

# JOHANN BREHMER

Researcher at the intersection of machine learning and physics

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## WORK EXPERIENCE

**Moore-Sloan Postdoctoral Researcher** 09/2017 – now  
*Center for Data Science & Physics Department, New York University, USA*

- Developed machine learning algorithms for statistical inference in models described by computer simulations
- Turned these algorithms into a widely used open-source Python library
- Applied this research to particle physics problems, enabling up to 90% more efficient measurements of the most fundamental properties of nature
- Introduced first-ever scalable method to analyze satellite images for the almost imperceivable effects of Dark Matter clumps, based on deep convolutional networks and Bayesian statistics
- Designed a new type of flow-based generative neural network
- Led interdisciplinary and international research teams, supervised students, managed projects from idea to publication / release

**Research and Teaching Assistant** 07/2014 – 08/2017  
*Institute for Theoretical Physics, Heidelberg University, Germany*

- Introduced statistical metrics to guide particle physics experiments
- Discovered new aspects of the phenomenology of the Higgs boson (the elementary particle discovered in 2012, Nobel Prize 2013)
- Taught undergraduate and graduate physics students

**Summer Student** 06/2012 – 09/2012  
*CERN, Switzerland*

- Won the competitive CERN summer student programme scholarship
- Designed and deployed a neural network-based signal-noise classifier for the LHCb experiment, used in hundreds of analyses

## EDUCATION

**PhD in Physics** 07/2014 – 08/2017  
*Heidelberg University, Germany*

- Graduated summa cum laude (best possible)

**Master of Science in Physics** 02/2012 – 06/2014  
*Heidelberg University, Germany*

- Proposed a new data analysis strategy for particle physics experiments
- Graduated with 1.0 (best possible), won Otto Haxel prize for best thesis

**Bachelor of Science in Physics** 09/2008 – 02/2012  
*Heidelberg University, Germany*

- Developed a numerical simulation tool for particle physics
- Was awarded the prestigious German Studienstiftung scholarship
- Won Erasmus stipend to study at Imperial College London, UK, for one year
- Graduated with 1.0 (best possible)

**Abitur** 06/2007  
*Ökumenisches Gymnasium Bremen, Germany*

- Graduated with 1.0 (best possible), won Karl-Nix-Stiftung award

## RESEARCH RESULTS

**Publications** see page 2

13 first-author publications in top peer-reviewed journals (PRL, PNAS, ...)  
4 workshop papers at NeurIPS, ICML  
24 publications in total, 1700 citations

**Talks** bit.ly/jb-talk

16 invited talks (26 total) at international conferences / seminars in several fields  
Keynote speaker at ACAT 2019

**Software** bit.ly/jb-madm

Lead developer of the open-source Python library MadMiner, now used in several cutting-edge research efforts

## Research community engagement

Organizer of workshops and seminars with up to 150 participants  
Reviewer for NeurIPS, ICML, PRL, ...  
Elected grad. student representative

## SKILLS

### Programming

5 years experience designing, developing, and maintaining Python software  
*Python, Jupyter, git, Docker, SLURM, Unix; C++ basics*

### Machine learning

Deep learning (convolutional neural networks, graph neural networks), probabilistic / generative models (normalizing flows, VAEs), reinforcement learning  
*PyTorch, scikit-learn; TensorFlow basics*

### Statistics and data science

Probability theory, frequentist / Bayesian statistics (MCMC, variational inference), data processing, visualization  
*NumPy, SciPy, pandas, Matplotlib*

### Writing and communication

Technical writing, presentations to experts and non-experts, teaching  
*LaTeX*

### Languages

German (native), English (fluent)

## SELECTED PUBLICATIONS

For a full list of all 24 publications and 1700 citations, please see my Google Scholar profile at [bit.ly/jb-pub](https://bit.ly/jb-pub).

### Probabilistic / generative models

Johann Brehmer and Kyle Cranmer  
*Flows for simultaneous manifold learning and density estimation*  
Submitted to NeurIPS 2020, arXiv:2003.13913, 8 citations

Johann Brehmer and Kyle Cranmer  
*NOTAGAN: Flows for the data manifold*  
Spotlight talk, ICML workshop on Invertible Neural Networks, Normalizing Flows & Explicit Likelihood Models (2020)

### Simulation-based (likelihood-free) inference

Johann Brehmer, Gilles Louppe, Juan Pavez, and Kyle Cranmer  
*Mining gold from implicit models to improve likelihood-free inference*  
Proceedings of the National Academy of Science 117 (2020), arXiv:1805.12244, 34 citations

Kyle Cranmer, Johann Brehmer, and Gilles Louppe  
*The frontier of simulation-based inference*  
Proceedings of the National Academy of Science (2020), arXiv:1911.01429, 12 citations

Johann Brehmer, Kyle Cranmer, Siddharth Mishra-Sharma, Felix Kling, and Gilles Louppe  
*Mining gold: Improving simulation-based inference with latent information*  
NeurIPS workshop on Machine Learning and the Physical Sciences (2019)

Markus Stoye, Johann Brehmer, Gilles Louppe, Juan Pavez, and Kyle Cranmer  
*Likelihood-free inference with an improved cross-entropy estimator*  
NeurIPS workshop on Machine Learning and the Physical Sciences (2019), arXiv:1808.00973, 12 citations

### Simulation-based inference for particle physics

Johann Brehmer, Felix Kling, Irina Espejo, and Kyle Cranmer  
*Constraining Effective Field Theories with Machine Learning*  
Physical Review Letters 121 (2018), arXiv:1805.00013, 65 citations

Johann Brehmer, Felix Kling, Irina Espejo, and Kyle Cranmer  
*MadMiner: Machine learning-based inference for particle physics*  
Computing and Software for Big Science 4 (2020), arXiv:1907.10621, 10 citations

### Simulation-based inference for cosmology

Johann Brehmer, Siddharth Mishra-Sharma, Joeri Hermans, Gilles Louppe, and Kyle Cranmer  
*Mining for Dark Matter substructure: Inferring subhalo population properties from strong lenses with machine learning*  
The Astrophysical Journal 886 (2019), arXiv:1909.02005, 8 citations

### Statistical metrics for particle physics

Johann Brehmer, Kyle Cranmer, Felix Kling, Tilman Plehn  
*Better Higgs Measurements Through Information Geometry*  
Physical Review D 95 (2017), arXiv:1612.05261, 40 citations

### Graph neural networks for particle physics

Isaac Henrion, Johann Brehmer, Joan Bruna, Kyunghun Cho, Kyle Cranmer, Gilles Louppe, and Gaspar Rochette  
*Neural Message Passing for Jet Physics*  
NeurIPS workshop on Deep Learning for the Physical Sciences (2017), 20 citations

### Particle physics theory

Johann Brehmer, Ayres Freitas, David Lopez-Val, Tilman Plehn  
*Pushing Higgs Effective Theory to its Limits*  
Physical Review D 93 (2016), arXiv:1510.03443, 95 citations