

# Vanessa Martina Böhm (she/her)

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## Berkeley Center for Cosmological Physics

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## EDUCATION AND DEGREES

- **Ph.D. - Ludwig-Maximilian University (LMU), Munich, Germany, July 2017**  
graduated *summa cum laude*
- **Master of Science (Physics Major) - Heidelberg University, Germany, July 2013**  
Graduation with 1.0 (4.0 in the US system)  
Focus on Theoretical-, Environmental- and Astrophysics
- **Bachelor of Science (Physics Major) - Heidelberg University, Germany, July 2011**

## RESEARCH EXPERTISE

- **Accelerated inference in astrophysics:** differentiable simulations, simulation-based inference, probabilistic machine learning for scientific inquiry
- **Machine learning and Bayesian inference:** generative modeling, uncertainty quantification, high-dimensional inverse problems, anomaly detection
- **Cosmology:** weak lensing of the cosmic microwave background & galaxies - their cross correlations, higher order statistics, and systematics

## RESEARCH AND POSITIONS

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

Nov 2017 - present

- Designed deep learning frameworks for scientific applications
  - 1) A robust deep generative model for data generation and anomaly detection
  - 2) A framework for computationally tractable and fast Bayesian inference with uncertainty quantification in high dimensions
- Developed a highly parallelizable, non-linear, and differentiable lensing simulation code inspired by machine learning. The code's properties enable new inference techniques required for data from upcoming high-resolution experiments.
- Included and evaluated the impact of higher-order lensing on galaxy-lensing and galaxy-galaxy correlations, helping to resolve ongoing debates in the community about their importance.
- Applied ML methods to accurately estimate the mortality rate from COVID-19 in the early stages of the pandemic- work that was published in Nature Communications.

- As part of the Bay Area Summer Institute in Computational Social Science 2020 worked with the data science team of Code for America, a non-profit organization, to characterize applications to the California food stamp program during COVID-19.

## **Ph.D. Candidate - Max-Planck Institute for Astrophysics, Garching, Germany**

Oct 2013 - Oct 2017

- Developed the first Bayesian reconstruction algorithm for weak lensing with a non-linear data model (solving an optimization problem in  $10^6$  dimensions).
- First to identify an important bias to cosmic microwave background 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:**  
Max E. Lee, Jamie Lin, Lister Chen, Tess Werhane, Mrunal Puram
  - *various projects, including testing likelihood-free and ML-based inference schemes*
- **Master Students:** Natalia Porqueres
  - *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**

- *LSSTC Data Science Fellowship Program* - Course on *Probabilistic Machine Learning*, March 2022
- *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

## **SELECTED WORKSHOP AND SEMINAR ORGANIZATION**

- *Machine Learning for Astrophysics Workshop* at ICML 2022
- *Berkeley Machine Learning and Science Forum* hosted by the Berkeley Institute for Data Science, since January 2020
- *Learn the Universe Workshop*, Center for Cosmological Astrophysics at the Flatiron Institute, NYC, August 2021
- *Workshop on Deep Generative Models for Fundamental Physics*, LBNL, March 2021
- Organizer and chair of the weekly *BCCP journal club*, 2018-2020

## SELECTED INVITED TALKS

- MSML21 Computational Physics Workshop, 08/2021
- Astronomy Colloquium, University of Florida, 04/2021
- Physics & Astronomy Colloquium, UC Davis, 03/2021
- Panelist at 'What can ML do for LSS' Panel Discussion, LSST-DESC Meeting, 02/2021
- 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  
*Nonlinear Bayesian weak lensing reconstruction (talk)*
- 51<sup>st</sup> Rencontre de Moriond 2016, Cosmology  
*A bias to CMB lensing measurements from the bispectrum of large-scale structure (talk)*

## 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*

## 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

## LIST OF PUBLICATIONS

### First-Author

- 1) **Böhm, V.**, Feng, Y., Lee, M., Dai, B., "MADLens - a package for fast and differentiable non-Gaussian lensing simulations", *Astronomy and Computing*, Volume 36, July 2021, <https://doi.org/10.1016/j.ascom.2021.100490>
- 2) **Böhm, V.** and Seljak, U., "Probabilistic autoencoder", *submitted to Journal on Mathematics of Data Science (SIMODS)*. <https://arxiv.org/abs/2006.05479>
- 3) **Böhm, V.** and Liu, J., "Impact of Covid on Astronomy - Two years in", under review. <https://arxiv.org/abs/2203.15621v1>
- 4) **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>
- 5) **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>
- 6) **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>
- 7) **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>
- 8) **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

- 1) Stein, G., Seljak, U., **Böhm, V.**, The Nearby Supernova Factory Collaboration, "A Probabilistic Autoencoder for Type Ia Supernovae Spectral Time Series", submitted.
- 2) Modi, C., **Böhm, V.**, Ferraro, S., Seljak, U., Stein, G., "Estimating COVID-19 mortality in Italy early in the COVID-19 pandemic", *Nat Commun* **12**, 2729 (2021). <https://doi.org/10.1038/s41467-021-22944-0>
- 3) 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>

- 4) 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>
- 5) 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>
- 6) 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>
- 7) 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>