Anthony Burrow, Ph.D.

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Summary

Research scientist with a Ph.D. in Physics and a robust background in applying machine-learning concepts to complex datasets in astrophysics. Extensive work utilizing Python, C/C++, and more to develop software tools which have shown to be significant contributions to the scientific community. Experienced with the entire data science life cycle: identifying problems, data wrangling, and model deployment, evaluation, and maintenance.

Education

- **Ph.D. in Physics** (GPA: 3.92)
  July 2024, *University of Oklahoma*
  Dissertation on SHAREOK
- **Professional Certificate, Machine Learning**
  Ongoing, *IBM*
- **Professional Certificate, Data Science** (View)
  Aug. 2024, *IBM*
- **B.S. in Astrophysics** (GPA: 3.91)
  May 2017, *University of Oklahoma*

Technical Skills

Programming:
Python, C/C++, C#, SQL, Bash, Fortran, IDL, Make/Makefiles, CMake

Platforms:
Linux/UNIX, Windows

Technologies:
Git (Version Control), LaTeX, RStudio, Microsoft Office, Mathematica, IRAF

Experience with Python Libraries:
NumPy pandas scikit-learn matplotlib SciPy Astropy Tensorflow GPy

Data Science Skills:
Machine Learning Data Wrangling Statistics Data Analysis Data Visualization Model Evaluation
Regression Classification Parameter Optimization Cluster Analysis Dimensionality Reduction

Research Experience

- **Graduate Research Assistant** July 2019 – Present
  University of Oklahoma, Advised by Dr. Eddie Baron *Norman, OK*
  - Develop Python software to implement machine-learning techniques to model the behavior of supernovae.
  - Perform thorough preprocessing, standardization, and feature engineering of spectroscopic data.
  - Conduct detailed statistical analyses, resulting in two publications in a peer-reviewed journal (ApJ).
  - Collaborate with leading researchers from several other universities and facilities around the world (CSP, POISE).
  - Present results to peers and collaborators at meetings and conferences.
  - Synthesize models in a supercomputing environment with Slurm scripts using `PHOENIX` radiative transfer code.

  Products:
  - SNEx (Python): Spectrum extrapolation into near-infrared wavelengths using principal component analysis.
  - Spextractor (Python): Fast spectrum-smoothing using Gaussian process regression.
  - SNIaDCA (Python): Wrapper for probablistically classifying supernovae with Gaussian mixture models.

- **Undergraduate Research Assistant** June 2015 – May 2017
  University of Oklahoma, Advised by Dr. John Wisniewski *Norman, OK*
  - Calibrated observed data by removing multiple sources of noise from raw `FITS` images of stars using `IRAF`.
  - Modeled the observed light profile of stars on images using `IRAF` to calculate their brightness values.
  - Created Python and IDL scripts needed to analyze data and propagate errors derived from observations.
  - Conducted multiple remote observations at the Apache Point Observatory to obtain more raw data for analysis.
  - Presented results at the American Astronomical Society conference.

Additional Projects

- Rad1D: A 1D radiative transfer code written in C++ featuring a Python wrapper for easy implementation into Python for analysis and plotting. This program converges a solution to wavelength-dependent radiative transfer equations, which describes how light behaves as it passes through a medium as a function of optical depth.
- Hydro1D: A 1D hydrodynamical code written primarily in C++ with some Python additions. This program models the fluid dynamics of a massive (10 $M_\odot$) star undergoing a collapse and a shock event, which leads to a core-collapse supernova.

Publications

First-Authored Papers:

- **Burrow, Anthony**, Baron, E., Burns, Christopher R., et al. (2024). *Extrapolation of Type Ia Supernova Spectra into the Near-Infrared Using PCA*. ApJ , doi: 10.3847/1538-4357/ad3c45
- **Burrow, Anthony**, Baron, E., Ashall, C., et al. (2020). *Carnegie Supernova Project: Classification of Type Ia Supernovae*. ApJ , doi: 10.3847/1538-4357/abafa2

Relevant Co-Authored Papers:

- DerKacy, James M., ..., **Burrow, Anthony**, et al. (2024). *JWST MIRI/Medium Resolution Spectrograph (MRS) Observations and Spectral Models of the Underluminous Type Ia Supernova 2022xkq*. ApJ , doi: 10.3847/1538-4357/ad0b7b
- Shahbandeh, Melissa, ..., **Burrow, Anthony**, et al. (2024). *JWST NIRSpec+MIRI Observations of the nearby Type IIP supernova 2022acko*. arXiv e-prints , doi: 10.48550/arXiv.2401.14474
- Yarbrough, Zach, ..., **Burrow, Anthony**, et al. (2023). *Direct analysis of the broad-line SN 2019ein: connection with the core-normal SN 2011fe*. MNRAS , doi: 10.1093/mnras/stad758
- DerKacy, J. M., ..., **Burrow, Anthony**, et al. (2023). *JWST Low-resolution MIRI Spectral Observations of SN 2021aefx: High-density Burning in a Type Ia Supernova*. ApJ , doi: 10.3847/2041-8213/acb8a8
- Burns, C., ..., **Burrow, Anthony**, et al. (2021). *Introducing POISE: Precision Observations of Infant Supernova Explosions*. ATel

Technical Presentations

- **POISE Collaboration Meeting, August 2023**: *Extrapolation of Type Ia Spectra into the Near-Infrared Using PCA*; a final discussion leading to Burrow et al. (2024).
- **POISE Collaboration Meeting, July 2022**: *Extrapolation of Type Ia Spectra into the Near-Infrared Using PCA*; the beginning of the project leading to Burrow et al. (2024).
- **CSP Collaboration Workshop, September 2020**: *Carnegie Supernova Project: Classification of Type Ia Supernovae*; a presentation of the publication by Burrow et al. (2020).
- **American Astronomical Society Winter Conference, January 2017**: Poster presentation highlighting my undergraduate research.
- **OU REU Program, Summer 2015**: Several presentations describing the results of my undergraduate research during this program.

Teaching Experience

- **Graduate Teaching Assistant** — Aug. 2019 – Dec. 2021
  University of Oklahoma — *Norman, OK*
  - Provide lectures and guide group discussions on topics in-class to undergraduate students in Introductory Astronomy and Physics courses.
  - Lead students with hands-on operation of telescopes during astronomy labs.
  - Grading and evaluation for higher-level undergraduate astronomy courses, such as Galaxies & Cosmology and Stellar Astrophysics.

Awards

- **Avenir Foundation Graduate Student Fellowship**:
  Spring 2022, Summer 2022; *University of Oklahoma*
- **Provost's Certificate of Distinction in Teaching**:
  Fall 2019; *University of Oklahoma*
- **Award for Outstanding Scholarship by a Graduating Senior**:
  May 2017; *University of Oklahoma Homer L. Dodge Department of Physics and Astronomy*
- **William Schriever Award for Outstanding Scholarship in Physics & Astronomy**:
  2014-2015; *University of Oklahoma*

Relevant Coursework

- **Machine Learning**: (See repository.)
  Discusses advanced statistical techniques and machine learning concepts such as:
  - Regression Analysis
  - Cluster Analysis
  - Kernel Density Estimation
  - Gaussian Processes
  - Probabilistic Classification
  - Neural Networks
- **Numerical Methods**: (See repository.)
  Discusses the most common problems that arise in computation and methods to address them, such as root-solving, solving systems of equations, and numerically solving ordinary and partial differential equations. This course also provides an introduction to high-performance computing, describing the architecture of modern supercomputing and giving practice with parallelization of computation using interfaces such as MPI and OpenMP.
- **Stellar Atmospheres**:
  Largely focuses on understanding the physics of light propagating through a medium by solving mathematically complex systems of equations that describe radiative transfer, which are only solvable numerically in application. This is a fundamental approach to understanding and modeling spectra observed from astronomical objects.
- **Core & Advanced Physics Courses**:
  An assortment of courses that allow for the fundamental understanding of physics at the post-graduate level, including Classical Mechanics, Statistical Mechanics, Quantum Mechanics, and Electrodynamics, and classes covering advanced topics in physics, including Quantum Mechanics of Atoms and General Relativity.