Jamboree 2021

The McWilliams Center of Cosmology
Poojan Agrawal
Postdoctoral researcher with Carl Rodriguez

Role of massive stars in stellar population studies

Massive stars contribute to:
- Transient phenomena
- Compact remnants
- Uncertainties in their evolution
  - Mass loss rates
  - Rotation
- Chemical enrichment
- Ionizing radiation
- Nuclear reaction networks
- Mixing processes

How these uncertainties affect the properties of their populations:
- Stellar binaries
- globular clusters
- Nuclear star clusters
- Galactic nuclei
- Potential explanation for
  - Binary properties
  - Dynamical properties of clusters
  - Gravitational wave observations
  - Multiple stellar populations
Cat Fielder: Milky Way SED with Gaussian Process Regression (arXiv: 2106.14900)

Biprateep Dey: Photometric Redshifts with a Deep Capsule Network
Local Calibration of Photo-z PDFs (arXiv: 2110.15209)
Federico Berlfein  
1st Year Physics Graduate Student  
Advisor: Rachel Mandelbaum

Research:

- Weak lensing and clustering analysis of HSC (Hyper Supreme-Cam) data
- Simple models using auto-correlations and cross-correlations
- 1st semester ➔ Neural Network ➔ How to be a grad student
Emily Biermann  
University of Pittsburgh  
Advised by Arthur Kosowsky

- Search for transient events using ACT data
- Found 524 candidate events, many repeat several times
- Currently working on finding counterparts. We expect to mostly find flaring stars
- Results shown are preliminary
Rachel Buttry (3rd Year Grad Student)
Advisor: Matt Walker

**What I study:**

- Dwarf Galaxies
- Binary star populations
- Spectroscopic binaries
Tomás Cabrera
2nd Year Physics Graduate Student
Advisor: Carl Rodriguez

Star Cluster Dynamics
via. Monte-Carlo Simulations

Astrophysical products of clusters
- Hypervelocity stars
- Compact object binaries
- Tidal disruption events

Model development
- $10^7 M_\odot$ clusters (NSCs)
- SMBH physics
Nianyi Chen (4rd year grad)
Work with: Hy Trac & Tiziana Di Matteo

Semi-numerical Reionization + kSZ Effect
- New semi-numerical code for patchy reionization
- Study the patchy kSZ effect with various reionization scenarios

Spectra with Gaussian Process Emulation
- Combine semi-numerical simulation with ML
- Fast emulations or constraining EoR parameters

Hydro Simulation + BH Mergers
- More physical BH dynamics in large cosmological simulations
- BH merger rate/signal-to-noise predictions for future experiments (e.g. LISA)
Research: Primordial Magnetic Fields & Early-Universe Turbulence

- Turbulent evolution of magnetic fields
- Observable signatures
  - CMB & LSS
  - Gravitational waves
Intensity mapping (mapping large-scale structure with spectral lines) in simulations and observations.

Measuring H0 with galaxy parallax.

>10,000 downloads!

Galaxy Formation: the game available on Apple App and Google Play stores.

Also: weak gravitational lensing galaxy formation simulations deep learning and cosmology.
1. Inferring galaxy formation from dynamical scaling relations
2. Probing new fundamental forces with galaxies
3. Testing gravity with variable stars
4. The structure of the local universe
Ugo Niccolò Di Carlo (He/Him) - Postdoc

Main research interests:
- Dynamics of star clusters
- Formation of gravitational wave sources
- Formation of massive stellar BHs and IMBHs
- Direct N-body simulations

Other interests:
- Cooking & Baking
- Music & Playing Drums
- Videogames
Scott Dodelson

Interests (Ordered chronologically):
1. Theoretical Particle Physics and Cosmology (inflation, dark matter, neutrinos, dark energy/modified gravity)
2. Numerical Work (hydro code! cosmosis)
3. Constraints on local density
4. Cosmological Analysis of Surveys (Dark Energy Survey, South Pole Telescope)
5. Anisotropic clustering (e.g., in lensing, also in clustering, Galactic dust/B-modes)
6. Machine Learning for Analysis
7. ???
I have been involved in the LSST project, now the Vera Rubin Observatory, since CMU joined the LSST Corporation in 2008.

– After chairing the oversight committee for construction of the Observatory, I became a member of the Management Board for Operations of the Vera Rubin Observatory.

– Considerations: Impacts of delays induced by the Covid epidemic, ramping up operations with NSF/DOE + AURA/SLAC + hundreds of other stakeholders; appointments; data rights, in-kind contributions to operations from international institutions; interim data facility; personnel, etc.

The Management Board will meet again at the end of November with more interesting issues to consider.
Cluster Cosmology
- Inference from observations (spec-z’s, lensing, X-ray, …)
- Cluster finding, member selection
- Mock observations from N-body + hydro simulations
- Survey analysis (DESC)

Data Science
- Deep Learning
- Generative Models
- Bayesian Modeling, Approximate Inference, Nonparametric Statistics

Technical Expertise: Python, Jupyter, Keras/TF, Git, HPC, SLURM
Yesukhei - Weak lensing: Intrinsic alignment of galaxies

Figure 7. Dependence of the alignment strength parameter $A_M$ on $f_{\text{disc}}$. The purple points are the main mass controlled samples presented in Table 1. Orange points are the non-mass controlled (i.e. full samples from the simulation). In both cases there is a clear decreasing trend with $f_{\text{disc}}$ in the strength of the alignments. The purple points are slightly below the orange points indicating that there is some little dependence on mass, however the overall trend is the same. Additionally we have also plotted the color split samples indicated by the diamond shape, for the red sample half filled diamond represents the mass-controlled sample and the full diamond - full sample.
Cosmology
- Very early universe
  - Gravitational waves
  - Cosmic microwave background
  - Fundamental symmetries
- Late-time cosmology
  - Dark energy
  - Massive gravity
- Astro-particle physics
  - Neutrinos mass origin

Astrophysics
- Cosmic magnetic fields
- Cosmic turbulence
Patrick LaChance
3rd Year Graduate Student
Advisor: Rupert Croft

- Interests / Area of Research:
  - Applications of machine learning to cosmological simulations.
  - Galaxy structure and populations
- Current Projects:
  - Using GANs to increase the fidelity of low resolution simulations
  - Investigating density-morphology relation in the Astrid simulation

Dark Matter Density Fields

FUV images of Redshift 4 Astrid Subhalos

Li et. al. 2021
Xiangchong Li (Postdoc)
UTokyo/IPMU (PhD) -> CMU (working with Rachel Mandelbaum)
Dotfiles: https://github.com/mr-superonion/dotfiles

From image to shear catalog

- Galaxy Image simulation;
- Shear estimator:
  - Analytical shear estimator controlling bias to subpercent level for isolated galaxies (FPFS);
  - Bias related to blending.

From shear catalog to 3D mass map

- Sparsity;
- Oracle property;
- Adaptive lasso.
Rachel Mandelbaum

Observational cosmology:
- how can we make the best use of large datasets? (+stats, ML method)
- cosmology: dark energy, modified gravity
- the galaxy-dark matter connection

I measure weak lensing for tens of millions of galaxies to (statistically) map dark matter and answer these questions

Currently working on:

While preparing for...

Rubin Observatory

Including a new effort funded by the Schmidt Futures Foundation, to build scalable science analysis frameworks for LSST – collaborators welcome!
Carleen Markey
1st year grad student
Advisors: Tiziana Di Matteo and Rupert Croft

Low Resolution

Super Resolution

Super-resolution of black hole merger simulations
Ben Moews
(aka "that person with the weird beard")

Research:
- Bayesian nonparametrics and HPC for cosmological Inference
- Machine learning for hybrid analytical models of galaxy evolution
- Density ridge estimation and cosmic voids for alternative cosmologies
- Impact work in finance and criminology, for reasons, surely

Hobbies:
- Books (the happy kind)
- Music (the unhappy kind)
- Tinkering with vintage watches while swearing in German or Scottish English

Brand new at the McWilliams Center
Midgardsblot Music Festival 2018, Norway, on a way-too-big chair
Research Interests:

- Supermassive Black Hole mergers in Nuclear Star Clusters
- Sources of millihertz gravitational waves for LISA
- Fast N-body techniques using Fast Multipole Methods for collisional dynamics
Yueying Ni  (https://yueyingn.github.io)
5th year PhD candidate, Advisor: Tiziana Di Matteo

- Growth and evolution of high-z galaxies and quasars with Large cosmological hydrodynamic simulations & Constrained Gaussian Realizations

- ML in simulation / Super-resolution simulations

- Astrophysical probes of alternative dark matter models
Andrew Pace
Postdoc, Milky Way Group

Research Interests:
- Dark Matter
- Dwarf Galaxies
- Stellar Streams
Andy Park  
1st year graduate student  
Advisor: Rachel Mandelbaum

Research

Joint Rubin observatory and Roman Space Telescope pixel-level simulations.

How many separate Roman objects can be identified among blends in the LSST images?

- Study blending properties by cross matching catalogs

20 sq. deg overlapping area
Jeff Patrick

Working with Sergey Koposov and Matt Walker

6th year grad student

Worked on automated modelling of stellar streams

Currently studying their characteristics as a group
Riccardo Penco
Office: Wean 7408
Email: rpenco@cmu.edu

Research Interests:
effective field theories for high energy, condensed matter, and cosmology

- Scattering Amplitudes
- EFTs for magnetic systems
- EFTs for open systems
- Black Holes
- Gravitational waves
Current Research:

- Weak lensing of the Lyman-alpha forest
- Use estimator developed by R. Benton Metalf, Nicolas Tessore, Rupert Croft to reconstruct the gravitational lensing potential from Lyman-alpha forest
- Apply to more realistic non-gaussian mock data

(If you confuse me and Patrick LaChance it’s ok… we are identical to leading order)

(Although my hair has lifted one degeneracy)
Sukhdeep Singh
McWilliams Postdoc fellow

Research interests

• Large Scale structure in the Universe
  • Weak Lensing measurements, systematics
  • Cross correlations, joint analysis, statistics.

• Intrinsic alignments of galaxies
• Fundamental plane / size relations of galaxies
Jonathan Stepp

Undergraduate

Research Advisor: Tina Kahniashvili

Research: Studying BBN limits on lepton asymmetry and a connection to primordial magnetic fields.
The Verge
Dark Skies Over Pittsburgh, PA - Interview: "THERE WERE NO MORE STARS..."
by Nick Rice, June 2016

The Times
The bright lights of New York mean dark times for stargazers
by Sally Smith, September 23, 2015

Diane Turnshek
Special Faculty
DH 2200
dianeturnshek.com/dark-skies/

90.5 WESA
Heard on Morning Edition

Trib Live
Peduto introduces ‘Dark Sky’ legislation to reduce light pollution in Pittsburgh.
by Tim Benz, August 16, 2016

KDRA Live interview
Diane Turnshek – Carnegie Mellon University astronomer.

The Allegheny Front: A DARK SKY ADVOCATE SAYS LIGHT POLLUTION SEPARATES US FROM THE STARS
by Renee Casterline, October 13, 2015

Metro21 Podcast: Diane Turnshek Talks Light Pollution and the Night Sky
November 14, 2014

Carnegie Science Center Podcast: Light Up the Sky with Stars
December 19, 2014

Metro21: Partners for a Darker Night’s Sky
by Jason Bailey, June 2016

The Turran
Pittsburgh group fights for dark skies
by Sam Stitt, May 21, 2015

CMU News
Diane Turnshek to Present at TEDxPittsburgh

by Jordan Daily, May 11, 2015

Astronauts aboard the ISS take “before” images of Pittsburgh at night
by Emily Arndt, August 1, 2015

Washington Examiner
Pittsburgh enacts measure targeting light pollution to become ‘dark sky’ city
by Jenny Sonner, Energy and Environment Reporter, October 14, 2015

CMU News
Dark Skies Ordinance To Dim Pittsburgh’s Light Pollution
by Amy Hays, September 15, 2015

IDA.org September Monthly Star: Q&A with Advocate Diane Turnshek from Pittsburgh, USA

Pittsburgh Post Gazette
Seeing the light: Peduto administration aims to reduce light pollution in proposed ordinance
by Dan Haggerty, August 15, 2016

CMU News
Artificial Light Survey of Nighttime Pittsburgh
by Amy Hays, October 15, 2015

CMU News
A Light Map Could Illuminate How Street Lamps Are Part Of Pittsburgh’s Pollution Problems
by Amy Hays, October 18, 2015

90.5 WESA
The Daily Kos: The first major city in the United States passes a dark-sky ordinance.

by Emily Arndt, August 1, 2015

Sky & Telescope
Pittsburgh Goes Dark: Could this new Dark-Sky ordinance begin a trend?
by Victor Lesh, May 12, 2015

Could the Milky Way be so clear to see in a city like Pittsburgh ever again?
by Victor Lesh, May 12, 2015

Pittsburgh is trying to dim light pollution. The city’s Dark Sky Lighting Ordinance signed by Mayor Bill Peduto in September could be modifying lighting in nearly completed or renovated city buildings, city parks, and street lights.

CMU Special Faculty Diane Turnshek says Pittsburgh being a dim city is great.

Carnegie Mellon University Science Director says Pittsburgh could be a leader in the nation.

Christian Science Monitor
Chasing darkness: One reporter’s journey into the night
by Yael Traver, May 19, 2015

Metro21: Partners for a Darker Night’s Sky
by Jason Bailey, June 2016

Carnegie Science Center
Rearranging the stars in the sky
by Jason Bailey, May 13, 2015

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Bought the last of the new Milky Way in the 200s now longer seen
in the Milky Way.
by Sam Stitt, May 21, 2015

View more

Diane Turnshek interviewed on 90.5 WESA’s Morning Edition.
Text and audio recording.
Two archival emails.
Continue reading

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Tianqing Zhang
4th year grad student
Advisor: Rachel Mandelbaum

Weak lensing systematics by PSF

- Learn how HSC PSF higher-moments uncertainties cause systematics in weak lensing shear.
- Propagate these systematics to the cosmology analysis.
- Put requirements on LSST PSF higher moments.

Also interested in:
- Photo-z as a weak lensing systematics
- Galaxy blending
- Statistics and ML methodology in cosmology.