

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 ¹

EDUCATION

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

AWARDS AND GRANTS

- PI, HST GO 16764, USD 274,723, Spring 2022–present
- PI, LSST Enabling Science Awards for undergraduates at UIUC, USD 10,000, Fall 2021
- List of Instructors rated Outstanding, Spring 2020
- PI, NASA ADAP “The Stars Like Dust: Building an All-Sky Photometric Reference”, USD 334,711, 2020–present
- PI, LSST Enabling Science Award, USD 27,000, 2020–present
- Co-I, NCSA Internal Award, “ANTARES at NCSA”, USD 65,000, 2020–2
- Co-I on three *James Webb Space Telescope* GO Cycle 1 programs
- Co-I on several *Hubble Space Telescope* programs with grants totaling over USD 1M, 2012–present
- Co-I on two NASA ADAP proposals, USD 76,447 to UIUC (PIs. D. Jones, A. Rest) 2021–present
- Co-I, grant for developing ANTARES, Heising-Simons Foundation, USD 567,000, 2018–21
- PI, STScI Director’s Discretionary Funding for student research, USD 2500, 2017–9
- LSST Cadence Hackathon, USD 1400, 2018

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

- 2nd 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.

Machine Learning for Time-Domain Discovery

- Lead developer of machine-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 Photometric LSST Astronomical Time-Series Classification Challenge v2. ([vi](#)) 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](#)"

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*

Cosmology and the Nature of Dark Energy

- **Deputy Analysis Coordinator**, LSST Dark Energy Science Collaboration (DESC)
- 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*

Operations, Calibration & Optimization of Wide-field Surveys

- Implementing active learning for LSST — targeted observations of least-understood sources to iteratively refine AI models
- Lead analysis to use *Hubble* imaging and large-aperture spectroscopy to establish faint spectrophotometric standards for LSST and future surveys
- Extensive involvement in transient pipeline development & validation several current and past astrophysical surveys

Narayan et al., '19, "Sub-percent Photometry: Faint DA White Dwarf 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 Foundation Survey	The Young Supernova Experiment (YSE)
The ANTARES Project	The SCiMMA Team
The LSST Transient & Variable Stars Collaboration (TVS)	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
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), Gemini N (2020A-Q-115, 2021B-Q-310), Gemini S (2021B-Q-317)
- Co-PI, Young Supernova Experiment, $\sim 15\%$ 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)
- 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

I've helped design, implement, schedule and optimize numerous surveys. Together with Armin Rest and Mark Huber, I adapted the SMSN photpipe pipeline to work on numerous other projects. To date, it has processed ~ 7 PB of images, discovering several tens of thousand transient and variable sources.

SOFTWARE PROFICIENCIES

- Core research strength: inference with bespoke probabilistic and machine learning models
- Extensive experience developing image processing pipelines for ground and space telescopes
- Fluent in Python, C++, IDL and Perl; comfortable with C, R, Java, Fortran 95, and IRAF
- Well-versed with several database architectures, provenance, redundancy, and version control
- Proficient with SLURM, HTCondor, PBS, LSF and SGE distributed computing environments

MENTORING AND TEACHING

Graduate Students

Amanda Wasserman (UIUC), Adviser, 2021–present

- First year student, completing coursework, previous experience with DESI Survey
- Working on spectroscopy of Transients with Narayan’s and Gagliano’s Gemini GMOS programs
- Now a member of LSST DESC, and will work on developing active learning and real-time followup for LSST

Patrick Aleo (UIUC), Adviser, 2020–present

- Winner of Illinois Survey Science Fellowship (2020, 2021)
- Working on anomaly detection for transients within ZTF and YSE
- Leading 1st data-release of YSE, combining data from three telescopes, using novel ML classification

Alex Gagliano (UIUC), Adviser, 2019–present

- Finalist for 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)
- Working on correlations between supernovae and their hosts [7, GHOST], SN 2020oi [3, submitted], LSST PLAsTiCC and other projects.

Stephen Thorp (U. Cambridge), Co-Adviser, 2019–present

- Preparing to defend thesis, and applying for postdoctoral positions
- Developed BayeSN model building on Mandel and Narayan’s previous work
- Integrating BayeSN into LSST DESC Time Domain Analysis Pipeline with Narayan and Dr. Richard Kessler (U. Chicago)

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

- Now postdoc at MIT, 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

I’ve served as summer research advisor for students Laura Salo (also co-author on ELAsTiCC papers) and Sai Sharan Sundar (together with Eliu Huerta) both from U. Minnesota. I’ve authored papers with grad students from the U. Arizona Computer Science Dept. on ANTARES, particularly Zhe Wang and Shuo Yang. I work closely with students Qinan Wang (JHU) and Sam Ward (Cambridge). In addition to the committee my own students, I have served on the thesis committee for Alejandro Cardenas-Avendano, Scott Perkins (UIUC Physics), the prelim committee of Chris Tandoi (as chair), Colin Burke, Sunny Tang (UIUC Astro), and Malema Hendrick Ramonyai (University of the Western Cape, S. Africa)

Undergraduate Students

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

- Developing new dwarf nova model with Narayan and postdocs Soraisam & Malanchev
- Northwestern REU with Wen-fai Fong, 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

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

- Working on photometric classification of YSE DR1 with Narayan and Patrick Aleo
- Adapted method to retrieve ZTF forced photometry from IPAC & modeling SNe
- REU on Multi-messenger Astrophysics at RIT, Summer 2021

Ved Shah Gautam (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)
- Will begin examining using ML to distinguish M-dwarf flares from rapid transients, Fall 2021

Filip Matasic (UIUC CS+Astro), Adviser, Sep. 2021–present

- Working with Aleo on YSE 1st data release
- Analyzed properties of YSE and ZTF observations to generate simulations for ML models
- Applying to UIUC CS Masters Program

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 and Dr. Charlie Kilpatrick
- Leading paper on SN2019mhm with Kilpatrick and Wong

Holly Wingren (UIUC Astro, LAS Physics Special Curricula), Adviser, Jan. 2022–present

- URAP program with graduate student Alex Gagliano, Narayan and Prof. Brian Fields
- Analyzing if SNe of different types show a preference for spiral arms of galaxies
- Applying to Summer 2022 REU programs

Athish Thiruvengadam (UIUC CS+Astro), Adviser, Sep. 2021–present

- Working with graduate student Alex Gagliano & Narayan on early classification techniques for YSE
- Building on previous work by Daniel Muthukrishna
- Applying to Summer 2022 REU programs

Tanner Murphy (UIUC Astro), Research Collaborator, Aug. 2020-May 2021

- Now a graduate student at SUNY Stonybrook working with Prof. Will Farr on transients
- Advised by Prof. Brian Fields and worked with Narayan to study distribution of SNe within our Galaxy

Kunal Bhatia (UIUC CS+Astro), Adviser, Jun. 2020-Sept. 2021

- Was accepted to masters program in Astronomy at University College, London
- Worked with Monika Soraisam and Narayan to examine locations of dwarf novae in M31
- Built web service to generate on-the-fly forced photometry from public ZTF images

Andrew Engel (UIUC Physics), Adviser, 2017-2021

- Graduated May 2020 - now data scientist at PNNL
- Working on machine learning for photometric redshifts from galaxies
- Algorithm developed being used in both ANTARES and YSE - completing paper on research with Narayan in 2022

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

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

Deep Chatterjee (UIUC), 2020–present

- Second recipient of Illinois Survey Science Postdoctoral Fellowship
- Working with Narayan on ANTARES on kilonovae detection and integration with SCiMMA
- Working on using deep-learning for rapid approximation of neutron star EoS and identification of electromagnetic counterpart (El-Cid)

Konstantin Malanchev (UIUC), 2020–present

- Working with Narayan and Patrick Aleo on anomaly detection &
- Developing large cross-matched, cross-calibrated photometric database for LSST

Monika Soraisam (UIUC), 2019–2021

- Now Research Staff at Gemini Observatory
- 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)

ASTR 310, Computing in Astronomy, UIUC, Fall 2021, Spring 2022

ASTR 210, Introduction to Astrophysics, UIUC, Fall 2020

ASTR 596, Fundamentals of Data Science, UIUC, Spring 2020

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, 2017–PRESENT

Pennsylvania State University, Dept. of Astronomy and Astrophysics, scheduled 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 Timedomain Meeting, Apr 2021
 Kaler Lecture, Starkel Planetarium - Champaign, IL, Oct 2020
 LSST DESC Virtual Meeting - Jul 2020
 SciMMA Virtual Meeting, May 2020
 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
 LSST TVS and SMWLW workshop - Newark, DE, Oct 2019
 SNIa Cosmology Analysis Meeting - KICP Chicago, IL, Oct 2019
 Inference for Multi-messenger Astrophysics - Berkeley, CA, May 2019
 University of Delaware, Astronomy Seminar - Newark, DE, May 2019
 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
 LSST Cadence Hackathon - New York, NY, Sep. 2018
 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
 Python in Astronomy - New York, NY, Apr. 2018
 New Advances in NIR type Ia Supernova Science - Pittsburgh, PA, Apr. 2018
 LSST PLAsTiCC Workshop - New York, NY, Jul. 2017
 Supernovae: The LSST Revolution - Evanston, IL, Jun. 2017
 Building the Infrastructure for Time-Domain Alert Science in the LSST Era - Tucson, AZ, May 2017

SERVICE & PUBLIC OUTREACH WORK

Deputy Analysis Coordinator, LSST Dark Energy Science Collaboration, 2021–present
 Representative, UIUC Astronomy X Data Science Program, Spring 2022
 UIUC AURA Member Representative, 2021–present
 Member, UIUC Astronomy Curriculum Committee, AY 2021
 Deputy Director, UIUC/NCSA Center for Astrophysical Surveys, Spring 2021–present
 Co-convenor, LSST DESC Supernova Working Group, 2019–2021
 Member, SN Science Investigation Team, Nancy Grace Roman Space Telescope, 2020–present
 SOC, COSMO-2021 meeting, UIUC, Aug 2021
 Member, UIUC Astronomy EDI Committee, ongoing
 Colloquium Chair, UIUC Astronomy, AY 2020
 Member, Faculty Search Committee, UIUC, 2020 & 2021
 Chair, SNe Across LSST, Originally Apr. 28–30, 2020, rescheduled due to COVID-19
 Panelist, NSF Review Panel, Mar 2020
 Speaker, Astronomy on Tap - Urbana-Champaign, “The Myth and Mythology of the Planets”, Feb 2020
 Organizer, Astronomy on Tap - Urbana-Champaign, Nov 2019–present
 SOC, Managing Follow-up Observations in the Era of ZTF and LSST, Sep. 30–Oct. 4, 2019
 Speaker, Astronomy on Tap - Urbana-Champaign, “Making a Movie of the Night Sky”, Sep. 2019
 Chair, Enabling Multi Messenger Astrophysics in the Big Data Era, 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, Astronomy on Tap - Tucson/Space Drafts, 2015–2017
 Organizer, NOAO FLASH Talk Series, 2015–2017
 Organizer, NOAO Coffee Hour Series, 2014–5
 Reviewer for the AAS Journals, ongoing
 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

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LIST OF PUBLICATIONS

h-index: 37, 5451 citations. (Scopus/Google Scholar)

Publications are listed with 1st author or major contributor first.

Primary Publications

- [1] **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.
- [2] **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.
- [3] **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. Tanyanont, and S. Tanyanont. *Astrophys. J.*, Jan. 2022. 924(2):55.
- [4] **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.
- [5] **SN 2018agk: A Prototypical Type Ia Supernova with a Smooth Power-law Rise in Kepler (K2).** Q. Wang, A. Rest, Y. Zenati, R. Ridden-Harper, G. Dimitriadis, **G. Narayan**, V. A. Villar, M. R. Magee, R. J. Foley, E. J. Shaya, P. Garnavich, L. Wang, L. Hu, A. Bódi, P. Armstrong, K. Auchettl, T. Barclay, G. Barentsen, Z. Bognár, J. Brimacombe, J. Bulger, J. Burke, P. Challis, K. Chambers, D. A. Coulter, G. Csörnyei, B. Cseh, M. Deckers, J. L. Dotson, L. Galbany, S. González-Gaitán, M. Gromadzki, M. Gully-Santiago, O. Hanyecz, C. Hedges, D. Hiramatsu, G. Hosseinzadeh, D. A. Howell, S. B. Howell, M. E. Huber, S. W. Jha, D. O. Jones, R. Könyves-Tóth, C. Kalup, C. D. Kilpatrick, L. Kriskovics, W. Li, T. B. Lowe, S. Margheim, C. McCully, A. Mitra, J. A. Muñoz, M. Nicholl, J. Nordin, A. Pál, Y.-C. Pan, A. L. Piro, S. Rest, J. Rino-Silvestre, C. Rojas-Bravo, K. Sárneczky, M. R. Siebert, S. J. Smartt, K. Smith, Á. Sódor, M. D. Stritzinger, R. Szabó, R. Szakáts, B. E. Tucker, J. Vinkó, X. Wang, J. C. Wheeler, D. R. Young, A. Zenteno, K. Zhang, and G. Zsidi. *Astrophys. J.*, Dec. 2021. 923(2):167.
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- [7] **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.
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