Sam **Foreman**

PHYSICS · ML / DATA SCIENCE

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Education

PhD. Physics *University of Iowa*
B.S. Engineering Physics *University of Illinois at Urbana-Champaign*
B.S. Applied Mathematics *University of Illinois at Urbana-Champaign*

Dissertation

Learning Better Physics: A Machine Learning Approach to Lattice Gauge Theory *University of Iowa*

SUPERVISOR: YANNICK MEURICE *Spring 2016 – Summer 2019*

- Developed new technique for applying renormalization group transformations to arbitrary 2D images.
- Designed and implemented a new algorithmic technique for Markov Chain Monte Carlo simulations that is able to generate gauge configurations.
- Carried out interdisciplinary research focused on applying ideas from machine learning and data science to simulations in high-energy physics.
- Discovered a new method for describing the phase transition in the 2-dimensional Ising model by applying unsupervised learning techniques (PCA, k-means clustering) to Monte Carlo simulation images.
- Helped to create a new technique for implementing renormalization group transformations on arbitrary image sets, and explored potential applications in dynamic image analysis and action recognition.
- Worked with Tensorflow/Keras to construct convolutional neural networks capable of classifying configurations of the Ising model by temperature.
- Current work focuses on improving the efficiency of the Hybrid Monte Carlo algorithm by using neural networks to improve the quality of the sampler. These improvements have wide applications across a variety of industries.

Experience

Argonne National Laboratory *Computational Sciences Division*

GRADUATE RESEARCH FELLOW *Summer 2018 — Summer 2019*

- Software development focused on applying machine learning models to help improve the efficiency of Hybrid Monte Carlo simulations and their use in Lattice QCD.
- Built and deployed learning models using Tensorflow/Keras on some of the world's fastest supercomputers using state-of-the-art high-performance computing techniques.
- Developed a method for training Markov Chain Monte Carlo kernels parameterized with deep neural networks that shows promise in out performing traditional methods on a variety of different models.

University of Iowa *Department of Physics & Astronomy*

RESEARCH ASSISTANT *Spring 2016 — Fall 2016*

- Software and hardware development for HaloSat, a nanosatellite built with the goal of better understanding the missing baryon problem.
- Implemented a variety of in-flight optimization algorithms aimed at maximizing the incoming X-ray signals (by minimizing background noise) while in operation.

University of Illinois *Center for Complex Systems Research*

RESEARCH ASSISTANT *Spring 2011 — Spring 2015*

- Actively maintained the legacy code base (C++ / MATLAB) for our research group and was in charge of quality analysis of new contributions.
- Constructed a model capable of describing the energy density and self-discharge time of nanoscale capacitors.
- This work was submitted as a patent (pending) titled "Energy Storage in Quantum Resonators", on which I was designated a co-inventor together with my advisor Alfred Hübler.

Publications & Talks

- **S. Foreman**, X.J. Jin, and J. Osborn,**"Machine Learning and Neural Networks for Field Theory"**
- **S. Foreman**, Y. Meurice, J. Giedt and J. Unmuth-Yockey, **"Examples of renormalization group transformations for image sets"** *Physical Review E.*
- **S. Foreman**, **"Machine learning inspired analysis of the Ising model transition"** The 36th Annual International Symposium on Lattice Field Theory
- **S. Foreman**, J. Giedt, Y. Meurice and J. Unmuth-Yockey, **"RG inspired Machine Learning for lattice field theory."** *arXiv:1710.02079*
- **S. Foreman**, **"Machine Learning Analysis of Ising Worms."** Brookhaven National Laboratory, Dec. 2017 (invited speaker)
- A. Hubler, **S. Foreman**, J. Liu, and L. Wortsmann, **"Large Energy Density in Three-Plate Nanocapacitors due to Coulomb Blockade"** *Journal of Applied Physics*