Sam **Foreman**

PhD. Candidate · Science Enthusiast

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Education

University of Iowa — *Iowa City, IA*

PhD. Physics, supervisor: Yannick Meurice — *May 2019 (expected)*

University of Illinois at Urbana-Champaign — *Champaign, IL*

B.S. Engineering Physics — *May 2015*

University of Illinois at Urbana-Champaign — *Champaign, IL*

B.S. Applied Mathematics — *May 2015*

Thesis Research

University of Iowa, Department of Physics & Astronomy — *Iowa City, IA*

Research Assistant — *Spring 2016 - Present*

- Carried out interdisciplinary research focused on applying ideas from machine learning and data science to simulations in lattice gauge theory (LGT) and lattice quantumchromodynamics (LQCD).
- 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 data.
- Helped to create a new technique for implementing renormalization group transformations on arbitrary image sets, which may have potential applications in dynamic image analysis and action recognition.
- Built and trained a multi-layer convolutional neural network in tensorflow used for classifying configurations of the Ising model by temperature.
- Current work involves using deep feed-forward neural networks and restricted Boltzmann machines to help improve the efficiency of Hybrid Monte Carlo simulations in LQCD.

Experience

Computational Sciences Division, Argonne National Laboratory — *Argonne, IL*

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 (tensorflow) on Argonne's massively parallel, many-core supercomputer (Theta) using state of the art high performance computing techniques.
- Developed a generalized method for training Markov Chain Monte Carlo kernels parameterized with deep neural networks that successfully outperforms traditional methods for a variety of different models.

University of Iowa, Department of Physics & Astronomy — *Iowa City, IA*

Research Assistant — *Spring 2016 - Fall 2016*

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

Center for Complex Systems Research — *Champaign, IL*

Research Assistant — *Spring 2011 - Spring 2015*

- Helped to construct a model 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.

Programming Skills & Projects

- **Languages: Python** (including numpy, pandas, tensorflow, and scikit-learn), **C/C++**, **MATLAB** and brief experience with **SQL**,**R**, **Go**, and **Ruby**.
- **LatticeMC:** A python library used for performing highly efficient Monte Carlo simulations on various lattice models and analyzing and interpreting the results.

Publications & Talks

- S. Foreman, Y. Meurice, J. Giedt and J. Unmuth-Yockey, "Examples of renormalization group transformations for image sets" *arXiv:1807.10250*.
- 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*. https://doi.org/10.1063/1.5009698