Neil Goeckner-Wald email: ngoecknerwald@stanford.edu

## Specialization

Data analysis for astronomical telescopes using techniques from machine learning and advanced statistics. Expertise in computer vision, signal processing, differential equations, numerical methods and high-performance computing.

Major contributor to several 100,000+ line PYTHON / C telescope image reconstruction and data reduction codebases. Proficient with scientific PYTHON including libraries `numpy`, `scipy`, `TensorFlow`, and `PyTorch`.

Member of the POLARBEAR-1, *Simons Array*, *Simons Observatory*, BICEP/*Keck* and South Pole Telescope collaborations.

## Education

### Degrees

**Ph.D. in Physics, University of California Berkeley** 2019
*A Measurement of the Degree Scale B-mode Cosmic Microwave Background Angular Power Spectrum from the POLARBEAR Experiment*

**B.S. in Electrical and Computer Engineering with Honors**, Carnegie Mellon University 2013

**B.S. in Physics with Honors**, Carnegie Mellon University 2013

### Coursework

#### Coursera

Machine Learning

#### University of California Berkeley

Applications of Parallel Computers
Extragalactic Astronomy and Cosmology
Quantum Mechanics I & II
Quantum Field Theory
Equilibrium Statistical Physics
General Relativity
Electromagnetism

#### Carnegie Mellon University

Analog Integrated Circuits I
Microelectronic Circuits
RF Circuits and Antennas for Wireless Systems
Introduction to Computer Systems
Electronic Devices and Analog Circuits
Signals and Systems
Structure and Design of Digital Systems
Introduction to Nuclear and Particle Physics
Advanced Quantum Physics I & II
General Relativity
Intermediate Electricity and Magnetism I & II
Physical Mechanics I & II
Linear Algebra
Probability Theory and Random Processes

## Professional Experience

**Kavli Postdoctoral Fellow**, Stanford University 2019 -

• Wrote and maintained several large and critical components of the South Pole Telescope (SPT-3G) instrument characterization and image reconstruction software

• Delivered instrument calibration data products with robustly understood uncertainties within tight deadlines

• Coordinated sharing of code and data between independent analyses saving significant time and computational resources

• Implemented a `PyTorch` convolutional variational auto-encoder framework to leverage unsupervised machine learning to identify anomalous features in telescope images

• Co-organized the KIPAC statistics and machine learning journal club

**Graduate Student Researcher**, University of California Berkeley 2014 - 2019

• Led the analysis of a large and complex astronomical dataset from the POLARBEAR experiment

• Demonstrated a new approach to measuring the polarization of the cosmic microwave background; primary author of the main science results paper from a 50 - person collaboration

• Designed, implemented, and analyzed massive end-to-end physical simulations of the experiment to search for spurious features in the dataset

**Graduate Student Instructor**, University of California Berkeley 2013 - 2014

• Taught one semester of Physics 7B (electromagnetism) and Physics 7C (modern physics).

**Undergraduate Intern**, European Center for Nuclear Research (CERN) 2012

• Implemented C++ physics simulations of a subsystem in the Compact Muon Solenoid (CMS) detector

**Undergraduate Intern**, Thomas Jefferson National Lab 2010 - 2011

• Designed and built a prototype position-sensitive particle tracking detector

---

# Selected Publications

## Journal articles

The BICEP/Keck Collaboration, *Improved constraints on primordial gravitational waves using Planck, WMAP, and BICEP/Keck observations through the 2018 observing season*, Physical Review Letters 127:15, https://arxiv.org/abs/2110.00483 2021h

J. Sobrin et al, *The Design and Integrated Performance of SPT-3G*, The Astrophysical Journal Supplement Series, Volume 258:2, arXiv:2106.11202 † 2021e

D. Dutcher et al, *Measurements of the E-Mode Polarization and Temperature-E-Mode Correlation of the CMB from SPT-3G 2018 Data*, Physical Review D 104:2, arXiv:2101.01684 2021a

The POLARBEAR Collaboration, *A Measurement of the Degree-scale CMB B-mode Angular Power Spectrum with POLARBEAR*, The Astrophysical Journal 897:1, arxiv:1910.02608 † 2020a

S. Takakura et al, *Performance of a Continuously Rotating Half-Wave Plate on the POLARBEAR Telescope*, Journal of Cosmology and Astroparticle Physics 2017 (05) 008, arXiv:1702.07111 2017a

The POLARBEAR Collaboration, *A Measurement of the Cosmic Microwave Background B-Mode Polarization Power Spectrum at Sub-Degree Scales from 2 years of POLARBEAR Data*, The Astrophysical Journal, 848:141, arXiv:1705.02907 2017b

T Adams, P Adzic, S Ahuja et al, *Beam Test Evaluation of Electromagnetic Calorimeter Modules Made from Proton-Damaged PbWO4 Crystals*, Journal of Instrumentation, 11 04 P04012 2016

The APEX Collaboration, *Search for a new Gauge Boson in the A' Experiment (APEX)*, JLAB-PHY-11-1406 / SLAC-PUB-14491, arXiv:1108.2750 2011

## Conference Proceedings

K.T. Crowley, S. M. Simon, M. Silva-Feaver, N. Goeckner-Wald et al, "Studies of Systematic 2018a

Uncertainties for Simons Observatory: Detector Array Effects," Proc. SPIE 2018, arXiv:1808.10491†

J. Stevens, N. Goeckner-Wald, R. Keskitalo et al, "Designs for Next Generation CMB Survey Strategies from Chile," Proc. SPIE 2018, arXiv:1808.05131† 2018b

M. Salatino, J. Lashner, M. Gerbino, S. Simon, J. Didier et al, "Studies of Systematic Uncertainties for Simons Observatory: Polarization Modulator Related Effects," Proc. SPIE 2018, arXiv:1808.07442 2018c

† **Lead author.**

---

# Open Source Machine Learning Projects

**Kaggle `TensorFlow` Great Barrier Reef Computer Vision Competition** 2022

• Implemented a `TensorFlow` model based on the Faster R-CNN algorithm to detect invasive starfish in underwater images of the Great Barrier Reef

• Demonstrated modestly successful performance in a challenging computer vision setting detecting small and partially occluded objects against a complex background; identified directions for future improvements

• Code made publicly available at `https://github.com/ngoecknerwald/starfish-perception-telescope`

---

# Teaching and Mentoring

## Courses

University of California Berkeley Physics 7C, Physics for Scientists and Engineers (Relativity and Quantum Mechanics), Graduate Student Instructor 2014 Spring

University of California Berkeley Physics 7B, Physics for Scientists and Engineers (Electromagnetism), Graduate Student Instructor 2013 Fall

## Graduate Students Mentored

Jessica Avva
Cyndia Yu
George Halal
Eric Yang
Mario Aguilar Faundez
Dominic Beck
Kolen Cheung