

# Gautham Narayan

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## RESEARCH INTERESTS

- Observational Cosmology and Cosmography
- Time-domain Astrophysics, particularly Transient Phenomena
- Wide-field Ultraviolet, Optical and Infrared Surveys
- Multi-messenger Astrophysics & Rapid Follow-up Studies
- Statistics, Data Science and Machine Learning

## PROFESSIONAL APPOINTMENTS

Current:	Assistant Professor, University of Illinois at Urbana-Champaign Aug 2019–present
Previous:	Lasker Data Science Fellow, Space Telescope Science Institute Jun 2017–Aug 2019
	Postdoctoral Fellow, National Optical Astronomy Observatory (now NOIRLab) Jul 2013–Jun 2017 <sup>1</sup>

## EDUCATION

Harvard University	Ph.D. Physics, May 2013 Thesis: “ <a href="#">Light Curves of Type Ia Supernovae and Cosmological Constraints from the ESSENCE Survey</a> ” Adviser: Prof. Christopher W. Stubbs A.M. Physics, May 2007
Illinois Wesleyan University	B.S. (Hons) Physics, Summa Cum Laude, May 2005 Thesis: “ <a href="#">Photometry of Outer-belt Objects</a> ” Adviser: Prof. Linda M. French

## GRANTS DURING TENURE AT ILLINOIS

- PI, NSF CSSI, USD 3,554,724, Aug 2023–present
- PI, NSF CAREER, USD 717,600, Aug 2023–present
- PI, NSF AAG, USD 328,618, Aug 2022–present
- PI, HST GO 16764, USD 274,723, Aug 2022–present
- PI, LSST-Wasabi Enabling Science Award, USD 25,000, Aug 2022–present
- PI, LSST Enabling Science Awards for undergraduates at UIUC, USD 10,000, Fall 2021
- PI, NASA ADAP, USD 334,711, 2020–2
- PI, LSST Enabling Science Award, USD 27,000, 2020–2
- Co-I, US DoE High Energy Theory & Cosmology, USD 50,000, Apr 2023–present
- Co-I, HST GO 17128 USD 82,030, Oct 2022–present
- Co-I, NCSA Internal Award, “ANTARES at NCSA”, USD 88,683, 2020–2
- Co-I on three *James Webb Space Telescope* GO Cycle 1 programs
- Co-I on two NASA ADAP proposals, USD 66,835 to UIUC (PIs. D. Jones, A. Rest) 2021–present

<sup>1</sup>Formally employed by The University of Arizona CS Dept. from Dec 2014–Apr 2016, but located at NOAO

- Co-I, grant for developing ANTARES, Heising-Simons Foundation, USD 567,000, 2018–21

## AWARDS

- Lincoln Excellence for Assistant Professors, 2023
- Selected for the 1<sup>st</sup> cohort of the [Illinois Academic Leadership and Management Institute](#)
- List of Instructors rated Excellent, Spring 2023
- List of Instructors rated Outstanding, Spring 2020
- 2<sup>nd</sup> ever recipient of the Barry M. Lasker Data Science Fellowship, STScI, 2017–9
- Best-in-Show, Art of Planetary Science, Lunar and Planetary Laboratory, U. Arizona, 2015

## RESEARCH HISTORY AND SELECTED PUBLICATIONS

Below are brief descriptions of my work on key topics, together with a related publication.

### Cosmology and the Nature of Dark Energy

- **Analysis Coordinator**, LSST Dark Energy Science Collaboration (DESC), previously Deputy Analysis Coordinator (2021–2023) and Supernova Working Group Convener (2019–2021).
- Led analysis using ESSENCE and literature SNIa to derive cosmological constraints on dark energy equation of state  $w$ ; co-authored analysis on PS1 SNIa Foundation photometric SNIa
- Co-developed BayeSN with K. Mandel — probabilistic model to infer distance moduli, light curve, and dust properties from UV+Optical+NIR data of low- $z$  SNIa; currently evolving into model for SNIa SED inference at cosmological distances for *NGRST*, future surveys
- Leading analysis apply BayeSN-SED to combined Foundation, Pan-STARRS & literature samples — will be the largest dataset of confirmed cosmological SNIa

**Narayan et al.**, ‘16, “Light Curves of 213 Type Ia Supernovae from the ESSENCE Survey”, *ApJS*

### Understanding the Physics of Rare and Unusual Transients

- Led or made major contributions to several projects studying unusual SN, including SN 2020oi, SN 2018oh, SN 2009ku, SN 2008ha, as well as open-source tools to model such events
- Combining work on machine learning with interest in rare & unusual transients by developing novel methods for anomaly detection, incorporating gravitational wave, neutrino and high-energy gamma ray signals into alert-brokers.

**Narayan et al.**, ‘11, “Displaying the Heterogeneity of the SN 2002cx-like Subclass of Type Ia Supernovae with Observations of the Pan-STARRS-1 Discovered SN 2009ku”, *ApJL*

### Machine Learning for Time-Domain Discovery

- Lead developer of deep-learning, traditional ML and active learning algorithms for time-series classification on state-of-the-art alert broker system: [ANTARES](#) operating on Zwicky Transient Facility (ZTF) alerts as test bed for Legacy Survey of Space and Time (LSST)
- Lead for [Extended LSST Astronomical Time-Series Classification Challenge \(ELAsTiCC\)](#). (v1) remains the largest simulation of the entire time-domain sky for statistical studies, and the largest Kaggle challenge in Astronomy.

**Narayan et al.**, ‘18, “Machine-learning-based Brokers for Real-time Classification of the LSST Alert Stream”, *ApJS Special Issue “Data: Insights and Challenges in a Time of Abundance”*

### Operations, Calibration, Infrastructure & Optimization of Wide-field Surveys

- PI of SCiMMA Team, developing real-time system to coordinate LIGO, high-energy particle and neutrino, ground- and space-based facilities

- Extensive involvement in transient pipeline development & validation several current and past astrophysical surveys
- Lead analysis to use *Hubble* imaging and large-aperture spectroscopy to establish faint spectrophotometric standards for LSST and future surveys

**Narayan** et al., '19, "Sub-percent Photometry: Faint DA WD Spectrophotometric Standards for Astrophysical Observatories", *ApJS*

## PROFESSIONAL AFFILIATIONS

I am an active member of several groups and projects, completed and on-going:

- |  |                                       |
|--|---------------------------------------|
| The LSST Dark Energy Science Collaboration (DESC)          | The [P/E]LASTiCC Team                 |
| The SCiMMA Team  | The Young Supernova Experiment (YSE)  |
| The ANTARES Project  | The DECam Alliance for Transients     |
| The <i>Kepler</i> & <i>TESS</i> Extra Galactic Survey      | The DA White Dwarf Calibration Team   |
| The Pan-STARRS PS1 Science Collaboration                   | The ESSENCE Collaboration             |
| The Mosaic z-band Legacy Survey (MzLS)                     | The <i>HST</i> RAISIN & SIRAH Surveys |
| The LSST Transient & Variable Stars Collaboration (TVS)    | The Foundation Supernova Survey       |
| Member of the American Astronomical Society (2007–present) |                                       |

## OBSERVING EXPERIENCE

I am an observational cosmologist with extensive experience with different facilities:

- PI, *HST* GO-16764, (34 orbits)
- PI, Gemini N (2020A-Q-115, 2021B-Q-310), Gemini S (2021B-Q-317), programs continue but now led by my students
- Co-PI, Young Supernova Experiment, ~15% of total time on Pan-STARRS PS1 & PS2, 2020–2024
- Co-PI on NOIRLab Young Supernova Program on DECam with Long-term Status (LTS) for 2 years (30 nights)
- Co-I on 3 accepted JWST GO Cycle 1 programs for multi-messenger astrophysics
- PI and Co-I on numerous accepted NOIRLab, Las Cumbres Observatory, ESO and *Swift* observing proposals
- Co-I on several major *HST* programs with *WFC3*, *ACS* and *STIS* including: GO-12967 (18 orbits), 12999 (8 orbits), 13046 (100 orbits), 13711 (60 orbits), 14216 (100 orbits), 14244 (8 orbits) and 15113 (54 orbits), 17128 (105 orbits)
- MMT Observatory: 15 nights of Blue Channel spectroscopy on site, 2 nights of remote observing
- Magellan Observatory: 7 nights LDSS3 imaging and long-slit spectroscopy  
1 night of IMACS long-slit spectroscopy
- Gemini Observatory: Analysis of GMOS spectroscopy from several nights of queue observing
- Kitt Peak National Observatory: several nights of imaging on the 4 m with MOSAIC 1.1 & 3
- Cerro-Tololo Inter-American Observatory: several nights with 0.9 m & 4 m with DECam  
Analysis of 197 nights of MOSAIC-II imaging for ESSENCE/SuperMacho
- WIYN Observatory: 3 nights of imaging on the WIYN 3.5 m with ODI
- F. L. Whipple Observatory: several nights of long-slit spectroscopy on the 1.5 m with FAST and imaging on the 1.2 m with Keplercam, both on-site and remote
- Las Cumbres Observatory: Analysis of 120 hours of 1 m SINISTRO imaging

## MENTORING AND TEACHING

### Graduate Students

**Tanner Murphy** (UIUC Astro), Adviser, Aug. 2023–present, Research Collaborator, Aug. 2020–May 2021

- Beginning PhD at UIUC in Aug. 2023, Working with Narayan on YSE
- Previous Masters at SUNY Stonybrook working with Prof. Will Farr on transients
- Published Murphy, Fields, Hogan and Narayan, MNRAS 2021 as an undergraduate at UIUC
- Advised by Prof. Brian Fields and worked with Narayan to study distribution of SNe within our Galaxy

**Haille Perkins** (UIUC Astro), Adviser, 2023–present

- Second year graduate student, working with Narayan on adding AGN afterglow model to KNe
- Assessing detectability of KNe with Rubin and Roman, and hierarchical inference of KNe population parameters
- Working with Prof. Brian Fields on determining lethality of nearby KNe

**Aiden Berres** (UIUC), Adviser, 2022–present

- Second year graduate student, formerly working on LSST Asteroid Orbit Integrator
- Working with Narayan on adding HST STIS Data (GO-16764, PI Narayan) to DA White Dwarfs
- Working with Narayan and Prof. Ryan Foley on HST SNIa Dust Program (GO-17128, PI Foley)
- Developing methods to automatically find HST targets using ANTARES, Transient Name Server

**Amanda Wasserman** (UIUC), Adviser, 2021–present

- Completed PhD preliminary exam, April 2023, won DOE SCGSR Award to work on RESSPECT at LBNL in 2023
- Working on developing RESSPECT active learning and real-time followup for LSST
- Member of LSST DESC & LSST commissioning team, and member of YSE and DECAT teams
- Working on spectroscopy of YSE SNIa, PI of Gemini N & S programs begun by Narayan

**Patrick Aleo** (UIUC), Adviser, 2020–present

- Winner of Illinois Survey Science Fellowship (2020, 2021) and the Chu Award, 2023
- Working on anomaly detection for transients within ZTF and YSE
- Led 1<sup>st</sup> data-release of YSE, combining data from three telescopes, using novel ML classification
- Planning on graduating May 2024

**Alex Gagliano** (UIUC), Adviser, 2019–2023

- Defended Ph.D., April 2023, began as NSF IAIFI Fellow between MIT/Harvard, Fall 2023
- Winner of American Statistical Association Astrophysics Interest Group Paper of the Year, 2021
- Winner of the Simons Fellowship CCA (2021), NSF GRF (2020) and Illinois Survey Science Fellowship (2019)
- Worked on correlations between supernovae and their hosts [11, GHOST], SN 2020oi [7], LSST PLAsTiCC and other projects.

**Daniel Muthukrishna** (U. Cambridge), Co-Adviser, 2017–2021

- Now postdoc at MIT, working on *TESS* with Prof. George Ricker, Fall 2021
- Research with Narayan on deep learning for transient classification (RAPID, Muthukrishna et al., 2019)
- Muthukrishna is member of LSST PLAsTiCC team and the ANTARES project

### Other Mentorship of Graduate Students

- Working closely with students Qinan Wang (JHU, w/ Dr. Armin Rest), Ben Boyd, and Sam Ward (Cambridge, w/ Prof. Kaisey Mandel) and previously with Dr. Stephen Thorp (Stockholm)
- Served/serving on the prelim/thesis committee for Alejandro Cardenas-Avendano, Scott Perkins, Yiqie Xie (UIUC Physics), Colin Burke, Nicholas Earl, Chris Tandoi (Chair), Sunny Tang, Qiaoya Wu (UIUC Astro), and Malema Hendrick Ramonyai (University of the Western Cape, S. Africa)
- 2021 summer research advisor for NCSA NRT Summer students Laura Salo (also co-author on ELAsTiCC papers) and Sai Sharan Sundar (together with Eliu Huerta) both from U. Minnesota
- Mentorship of grad students from the U. Arizona Computer Science Dept. on ANTARES, particularly Zhe Wang and Shuo Yang (2015–7)

### Undergraduate Students

**Ved Shah** (UIUC CS), Adviser, Jan. 2021–present

- Developed M-dwarf flare model with Narayan and postdoc Malanchev; being integrated into PLAsTiCC
- NCSA Summer 2021 Intern; funded by LSST Enabling Science Program (PI Narayan)
- Used ML to distinguish M-dwarf flares from rapid transients
- Leading kilonova rate analysis using Bayesian Inference Framework (Shah et al., '23, in prep)

**Jason Vazquez** (UIUC CS+Astro), Adviser, Feb. 2021–present

- Working on SN2021blg and 2022 YSE supernovae with other survey members
- 2021 Summer REU at Northwestern University with Prof. Wen-fai Fong & C.D. Kilpatrick
- First-authored paper on SN2019mhm with Kilpatrick and Wong
- Working on YSE type IIp sample with Narayan and Kilpatrick, graduating May 2023

**Qifeng Cheng** (UIUC Astro), Adviser, Feb. 2021–present

- Developed new dwarf nova and changing-look AGN model with Narayan and postdocs Soraisam & Malanchev
- Northwestern REU with Patrick Sheehan, Summer 2021, funded by LSST Enabling Science Program (PI Narayan)
- Earned honors with Narayan for work in ASTR 210 by developing viz. of analema for exoplanetary systems
- Graduated May 2023, beginning PhD in Astronomy at Duke University in Fall 2023

**Sammy Sharief** (UIUC CS+Astro), Adviser, Feb. 2021–present

- Third author on YSE DR1 with Narayan and Patrick Aleo, and implemented YSE DECam pipeline
- Adapted method to retrieve ZTF forced photometry from IPAC & modeling SNe

- REU on Multi-messenger Astrophysics at RIT, Summer 2021 and at TAURUS program, UT Austin, Summer 2022
- Graduating May 2023, completed senior thesis on work at TAURUS program with Stella Offner (UIUC adviser, Narayan)
- Began PhD in Computer Science at U. Montreal in Fall 2023

**Filip Matasic** (UIUC CS+Astro), Adviser, Sep. 2021–May 2022

- Working with Aleo on YSE 1st data release
- Analyzed properties of YSE and ZTF observations to generate simulations for ML models
- Graduated May 2022, completed a senior honors thesis with Narayan, now working in InfoSec

**Andrew Engel** (UIUC Physics), Adviser, 2019–present

- Graduated May 2020 - now data scientist at PNNL
- Working on machine learning for photometric redshifts from galaxies – awarded NASA ADAP for photo-z work, and continuing to work with Narayan
- Algorithm developed being used in both ANTARES and YSE - completing paper on research with Narayan in 2023
- Planning to apply for graduate programs in Fall 2023 after his time at PNNL

**Daniel Alcantara** (Bard College), Research Collaborator, 2016–9

- Intern with R. Street at Las Cumbres Observatory working on microlensing detection
- Worked with Narayan to dramatically improve performance of prototype classifier
- Published Alcantara, Bachelet, Narayan and Street, 2019
- Algorithm being used with MARS broker to find microlensing candidates with ZTF

**Tayeb Zaidi** (Macalester College), Honors Thesis Adviser, 2016–7

- Worked with Narayan on ANTARES as summer REU student at NOAO in 2015
- Continued work on time-series classification for Senior Honors (earned April 2017)
- Published Narayan, Zaidi, Soraisam et al., 2018, adapted for LSST PLAsTiCC
- Now in PhD Program for Biophysics at Northwestern University

### Co-mentorship of Other Undergraduate Students

- Holly Wingren (UIUC Astronomy, '24) - jointly with Prof. Brian Fields and Alex Gagliano. REU at Fermilab & UIUC Statistics
- Athish Thiruvengadam (UIUC CS+Astronomy, '24) - jointly with Prof. Eliu Huerta
- Kunal Bhatia (UIUC Astronomy, '21) - jointly with Dr. Monika Soraisam. Was admitted to Astronomy PhD at Imperial College, London, but ultimately decided to pursue opportunities in industry.

### Previous REU Students

- Marcus Lee (NOAO, 2014) was the first indigenous (Tohono O'odham) student to complete REU program at NOAO
- Linoy Kotler (STScI, 2018) worked on wavelet-based classification of Foundation photometric SNIa sample and is now at Rice University

## Postdoctoral Scientists Mentored

### Konstantin Malanchev (UIUC), 2020–present

- Working with Narayan and Patrick Aleo on anomaly detection, YSE DR1, developing feature extraction & ELAsTiCC
- Developing large cross-matched, cross-calibrated photometric database for LSST
- Worked with undergrad Qifeng Cheng on changing-look AGN model
- Beginning as LINCC Research Scientist at Carnegie-Mellon University, Summer 2023

### Deep Chatterjee (UIUC), 2020–2022

- Second recipient of Illinois Survey Science Postdoctoral Fellowship
- Worked with Narayan on ANTARES on kilonovae detection and integration with SCiMMA
- Worked on using deep-learning for rapid approximation of neutron star EoS and identification of electromagnetic counterpart (El-Cid)
- Advised undergrad Ved Shah Gautam along with Narayan on estimating KN rates
- Now Alerts and Real-time Inference Lead at MIT LIGO Lab

### Monika Soraisam (UIUC), 2019–2021

- First recipient of Illinois Survey Science Postdoctoral Fellowship
- Working with Narayan on ANTARES (since 2016), YSE and studies of interesting time-domain phenomena
- PI of NCSA CDDR grant to deploy ANTARES broker system on Radiant (Co-I Narayan)
- Worked with undergrads Qifeng Cheng on dwarf nova model, and Kunal Bhatia on ZTF Transient Detection
- Now Research Staff at Gemini Observatory

ASTR 350, The Big Bang, Black Holes, and the End of the Universe, Fall 2023  
 ASTR 310, Computing in Astronomy, UIUC, Fall 2021, Spring 2022, Fall 2022  
 ASTR 210, Introduction to Astrophysics, UIUC, Fall 2020  
 ASTR 596, Fundamentals of Data Science, UIUC, Spring 2020, Spring 2023  
 ZTF Summer School, Pasadena, Aug. 2018  
**Instructor for:** LSST Data Science Fellowship Program, [Session 5](#), Baltimore, Jan. 2018  
 LSST Data Science Fellowship Program, [Session 3](#), Tucson, Apr. 2017  
 NOAO Teen Astronomy Cafe, “[How Stars Die](#)”, Tucson, Nov. 2017  
 NOAO Big Data Workshop for Tucson High School Students, Tucson, Jan. 2017  
 Python Workshop for NOAO/NSO REU Students, Tucson, Summer 2014 & 2015

I’ve additionally served as a Teaching Assistant at Harvard, as Teaching Assistant, Lab Assistant and Tutor at Illinois Wesleyan, and as guest lecturer for Astro 102 (Instructors: C. Salyk and K. Garmany) at the Tohono O’odham Community College.



**INVITED COLLOQUIA/SEMINARS/CONFERENCES, 2018–PRESENT**

University of Pennsylvania, Dept. of Physics and Astronomy, Colloquium, Oct. 2023  
 Invited Speaker, Windows on the Universe, Tucson, Oct. 2023  
 Indiana University, Dept. of Astronomy, Colloquium, Sep. 2023  
 Invited Speaker, LSST Project and Community Workshop, Aug. 2023  
 Invited Speaker, SuperNova EXplosions: Theory and Observations, Technion, Israel, Aug. 2023  
 Invited Speaker, MARS Lecture Series, Pacific Northwest National Labs, May 2023  
 Invited Speaker, Multi-wavelength follow-up of Fast Radio Bursts, Toronto, Apr. 2023  
 Session Chair, Supporting Computational Science with Rubin LSST, Virtual, Mar. 2023  
 Panelist, The Future of Astrophysical Data Infrastructure, New York, Feb. 2023  
 Speaker, Panelist, Session Chair, AAS 241, Seattle, Jan. 2023  
 Dark Energy Science Collaboration, Plenary Talk, University of Chicago, Jul. 2022  
 Speaker, Bayesian Deep Learning for Cosmology and Time Domain Astrophysics, Paris, Jun 2022  
 Pennsylvania State University, LSST Workshop, May. 2022  
 LSST European Broker Coordination Seminar, Apr. 2022  
 SCiMMA Public Telecon, “[A Data Lake for Multi-messenger Astrophysics](#)”, Oct. 2021  
 Pennsylvania State University, Dept. of Astronomy and Astrophysics Colloquium, Mar. 2022  
 Invited Speaker, Cherenkov Telescope Array Project, Jun 2021  
 Invited Speaker, AAS 238, Meeting-in a-meeting (MiM) on Machine Learning, Jun 2021  
 LSST Photometric Calibration Working Group Workshop, May 2021  
 LSST Broker Workshop, Apr 2021  
 DESI Time-domain Meeting, Apr 2021  
 LSST DESC Virtual Meeting - Jul 2020  
 SciMMA Virtual Meeting, May 2020  
 Plenary, Kentucky Area Astronomy Annual Meeting - Louisville, KY, Mar 2020  
 LSST DESC Annual Meeting - Tucson, AZ, Jan 2020  
 Kavli Visitor, University of Cambridge, Institute of Astronomy, Dec 2019  
 Speaker, Session Chair, LSST TVS and SMWLW workshop - Newark, DE, Oct 2019  
 Speaker, SNIa Cosmology Analysis Meeting - KICP Chicago, IL, Oct 2019  
 Invited Speaker, Inference for Multi-messenger Astrophysics - Berkeley, CA, May 2019  
 Invited Speaker, University of Delaware, Astronomy Seminar - Newark, DE, May 2019  
 Invited Speaker, University of Illinois, LSST Seminar - Urbana-Champaign, IL, Apr. 2019  
 Iowa State University, Dept. of Physics & Astronomy Colloquium - Ames, IA, Apr. 2019  
 Louisiana State University, Dept. of Physics & Astronomy Colloquium - Baton Rouge, LA, Mar. 2019  
 University of Wisconsin, Dept. of Physics Colloquium - Milwaukee, WI, Mar. 2019  
 University of Alabama, Dept. of Physics & Astronomy Colloquium - Tuscaloosa, AL, Mar. 2019  
 Michigan Technological University, Dept. of Physics Colloquium - Houghton, MI, Feb. 2019  
 University of Illinois, Dept. of Astronomy Colloquium - Urbana-Champaign, Feb. 2019  
 University of Minnesota, Dept. of Physics and Astronomy Colloquium - St. Paul, Nov. 2018  
 Rolling Cadence Session Lead, LSST Cadence Hackathon - New York, NY, Sep. 2018  
 Speaker, Machine Learning for Science and Engineering - Pittsburgh, Jun. 2018  
 NSF Workshop on Multi Messenger Astrophysics - College Park, May 2018  
 LSST Photometric Classification Challenge “PLAsTiCC” Sprint Week - New York, NY, May. 2018  
 Speaker, Python in Astronomy - New York, NY, Apr. 2018  
 Speaker, New Advances in NIR type Ia Supernova Science - Pittsburgh, PA, Apr. 2018



## SERVICE & PUBLIC OUTREACH WORK

### Service to Scientific Collaborations

Analysis Coordinator, LSST Dark Energy Science Collaboration, 2023–present  
 Deputy Analysis Coordinator, LSST Dark Energy Science Collaboration, 2021–2023  
 Executive Committee, Young Supernova Experiment, 2020–present  
 Member, SN Science Investigation Team, Nancy Grace Roman Space Telescope, 2020–present  
 Organizer, LSST DESC Hack Week at UIUC, Summer 2022  
 Co-convener, LSST DESC Supernova Working Group, 2019–2021

### Service to the UIUC Astronomy Department

Deputy Director, UIUC/NCSA Center for Astrophysical Surveys, Spring 2021–present  
 Senator, UIUC Faculty Senate, Fall 2022–present  
 UIUC AURA Member Representative, 2021–present  
 Colloquium Chair, UIUC Astronomy, AY 2020, Spring 2023  
 Member, Faculty Search Committee, UIUC Astronomy, 2020, 2021 & 2023  
 Reader, Graduate Admissions Committee, UIUC Astronomy, 2023, 2024  
 Representative, UIUC Astronomy X Data Science Program, 2022–present  
 Member, UIUC Astronomy Curriculum Committee, AY 2021–present  
 Member, UIUC Astronomy Computing Committee, AY 2022–present  
 Member, UIUC Astronomy EDI Committee, 2020–2023

### Meetings and Talk Series

SOC, [Unveiling the Dynamic Universe: Cosmic Streams in the Era of Rubin](#), Puerto Varas, Chile, Dec. 2023  
 SOC & LOC, [The Transient and Variable Universe](#), UIUC, July 2023  
 Chair, [Boom! A Workshop on LSST Transients](#), UIUC, July 25–9, 2022  
 SOC, [COSMO-2021 meeting](#), Virtual, Aug 2–6, 2021  
 SOC, Managing Follow-up Observations in the Era of ZTF and LSST, NSF's NOIRLab, Sep. 30–Oct. 4, 2019  
 Chair, [Enabling Multi Messenger Astrophysics in the Big Data Era](#), STScI, Apr. 25–26, 2019  
 SOC, [Deep Learning for Multimessenger Astrophysics: Real-time Discovery at Scale](#), Oct. 2018  
 LOC, Building the Infrastructure for Time-Domain Alert Science in the LSST Era, May 2017  
 Organizer, NOAO FLASH Talk Series, 2015–2017  
 Organizer, NOAO Coffee Hour Series, 2014–5

### Service to the Community

Panelist, NASA Review Panel, Jan–Jun 2022  
 Panelist, NSF Review Panel, Mar 2020  
 Editorial Board, Astronomy and Computing, to begin Fall 2023  
 Reviewer for the AAS Journals, MNRAS, ongoing

## Public Outreach

Invited Talk, Stargazing and S'mores, Allerton Park & Retreat Center, Sep. 2023  
 Invited Talk, UIAS Open Night, May 2023  
 Invited Talk, Illinois Dark Skies Star Party, Sangamon Astronomical Society, Oct 2022  
 Stargazing, Family Night Campout, Allerton Park & Retreat Center, Oct 2022  
 Invited Talk, University of Illinois Astronomical Society, Sep 2022  
 Kaler Lecture, Starkel Planetarium - Champaign, IL, Oct 2020  
 Speaker, Astronomy on Tap - Urbana-Champaign, "The Myth and Mythology of the Planets", Feb 2020  
 Organizer, Astronomy on Tap - Urbana-Champaign, Nov 2019-Aug 2022  
 Speaker, Astronomy on Tap - Urbana-Champaign, "Making a Movie of the Night Sky", Sep. 2019  
 Organizer, Astronomy on Tap - Tucson/Space Drafts, 2015-2017  
 Speaker, Space Telescope Public Lecture Series, [Chasing Supernovae with Kepler](#), Sep. 2018  
 Guest, Three Body Problems Podcast, [Bringing Data Science Into Astronomy](#), Sept. 2018  
 Scientist, TED-Ed Original Videos ([Pt. 1](#)) ([Pt. 2](#))  
 Speaker, 365 Days of Astronomy Podcast ([Pt. 1](#)) ([Pt. 2](#))  
 Speaker, Youth for Astronomy and Engineering, Nov. 2018  
 Speaker, NerdNite Baltimore, Mar. 2018  
 Panelist, Tucson Comic Con and TUSCon, Nov. 2015 and 2016  
     ["Robots in Space"](#) and ["The Physics of Space Battles"](#)  
 Speaker, Astronomy on Tap - Tucson with the Tucson Symphony Orchestra, Oct. 2016  
     ["A Trip through Gustav Holst's Planets"](#)  
 Speaker, Astronomy on Tap - Tucson, Jan. 2015  
     ["If You Only Knew The Power of The Dark Side"](#)  
 Speaker, Green Valley Astronomy Club, Sahuarita, AZ, May 2016  
 Volunteer, Science Night, Elvira Elementary School, Tucson, AZ, Mar. 2015 and Mar. 2017  
 Volunteer, Astronomy Night, Arizona Sonoran Desert Museum, Jul. 2015  
 Volunteer, Kitt Peak National Observatory Open Night for the Tohono O'odham Nation, May 2015  
 Volunteer, Tucson Festival of Books, Mar. 2015

I've led public stargazing at the Museum of Science in Boston (2011-2), the Table Mountain star party, WA (2006) and throughout my time as an undergraduate at Illinois Wesleyan's Mark Evans Observatory (2001-5).

## REFERENCES

- Prof. Christopher Stubbs      Dean of Science, Harvard University  
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- Dr. Armin Rest                Space Telescope Science Institute  
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- Prof. Kaisey Mandel           Institute for Astronomy, University of Cambridge  
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- Prof. Ryan Foley              Dept. of Astronomy & Astrophysics, University of California, Santa Cruz  
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## LIST OF PUBLICATIONS

h-index: 40, 7430 citations. (Scopus/Google Scholar)

Publications are listed with 1<sup>st</sup> author or major contributor first.

### Primary Publications

- [1] **Results of the Photometric LSST Astronomical Time-series Classification Challenge (PLAsTiCC).** R. Hložek, A. I. Malz, K. A. Ponder, M. Dai, **G. Narayan**, E. E. O. Ishida, J. Allam, T., A. Bahmanyar, X. Bi, R. Biswas, K. Boone, S. Chen, N. Du, A. Erdem, L. Galbany, A. Garreta, S. W. Jha, D. O. Jones, R. Kessler, M. Lin, J. Liu, M. Lochner, A. A. Mahabal, K. S. Mandel, P. Margolis, J. R. Martínez-Galarza, J. D. McEwen, D. Muthukrishna, Y. Nakatsuka, T. Noumi, T. Oya, H. V. Peiris, C. M. Peters, J. F. Puget, C. N. Setzer, Siddhartha, S. Stefanov, T. Xie, L. Yan, K. H. Yeh, and W. Zuo. *Astrophys. J. Suppl. Ser.*, Aug. 2023. 267(2):25.
- [2] **The simulated catalogue of optical transients and correlated hosts (SCOTCH).** M. Lokken, A. Gagliano, **G. Narayan**, R. Hložek, R. Kessler, J. F. Crenshaw, L. Salo, C. S. Alves, D. Chatterjee, M. Vincenzi, A. I. Malz, and LSST Dark Energy Science Collaboration. *Mon. Not. R. Astron. Soc.*, Apr. 2023. 520(2):pp. 2887–2912.
- [3] **The Young Supernova Experiment Data Release I (YSE DRI): Light Curves and Photometric Classification of 1975 Supernovae.** P. D. Aleo, K. Malanchev, S. Sharief, D. O. Jones, **G. Narayan**, R. J. Foley, V. A. Villar, C. R. Angus, V. F. Baldassare, M. J. Bustamante-Rosell, D. Chatterjee, C. Cold, D. A. Coulter, K. W. Davis, S. Dhawan, M. R. Drout, A. Engel, K. D. French, A. Gagliano, C. Gall, J. Hjorth, M. E. Huber, W. V. Jacobson-Galán, C. D. Kilpatrick, D. Langeroodi, P. Macias, K. S. Mandel, R. Margutti, F. Matasić, P. McGill, J. D. R. Pierel, E. Ramirez-Ruiz, C. L. Ransome, C. Rojas-Bravo, M. R. Siebert, K. W. Smith, K. M. de Soto, M. C. Stroh, S. Tinyanont, K. Taggart, S. M. Ward, R. Wojtak, K. Auchettl, P. K. Blanchard, T. J. L. de Boer, B. M. Boyd, C. M. Carroll, K. C. Chambers, L. DeMarchi, G. Dimitriadis, S. A. Dodd, N. Earl, D. Farias, H. Gao, S. Gomez, M. Grayling, C. Grillo, E. E. Hayes, T. Hung, L. Izzo, N. Khetan, A. N. Kolborg, J. A. P. Law-Smith, N. LeBaron, C. C. Lin, Y. Luo, E. A. Magnier, D. Matthews, B. Mockler, A. J. G. O'Grady, Y. C. Pan, C. A. Politsch, S. I. Raimundo, A. Rest, R. Ridden-Harper, A. Sarangi, S. L. Schröder, S. J. Smartt, G. Terreran, S. Thorp, J. Vazquez, R. J. Wainscoat, Q. Wang, A. R. Wasserman, S. K. Yadavalli, R. Yarza, Y. Zenati, and Young Supernova Experiment. *Astrophys. J. Suppl. Ser.*, May 2023. 266(1):9.
- [4] **SN 2021hpr and its two siblings in the Cepheid calibrator galaxy NGC 3147: A hierarchical BayeSN analysis of a Type Ia supernova trio, and a Hubble constant constraint.** S. M. Ward, S. Thorp, K. S. Mandel, S. Dhawan, D. O. Jones, K. Taggart, R. J. Foley, **G. Narayan**, K. C. Chambers, D. A. Coulter, K. W. Davis, T. de Boer, K. de Soto, N. Earl, A. Gagliano, H. Gao, J. Hjorth, M. E. Huber, L. Izzo, D. Langeroodi, E. A. Magnier, P. McGill, A. Rest, C. Rojas-Bravo, and R. Wojtak. *arXiv e-prints*, Sep. 2022. arXiv:2209.10558.
- [5] **A hierarchical Bayesian SED model for Type Ia supernovae in the optical to near-infrared.** K. S. Mandel, S. Thorp, **G. Narayan**, A. S. Friedman, and A. Avelino. *Mon. Not. R. Astron. Soc.*, Mar. 2022. 510(3):pp. 3939–3966.
- [6] **EI-CID: a filter for gravitational-wave electromagnetic counterpart identification.** D. Chatterjee, **G. Narayan**, P. D. Aleo, K. Malanchev, and D. Muthukrishna. *Mon. Not. R. Astron. Soc.*, Jan. 2022. 509(1):pp. 914–930.
- [7] **An Early-time Optical and Ultraviolet Excess in the Type-Ic SN 2020oi.** A. Gagliano, L. Izzo, C. D. Kilpatrick, B. Mockler, W. V. Jacobson-Galán, G. Terreran, G. Dimitriadis, Y. Zenati, K. Auchettl, M. R. Drout, **G. Narayan**, R. J. Foley, R. Margutti, A. Rest, D. O. Jones, C. Aganze, P. D. Aleo, A. J. Burgasser, D. A. Coulter, R. Gerasimov, C. Gall, J. Hjorth, C.-C. Hsu, E. A. Magnier, K. S. Mandel, A. L. Piro, C. Rojas-Bravo, M. R. Siebert, H. Stacey, M. C. Stroh, J. J. Swift, K. Taggart, S. Tinyanont, and S. Tinyanont. *Astrophys. J.*, Jan. 2022. 924(2):55.
- [8] **The ANTARES Astronomical Time-domain Event Broker.** T. Matheson, C. Stubens, N. Wolf, C.-H. Lee, **G. Narayan**, A. Saha, A. Scott, M. Soraisam, A. S. Bolton, B. Hauger, D. R. Silva, J. Kececioglu, C. Scheidegger, R. Snodgrass, P. D. Aleo, E. Evans-Jacquez, N. Singh, Z. Wang, S. Yang, and Z. Zhao. *Astronomical J.*, Mar. 2021. 161(3):107.
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- [10] **Testing the consistency of dust laws in SN Ia host galaxies: a BAYESN examination of Foundation DRI.** S. Thorp, K. S. Mandel, D. O. Jones, S. M. Ward, and **G. Narayan**. *Mon. Not. R. Astron. Soc.*, Dec. 2021. 508(3):pp. 4310–4331.
- [11] **GHOST: Using Only Host Galaxy Information to Accurately Associate and Distinguish Supernovae.** A. Gagliano, **G. Narayan**, A. Engel, M. Carrasco Kind, and LSST Dark Energy Science Collaboration. *Astrophys. J.*, Feb. 2021. 908(2):170.

- [12] **The Young Supernova Experiment: Survey Goals, Overview, and Operations.** D. O. Jones, R. J. Foley, **G. Narayan**, J. Hjorth, M. E. Huber, P. D. Aleo, K. D. Alexander, C. R. Angus, K. Auchettl, V. F. Baldassare, S. H. Bruun, K. C. Chambers, D. Chat-terjee, D. L. Coppejans, D. A. Coulter, L. DeMarchi, G. Dimitriadis, M. R. Drout, A. Engel, K. D. French, A. Gagliano, C. Gall, T. Hung, L. Izzo, W. V. Jacobson-Galán, C. D. Kilpatrick, H. Korhonen, R. Margutti, S. I. Raimundo, E. Ramirez-Ruiz, A. Rest, C. Rojas-Bravo, M. R. Siebert, S. J. Smartt, K. W. Smith, G. Terreran, Q. Wang, R. Wojtak, A. Agnello, Z. Ansari, N. Arendse, A. Baldeschi, P. K. Blan-chard, D. Brethauer, J. S. Bright, J. S. Brown, T. J. L. de Boer, S. A. Dodd, J. R. Fairlamb, C. Grillo, A. Hajela, C. Hede, A. N. Kolborg, J. A. P. Law-Smith, C. C. Lin, E. A. Magnier, K. Malanchev, D. Matthews, B. Mockler, D. Muthukrishna, Y. C. Pan, H. Pfister, D. K. Ra-manah, S. Rest, A. Sarangi, S. L. Schröder, C. Stauffer, M. C. Stroh, K. L. Taggart, S. Tyanont, R. J. Wainscoat, and Young Supernova Experiment. *Astrophys. J.*, Feb. 2021. 908(2):143.
- [13] **Models and Simulations for the Photometric LSST Astronomical Time Series Classification Challenge (PLAs-TiCC).** R. Kessler, **G. Narayan**, A. Avelino, E. Bachelet, R. Biswas, P. J. Brown, D. F. Chernoff, A. J. Connolly, M. Dai, S. Daniel, R. Di Stefano, M. R. Drout, L. Galbany, S. González-Gaitán, M. L. Graham, R. Hložek, E. E. O. Ishida, J. Guillochon, S. W. Jha, D. O. Jones, K. S. Mandel, D. Muthukrishna, A. O'Grady, C. M. Peters, J. R. Pierel, K. A. Ponder, A. Prša, S. Rodney, V. A. Villar, LSST Dark Energy Science Collaboration, and Transient and Variable Stars Science Collaboration. *Publ. Astron. Soc. Pac.*, Sep 2019. 131(1003):p. 094501.
- [14] **A machine learning classifier for microlensing in wide-field surveys.** D. Godines, E. Bachelet, **G. Narayan**, and R. A. Street. *Astronomy and Computing*, Jul 2019. 28:100298.
- [15] **Subpercent Photometry: Faint DA White Dwarf Spectrophotometric Standards for Astrophysical Obser-vatories.** **G. Narayan**, T. Matheson, A. Saha, T. Axelrod, A. Calamida, E. Olszewski, J. Claver, K. S. Mandel, R. C. Bohlin, and J. B. Holberg. *Astrophys. J. Suppl. Ser.*, Apr 2019. 241(2):20.
- [16] **RAPID: Early Classification of Explosive Transients Using Deep Learning.** D. Muthukrishna, **G. Narayan**, K. S. Mandel, R. Biswas, and R. Hložek. *Publ. Astron. Soc. Pac.*, Nov. 2019. 131(1005):p. 118002.
- [17] **Machine-learning-based Brokers for Real-time Classification of the LSST Alert Stream.** **G. Narayan**, T. Zaidi, M. D. Soraisam, Z. Wang, M. Lochner, T. Matheson, A. Saha, S. Yang, Z. Zhao, J. Kececioglu, C. Scheidegger, R. T. Snodgrass, T. Ax-elrod, T. Jenness, R. S. Maier, S. T. Ridgway, R. L. Seaman, E. M. Evans, N. Singh, C. Taylor, J. Toeniskoetter, E. Welch, S. Zhu, and ANTARES Collaboration. *Astrophys. J. Suppl. Ser.*, May 2018. 236:9.
- [18] **Photometry and Spectroscopy of Faint Candidate Spectrophotometric Standard DA White Dwarfs.** A. Calamida, T. Matheson, A. Saha, E. Olszewski, **G. Narayan**, J. Claver, C. Shanahan, J. Holberg, T. Axelrod, and R. Bohlin. *Astro-phys. J.*, Feb 2019. 872(2):199.
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- [20] **Toward a Network of Faint DA White Dwarfs as High-precision Spectrophotometric Standards.** **G. Narayan**, T. Axelrod, J. B. Holberg, T. Matheson, A. Saha, E. Olszewski, J. Claver, C. W. Stubbs, R. C. Bohlin, S. Deustua, and A. Rest. *Astrophys. J.*, May 2016. 822:67.
- [21] **Displaying the Heterogeneity of the SN 2002cx-like Subclass of Type Ia Supernovae with Observations of the Pan-STARRS-I Discovered SN 2009ku.** **G. Narayan**, R. J. Foley, E. Berger, M. T. Botticella, R. Chornock, M. E. Huber, A. Rest, D. Scolnic, S. Smartt, S. Valenti, A. M. Soderberg, W. S. Burgett, K. C. Chambers, H. A. Flewelling, G. Gates, T. Grav, N. Kaiser, R. P. Kirshner, E. A. Magnier, J. S. Morgan, P. A. Price, A. G. Riess, C. W. Stubbs, W. E. Sweeney, J. L. Tonry, R. J. Wainscoat, C. Waters, and W. M. Wood-Vasey. *Astrophys. J. Lett.*, Apr. 2011. 731:L11.
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- [23] **SN 2006bt: A Perplexing, Troublesome, and Possibly Misleading Type Ia Supernova.** R. J. Foley, **G. Narayan**, P. J. Challis, A. V. Filippenko, R. P. Kirshner, J. M. Silverman, and T. N. Steele. *Astrophys. J.*, Jan. 2010. 708:pp. 1748–1759.
- [24] **Survey requirements for accurate and precise photometric redshifts for Type Ia supernovae.** Y. Wang, **G. Narayan**, and M. Wood-Vasey. *Mon. Not. R. Astron. Soc.*, Nov. 2007. 382:pp. 377–381.
- [25] **The Complete Light-curve Sample of Spectroscopically Confirmed SNe Ia from Pan-STARRS1 and Cosmo-logical Constraints from the Combined Pantheon Sample.** D. M. Scolnic, D. O. Jones, A. Rest, Y. C. Pan, R. Chornock, R. J. Foley, M. E. Huber, R. Kessler, **G. Narayan**, A. G. Riess, S. Rodney, E. Berger, D. J. Brout, P. J. Challis, M. Drout, D. Finkbeiner, R. Lunnan, R. P. Kirshner, N. E. Sanders, E. Schlafly, S. Smartt, C. W. Stubbs, J. Tonry, W. M. Wood-Vasey, M. Foley, J. Hand, E. Johnson, W. S. Burgett, K. C. Chambers, P. W. Draper, K. W. Hodapp, N. Kaiser, R. P. Kudritzki, E. A. Magnier, N. Metcalfe, F. Bresolin, E. Gall, R. Kotak, M. McCrum, and K. W. Smith. *Astrophys. J.*, Jun. 2018. 859:101.
- [26] **Cosmological Constraints from Measurements of Type Ia Supernovae Discovered during the First 1.5 yr of the Pan-STARRS1 Survey.** A. Rest, D. Scolnic, R. J. Foley, M. E. Huber, R. Chornock, **G. Narayan**, J. L. Tonry, E. Berger, A. M. Soderberg, C. W. Stubbs, A. Riess, R. P. Kirshner, S. J. Smartt, E. Schlafly, S. Rodney, M. T. Botticella, D. Brout, P. Challis, I. Czekala, M. Drout, M. J. Hudson, R. Kotak, C. Leibler, R. Lunnan, G. H. Marion, M. McCrum, D. Milisavljevic, A. Pastorello, N. E. Sanders,

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- [27] **Systematic Uncertainties Associated with the Cosmological Analysis of the First Pan-STARRS1 Type Ia Supernova Sample.** D. Scolnic, A. Rest, A. Riess, M. E. Huber, R. J. Foley, D. Brout, R. Chornock, **G. Narayan**, J. L. Tonry, E. Berger, A. M. Soderberg, C. W. Stubbs, R. P. Kirshner, S. Rodney, S. J. Smartt, E. Schlafly, M. T. Botticella, P. Challis, I. Czekala, M. Drout, M. J. Hudson, R. Kotak, C. Leibler, R. Lunnan, G. H. Marion, M. McCrum, D. Milisavljevic, A. Pastorello, N. E. Sanders, K. Smith, E. Stafford, D. Thilker, S. Valenti, W. M. Wood-Vasey, Z. Zheng, W. S. Burgett, K. C. Chambers, L. Denneau, P. W. Draper, H. Flewelling, K. W. Hodapp, N. Kaiser, R.-P. Kudritzki, E. A. Magnier, N. Metcalfe, P. A. Price, W. Sweeney, R. Wainscoat, and C. Waters. *Astrophys. J.*, Nov. 2014. 795:45.
- [28] **Seeing Double: ASASSN-18bt Exhibits a double-power-law Rise in the Early-Time  $\{em K2\}$  Light Curve.** B. J. Shappee, T. W.-s. Holoi, M. R. Drout, K. Auchettl, M. D. Stritzinger, C. S. Kochanek, K. Z. Stanek, E. Shaya, **G. Narayan**, J. S. Brown, S. Bose, D. Bersier, J. Brimacombe, P. Chen, S. Dong, S. Holmbo, B. Katz, J. A. Munoz, R. L. Mutel, R. S. Post, J. L. Prieto, J. Shields, D. Tallon, T. A. Thompson, P. J. Vallely, S. Villanueva, Jr., L. Denneau, H. Flewelling, A. N. Heinze, K. W. Smith, B. Stalder, J. L. Tonry, H. Weiland, T. Barclay, G. Barentsen, A. M. Cody, J. Dotson, F. Foerster, P. Garnavich, M. Gully-santiago, C. Hedges, S. Howell, D. Kasen, S. Margheim, R. Mushotzky, A. Rest, B. E. Tucker, A. Villar, A. Zenteno, G. Beerman, R. Bjella, G. Castillo, J. Coughlin, B. Elsaesser, S. Flynn, R. Gangopadhyay, K. Griest, M. Hanley, J. Kampmeier, R. Klotzel, L. Kohnert, C. Labonde, R. Larsen, K. A. Larson, K. M. Mccalmont-everton, C. McGinn, L. Migliorini, J. Moffatt, M. Muszynski, V. Nystrom, D. Osborne, M. Packard, C. A. Peterson, M. Redick, L. H. Reedy, S. E. Ross, B. Spencer, K. Steward, J. E. Van Cleve, J. V. D. M. Cardoso, T. Weschler, A. Wheaton, J. Bulger, T. B. Lowe, E. A. Magnier, A. S. B. Schultz, C. Z. Waters, M. Willman, E. Baron, Z. Chen, J. M. Derkacy, F. Huang, L. Li, W. Li, X. Li, L. Rui, H. Sai, L. Wang, X. Wang, D. Xiang, J. Zhang, J. Zhang, K. Zhang, T. Zhang, X. Zhang, X. Zhao, P. J. Brown, J. J. Hermes, J. Nordin, S. Points, G. M. Strampelli, and A. Zenteno. *ArXiv e-prints*, Jul. 2018.
- [29] **GALEX and Pan-STARRS1 Discovery of SN IIP 2010aq: The First Few Days After Shock Breakout in a Red Supergiant Star.** S. Gezari, A. Rest, M. E. Huber, **G. Narayan**, K. Forster, J. D. Neill, D. C. Martin, S. Valenti, S. J. Smartt, R. Chornock, E. Berger, A. M. Soderberg, S. Mattila, E. Kankare, W. S. Burgett, K. C. Chambers, T. Dombeck, T. Grav, J. N. Heasley, K. W. Hodapp, R. Jedicke, N. Kaiser, R. Kudritzki, G. Luppino, R. H. Lupton, E. A. Magnier, D. G. Monet, J. S. Morgan, P. M. Onaka, P. A. Price, P. H. Rhoads, W. A. Siegmund, C. W. Stubbs, J. L. Tonry, R. J. Wainscoat, M. F. Waterson, and C. G. Wynn-Williams. *Astrophys. J. Lett.*, Sep. 2010. 720:pp. L77–L81.

## Unrefereed Publications

- [30] **Applications of Deep Learning to physics workflows.** M. Agarwal, J. Alameda, J. Audenaert, W. Benoit, D. Beveridge, M. Bhattacharya, C. Chatterjee, D. Chatterjee, A. Chen, M. Saleem Cholayil, C.-J. Chou, S. Choudhary, M. Coughlin, M. Dax, A. De-sai, A. Di Luca, J. M. Duarte, S. Farrell, Y. Feng, P. Goodarzi, E. Govorkova, M. Graham, J. Guiang, A. Gunny, W. Guo, J. Hakenmueller, B. Hawks, S.-C. Hsu, P. Jawahar, X. Ju, E. Katsavounidis, M. Kellis, E. E Khoda, F. Zahra Lahbabi, V. Tha Bik Lian, M. Liu, K. Malanchev, E. Marx, W. P. McCormack, A. McLeod, G. Mo, E. A. Moreno, D. Muthukrishna, **G. Narayan**, A. Naylor, M. Neubauer, M. Norman, R. Omer, K. Pedro, J. Peterson, M. Pürer, R. Raikman, S. Raj, G. Ricker, J. Robbins, B. Safarzadeh Samani, K. Scholberg, A. Schuy, V. Skliris, S. Soni, N. Sravan, P. Sutton, V. A. Villar, X. Wang, L. Wen, F. Wuethwein, T. Yang, and S.-W. Yeh. *arXiv e-prints*, Jun. 2023. arXiv:2306.08106.
- [31] **Snowmass2021 Cosmic Frontier CF6 White Paper: Multi-Experiment Probes for Dark Energy – Transients.** A. G. Kim, A. Palmese, M. E. S. Pereira, G. Aldering, F. Andrade-Oliveira, J. Annis, S. Bailey, S. BenZvi, U. Braga-Neto, F. Courbin, A. Garcia, D. Jeffery, **G. Narayan**, S. Perlmutter, M. Soares-Santos, T. Treu, and L. Wang. *arXiv e-prints*, Mar. 2022. arXiv:2203.11226.
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