



McWilliams Jamboree

November 3rd, 2023

Lbox = 600 ckpc/h

ASTRID Simulations

z = 2.950

Tiziana Di Matteo: How do massive black holes form?

A key prediction of MBH formation is that BH 'seeds' (a population of IMBHs) should exist as relics to this day.

If we can find these elusive IMBHs in galaxies we have a chance to reconstruct how MBHs form (in the early Universe).

Team: Y.Ni (grad, now fellow at Harvard), Niayi Chen (grad.), Yihao Zhou (grad), Eka Dadiani (grad), Junyu Chen, C. Hoffmann(undergrad), Clytie Qiu (undergrad),

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Current Research Project:

Gravitational wave background from black holes mergers in ASTRID



Junyu Chen 1st year PhD student Advisor: Tiziana Di Matteo

Ann-Marsha Alexis (she/hers)

Second-year PhD student @ CMU Advisor: Katie Breivik

Research and research interests:

- → Using close DWDs to constrain the shape of Milky Way based on LISA detectability
- → physics of binary evolution,
- → star formation and evolution







Other interests: playing instruments/music, writing, baking, learning languages

Andy Park

3rd Year Grad Student Advisor: Rachel Mandelbaum

> **Research Interests** Weak Gravitational Lensing

Data to Catalog

- Using higher order shear estimator to reduce shape noise
- Optimizing bright star masks for weak lensing
- Recovering cosmic shear from field distortion

Catalog to Cosmology

- Developing a consistent way to measure two-point functions
- Cross correlations and joint analysis



Hy Trac

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

Group

Nianyi Chen, Dipto Mukherjee, Jayanth Tumuluri, Eileen Xiao

Interests

cosmology, astrophysics, machine learning, reionization, galaxies, clusters, dark matter

Supercomputing

N-body, hydro, radiative transfer, semi-numerical

AMBER: https://github.com/hytrac/amber HYPER: fast hydro-particle RadHydro: radiation-hydrodynamics



Galaxy Cluster Mass Reconstruction with ML



Nianyi Chen CMU 6-year PhD student Advisors: Tiziana Di Matteo, Hy Trac

Other interests: Food, Sports, Cats



Research interests: Galaxy Formation (high-redshift), Numerical Simulations, Massive Black Hole (Binaries), Epoch of Reionization, Gravitational Waves





Dipto Mukherjee 5th year PhD student Advisor: Hy Trac





f (O) @ AoT.PGH

>make direct_nbody_dynamics

>[||||...] >[||||.].

>[|||. . . .] compiling lisa_mergers >[||||||. . .] compiling DM_imprints_GW compiling taichi_fmm.exe compiling interstellar_objects >[||||||||||] compiling hpc_toolkit

>pip install journal_club > requirement unsatisfied: volunteers_v3.0 Installation failed

>pip install astronomy_on_tap







I also enjoy taking pretty pictures of the sky (sometimes)...



Rupert Croft





faint quasar



Using the size of quasar proximity zones in the intergalactic medium to measure their luminosities and hence distances.

Using the parallax shifts of galaxies due to the motion of the Milky Way to measure their distances





+

- AI in astrophysics, including in simulations, data analysis
- Line intensity mapping
- Weak gravitational lensing of the intergalactic medium

Patrick LaChance 5th Year Graduate Student Advisor: Rupert Croft



Research Interests:

- High redshift galaxies (especially seen by JWST)
- Finding applications of machine learning in cosmology
- Current Project:
- Creating and analyzing mock JWST images of galaxies in the Astrid Simulation



Rachel Mandelbaum



I measure weak gravitational lensing...

HYPER SUPRIME-CAM



(she/her)

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

... for tens of millions of galaxies





Currently working on:

While preparing for...





Including a major focus on the LINCC Frameworks initiative to build robust, scalable, open-source science analysis frameworks for LSST!

THE NANCY GRACE ROMAN SPACE TELESCOPE

Federico Berlfein

- **Galaxy clustering systematics**
 - Mitigation of systematics Ο in two-point statistics
- **Chromatic effects** in Roman Space telescope image simulations
 - Quantifying and mitigating Ο chromatic effects on weak lensing
 - Identification and Ο implementation of new detector effects

3rd Year Graduate Student Advisor: Rachel Mandelbaum





F184

1800

H158

1600

Jeremy Kubica (he/him) Engineering Director LINCC-Frameworks





LINCC-Frameworks mission is to enable science on Rubin's LSST survey by developing scalable and productionised software/algorithms in collaboration with broader community.

Ongoing efforts:

- Scalable spatial analysis and storage formats (LSDB/HIPSCAT)
- Scalable time series analysis (TAPE)
- RAIL (w/ DESC)
- Moving object detection (KBMOD)
- Rolling incubators

Olivia Lynn

Software Engineer at LINCC Frameworks Wean 8109



I've been working on:

- RAIL (Redshift Assessment Infrastructure Layers)
 Redshift estimation and evaluation. at-scale
- PPT (Python Project Template)
 - Testing, restructuring, docs, publishing, & more
- Rolling projects:
 - Superphot+
 - DeepDISC
- Other projects:
 - LF Dash
 - Plot2PDF



Supervillain Origin Story: (my very first research position)

ofxMultitouch

- openFrameworks addon
- Carnegie Museum of Art
- use multi-touch gestures on a person-sized display to navigate a t-SNE visualization of Teenie Harris's photography archives



Sandro Campos

(he/him)

@camposandro

Software Engineer LINCC Frameworks



Main contributions

Python Project Template

- □ Software engineering practices
- □ Continuous integration and deployment
- Benchmarking

<u>LSDB</u>

- Spatial analysis for astronomical surveys at scale
- Parallel and distributed computing

Superphot+

- □ Supernova light-curve based classification
- □ Source physical parameter estimation

E-mail:

scampos@andrew.cmu.edu Office: Wean 8109

Konstantin (Kostya) Malanchev (he/him) LINCC-Frameworks Project Scientist



Wean 8101, malanchev@cmu.edu

Scientist for LINCC Frameworks projects and incubators:

Sponsored* Apply for LINCC
 Frameworks Incubator program! Next deadline is Feb 15th

http://incubator.rubin.science

Anomalies!

PhD in accretion disc theory

_0.001

0.0001









Time-domain astronomy — all about light curves:

- Anomaly detection with SNAD team
- Classification
- Feature extraction
 pip install light-curve
- Portal for ZTF DRs <u>https://ztf.snad.space</u>

LSST ISSC, TVS, DESC member

Lukin, Malanchev, et al., 2017



Research Faculty @Pitt LINCC Frameworks Research Scientist mi.dai@pitt.edu





SIRAI

Cosmology with Type Ia supernova

- Systematic uncertainties
- Photometric classification
- SED model training
- Spectroscopic follow-up strategies
- Machine Learning









Alex Malz (he/him)

LINCC-Frameworks Project Scientist

- COO L
- Wean 8101, aimalz@cmu.edu, github.com/aimalz

Research interests

- Extracting fundamental physics from uncertainty-dominated data (static & time-domain)
- Experimental design for optimal analyses (mostly cosmology)
- Probabilistic data products in general! 13087 true Other





Harping on performance & decision-making metrics The worst acronyms (see data challenges & code) Too many collaborations: COIN; LSST-DESC, -ISSC, +3



Mohit Bhardwaj McWilliams Postdoctoral Fellow IAU Gruber fellow

Research interests:

Short duration transients (< 1 sec), Astrostatistics, Radio instrumentation, Anything related to Fast Radio Bursts (FRBs)!



FRB Team at CMU: (all undergrads!)

Katherine Lu, Sarah Pelesky, Jimin Lee, Kevin Ji, Clytie Qiu

chime/frb

Matt Walker (I'm teaching right now)

I conduct and use observations to infer the structure of dark matter halos on small (sub-galactic) scales.









Nora Shipp NSF & McWilliams Fellow Wean 8313



Research interests: Stellar streams, near-field cosmology, Galactic dynamics, dark matter

Measuring dark matter in our Galaxy with stellar streams

Dwarf galaxy halos



Stream Discovery



Milky Way's dark matter halo

Simulations

t = -1.21 Gyr, r(LMC - MW) = 226.4 kpc





TEMPLATES



Building Galaxies from the ground up with JWST and Gravitational Lensing

Gourav Khullar (he/him)

Samuel P Langley PITT PACC Postdoctoral Fellow University of Pittsburgh Segurav.khullar@pitt.edu

I study mass assembly of galaxies, specifically (a) quiescent systems, as well as (b) sub-galactic structures within gravitationally lensed galaxies.



These days, I am super excited about JWST spectra. For the first time, the combo of deep JWST multi-band photometry, infrared spectra and lensing lets us simultaneously ask:

- a) How do we construct high-redshift galaxies from the ground up, starting with star forming clumps?
- b) Where in a galaxy does the cessation of star formation begin?





I like all sorts of mountains





Micro galaxies as a probe of CDM

Raphaël Errani

postdoc

gravitational dynamics, tidal evolution of dwarf galaxies, dark matter substructures

talk to me about Pizza dough



Tidal disruption for different dark matter models



high-resolution N-body models (not sure if dark matter is real)





Rachel Buttry (5th Year Grad Student) Advisor: Matt Walker





Things I work on:

- Hierarchical inference
- Binary stars in dwarf galaxies
- Sometimes a card game

Sofia Splawska (she/her) Ist year PhD student @ CMU (WH 6332) BS in Physics from Case Western Reserve University

Current advisor: Matt Walker







- Wide binaries in dwarf galaxies
- Milky Way satellites
- Dark matter substructure

Previous research

- Wide binaries @ CWRU
- Median statistics in cosmology @ Kansas State University
- Vertical dynamics of Milky UNIVERSITY Way @ CWRU



Interests

• galactic dynamics

KANSAS STATE

• dark matter

Carnegie

University

Mellon

- modified gravity as an alternative to dark matter
- cosmological simulations



Pulsar Timing Array (PTA) are sensible to gravitational waves generated or present at QCD energy scales

Messengers from the Early Universe: Gravitational Waves and Cosmological Magnetic Field



The space interferometer will be a unique device to observe the gravitational radiation from anisotropic phases possible at the energy scales 1TeV-100GeV.

Tina Kahniashvili





Deyan Mihaylov UPitt / CWRU / MPG



Research interests: Gravitational Waves, Early Universe Cosmology, Inflation, LIGO, LISA, PTAs

Sayan Mandal, Adjunct Instructor

Interested in Theoretical Cosmology:

- Using Primordial Magnetic Fields to find evidence of inflation.
- Interplay of PMFs and LSS.
- GWs as a probe of Early Universe.
- Models and phenomenology of dark matter
- Distinguishing between dark matter models using CMB Lensing





Murman Gurgenidze

Second year PhD student at CMU

Advisor: Dr. Tina Kahniashvili

Interests:

- Beyond GR physics
- Theoretical Cosmology







Chris Choi (he/him)

(Korean: 최민영) 4th Year Undergrad - CMU Advisor - Dr. Tina Kahniashvili (Georgian: თინათინ კახნიაშვილი) Interests:

- Theoretical Cosmology
- Gravitational Wave Theory
- Modified GR: Massive Gravity



Working with Jacob Magallanes (4th yr undergrad) & Murman Gurgenidze (2nd yr PhD)

- Compute gravitational wave (GW) spectra for models of **massive gravity** (MG)
- Look at **time independent** and **dependent** functions for the **graviton mass [1, 2]**
- Compare results with GW background from NANOGrav [3]
- Estimate the parameters needed if MG is to explain data

T. Fujita, S. Kuroyanagi, S. Mizuno, and S. Mukohyama, Physics Letters B **789**, 215 (2019).
 A. E. Gümrükçüoğlu, S. Kuroyanagi, C. Lin, *et al.*, Classical and Quantum Gravity **29**, 235026 (2012).
 G. Agazie, A. Anumarlapudi, A. M. Archibald, *et al.*, The Astrophysical Journal Letters **951**, L8 (2023).

Constraining Massive Gravity with NANOGrav 15-Year Data Set





Arthur Kosowsky, Pitt

Cosmological parameters, tests of the cosmological model

Physics of the very early universe, physics of inflation

Probes of linear structure growth, tests of gravitation

Cosmic microwave background signals and measurements

Primordial gravitational waves



Collaboration Spokesperson, Simons Observatory





Research Interests:

- Cosmological Gravitational Wave Background
- Gravitational Particle
 Production
- Quantum Gravity
- Modified Gravity
- Studying elastic scattering on cosmological gravitational wave backgrounds to constrain dark matter candidates e.g., primordial black holes
- Deriving new solutions to the quantized Hamiltonian of general relativity in the presence of fermions
- Using cosmological observables to constrain the possible modifications to Einstein's theory of general relativity

Marcell Howard 5th Year PhD Candidate Advisor: Arthur Kosowsky Office: Allen 300

https://marcellhoward.github.io/ https://inspirehep.net/authors/2624602



arxiv:2309.15925

Travis Court (he/him) 5th Year at Pitt Advisor: Carles Badenes Office: Allen 300

Interests: supernovae, binaries, computation

- Type la supernova remnant modeling
- I co-organize Astronomy on Tap 🤹
- Supernova remnants allow us to look at the interaction between supernova explosion ejecta and the ambient medium via X-rays, i.e. probe Type la progenitor problem.
- Different ambient medium (AM) environments will alter observational characteristics of supernova remnants tac136@pitt.edu



courtt.github.io





Taylor Starkman (he/him)

Junior at Pitt Physics and Astronomy Major



Research interests

- Gravitational waves
- Pulsars
- Data analysis
- Detector characterization
- Multimessenger astronomy

Current work

Dr. Wood-Vasey's group working on Type 1a Supernova

Past work

- RIT REU in multimessenger astro
- REU at LIGO Hanford observatory (funded by UWB)

Antonella Palmese (she/her/hers) Assistant Professor

apalmese@andrew.cmu.edu Wean Hall 8412

- Optical sky surveys: DES and DESI. <u>DESIRT</u> time domain program with DECam ★
- Gravitational waves (GW) sources from LIGO/Virgo/KAGRA, Cosmic Explorer, LISA ★
- **GW follow-up** (optical to NIR)
- **GW** cosmology \star
- Transients and host galaxies, applications for Supernova and origin of binary systems \star
- Machine learning ★

Credit: Ferguson, Jani, Shoemaker, Laguna - Georgia Tech, MAYA

#multimessenger on AstroPGH Slack!







ENER

Brendan O'Connor - McWilliams Fellow (Wean 8105)

Email: boconno2@andrew.cmu.edu Website: https://brendanoc95.wixsite.com/brendanoconnor/

Research Interests: Neutron stars, Gamma-ray Bursts, Kilonovae, Host galaxies and environments, Galactic X-ray sources (CVs, HMXBs), and any other interesting/unclassified transients, TBD???

Wavelengths: X-ray, Optical, Infrared







Lei Hu

(Postdoc @ CMU, Wean 8021) Email: <u>leihu@andrew.cmu.edu</u>

- Transient Surveys and GW follow-up based on DECam DESIRT time domain program & GW-MMADS program
- Searching High-z Supernovae in JWST Abell 2744 Cluster & PERALS program
- Transient detection Techniques GPU-powered SFFT method for image subtraction



Package Description

https://github.com/thomasvrussell/sfft

DOI 10.5281/zenodo.6576426 pypi v1.4.1 Downloads 8k Downloads/month 350 python 3.7 License MIT

* 10+ Faster! Automatic! Accurate!





Ariel Amsellem

2nd Year CMU Grad Student Advisor: Antonella Palmese

Electromagnetic/Optical Gravitational Waves

Interests:

- Standard Sirens and the Hubble Constant.
- Peculiar Velocities of galaxies (with DESI).
- Transients and cosmology.

Carnegie Mellon University DARK ENERGY SPECTROSCOPIC INSTRUMENT

U.S. Department of Energy Office of Science

https://www.legacysurvey.org/viewer-desi



Tomás Cabrera 4th year PhD cand. @ CMU Advisor: Antonella Palmese

Interests:

- Multi-messenger astronomy
- Amateur data stewardship
- High-performance computing

BBH formation channels (here, AGN) GW190403_051519 GW190514_065416 GW190521 GW190424_180648 S Flare(s) 💢 Flare(s) GW200216_220804 GW190909 114149 GW200220_124850 💢 Flare(s 💢 Flare(s)

Gravitational wave EM follow-up





Keerthi Kunnumkai

(2nd year PhD @ CMU) Advisor: Antonella Palmese

Interests:

- Multi Messenger Astronomy
- GW follow-up
- ML

GW simulations \rightarrow simulation parameters \rightarrow ejecta parameters \rightarrow Simulating Kilonova light curves



55

10

count





Ekaterine Dadiani (Eka) 🕂

3rd year Graduate Student Advisor: Antonella Palmese, Tiziana Di Matteo

• Dual AGN host galaxy morphology in ASTRID





Other interests: Skiing, hiking, climbing, film photography...

• Searching for Massive Black Hole Binaries in DESI



dec







My Projects:

 A temporally coherent super-resolution neural network for cosmological simulations



 A field-level emulator for super-resolved cosmological simulations, guided by initial conditions



SR output

After emulator with IC guidance

Real N-body Simulation with same IC

Xiaowen Zhang

3rd Year Grad Student



Alan Junzhe Zhou

2nd year now! @ CMU Advisor: Scott Dodelson https://azhou00.github.io

Field-level cosmological analysis

Multi-probe analysis

High-dimensional probabilistic learning, Bayesian networks



CMB, ISW, galaxy density maps joint reconstruction



Differentiable particle mesh ray tracing sims.



Weak lensing reconstruction & systematics control

Katie Breivik (she/her) CMU | McWilliams Center



Broadly stoked about binaries and



GWs/surveys

workflows



open code



COSMIC connects observed populations at each evolutionary phase



Anna O'Grady McWilliams Fellow Wean 8301

Research Interests: Observations of massive/weird star populations; binarity, variability, & evolution

Current Work: Identifying YSG binaries

Past Work: Thorne-Żytkow Objects and super-AGB stars





- Binary fraction of YSGs in Clouds
- Efficiency of binary envelope stripping
- Progenitors of partially-stripped envelope supernovae



Ignacio Magana Hernandez

McWilliams Fellow Wean 8313 imhernan@andrew.cmu.edu

Research Interests: Anything gravitational waves. More specifically: GW cosmology, populations and formation channels. I'm also interested on GW lensing and tests of GR with GWs.

Current work:

- Dark siren cosmology done right.
- Strong GW lensing identification and science case.
- Progenitors to GWs with COSMIC and a fully bayesian forward/backward modelling approach.
- Nonparametric mass function cosmology with GWs as well as populations.





GW190814 (q ~ 0.11) estimated masses and metallicity at ZAMS

Gina Chen

3rd year grad student working with Katie Breivik

- Astro Interests: everything black hole related, binaries, gravitational waves, star formation and evolution
- Current project: synthesizing a population of globular clusters based on the galaxy-merger history of TNG100



- Non-astro Interests: video games (BOTW/TOTK, Hollow Knight, Ace Attorney), drawing/art, and journaling
- Music Recs: Beyond by Synergy Sound, Con Todo El Mundo by Khruangbin





Kerry.Handron@pitt.edu



Field Trips Scout Groups Astronomy Clubs Kit program High School Research Haunted Space Mansion Special Events



Outreach at the Allegheny Observatory

Or just come visit!

Astrophysicist for a Day - Monday Nov. 20 Top High School Students. Paper, two talks then - small group work with you!

.

How many stars do you see?

Diane Turnshek

Special Faculty, Physics Department, Carnegie Mellon University (<u>dianet@andrew.cmu.edu</u>) Adjunct Assistant Professor, Department of Physics & Astronomy, University of Pittsburgh (<u>dianet@pitt.edu</u>) dianeturnshek.com

Working on local, state, national and international levels on light pollution mitigation. Editor for two IAU meeting proceedings on satellite and ground-based light pollution. Chaired 8th International Artificial Light at Night Conference in Calgary, Canada. Honorable Mention in the Carnegie Science Awards for Most Inspiring Educator. Scores of media interviews in print, TV, radio and podcasts including: 2023 documentary "Licht aus! Sterne an!" aired on German & French public television, Smithsonian Podcast Sidedoor introducing the Lights Out: Recovering Our Night Sky exhibit at the National Museum of Natural History on the Mall in Washington DC, Knights of Columbus Supreme Council video on the Veterans Administration's new observatory on the H. J. Heinz III hospital campus in O'Hara Township.



Climate change and light pollution VR games.

