Omar Alterkait Resume

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OBJECTIVE

PhD candidate developing differentiable simulators, multi-modal foundation models, and interpretability methods for large-scale scientific data. Focused on understanding what machine learning models learn about the underlying physics, and on using machine learning to answer scientific questions once out of reach.

EDUCATION

Tufts University
PhD Physics — Expected May, 2028
MS Physics — February, 2023

University of Colorado, Boulder — May, 2021
BA Physics (Magna Cum Laude)
BS Applied Mathematics

TECHNICAL SKILLS

Python (NumPy, JAX, Matplotlib, Pytorch, HDF5, Plotly, Pandas, Uproot, ...), LaTeX, Containers, Git/Github, Mathematica, C++, ROOT, Linux, C, MATLAB, Excel (VBA), Arabic Calligraphy, and Fluent in both English and Arabic.

ML EXPERTISE

Methods: Differentiable Programming, Sparse 3D Models (MinkowskiNet, PTv3), Equivariant Neural Networks (E3NN), Foundation Models, Self Supervised Learning, Hyperparameter Tuning
Scale: 10M training samples, Multi-GPU JAX/PyTorch, $100 - 10,000\times$ speedups
Applications: 3D Inverse Problems, Multi-Modal Sensor Fusion, Differentiable Physics Simulation for Calibration and Reconstruction

PREPRINTS

Omar Alterkait, César Jesús-Valls, Ryo Matsumoto, Patrick de Perio, and Kazuhiro Terao. *End-to-end Differentiable Calibration and Reconstruction for Optical Particle Detectors*. arXiv:2602.24129 [hep-ex], 2026.

WORKSHOP PAPERS

Omar Alterkait et al. *10 Million Particle Events: Enabling Foundation Models for Sparse 3D Inverse Problems*. NeurIPS 2025 AI for Science Workshop, Spotlight Poster.

Omar Alterkait and César Jesús Valls. *Differentiable Ray-Tracing for Optical Particle Detector Simulation*. NeurIPS 2025 Machine Learning and the Physical Sciences Workshop, Poster.

GRANTS & AWARDS

Anthropic AI for Science Program — 2026
$50,000 in credits supporting *A Differentiable Simulation Stack for Particle Physics*

POSITIONS

SCGSR-IRCA Fellow, CERN	July 2026
SCGSR Fellow, SLAC	January-December 2026
IAIFI Junior Investigator, MIT	August 2021-Present
Ozaki Program Fellow, Kavli IPMU, UTokyo	August-December 2024
Academic Scholar, Kuwait University	September 2023-Present
IRIS-HEP Fellow	January-June 2021

TALKS

Neutrino Physics and Machine Learning	2023, 2024, 2025, 2026
Nagoya University	November 2025
Kyoto University	November 2025
Tohoku University	October 2025
Colorado State University	October 2025
Fifth MODE Workshop on Differentiable Programming	June 2025
APS Global Physics Summit	March 2025
Center for Data-Driven Discovery Kavli IPMU, UTokyo	March 2024

POSTERS

Neutrino Physics and Machine Learning **(Best Poster)**	June 2026
NEUTRINO	June 2026
Neutrino Physics and Machine Learning **(Best Poster)**	November 2025
IAIFI Summer Workshop	August 2025
Fifth MODE Workshop on Differentiable Programming **(Best Poster)**	June 2025
Future of Artificial Intelligence for Science in Japan **(Best Poster)**	December 2024
International Neutrino Summer School	August 2023

EXPERIENCE

Neutrino Graduate RA August 2021 - Present
PI : Taritree Wongjirad

- **Multi-Modal Foundation Models for 3D Reconstruction in LArTPCs** (w/ Kazuhiro Terao, SLAC) [github.com/OmarAlterkait/JAXTPC]
  - Generating first 10M event dataset with raw sensor waveforms paired with 3D ground truth (30× larger than existing)
  - Achieved 100× speedup (50s to 0.5s per event) via JAX/GPU rewrite; captures charge+light dual-modality from same physics events
  - Processing extreme global sparsity with locally dense information; reconstructing 3D trajectories from 2D tomographic projections
  - Developing PTv3/Sonata transformers for efficient point cloud processing at scale; implementing cross-modal masked autoencoding directly on raw data
  - Releasing JAX framework with Data Olympics challenges to drive collaborative algorithm development and establish benchmarks
  - Planning mechanistic interpretability analysis to understand learned physics representations and inductive biases
- **Differentiable Ray-Tracing for Optical Detector Calibration (LUCiD)** (w/ César Jesús Valls, CERN) [github.com/CIDeR-ML/LUCiD]
  - Developed first differentiable ray-tracing framework achieving end-to-end differentiability from particle parameters to detector response
  - Models photon emission using neural representations trained on simulation data; handles stochastic interactions while maintaining differentiability
  - Achieved 10,000× speedup over CPU Monte Carlo (1M photons in 30ms) via JAX automatic differentiation, JIT compilation, and grid-based spatial filtering
  - Matches state-of-the-art reconstruction baselines while enabling direct optimization through complex parameter landscapes where MCMC fails
  - Creating open-source benchmark dataset for ML-based detector reconstruction algorithm development
- **Sparse Euclidean Equivariant Neural Networks for Particle Reconstruction** (w/ Tess Smidt, MIT)
  - Developing sparse equivariant neural networks that preserve Euclidean symmetry (rotation, translation, reflection) eliminating need for data augmentation
  - Addressing extreme sparsity of LArTPC data by combining sparse convolutions with equivariant architectures
  - Targeting MicroBooNE detector particle reconstruction with improved sample efficiency through geometric inductive biases

CMS HEP Undergraduate RA October 2019 - July 2021
PI : Kevin Stenson

- Developed ML classifier for track reconstruction at upgraded LHC, replacing cut-based approach (Honors Thesis)