

Jamboree 2020

The McWilliams Center of Cosmology

**Carnegie
Mellon
University**

HUSNI ALMOUBAYYED
GROUP: RACHEL MANDELBAUM

**THE MCWILLIAMS
Center for Cosmology**

5th year physics PhD student working
on:

- LSST requirements on photometric redshift errors for 3x2pt analysis
- Optimizing LSST observing strategy for weak lensing systematics



<https://husni.space>

Nianyi Chen (3rd year grad)

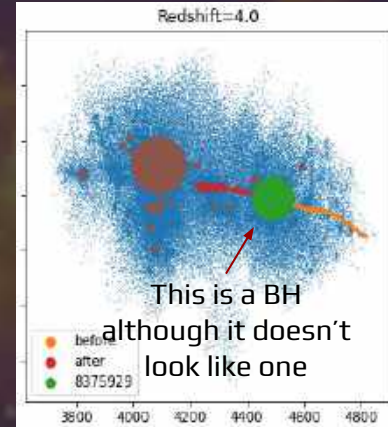
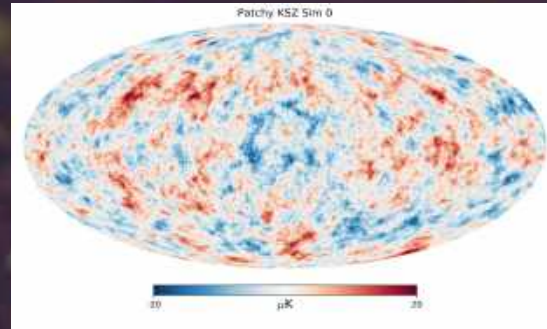
Advisor: Hy Trac



Reionization, Simulations,
kSZ, Lya, BH mergers

Patchy Reionization Simulations + Lya Forest

- Nbody + Hydro + Patchy-Reionization
- Constrain the mass of axion DM with Lya



Hydro Sim + BH Mergers

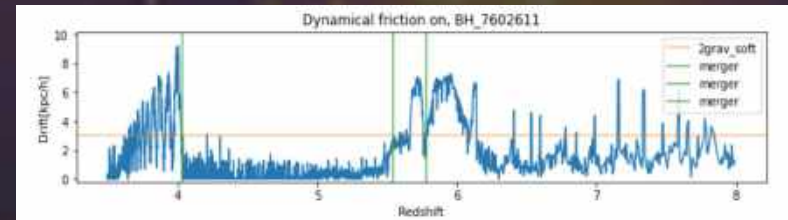
- More physical BH dynamics in large cosmological simulations
- Merger rate prediction for future surveys

Reionization Redshift Field

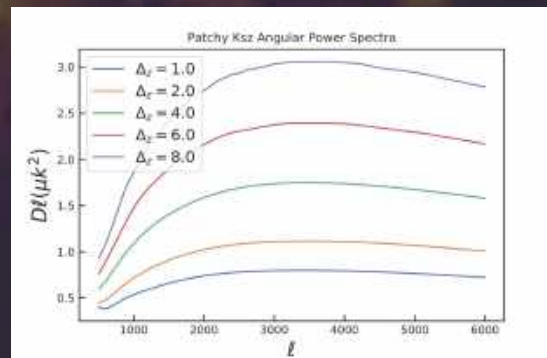


Semi-numerical Reionization + kSZ Effect

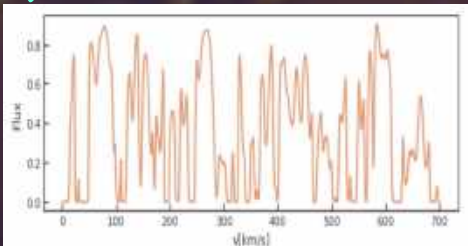
- New semi-numerical code for patchy reionization
- Use kSZ spectrum to constrain reionization parameters



kSZ angular power spectrum



Lya Flux



Other Interests

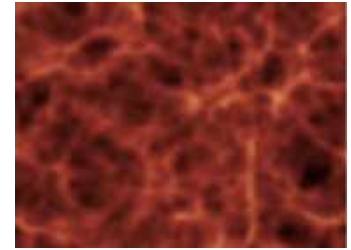
- Machine Learning?
- Maybe more theoretical projects but I'm currently bad at it...

Ad: Come to the Journal Club on Tuesdays:)

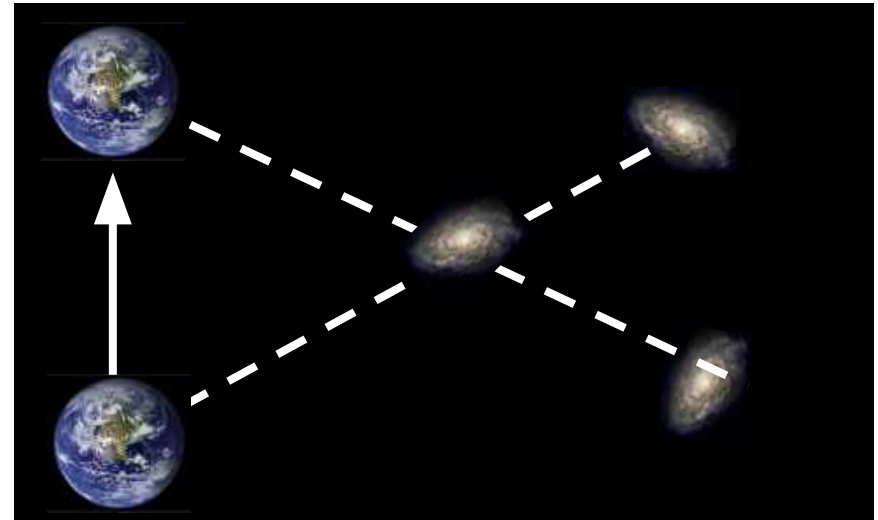


Rupert Croft

Intensity mapping
(mapping large-scale structure
with spectral lines)
in simulations and observations



Measuring H_0 with galaxy parallax



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

Also: weak gravitational lensing
galaxy formation simulations
deep learning and cosmology

Emma Clarke

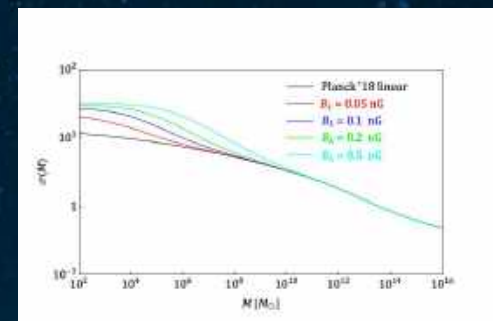
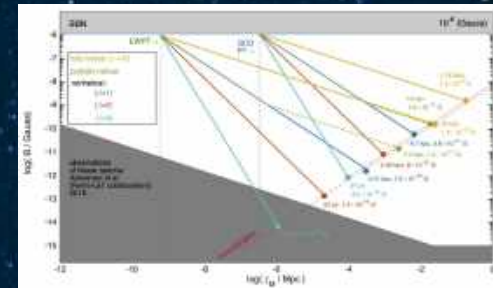


2nd Year Graduate Student
Advisor: Tina Kahniashvili

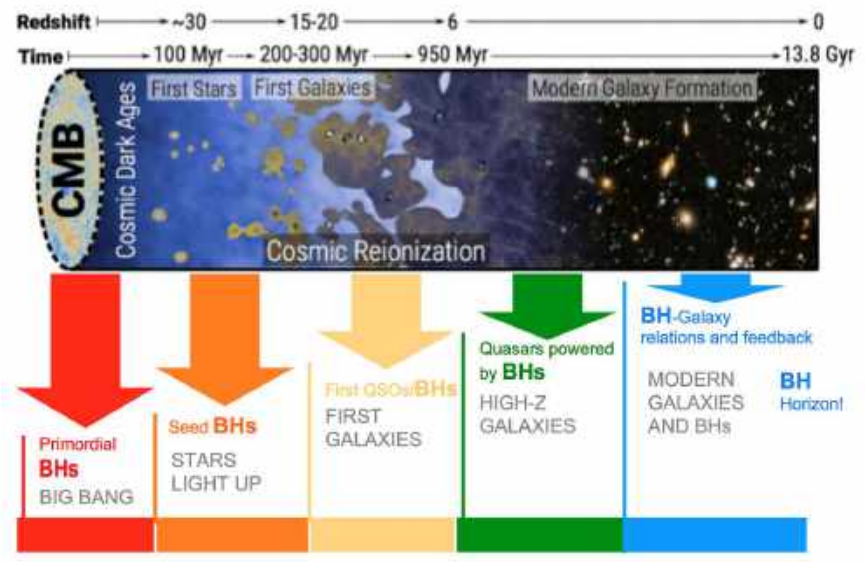


Research Primordial Magnetic Fields

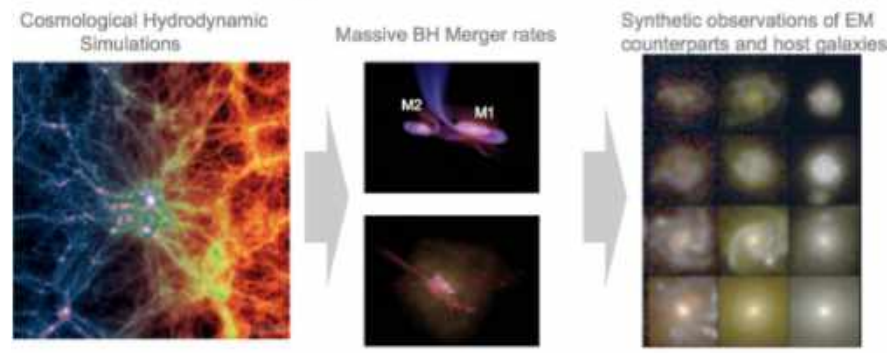
- initial conditions, field evolution
- effect on density perturbations



BHs across cosmic history

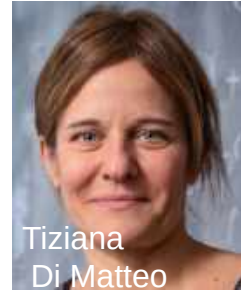


LISA and SKA/PTAs will detect SMBH mergers



Multi-messenger astrophysics (future IR and X-ray facilities + GW) : the final piece for the puzzle for the cosmic black hole growth

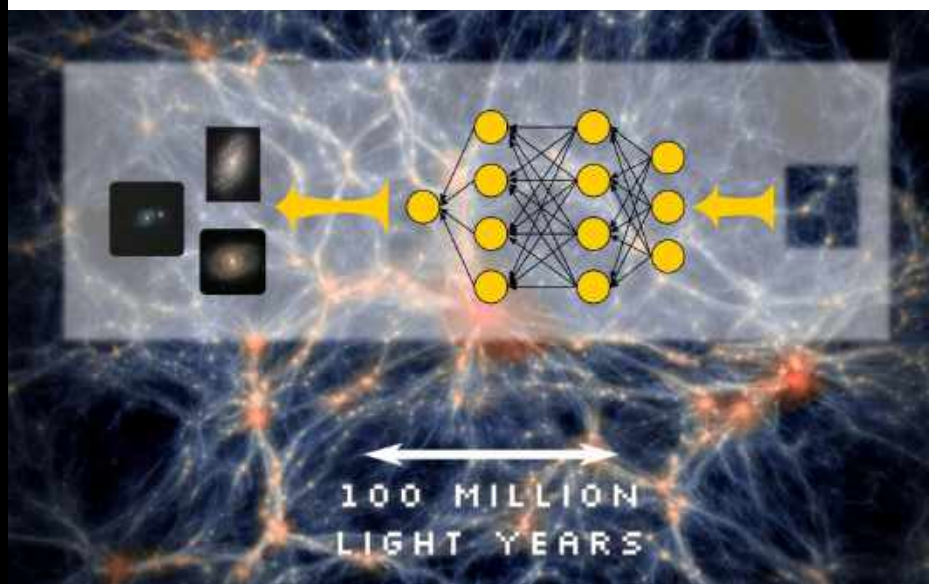
AI in Cosmological Simulations



Research challenge:

Cosmological simulations follow the history and fate of the Universe, all the way to the formation of all galaxies and their black holes.

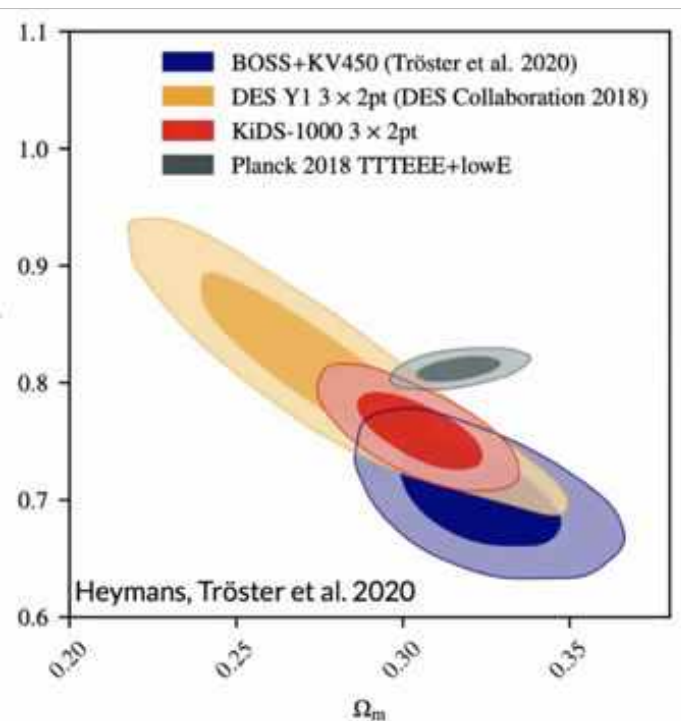
Dynamic range quickly makes this physically complex problem intractable even at exascale



AI methods to accelerate cosmological simulations

Scott Dodelson

Dark Energy Survey



Two facts I find fascinating:

1. The gray contours are roughly the same as the others: one of great successes of modern cosmology
2. There is a hint of tension between them: **the** most interesting thing in cosmology and DES will weigh in on this within the next month

Fred Gilman

McWilliams Center Jamboree 2020

- I have been involved in the LSST project, now the Vera Rubin Observatory, since CMU joined the LSST Corporation in 2008.
- Six years later, LSST construction started in August 2014. With a large portion of the project completed, In February, of this year, construction was halted because of the pandemic. Covid has probably cost us a year.
- After chairing the construction oversight committee, I am a member of the Management Board for operations with an Interim Data Facility and in-kind contributions to operations current issues.

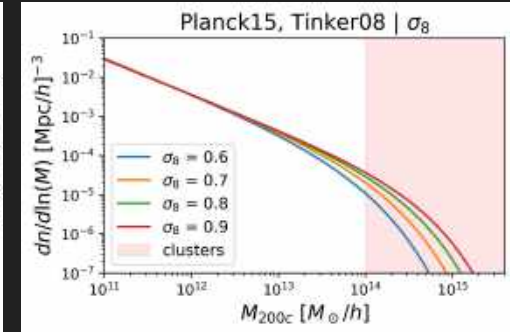
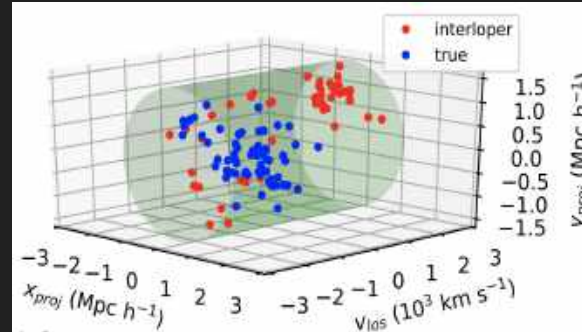
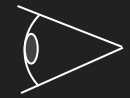




Matthew Ho

4th Year PhD Student @ CMU
Hy Trac group

Clusters + Machine Learning

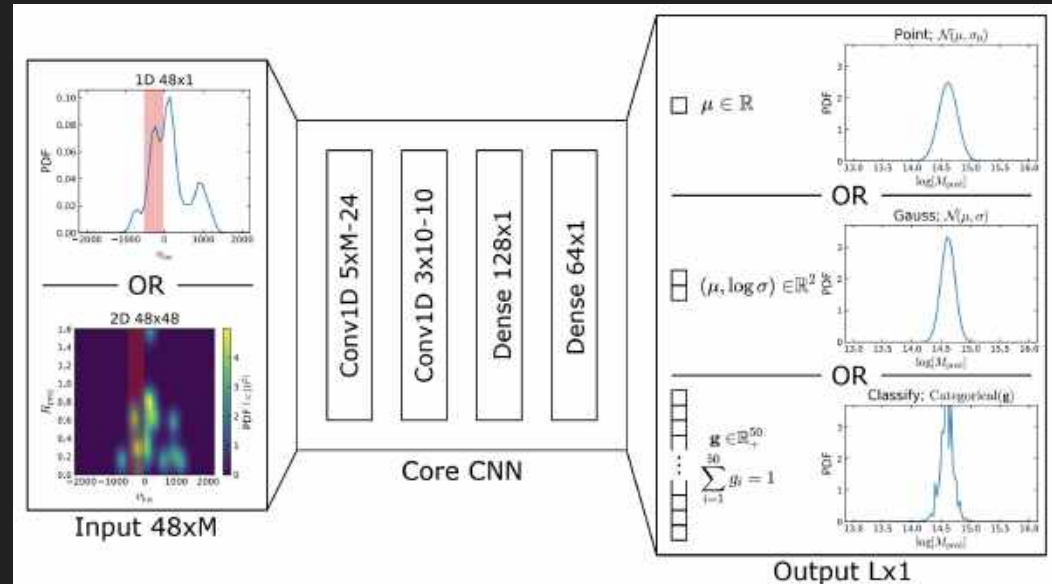


Cluster Cosmology

- 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 (Dense, CNNs, GANs, RNNs, R-CNNs)
- Bayesian Modeling, Approximate Inference, Nonparametric Statistics



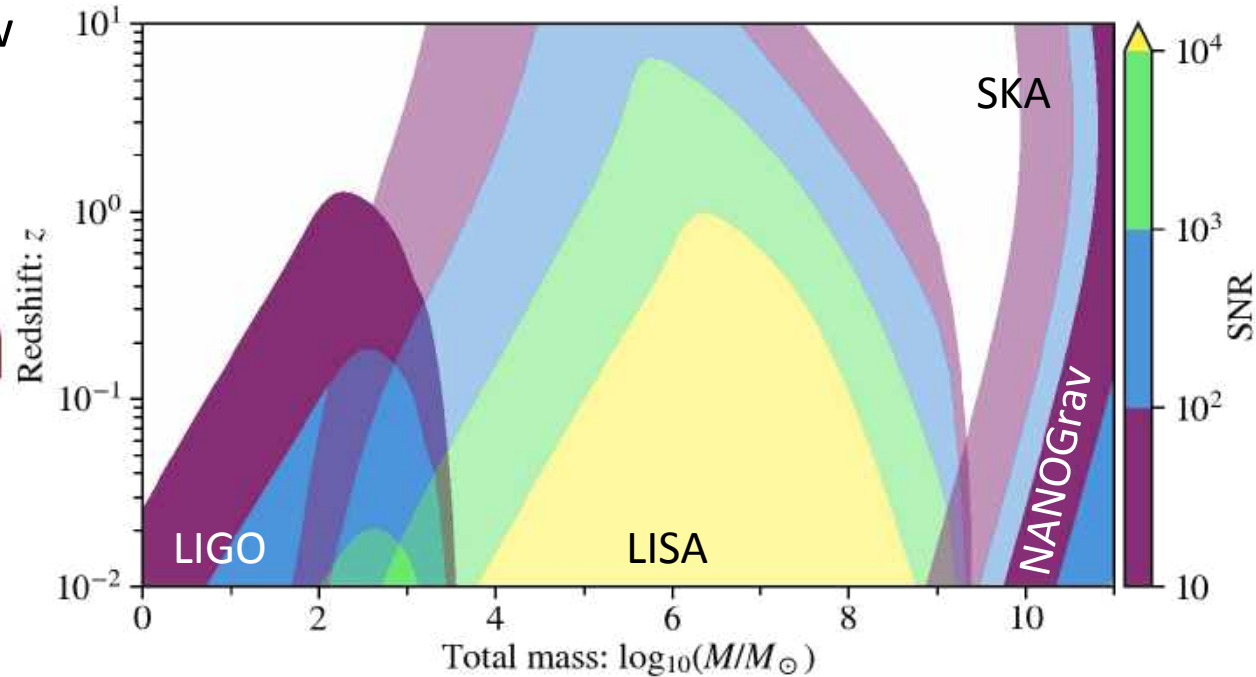
A. Miguel Holgado

McWilliams Postdoc Fellow



mholgado@andrew.cmu.edu

Detection capabilities of current and future GW detectors:



Research areas:

- Environmental effects on GW emission
 - Circumbinary accretion, supernovae in close binaries, etc.
- Multiband GW astronomy
 - Bridging the gap between LISA and LIGO
 - Nanohertz GW astrophysics with pulsar timing arrays
- Neutron star astrophysics and interior equation of state
 - Common-envelope evolution
 - I-Love-Q relations and binding energy

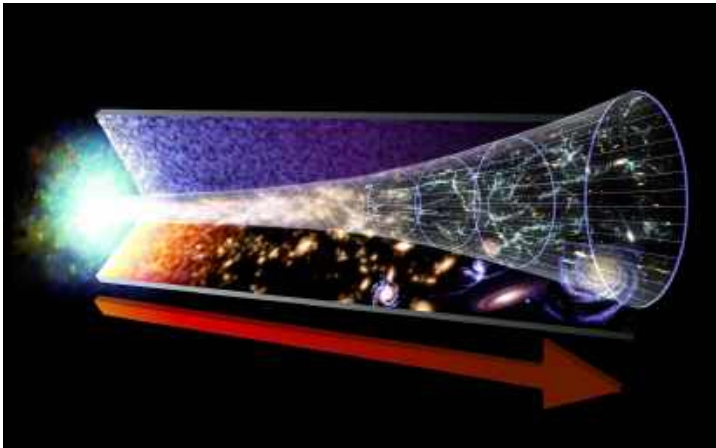


Kuan-Wei Huang

- 5th year PhD student
 - Group: Matthew Walker & Sergey Koposov
-
- Classify RR Lyrae stars from the ZTF survey using random forests
 - Search for globular clusters in Gaia using kernel density estimation

Tina Kahniashvili

The McWilliams Center For Cosmology



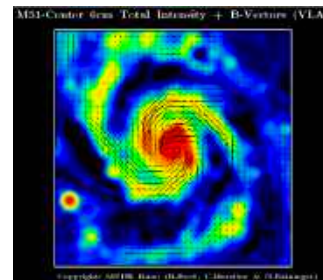
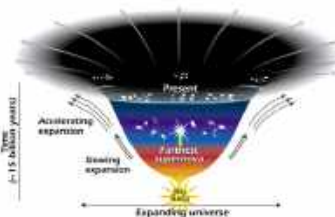
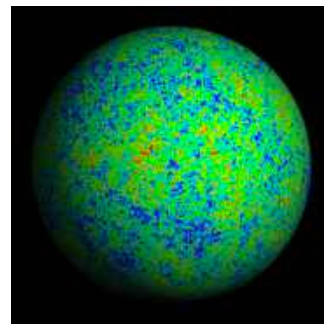
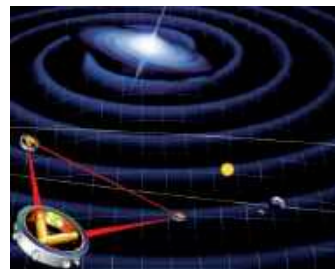
- Cosmology

- Very early universe

- Gravitational waves
- Cosmic microwave background
- Fundamental symmetries

- Late-time cosmology

- Dark energy
 - Massive gravity
- Astro-particle physics
 - Neutrinos mass origin



- Astrophysics

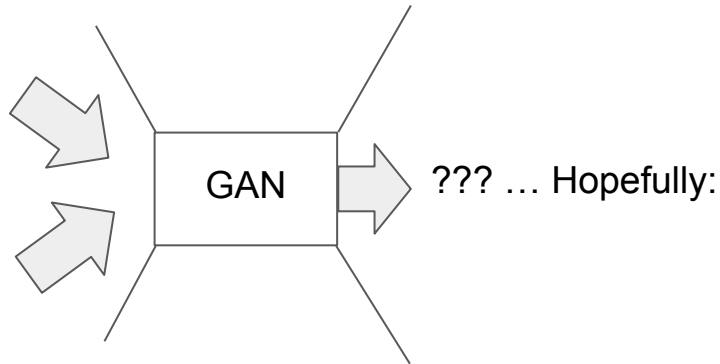
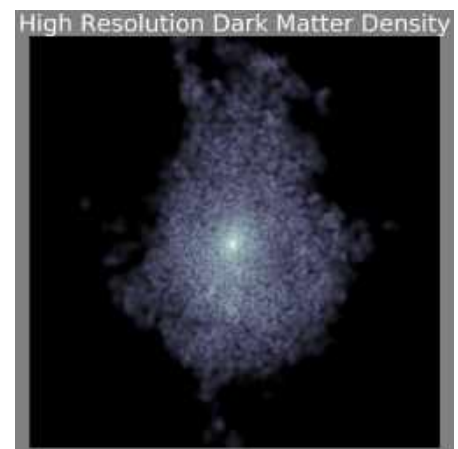
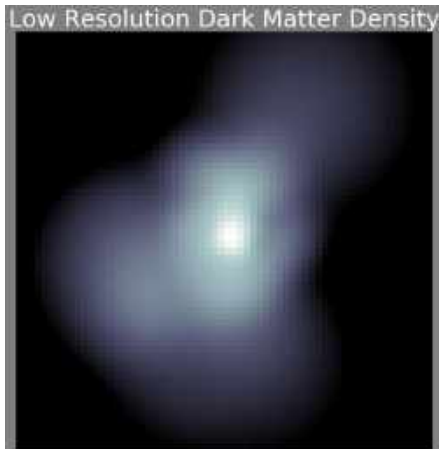
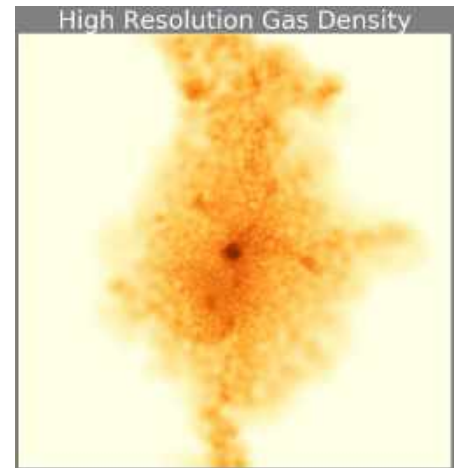
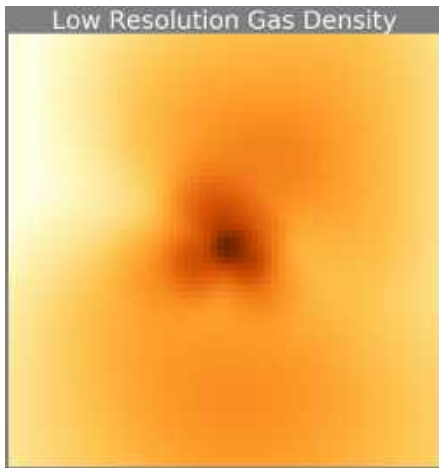
- Cosmic magnetic fields
- Cosmic turbulence



Patrick LaChance

2nd Year Graduate Student

- Working with Rupert Croft
- Interests / Area of Research: Applications of Machine Learning to Cosmological simulations
- Current Project: Using GANs to increase the fidelity of low resolution simulations



Alex Moskowitz

PhD Candidate

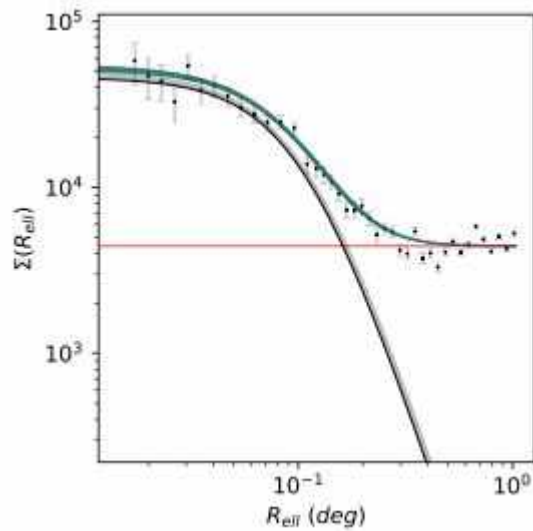
Advisor: Matt Walker

Dwarf Spheroidal Galaxies

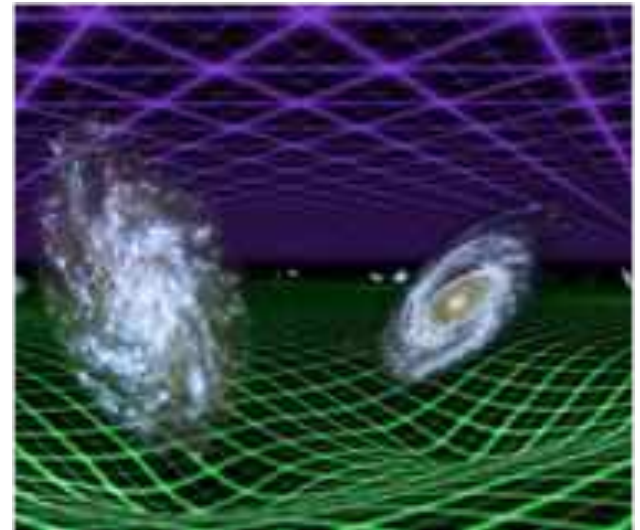


with a focus on

Stellar Distribution



Testing New Theories of Gravity



Dipto Mukherjee

2nd year graduate student,
Advisor: Hy Trac



Globular cluster N-body simulations

- ❖ Alternatives to direct summation based codes using **Fast Multipole Method**
- ❖ **Million and post million body simulations**
- ❖ **Binary black hole systems in GCs as gravitational wave sources.**

Supermassive black hole binary mergers

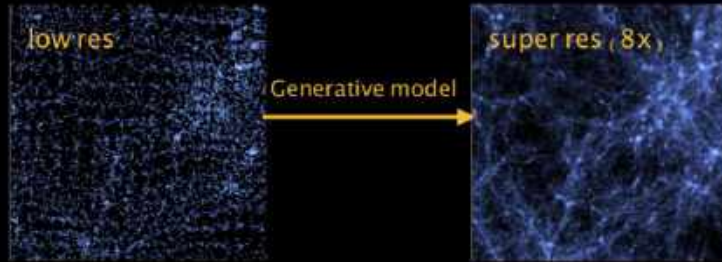
- ❖ Looking at treatment of **SMBH binaries using FMM based N-body code.**

Yueying Ni

4th year grad student,
work with Tiziana DiMatteo

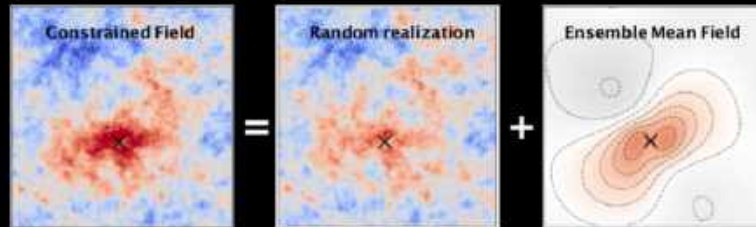


Super resolution simulation

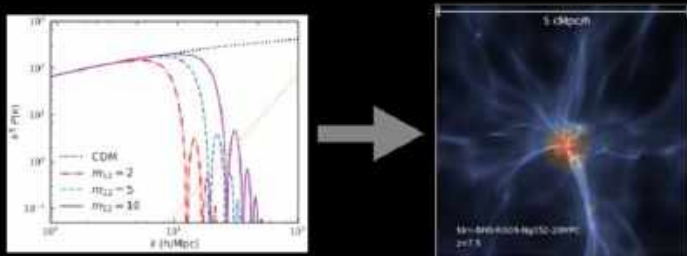


Constrained Gaussian Realizations

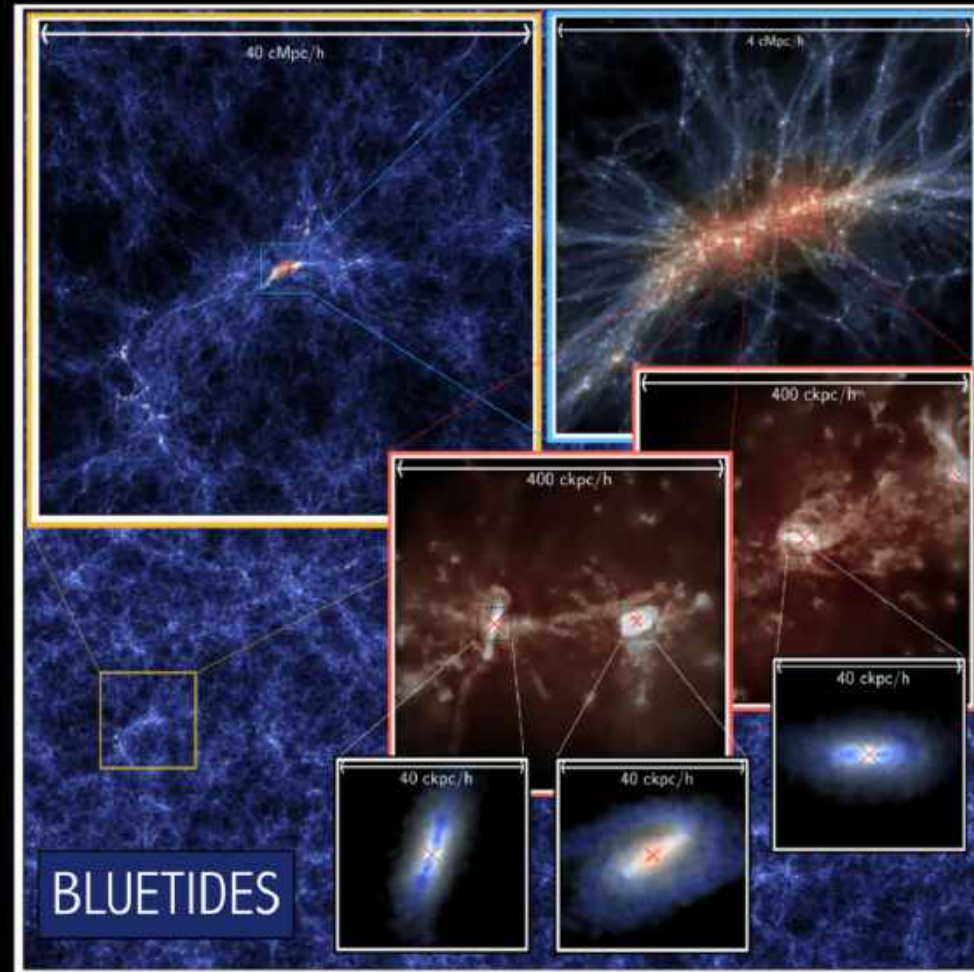
$$f(\mathbf{x}) = \int \frac{d\mathbf{k}}{(2\pi)^3} [\tilde{f}(\mathbf{k}) + P(k)\hat{H}_i(\mathbf{k})\xi_{ij}^{-1}(c_j - \bar{c}_j)] e^{i\mathbf{k}\cdot\mathbf{x}}$$



Alternative Dark Matter Models



Cosmological Hydrodynamic simulation to study the formation of galaxies and quasars

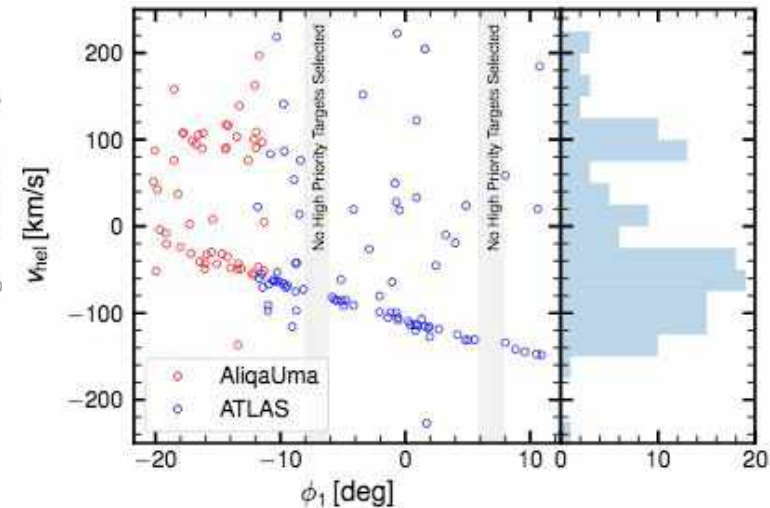
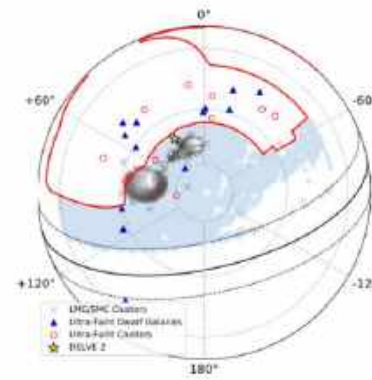
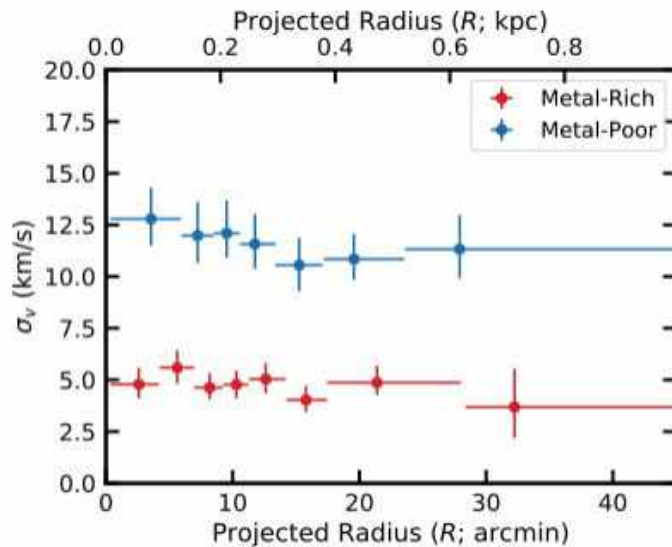


Andrew Pace

Postdoc, Milky Way Group

Research Interests:

- Dark Matter
- Dwarf Galaxies
- Stellar Streams

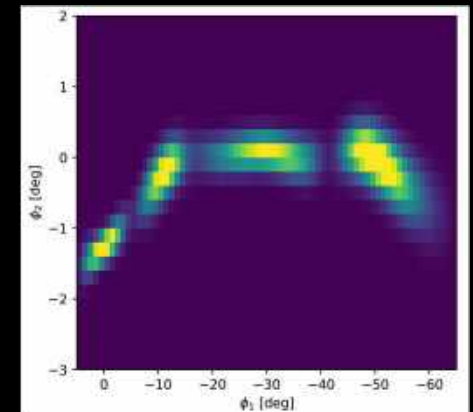
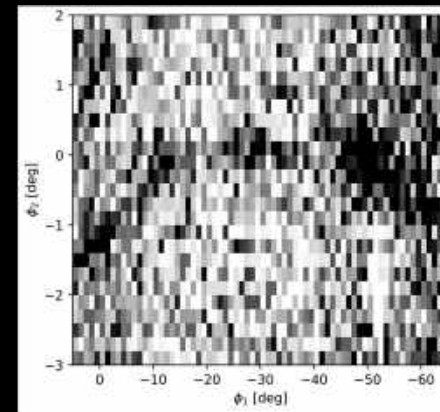
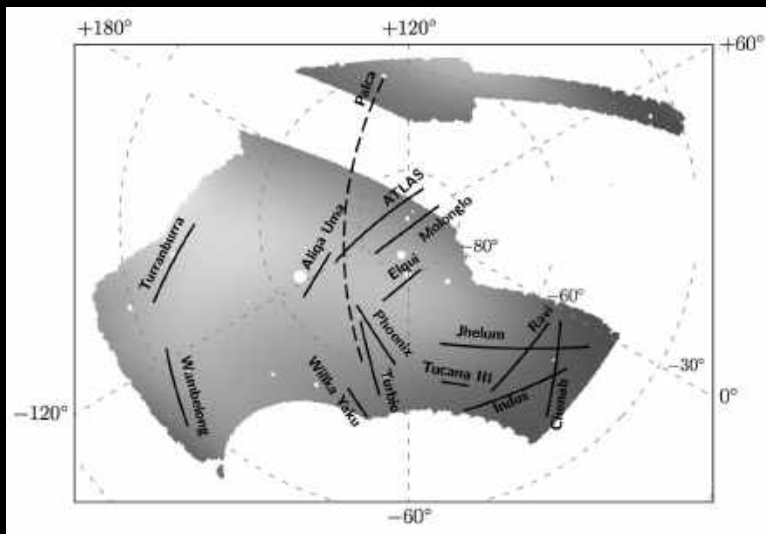
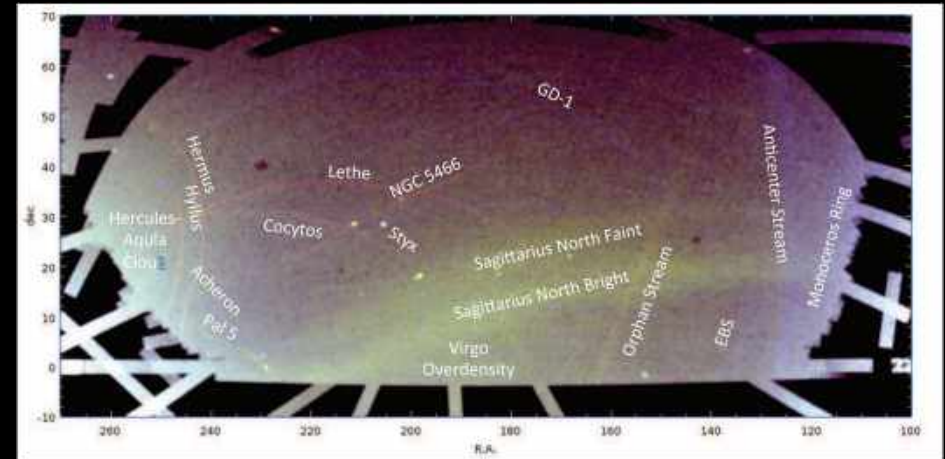


Jeff Patrick

Working with Sergey Koposov
and Matt Walker

5th year grad student

Automating the fitting and
characterizing stellar streams





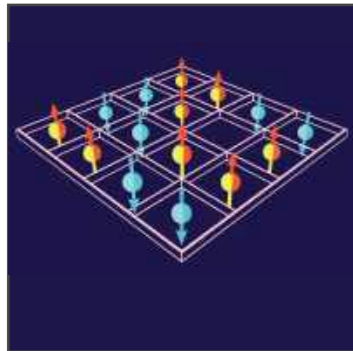
Riccardo Penco

Office: ~~Wean 7408~~ *home*

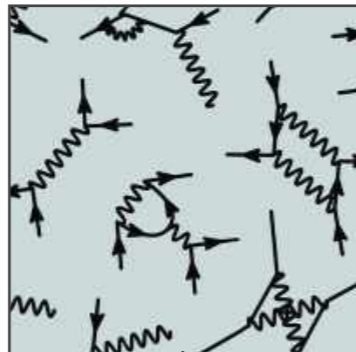
Email: rpenco@cmu.edu

Research Interests:

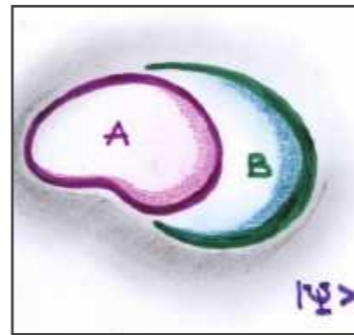
effective field theories for high energy, condensed matter, and cosmology



EFTs for magnetic systems



Scattering Amplitudes



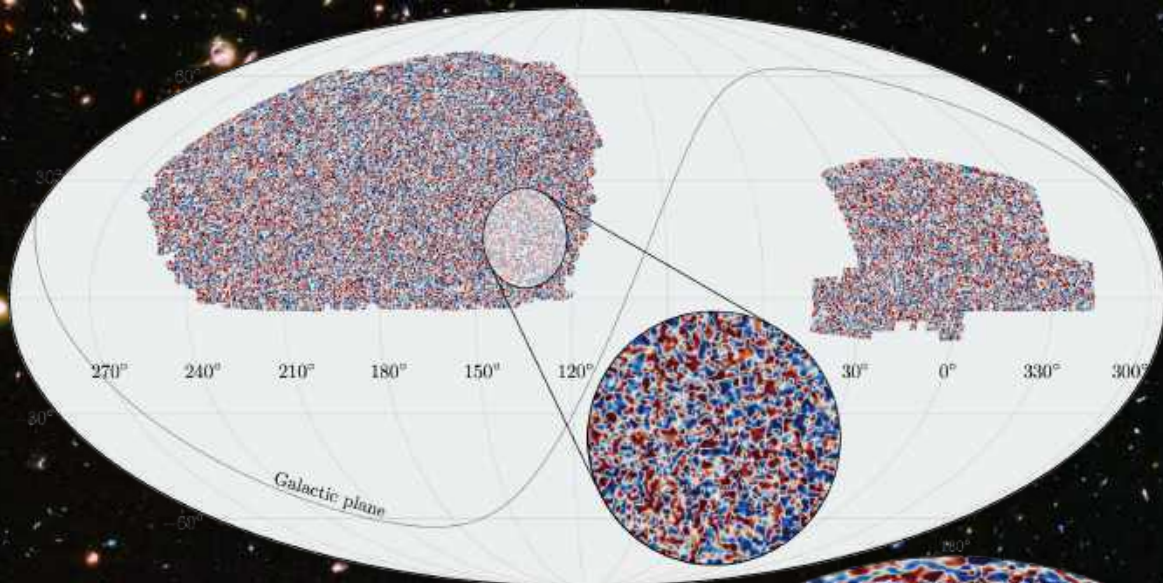
EFTs for open systems



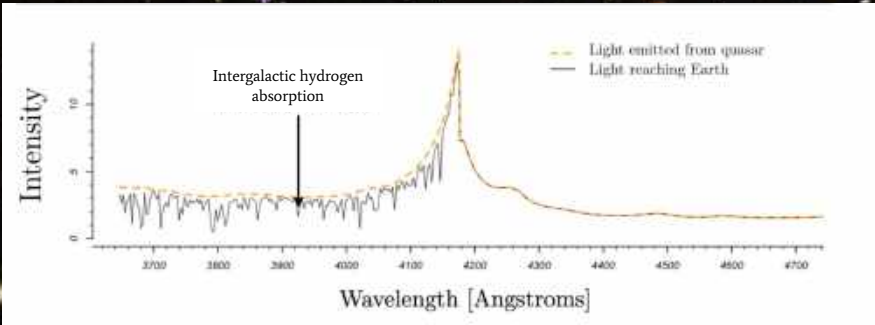
Black Holes



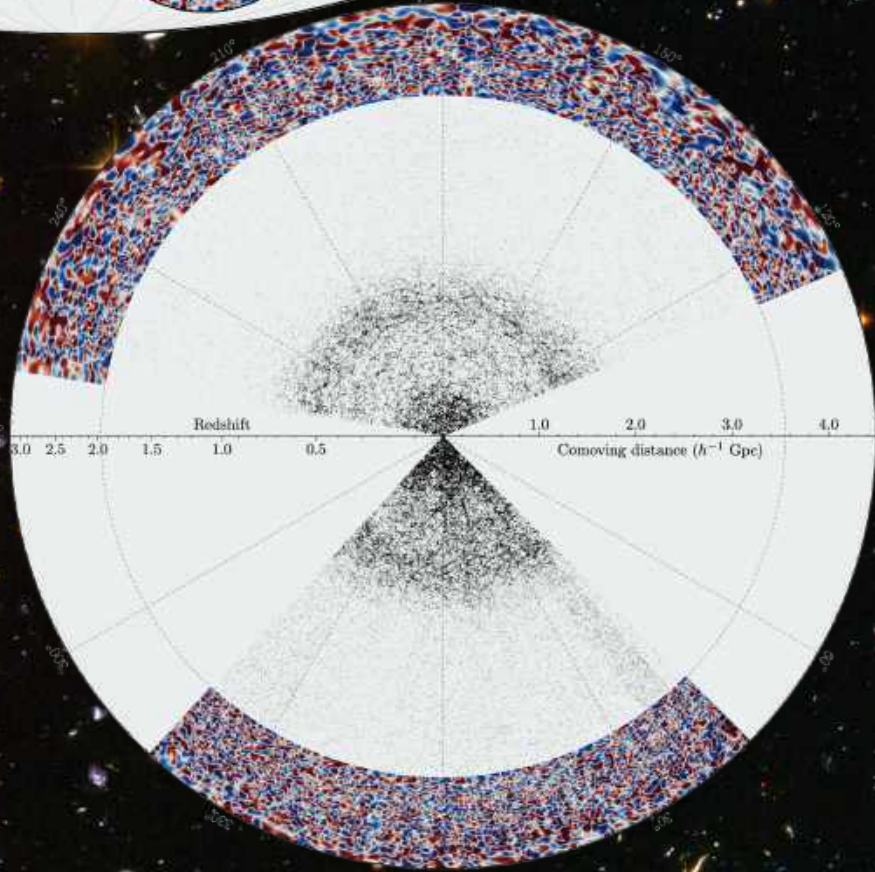
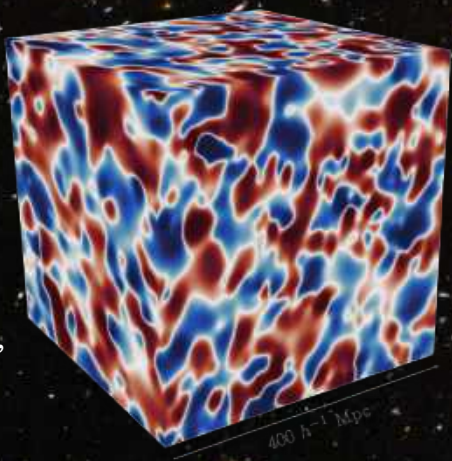
Gravitational waves



Collin Politsch
Postdoctoral Fellow
Machine Learning Department



Cosmography with the Lyman- α forest



Other interests: Exoplanet transits,
spectroscopic classification and
redshift estimation, etc.



Markus Michael Rau
Postdoc

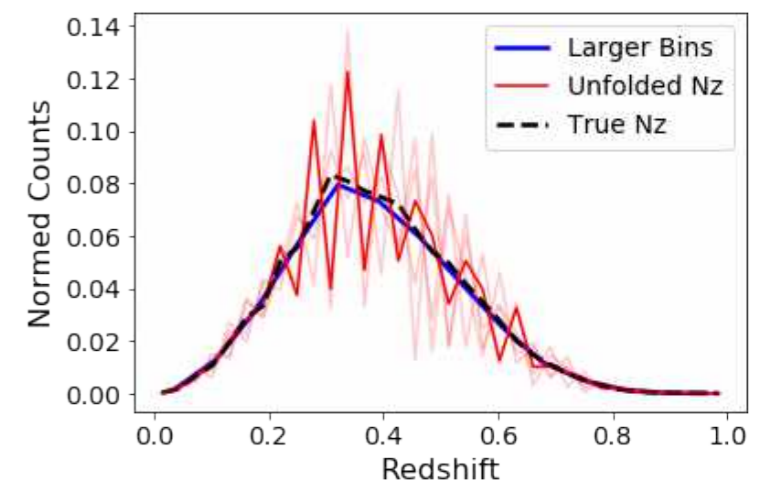
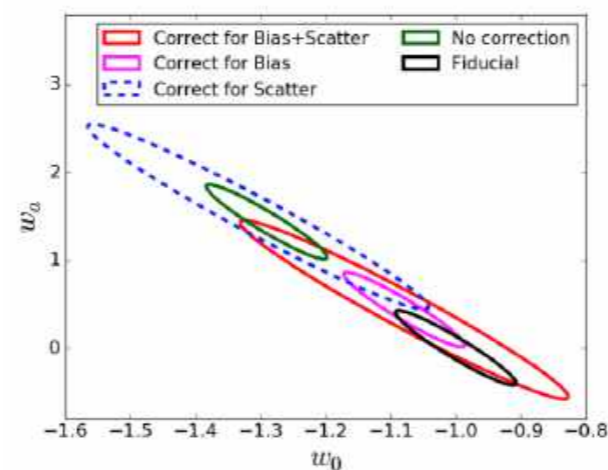
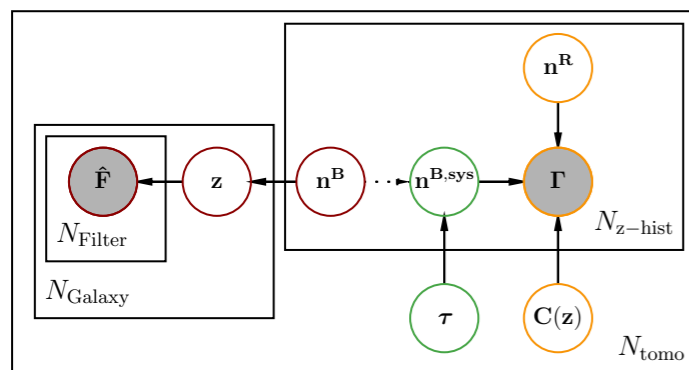
working with
Rachel Mandelbaum, Hy Trac



Machine Learning
Deep Learning
Bayesian Statistics
Hierarchical Models
Approximate Inference

Photometric Redshifts
Weak Lensing
Large Scale Structure
Cosmological Inference

Spatial Statistics
Probability Calibration
Inverse Problems
Deconvolution



Simon Samuroff

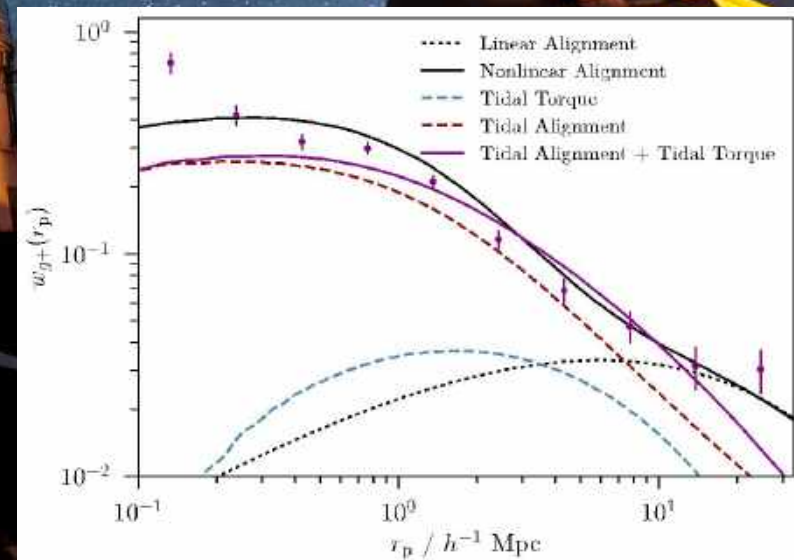
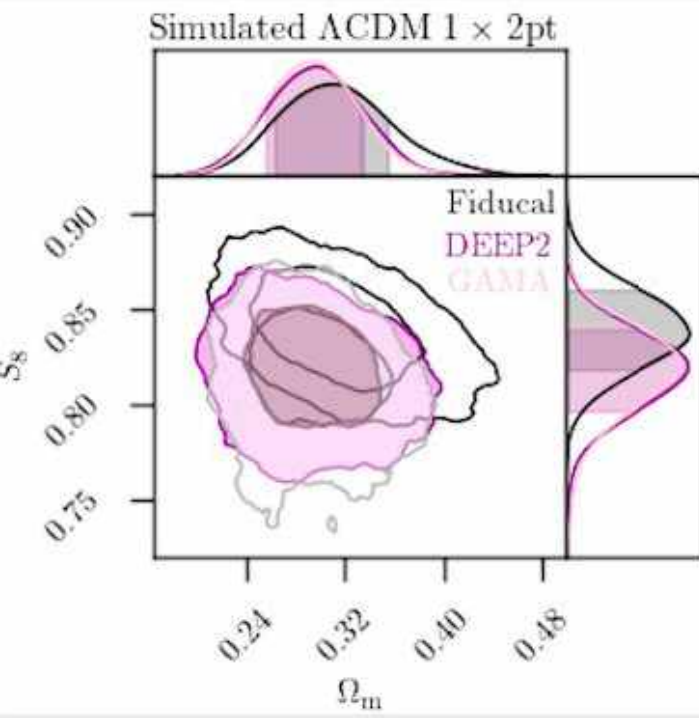
Postdoc, CMU

ssamurof@andrew.cmu.edu



Cosmology with galaxy lensing surveys

- **Intrinsic alignment modelling:**
Understanding the limitations of the current models of astrophysical systematics and developing better ones
- **Cosmic shear cosmology**
With DES Y3 + external probes
- **Weak lensing biases**
Understanding e.g. blending, shape measurement biases, IAs, photo-z biases, and how they interact.



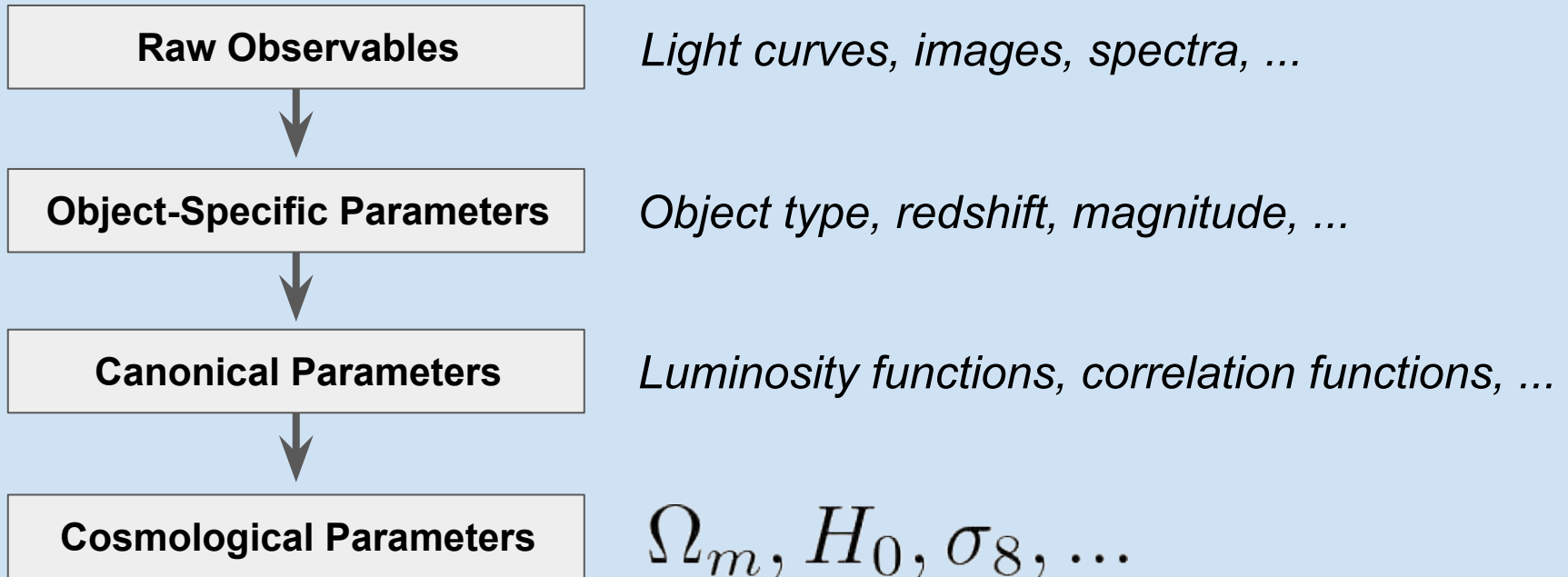


Chad Schafer

Professor, Department of Statistics & Data Science

<http://www.stat.cmu.edu/~cschafer>
cschafer@cmu.edu

What is astrostatistics? The big picture:



Patrick Shaw

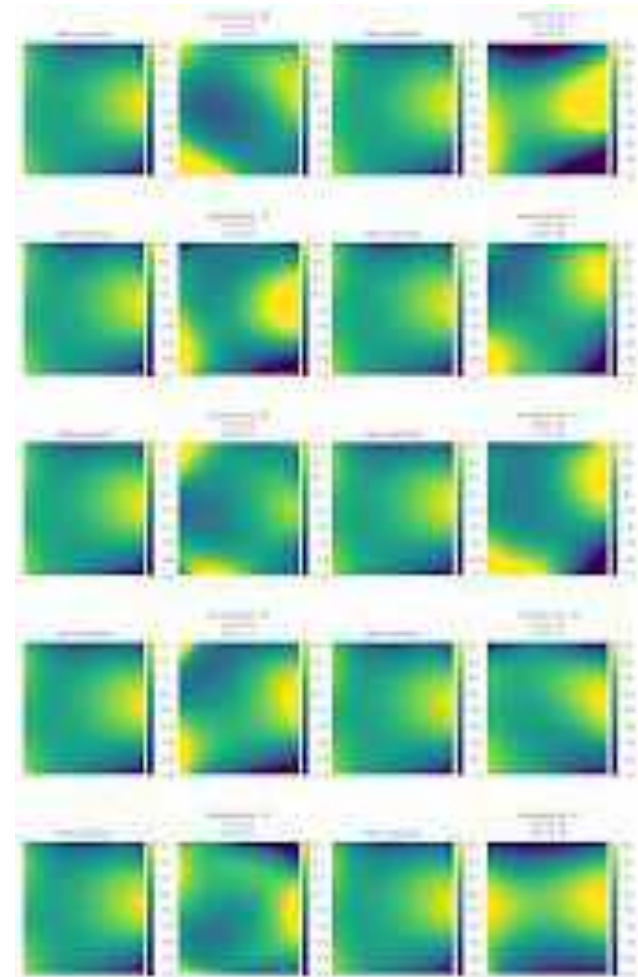
2nd Year Graduate Student
Working with Rupert Croft



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

Current Research:

- Weak lensing of the Ly-alpha forest
- Use estimator developed by R. Benton Metalf, Nicolas Tessore, Rupert Croft to reconstruct lensing potential
- Apply to realistic data sets from CLAMATO and LATIS surveys



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

Adam Solomon

Postdoc, High-Energy Theory &
McWilliams Center

Gravity, cosmology, and effective
field theory

Recent research interests:

- Dark energy, inflation, and modified gravity
- Black hole perturbation theory
- Cosmological constant problem



Hy Trac

Associate Prof
8307 Wean Hall
hytrac@andrew.cmu.edu



Group

Nianyi Chen, Yizhou He, Matt Ho, Dipto Mukherjee,
Markus Rau, Faith Ruehle, Qirong Zhu

Interests

cosmology, astrophysics, machine learning,
structure formation and evolution,
dark matter, galaxies, clusters, reionization,
hockey

Tools

Cosmological simulations
N-body, hydro, radiative transfer

Amber: semi-numerical reionization (Nianyi)

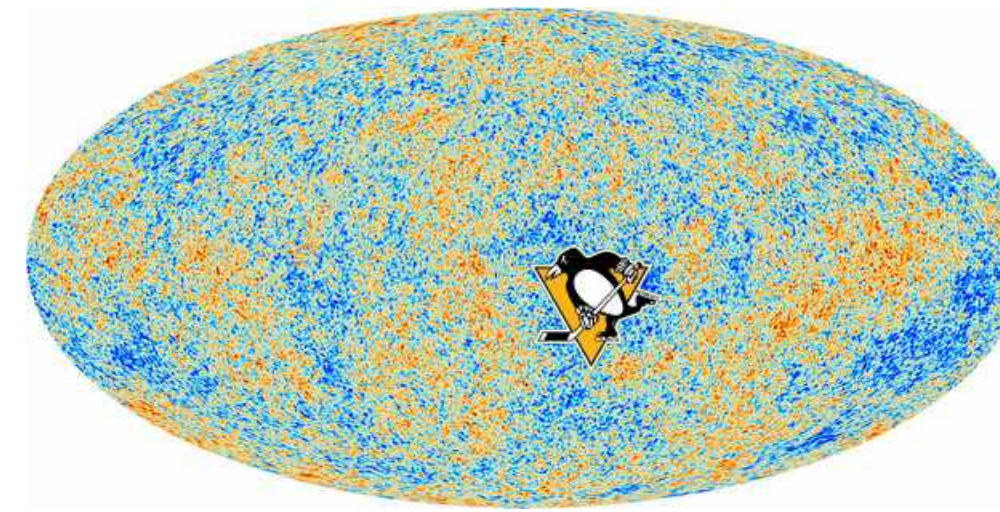
Ether: finite-volume particle method

Hyper: fast hydro-particle-mesh (Yizhou)

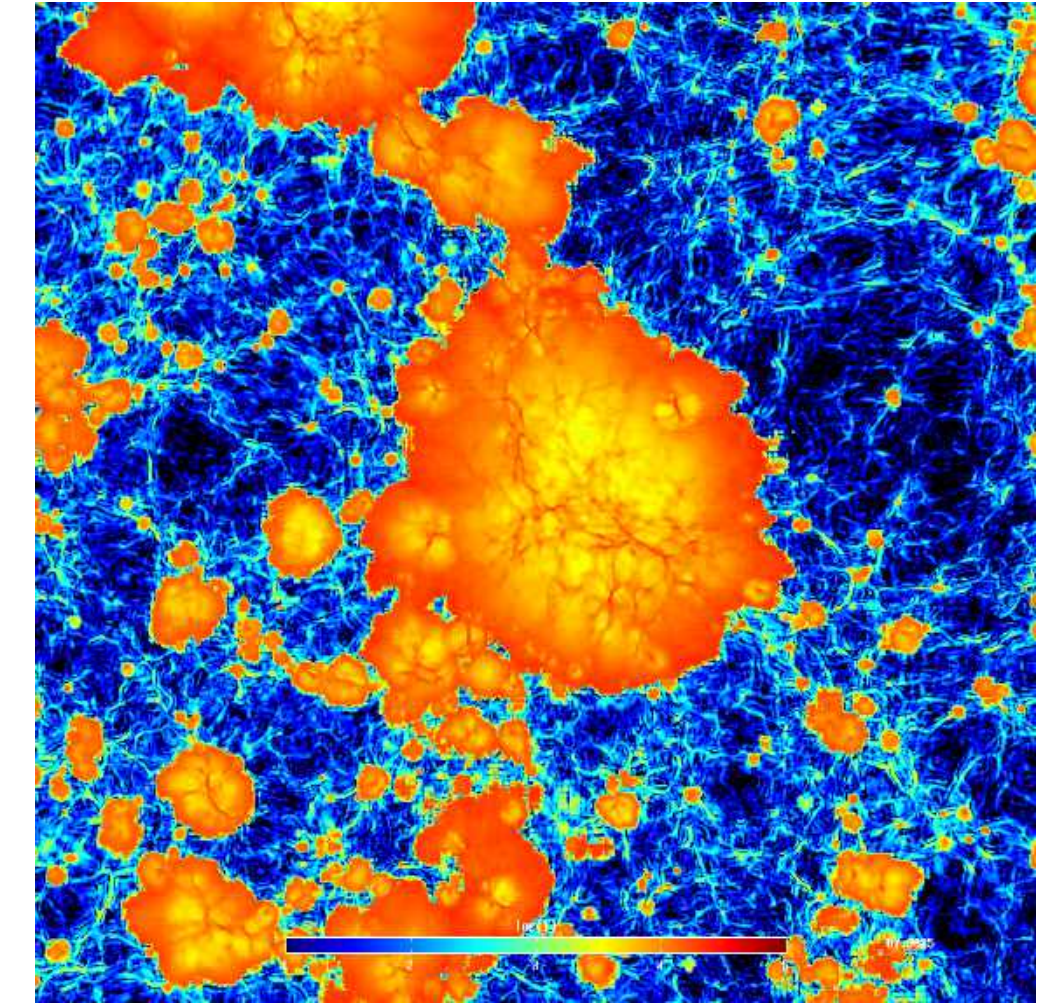
RadHydro: radiation-hydrodynamics

Bayesian Deep Learning: McWilliams-PSC Seed Grant
(Matt, Markus)

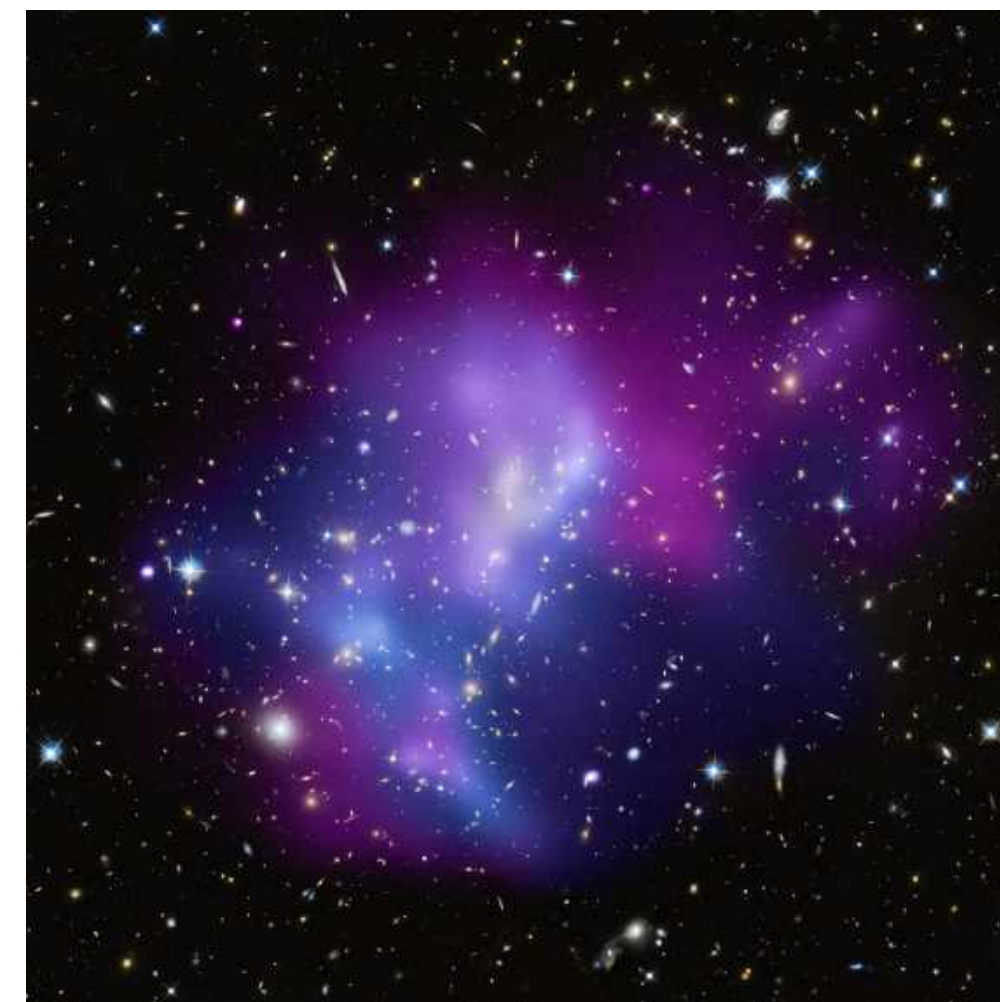
CMB



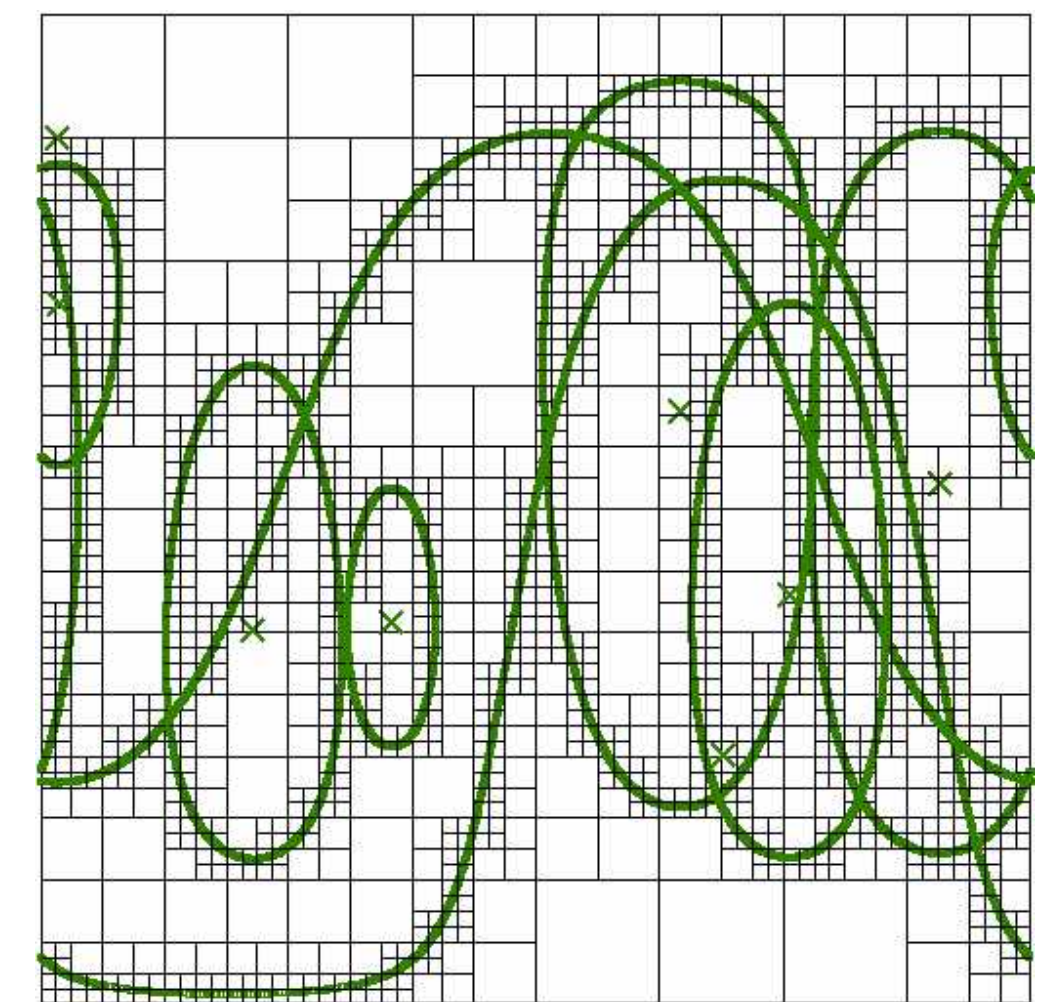
First stars and galaxies



Galaxy clusters



Supercomputing



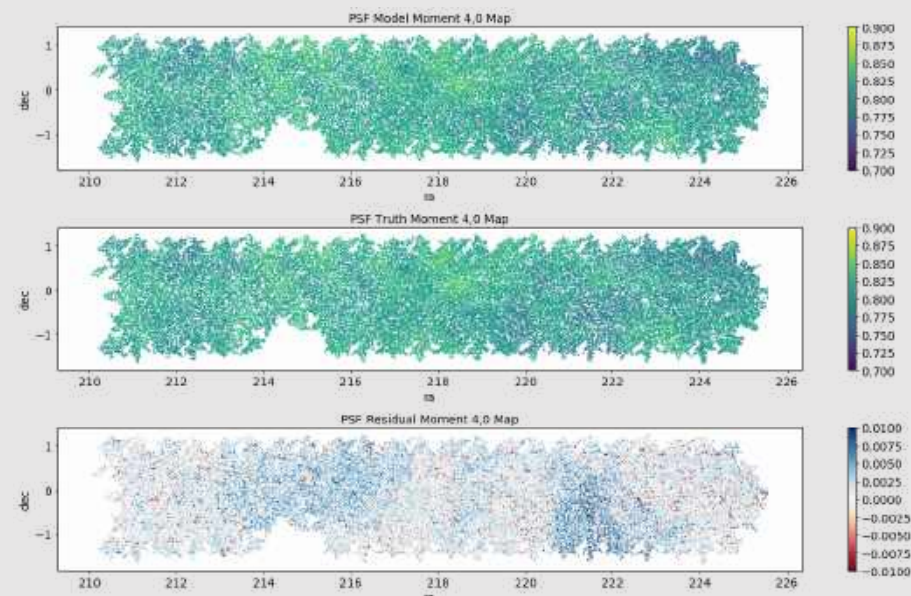
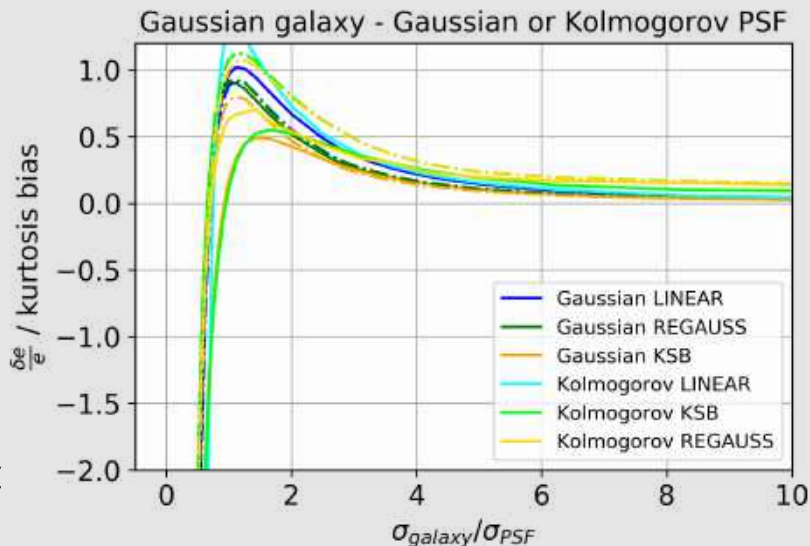
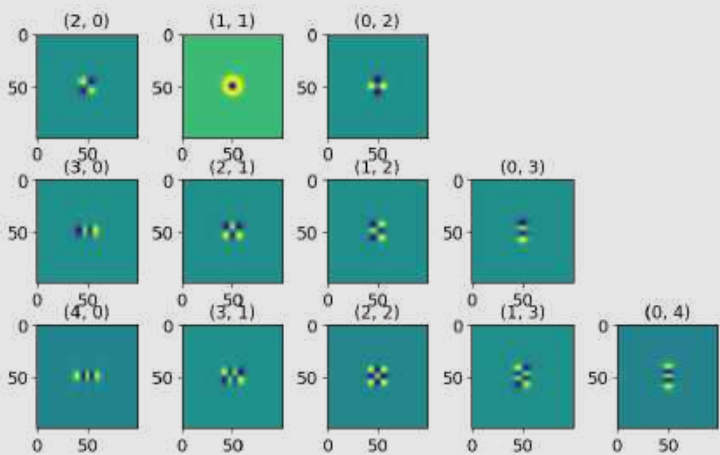
Tianqing Zhang

3rd year grad student

Advisor: Rachel Mandelbaum

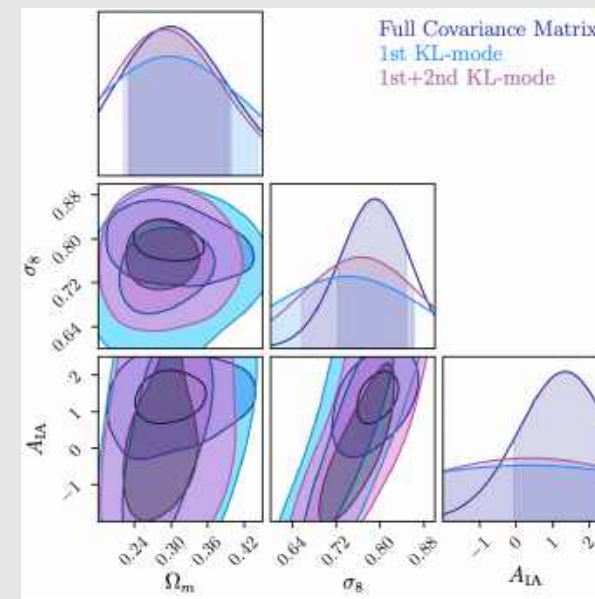
Weak Lensing Systematics by PSF

- Learn how PSF higher order moment uncertainty causes systematics in weak lensing shear measurement.
- Scheme PSF modeling requirement for DESC.
- Measure PSF modeling error for HSC



Covariance Matrices Testing

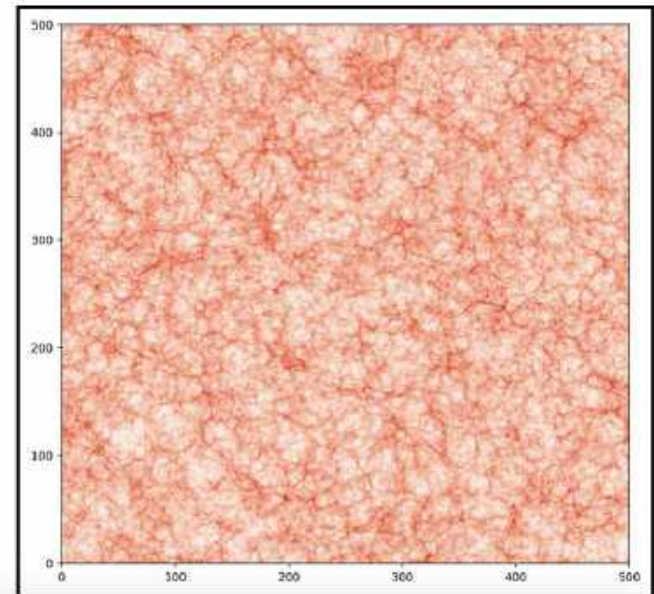
- Test compression methods for weak lensing data vector.
- Identify cosmological informative elements in the covariance matrices.



Qirong Zhu
McWilliams Postdoc Fellow

Research interests:

- Galaxy formation and evolution, giant low surface brightness galaxies in hydro simulations.
- N-body dynamics, fast multipole methods.



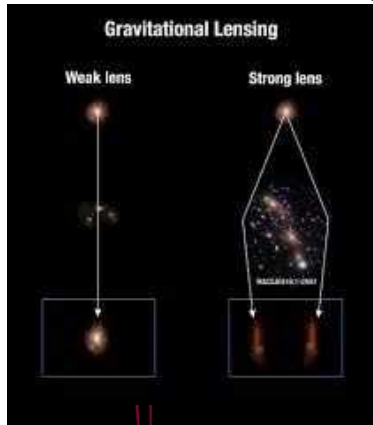
Rachel Mandelbaum



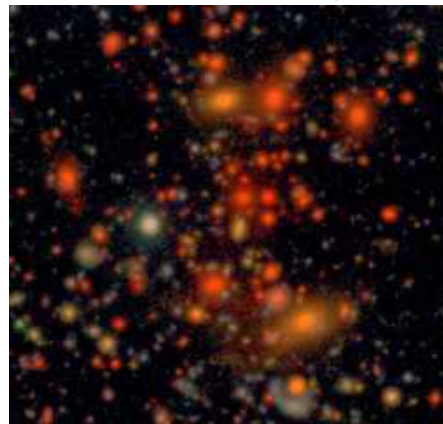
Observational cosmology:

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

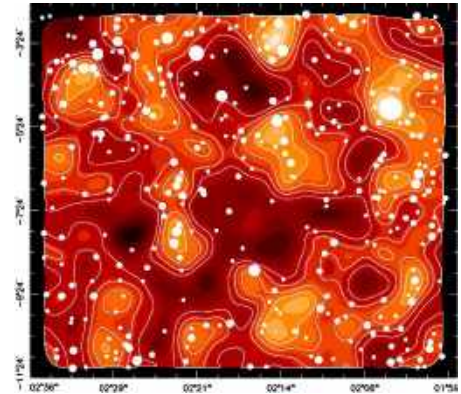
I measure weak lensing:



for tens of millions of galaxies



to (statistically) map dark matter and answer these questions



Currently Spokesperson of



My current playground:



Future surveys I'm involved in:

Rubin Observatory



NANCY GRACE ROMAN SPACE TELESCOPE

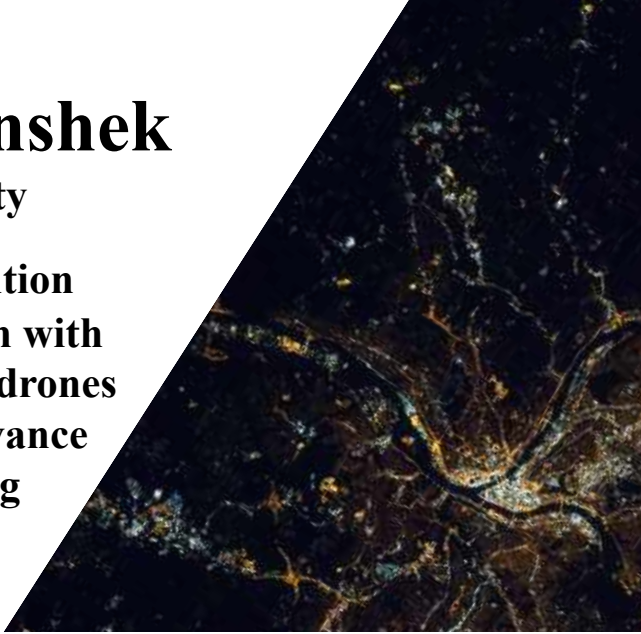


euclid

Diane Turnshek

Special Faculty

Making light pollution maps of Pittsburgh with satellites, the ISS, drones and aircraft in advance of the city changing 40K streetlights to shielded LEDs.



Diana Parno (*Asst. Prof., CMU*)

Constraining neutrino properties on Earth

- Direct neutrino mass from T_2 β decay
 - **KATRIN**: new lab constraint, effective neutrino mass < 1.1 eV at 90% CL
 - **TRIMS**: understanding the systematics
- **COHERENT**: coherent elastic neutrino-nucleus scattering
 - Cooling of neutron stars and supernovae
 - Backgrounds for dark-matter detection
 - *Bonus*: Cross sections for supernova neutrino detection

