

# Vanessa Martina Böhm

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## EDUCATION AND DEGREES<sup>1</sup>

### **PhD - Ludwig-Maximilian University (LMU), Munich, Germany, July 2017**

graduated *summa cum laude*

### **Master of Science (Physics)- Heidelberg University, Germany, July 2013**

Graduation with 1.0 (4.0 in the US system)

Focus on theoretical physics, cosmology and astrophysics

### **Bachelor of Science (Physics) - Heidelberg University, Germany, July 2011**

Focus on physics and mathematics

## RESEARCH EXPERTISE AND INTERESTS

- **Cosmology:** CMB lensing & cosmic shear - cross correlations, high order statistics and systematics
- **Deep learning in astrophysics:** differentiable simulations, probabilistic modeling, unsupervised learning
- **Machine learning and AI:** generative modeling, uncertainty quantification, explainable AI, inverse problems, anomaly detection

## RESEARCH AND POSITIONS

### **Postdoctoral Fellow - Berkeley Center for Cosmological Physics, UC Berkeley**

Nov 2017 - present

- Designed deep learning frameworks for scientific applications
  - 1) A robust generative model for data generation and anomaly detection
  - 2) A framework for computationally tractable Bayesian inference and uncertainty quantification (posterior analysis) in high dimensions
- Developed a highly parallelizable, non-linear and differentiable lensing simulation code inspired by machine learning techniques

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<sup>1</sup> LMU and Heidelberg have been continuously ranked 2 of the 3 top Universities in Germany in Physics and Astronomy. Both have received the title "University of Excellence" under the German Universities Excellence Initiative, which is also referred to as the *German Ivy League*:

[Top Physics Universities in Germany - US News Best Global Universities](#),  
[QS World University Rankings for Physics & Astronomy 2020](#), [German Excellence Initiative](#)

- Evaluated the impact of higher order lensing on galaxy-lensing cross correlations
- Applied ML methods to accurately estimate the mortality rate from COVID-19 in the early stages of the pandemic

## PhD Candidate - Max-Planck Institute for Astrophysics, Garching, Germany

Oct 2013 - Oct 2017

- Developed the first algorithm for Bayesian weak lensing reconstruction based on a non-linear forward model (in  $10^6$  dimensions)
- First to identify an important bias to CMB lensing measurements originating from the bispectrum of the matter density field

## TEACHING AND SUPERVISION

### Student Supervision

- **Graduate Students:** Chirag Modi, Avirukt Mittal
  - *Estimating the COVID-19 mortality with machine learning*  
(<https://www.medrxiv.org/content/10.1101/2020.04.15.20067074v3>)
  - *cosmological parameter from non-Gaussian lensing maps with machine learning*
- **Undergraduate Students:** Tess Werhane, Jamie Lin, Lister Chen, Mrunal Puram, Max E. Lee
  - *various projects, e.g. code development (differentiable simulations) and testing likelihood-free and ML based inference schemes*
- **Master Students:** Natalia Porqueres
  - *A Bayesian, non-parametric reconstruction of the cosmic expansion history*  
([https://www.aanda.org/articles/aa/full\\_html/2017/03/aa29527-16/aa29527-16.html](https://www.aanda.org/articles/aa/full_html/2017/03/aa29527-16/aa29527-16.html))

### Teaching and Mentoring

- *Information Theory & Signal Reconstruction*, Teaching Assistant, Ludwig-Maximilians-University Munich (LMU), summer term 2014
- *Mentor and Teacher for the Astrophysics and Environmental Physics Groups* at the Heidelberg-Life-Science Lab, Heidelberg, 2007-2013

## FELLOWSHIPS AND AWARDS

- Graduate Scholarship of the Max-Planck Society, 2013-2017
- Graduate Scholarship of the German Academic Exchange Service (DAAD), 2013
- Physical Review D editor's suggestion, August 2016, for *A bias to CMB lensing measurements from the bispectrum of large-scale structure*

## SELECTED INVITED TALKS

- Physics & Astronomy Colloquium, UC Riverside, 05/2020
- Applied Artificial Intelligence Initiative Seminar, UC Santa Cruz, 02/2020
- Stanford Cosmology Seminar, Stanford University, Stanford, CA, 11/2016
- Berkeley Cosmology Seminar, UC Berkeley, 11/2016

## SELECTED CONTRIBUTED TALKS AND POSTERS

- Bayesian Deep Learning Workshop at NeurIPS 2019, Vancouver  
*Deep uncertainty quantification with generative models (poster)*
- Cosmology with CMB-S4, Princeton, 2018  
*Higher order corrections to CMB lensing cross correlations (talk)*
- The Non-Linear Universe Workshop, Smartno, Slovenia, 2017  
*Bayesian weak lensing reconstruction with a lognormal field (talk)*
- 51<sup>st</sup> Rencontre de Moriond 2016, Cosmology  
*A bias to CMB lensing measurements from the bispectrum of large-scale structure (talk)*

## WORKSHOP AND SEMINAR ORGANIZATION

- Co-organizer and chair of the BIDS Machine Learning and Science Forum (since January 2020)
- Co-organizer and chair of the weekly BCCP journal club (2018-2020)
- Co-organizer of the 2nd *Non-Linear Universe Workshop*, Smartno, Slovenia, 2018

## OUTREACH

- Judge for 'Jugend Forscht', Germany's biggest youth science competition, 2014/2015/2016
- Selected Outreach Talks
  - QuarkNet Summer School at Lawrence Berkeley National Lab, 2019
  - What's Up! Astronomy Talks at Berkeley Public Library, 2019
  - Open Day of the Max-Planck Institute for Astrophysics, 2017

## PROGRAMMING SKILLS

- Programming languages: Python, C++, (Py)Stan
- Machine learning frameworks: tensorflow (1&2), keras
- Data manipulation: pandas, scikit learn
- Parallel computing: dask, mpi4py
- Project management: git(hub), anaconda

## PUBLICATIONS

**Böhm, V.**, Feng, Y., Lee, M., Dai, B., "MADLens - a package for fast and differentiable non-Gaussian lensing simulations", *submitted to Astronomy and Computing*.  
<https://arxiv.org/abs/2012.07266>

**Böhm, V.** and Seljak, U., "Probabilistic Auto-Encoder", *submitted to JMLR*.  
<https://arxiv.org/abs/2006.05479>

**Böhm, V.**, Modi, C., & Castorina, E. "Lensing corrections on galaxy-lensing cross correlations and galaxy-galaxy auto correlations", *Journal of Cosmology and Astroparticle Physics*, 2020(03):045–045, March 2020.  
<https://iopscience.iop.org/article/10.1088/1475-7516/2020/03/045>

**Böhm, V.**, Lanusse, F., & Seljak, U., "Uncertainty Quantification with Generative Models". *NeurIPS 2019 Bayesian Deep Learning Workshop*, (Dec 13, 2019).  
<http://bayesiandeeplearning.org/2019/papers/91.pdf>

**Böhm, V.**, Sherwin, B. D., Liu, J., Hill, J. C., Schmittfull, M., & Namikawa, T., "On the effect of non-Gaussian lensing deflections on CMB lensing measurements.", *Phys. Rev. D*, 98:123510, Dec 2018. <https://doi.org/10.1103/PhysRevD.98.123510>

**Böhm, V.**, Hilbert, S., Greiner, M., & Enßlin, T. A., "Bayesian weak lensing tomography: Reconstructing the 3D large-scale distribution of matter with a lognormal prior", *Phys. Rev. D*, 96:123510, Dec 2017. <https://doi.org/10.1103/PhysRevD.96.123510>

**Böhm, V.**, Schmittfull, M., & Sherwin, B. D., "A bias to CMB lensing measurements from the bispectrum of large-scale structure", *Phys. Rev. D*, 94:043519, Aug 2016.  
<https://doi.org/10.1103/PhysRevD.94.043519>

## Co-Authored

Modi, C., **Böhm, V.**, Ferraro, S., Seljak, U., Stein, G., "Total COVID-19 Mortality in Italy: Excess Mortality and Age Dependence through Time-Series Analysis", *submitted to Nature Communications*.  
<https://www.medrxiv.org/content/10.1101/2020.04.15.20067074v2.full.pdf>

Singh, C., Ha, W., Lanusse, F., **Boehm, V.**, Liu, J., Yu, B., "Transformation Importance with Applications to Cosmology." *ICLR 2020 Workshop on Fundamental Science in the era of AI*, (April 26, 2020).  
<https://deepai.org/publication/transformation-importance-with-applications-to-cosmology>

Coulton, W. R., Liu, J., Madhavacheril, M.S., **Böhm, V.**, Spergel, D.N., "Constraining Neutrino Mass with the Tomographic Weak Lensing Bispectrum", *Journal of Cosmology and Astroparticle Physics*, 2019(05):043–043, May 2019.  
<https://iopscience.iop.org/article/10.1088/1475-7516/2019/05/043>

Porqueres, N., Enßlin, T. A., Greiner, M., **Böhm, V.**, Dorn, S., Ruiz-Lapuente, P., & Manrique, A., "Cosmic expansion history from SNe Ia data via information field theory - the charm code", *Astronomy & Astrophysics* 599:A92, March 2017.  
<https://doi.org/10.1051/0004-6361/201629527>

Liu, J., Hill, J. C., Sherwin, B. D., Petri, A., **Böhm, V.**, & Haiman, Z., “CMB Lensing Beyond the Power Spectrum: Cosmological Constraints from the One-Point PDF and Peak Counts”, *Phys. Rev. D*, 94:103501, Nov 2016. <https://doi.org/10.1103/PhysRevD.94.103501>

Dorn, S., Enßlin, T. A., Greiner, M., Selig, M., & **Boehm, V.**, “Signal inference with unknown response: Calibration-uncertainty renormalized estimator”, *Phys. Rev. E*, 91:013311, Jan 2015. <https://doi.org/10.1103/PhysRevE.91.013311>