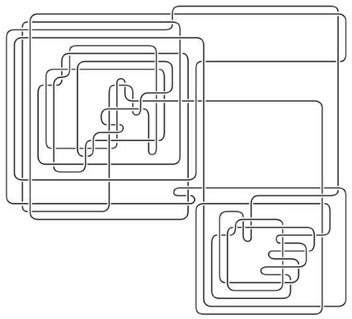
Dark Matter



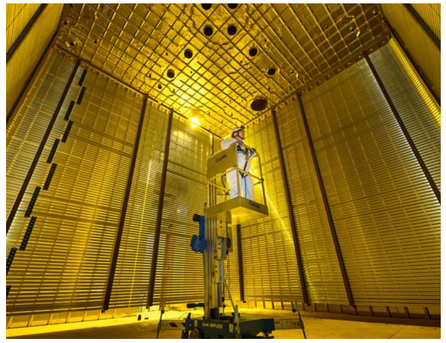
Particle Colliders



Mathematical Physics



Neutrino Detection



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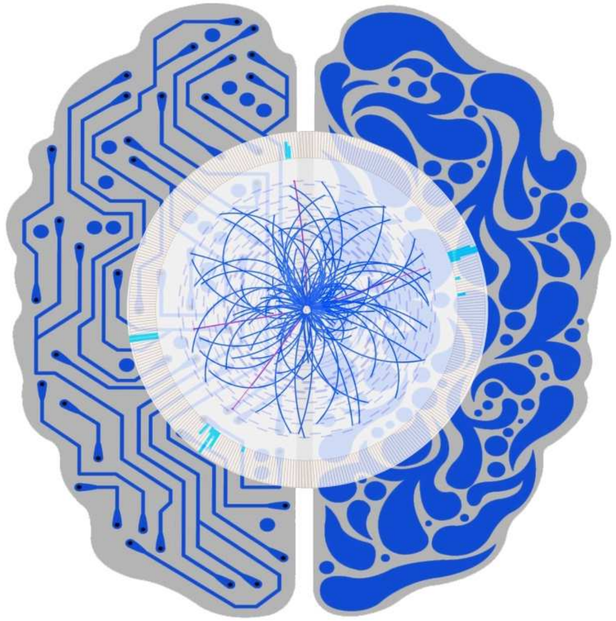
Towards AI²: Ab Initio Artificial Intelligence



Machine learning that incorporates first principles, best practices, and domain knowledge from fundamental physics

Symmetries, conservation laws, scaling relations, limiting behaviors, locality, causality, unitarity, gauge invariance, entropy, least action, factorization, unit tests, exactness, systematic uncertainties, reproducibility, verifiability, …

Key Goal of IAIFI: Cultivate Early-Career Talent with Cross-Disciplinary Expertise