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A Python API for OTTER

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Summary

The Open mulTiwavelength Transient Event Repository (or "OTTER") is a new catalog of published transient data. Here we present a thick Python wrapper on the REpresentational State Transfer (REST) application programming interface (API) built-in to the OTTER backend database (the "OTTER API"). Since the OTTER backend is built on the document database ArangoDB, using the REST API directly requires learning the Arango Query Language (AQL). Since AQL has a niche user base, OTTER users unfamiliar with it may face a roadblock to programmatic access of OTTER. To overcome this barrier, we created the OTTER Python API to make programmatic access easy and fast. In addition to wrapping the REST API, the OTTER Python API also provides additional methods for 1) Converting the stored photometry to standard units; 2) Helper methods for querying additional astronomy database services; and 3) Methods for quickly plotting the photometry stored in OTTER.

Statement of need

Transient astrophysical events provide a unique high energy laboratory that evolves on human timescales. Examples include supernovae, gamma ray bursts, tidal disruption events, and many other exotic transients (Colgate & White, 1966; Eichler et al., 1989; Heger et al., 2003; Hills, 1975; Kouveliotou et al., 1993; Maoz et al., 2014; Narayan et al., 1992; Norris et al., 1984; Rees, 1988; Smartt, 2009; Woosley & Weaver, 1995). Developing an understanding of the many astrophysical transients observed is not easy and typically requires detailed multiwavelength observations and analyses of the population of events (Alexander et al., 2025; Christy et al., 2024; Costa et al., 1997; Eftekhari et al., 2018, 2021; Gezari et al., 2017; Gomez et al., 2024; Guolo et al., 2024; Hajela et al., 2025; Laskar et al., 2022, 2023; Margutti et al., 2023; Masterson et al., 2024; Olivares E. et al., 2015; Pasham & Velzen, 2018). However, it can take years to gather the multiwavelength datasets from the literature, necessitating publicly available transient event data archives.

Furthermore, transient classification is a non-trivial process that typically requires detailed spectroscopic and/or multiwavelength follow-up observations (e.g., Arcavi et al., 2014; Charalampopoulos et al., 2022), a method that is only feasible with the current transient discovery rates. With the advent of Rubin Observatory's Legacy Survey of Space and Time (Ivezić et al., 2019) the number of known transients will increase by at least an order of magnitude (Bricman & Gomboc, 2020; Sjoert van Velzen et al., 2011). Therefore, additional methods for classifying transients, such as machine learning, are required (Boesky et al., 2025; Gomez et al., 2020, 2023; Soto et al., 2024; Stein et al., 2024; V. A. Villar et al., 2019; V. Ashley Villar et al., 2020, 2021). However, machine learning classifiers require large training datasets that can be laborious to curate. This further motivates archival services for cataloging transient metadata and photometry, and will be necessary to maximize the scientific output of the Rubin time domain survey.

For both of these reasons we created the Open mulTiwavelength Transient Event Repository (OTTER, Franz et al., 2025), a scalable catalog of transient event metadata and photometry. OTTER is a successor to the Open Astronomy Catalogs (OAC, Auchettl et al., 2017; Guillochon et al., 2017) [1], but designed and optimized for multiwavelength datasets. To store the various nuances of multiwavelength photometry (e.g., the model used to reduce and extract a flux from an X-ray observation), we chose to use a flexible document database management system as our backend: ArangoDB. The nested structure of the document database files also provides an intuitive way to store multiple values of a single measurement when different sources disagree.

One of our primary goals of OTTER is ease of access to the dataset, including a way to programmatically access it to make the curation of large transient samples easier. ArangoDB has a built-in REST API for programmatic access to the data. However, the API endpoints expect queries in the syntax of the "Arango Query Language" (AQL). Learning a new query language creates a barrier for user programmatic access to the indispensable dataset available in the OTTER catalog.

To help overcome this barrier, we present a Python API for access to the OTTER dataset. This API acts as a thick wrapper on the AQL-based API, with many additions that make it easier to access and analyze the dataset. Some of these features include:

- In OTTER we store photometry as close to the actual published value as possible to make the data more reproducible. However, this also means that the data is not stored in consistent units (but the unit of the photometry point is stored). In the OTTER API we automatically convert the photometry into the user-requested units. Specifically, the conversion is done in the `Otter.get_phot` and `Transient.clean_photometry` methods which use `astropy` (Astropy Collaboration et al., 2013, 2018, 2022) and `synphot` (STScI Development Team, 2018).
- The same raw data from an astronomical observation may be reduced[2] by multiple, distinct, teams. Depending on the differences in the reduction methodology this may produce different flux measurements. If this is the case, we store both flux measurements in the OTTER database to allow the user to choose their preferred reduction. However, to help users de-duplicate these datasets while curating large samples, we provide an (optional) automated algorithm for finding duplicates and choosing only one of the multiple reductions. This is done in the `Transient.deduplicate_photometry` method.
- Sometimes users want to quickly view the photometry for a specific transient event as either a light curve (flux as a function of time) or a spectral energy distribution (flux as a function of wavelength, frequency, or energy; i.e., an "SED"). In the `plotter` module of the OTTER API we provide numerous methods for quickly and automatically plotting the photometry (Hunter, 2007; Inc., 2015).
- Identifying the host galaxy of a transient event can be difficult and it is important to store identifying information (e.g., name and coordinates) for a host galaxy, if it is known. However, there are numerous existing astronomical databases that store galaxy properties and we do not want to duplicate their efforts. We therefore provide methods as part of the `Host` object to query other public services for host photometry or spectra. These other services include Simbad (Wenger et al., 2000), ATLAS (Tonry et al., 2018), ZTF (Sjoert van Velzen et al., 2019), iPTF (Blagorodnova et al., 2017), ASAS-SN (Hart et al., 2023; Kochanek et al., 2017; Shappee et al., 2014), Vizier (Ochsenbein et al., 2000), WISE (Hwang & Zakamska, 2020; Mainzer et al., 2011, 2014; Wright et al., 2010), FIRST (White et al., 1997), NVSS (Condon et al., 1998), HEASARC, and Sparcl (Juneau et al., 2024) — most of which are queried using the astropy-affiliated `astroquery` package (Ginsburg et al., 2019).
- Users may want to compare new observations stored locally with the publicly available

[1] The OAC was an indispensable resource but has not been maintained since 2022, further necessitating a successor like OTTER.

[2] By "reduced" we mean that the proper calibrations are applied and a flux, flux density, or magnitude is extracted from the raw data.

data in OTTER. As part of the OTTER API we make this very easy as long as their data is stored in a well-documented CSV file format (see the OTTER web application upload form or the example jupyter notebook titled "Interfacing with Private Data"). When the data is stored like this a user is able to use the `Otter.from_csvs` method to construct an `Otter` object that will pass their queries to both the public OTTER dataset and the one locally stored and return all relevant information in a consistent format.

- We allow for the storage of different measurements (e.g., redshift, discovery date, etc.) associated with the same property of the transient. The OTTER API will automatically choose a default value if multiple measurements are present for a single property.

Software Impact and Conclusions

Moving forward, OTTER, in its entirety, will be a useful infrastructure tool for time domain science. Even more, the OTTER API described here will make access to that dataset easier for users by lowering the API learning curve. Evidence of this is the impact of the Open Astronomy Catalogs, which has > 500 citations (Guillochon et al., 2017) and is still used today, despite being deprecated.

There are already multiple astronomers using the software for their research, spanning from undergraduate students to faculty. There are currently two papers citing OTTER (Alexander et al., 2025; Christy et al., 2025) and at least another in preparation (Farley et al., in prep.). Additionally, our immediate research groups has already used OTTER for writing successful telescope observing proposals. We presented this work at the Kavli Institute for Theoretical Physics: Towards a Physical Understanding of Tidal Disruption Events session, Astronomical Data Analysis Software and Systems: 2025 Monsoon Workshop, and the 2025 X-ray Quasi-Periodic Eruptions and Repeating Nuclear Transients Conference. It was positively received at all of these conferences and we accrued ~ 15 beta testers who provided invaluable feedback. We welcome GitHub issues with comments and feedback (or even pull requests!) from the community on our GitHub repository.

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References

Alexander, K. D., Margutti, R., Gomez, S., Stroh, M., Chornock, R., Laskar, T., Cendes, Y., Berger, E., Eftekhari, T., Franz, N., Hajela, A., Metzger, B. D., Terreran, G., Bietenholz, M., Christy, C., Colle, F. de, Komossa, S., Nicholl, M., Ramirez-Ruiz, E., … Wu, W. (2025). *The Multi-Wavelength Context of Delayed Radio Emission in TDEs: Evidence for Accretion-Driven Outflows*. arXiv. https://ui.adsabs.harvard.edu/abs/2025arXiv250612729A

Arcavi, I., Gal-Yam, A., Sullivan, M., Pan, Y.-C., Cenko, S. B., Horesh, A., Ofek, E. O., De Cia, A., Yan, L., Yang, C.-W., Howell, D. A., Tal, D., Kulkarni, S. R., Tendulkar, S. P., Tang, S., Xu, D., Sternberg, A., Cohen, J. G., Bloom, J. S., … Laher, R. R. (2014). A Continuum of H- to He-rich Tidal Disruption Candidates With a Preference for E+A Galaxies. *The Astrophysical Journal*, *793*, 38. https://doi.org/10.1088/0004-637X/793/1/38

Astropy Collaboration, Price-Whelan, A. M., Lim, P. L., Earl, N., Starkman, N., Bradley, L., Shupe, D. L., Patil, A. A., Corrales, L., Brasseur, C. E., Nöthe, M., Donath, A., Tollerud, E., Morris, B. M., Ginsburg, A., Vaher, E., Weaver, B. A., Tocknell, J., Jamieson, W., … Astropy Project Contributors. (2022). The Astropy Project: Sustaining and Growing a Community-oriented Open-source Project and the Latest Major Release (v5.0) of the Core Package. *The Astrophysical Journal*, *935*, 167. https://doi.org/10.3847/1538-4357/ac7c74

Astropy Collaboration, Price-Whelan, A. M., Sipőcz, B. M., Günther, H. M., Lim, P. L., Crawford, S. M., Conseil, S., Shupe, D. L., Craig, M. W., Dencheva, N., Ginsburg, A., VanderPlas, J. T., Bradley, L. D., Pérez-Suárez, D., Val-Borro, M. de, Aldcroft, T. L., Cruz, K. L., Robitaille, T. P., Tollerud, E. J., … Astropy Contributors. (2018). The Astropy Project: Building an Open-science Project and Status of the v2.0 Core Package. *The Astronomical Journal*, *156*, 123. https://doi.org/10.3847/1538-3881/aabc4f

Astropy Collaboration, Robitaille, T. P., Tollerud, E. J., Greenfield, P., Droettboom, M., Bray, E., Aldcroft, T., Davis, M., Ginsburg, A., Price-Whelan, A. M., Kerzendorf, W. E., Conley, A., Crighton, N., Barbary, K., Muna, D., Ferguson, H., Grollier, F., Parikh, M. M., Nair, P. H., … Streicher, O. (2013). Astropy: A community Python package for astronomy. *Astronomy and Astrophysics*, *558*, A33. https://doi.org/10.1051/0004-6361/201322068

Auchettl, K., Guillochon, J., & Ramirez-Ruiz, E. (2017). New Physical Insights about Tidal Disruption Events from a Comprehensive Observational Inventory at X-Ray Wavelengths. *The Astrophysical Journal*, *838*(2), 149. https://doi.org/10.3847/1538-4357/aa633b

Blagorodnova, N., Gezari, S., Hung, T., Kulkarni, S. R., Cenko, S. B., Pasham, D. R., Yan, L., Arcavi, I., Ben-Ami, S., Bue, B. D., Cantwell, T., Cao, Y., Castro-Tirado, A. J., Fender, R., Fremling, C., Gal-Yam, A., Ho, A. Y. Q., Horesh, A., Hosseinzadeh, G., … Wozniak, P. (2017). iPTF16fnl: A Faint and Fast Tidal Disruption Event in an E+A Galaxy. *The Astrophysical Journal*, *844*(1), 46. https://doi.org/10.3847/1538-4357/aa7579

Boesky, A., Villar, V. A., Gagliano, A., & Hsu, B. (2025). *SPLASH: A Rapid Host-Based Supernova Classifier for Wide-Field Time-Domain Surveys*. arXiv. https://doi.org/10.48550/arXiv.2506.00121

Bricman, K., & Gomboc, A. (2020). The Prospects of Observing Tidal Disruption Events with the Large Synoptic Survey Telescope. *The Astrophysical Journal*, *890*, 73. https://doi.org/10.3847/1538-4357/ab6989

Charalampopoulos, P., Leloudas, G., Malesani, D. B., Wevers, T., Arcavi, I., Nicholl, M., Pursiainen, M., Lawrence, A., Anderson, J. P., Benetti, S., Cannizzaro, G., Chen, T.-W., Galbany, L., Gromadzki, M., Gutiérrez, C. P., Inserra, C., Jonker, P. G., Müller-Bravo, T. E., Onori, F., … Young, D. R. (2022). A detailed spectroscopic study of tidal disruption events. *Astronomy and Astrophysics*, *659*, A34. https://doi.org/10.1051/0004-6361/202142122

Christy, C. T., Alexander, K. D., Laskar, T., Franz, N., Goodwin, A. J., Pearson, J., Berger, E., Cendes, Y., Chornock, R., Coppejans, D., Eftekhari, T., Margutti, R., Miller-Jones, J. C. A., Krips, M., Ramirez-Ruiz, E., Sand, D. J., Saxton, R., Shrestha, M., & van Velzen, S. (2025). Dichotomy in Long-Lived Radio Emission from Tidal Disruption Events AT 2020zso and AT 2021sdu: Multi-Component Outflows vs. Host Contamination. *arXiv e-Prints*, arXiv:2509.14317. https://arxiv.org/abs/2509.14317

Christy, C. T., Alexander, K. D., Margutti, R., Wieringa, M., Cendes, Y., Chornock, R., Laskar, T., Berger, E., Bietenholz, M., Coppejans, D. L., De Colle, F., Eftekhari, T., Holoien, T. W.-S., Matsumoto, T., Miller-Jones, J. C. A., Ramirez-Ruiz, E., Saxton, R., & Velzen, S. van. (2024). The Peculiar Radio Evolution of the Tidal Disruption Event ASASSN-19bt. *The Astrophysical Journal*, *974*, 18. https://doi.org/10.3847/1538-4357/ad675b

Colgate, S. A., & White, R. H. (1966). The Hydrodynamic Behavior of Supernovae Explosions. *The Astrophysical Journal*, *143*, 626. https://doi.org/10.1086/148549

Condon, J. J., Cotton, W. D., Greisen, E. W., Yin, Q. F., Perley, R. A., Taylor, G. B., & Broderick, J. J. (1998). The NRAO VLA Sky Survey. *The Astronomical Journal*, *115*(5), 1693–1716. https://doi.org/10.1086/300337

Costa, E., Frontera, F., Heise, J., Feroci, M., Zand, J. in't, Fiore, F., Cinti, M. N., Dal Fiume, D., Nicastro, L., Orlandini, M., Palazzi, E., Rapisarda#, M., Zavattini, G., Jager, R., Parmar, A., Owens, A., Molendi, S., Cusumano, G., Maccarone, M. C., … Butler, R. C. (1997). Discovery of an X-ray afterglow associated with the γ-ray burst of 28 February 1997. *Nature*, *387*, 783–785. https://doi.org/10.1038/42885

Eftekhari, T., Berger, E., Zauderer, B. A., Margutti, R., & Alexander, K. D. (2018). Radio Monitoring of the Tidal Disruption Event Swift J164449.3+573451. III. Late-time Jet Energetics and a Deviation from Equipartition. *The Astrophysical Journal*, *854*, 86. https://doi.org/10.3847/1538-4357/aaa8e0

Eftekhari, T., Margalit, B., Omand, C. M. B., Berger, E., Blanchard, P. K., Demorest, P., Metzger, B. D., Murase, K., Nicholl, M., Villar, V. A., Williams, P. K. G., Alexander, K. D., Chatterjee, S., Coppejans, D. L., Cordes, J. M., Gomez, S., Hosseinzadeh, G., Hsu, B., Kashiyama, K., … Yin, Y. (2021). Late-time Radio and Millimeter Observations of Superluminous Supernovae and Long Gamma-Ray Bursts: Implications for Central Engines, Fast Radio Bursts, and Obscured Star Formation. *The Astrophysical Journal*, *912*, 21. https://doi.org/10.3847/1538-4357/abe9b8

Eichler, D., Livio, M., Piran, T., & Schramm, D. N. (1989). Nucleosynthesis, neutrino bursts and γ-rays from coalescing neutron stars. *Nature*, *340*(6229), 126–128. https://doi.org/10.1038/340126a0

Franz, N., Alexander, K. D., Gomez, S., Christy, C. T., Laskar, T., van Velzen, S., Earl, N., Gezari, S., Karmen, M., Margutti, R., Pearson, J., Villar, V. A., & Zabludoff, A. I. (2025). The Open mulTiwavelength Transient Event Repository (OTTER): Infrastructure Release and Tidal Disruption Event Catalog. *arXiv e-Prints*, arXiv:2509.05405. https://arxiv.org/abs/2509.05405

Gezari, S., Cenko, S. B., & Arcavi, I. (2017). X-Ray Brightening and UV Fading of Tidal Disruption Event ASASSN-15oi. *The Astrophysical Journal*, *851*, L47. https://doi.org/10.3847/2041-8213/aaa0c2

Ginsburg, A., Sipőcz, B. M., Brasseur, C. E., Cowperthwaite, P. S., Craig, M. W., Deil, C., Guillochon, J., Guzman, G., Liedtke, S., Lian Lim, P., Lockhart, K. E., Mommert, M., Morris, B. M., Norman, H., Parikh, M., Persson, M. V., Robitaille, T. P., Segovia, J.-C., Singer, L. P., … a subset of astropy Collaboration. (2019). Astroquery: An Astronomical Web-querying Package in Python. *The Astronomical Journal*, *157*, 98. https://doi.org/10.3847/1538-3881/aafc33

Gomez, S., Berger, E., Blanchard, P. K., Hosseinzadeh, G., Nicholl, M., Villar, V. A., & Yin, Y. (2020). FLEET: A Redshift-agnostic Machine Learning Pipeline to Rapidly Identify Hydrogen-poor Superluminous Supernovae. *The Astrophysical Journal*, *904*, 74. https://doi.org/10.3847/1538-4357/abbf49

Gomez, S., Nicholl, M., Berger, E., Blanchard, P. K., Villar, V. A., Rest, S., Hosseinzadeh, G., Aamer, A., Ajay, Y., Athukoralalage, W., Coulter, D. C., Eftekhari, T., Fiore, A., Franz, N., Fox, O., Gagliano, A., Hiramatsu, D., Howell, D. A., Hsu, B., … Wang, Q. (2024). The Type I superluminous supernova catalogue I: Light-curve properties, models, and catalogue description. *Monthly Notices of the Royal Astronomical Society*, *535*, 471–515. https://doi.org/10.1093/mnras/stae2270

Gomez, S., Villar, V. A., Berger, E., Gezari, S., Velzen, S. van, Nicholl, M., Blanchard, P. K., & Alexander, Kate. D. (2023). Identifying Tidal Disruption Events with an Expansion of the FLEET Machine-learning Algorithm. *The Astrophysical Journal*, *949*, 113. https://doi.org/10.3847/1538-4357/acc535

Guillochon, J., Parrent, J., Kelley, L. Z., & Margutti, R. (2017). An Open Catalog for Supernova

Data. *The Astrophysical Journal*, *835*, 64. https://doi.org/10.3847/1538-4357/835/1/64

Guolo, M., Gezari, S., Yao, Y., Van Velzen, S., Hammerstein, E., Cenko, S. B., & Tokayer, Y. M. (2024). A Systematic Analysis of the X-Ray Emission in Optically Selected Tidal Disruption Events: Observational Evidence for the Unification of the Optically and X-Ray-selected Populations. *The Astrophysical Journal*, *966*(2), 160. https://doi.org/10.3847/1538-4357/ad2f9f

Hajela, A., Alexander, K. D., Margutti, R., Chornock, R., Bietenholz, M., Christy, C. T., Stroh, M., Terreran, G., Saxton, R., Komossa, S., Bright, J. S., Ramirez-Ruiz, E., Coppejans, D. L., Leung, J. K., Cendes, Y., Wiston, E., Laskar, T., Horesh, A., Schroeder, G., … Zauderer, B. A. (2025). Eight Years of Light from ASASSN-15oi: Toward Understanding the Late-time Evolution of TDEs. *The Astrophysical Journal*, *983*(1), 29. https://doi.org/10.3847/1538-4357/adb620

Hart, K., Shappee, B. J., Hey, D., Kochanek, C. S., Stanek, K. Z., Lim, L., Dobbs, S., Tucker, M., Jayasinghe, T., Beacom, J. F., Boright, T., Holoien, T., Ong, J. M. J., Prieto, J. L., Thompson, T. A., & Will, D. (2023). ASAS-SN Sky Patrol V2.0. *arXiv e-Prints*, arXiv:2304.03791. https://doi.org/10.48550/arXiv.2304.03791

Heger, A., Fryer, C. L., Woosley, S. E., Langer, N., & Hartmann, D. H. (2003). How Massive Single Stars End Their Life. *The Astrophysical Journal*, *591*(1), 288–300. https://doi.org/10.1086/375341

Hills, J. G. (1975). Possible power source of Seyfert galaxies and QSOs. *Nature*, *254*(5498), 295–298. https://doi.org/10.1038/254295a0

Hunter, J. D. (2007). Matplotlib: A 2D Graphics Environment. *Computing in Science & Engineering*, *9*(3), 90–95. https://doi.org/10.1109/MCSE.2007.55

Hwang, H.-C., & Zakamska, N. L. (2020). Lifetime of short-period binaries measured from their Galactic kinematics. *Monthly Notices of the Royal Astronomical Society*, *493*(2), 2271–2286. https://doi.org/10.1093/mnras/staa400

Inc., P. T. (2015). *Collaborative data science*. Plotly Technologies Inc. https://plot.ly

Ivezić, {\v{Z}}eljko., Kahn, S. M., Tyson, J. A., Abel, B., Acosta, E., Allsman, R., Alonso, D., AlSayyad, Y., Anderson, S. F., Andrew, J., Angel, J. R. P., Angeli, G. Z., Ansari, R., Antilogus, P., Araujo, C., Armstrong, R., Arndt, K. T., Astier, P., Aubourg, É., … Mills, D. J. (2019). LSST: From Science Drivers to Reference Design and Anticipated Data Products. *The Astrophysical Journal*, *873*, 111. https://doi.org/10.3847/1538-4357/ab042c

Juneau, S., Jacques, A., Pothier, S., Bolton, A. S., Weaver, B. A., Pucha, R., McManus, S., Nikutta, R., & Olsen, K. (2024). *SPARCL: SPectra Analysis and Retrievable Catalog Lab*. arXiv. https://doi.org/10.48550/arXiv.2401.05576

Kochanek, C. S., Shappee, B. J., Stanek, K. Z., Holoien, T. W.-S., Thompson, T. A., Prieto, J. L., Dong, S., Shields, J. V., Will, D., Britt, C., Perzanowski, D., & Pojmański, G. (2017). The All-Sky Automated Survey for Supernovae (ASAS-SN) Light Curve Server v1.0. *Publications of the Astronomical Society of the Pacific*, *129*(980), 104502. https://doi.org/10.1088/1538-3873/aa80d9

Kouveliotou, C., Meegan, C. A., Fishman, G. J., Bhat, N. P., Briggs, M. S., Koshut, T. M., Paciesas, W. S., & Pendleton, G. N. (1993). Identification of Two Classes of Gamma-Ray Bursts. *The Astrophysical Journal*, *413*, L101. https://doi.org/10.1086/186969

Laskar, T., Alexander, K. D., Margutti, R., Eftekhari, T., Chornock, R., Berger, E., Cendes, Y., Duerr, A., Perley, D. A., Ravasio, M. E., Yamazaki, R., Ayache, E. H., Barclay, T., Duran, R. B., Bhandari, S., Brethauer, D., Christy, C. T., Coppejans, D. L., Duffell, P., … Williams, P. K. G. (2023). The Radio to GeV Afterglow of GRB 221009A. *The Astrophysical Journal*, *946*, L23. https://doi.org/10.3847/2041-8213/acbfad

Laskar, T., Escorial, A. R., Schroeder, G., Fong, W., Berger, E., Veres, P., Bhandari, S., Rastinejad, J., Kilpatrick, C. D., Tohuvavohu, A., Margutti, R., Alexander, K. D., DeLaunay, J., Kennea, J. A., Nugent, A., Paterson, K., & Williams, P. K. G. (2022). The First Short GRB Millimeter Afterglow: The Wide-angled Jet of the Extremely Energetic SGRB 211106A. *The Astrophysical Journal*, *935*, L11. https://doi.org/10.3847/2041-8213/ac8421

Mainzer, A., Bauer, J., Cutri, R. M., Grav, T., Masiero, J., Beck, R., Clarkson, P., Conrow, T., Dailey, J., Eisenhardt, P., Fabinsky, B., Fajardo-Acosta, S., Fowler, J., Gelino, C., Grillmair, C., Heinrichsen, I., Kendall, M., Kirkpatrick, J. D., Liu, F., … Yan, L. (2014). Initial Performance of the NEOWISE Reactivation Mission. *The Astrophysical Journal*, *792*(1), 30. https://doi.org/10.1088/0004-637X/792/1/30

Mainzer, A., Bauer, J., Grav, T., Masiero, J., Cutri, R. M., Dailey, J., Eisenhardt, P., McMillan, R. S., Wright, E., Walker, R., Jedicke, R., Spahr, T., Tholen, D., Alles, R., Beck, R., Brandenburg, H., Conrow, T., Evans, T., Fowler, J., … Wilkins, A. (2011). Preliminary Results from NEOWISE: An Enhancement to the Wide-field Infrared Survey Explorer for Solar System Science. *The Astrophysical Journal*, *731*(1), 53. https://doi.org/10.1088/0004-637X/731/1/53

Maoz, D., Mannucci, F., & Nelemans, G. (2014). Observational Clues to the Progenitors of Type Ia Supernovae. *Annual Review of Astronomy and Astrophysics*, *52*, 107–170. https://doi.org/10.1146/annurev-astro-082812-141031

Margutti, R., Bright, J. S., Matthews, D. J., Coppejans, D. L., Alexander, K. D., Berger, E., Bietenholz, M., Chornock, R., DeMarchi, L., Drout, M. R., Eftekhari, T., Jacobson-Galán, W. V., Laskar, T., Milisavljevic, D., Murase, K., Nicholl, M., Omand, C. M. B., Stroh, M., Terreran, G., & VanderLey, B. A. (2023). Luminous Radio Emission from the Superluminous Supernova 2017ens at 3.3 yr after Explosion. *The Astrophysical Journal*, *954*, L45. https://doi.org/10.3847/2041-8213/acf1fd

Masterson, M., De, K., Panagiotou, C., Kara, E., Arcavi, I., Eilers, A.-C., Frostig, D., Gezari, S., Grotova, I., Liu, Z., Malyali, A., Meisner, A. M., Merloni, A., Newsome, M., Rau, A., Simcoe, R. A., & Velzen, S. van. (2024). A New Population of Mid-infrared-selected Tidal Disruption Events: Implications for Tidal Disruption Event Rates and Host Galaxy Properties. *The Astrophysical Journal*, *961*, 211. https://doi.org/10.3847/1538-4357/ad18bb

Narayan, R., Paczynski, B., & Piran, T. (1992). Gamma-Ray Bursts as the Death Throes of Massive Binary Stars. *The Astrophysical Journal*, *395*, L83. https://doi.org/10.1086/186493

Norris, J. P., Cline, T. L., Desai, U. D., & Teegarden, B. J. (1984). Frequency of fast, narrow γ-ray bursts. *Nature*, *308*(5958), 434–435. https://doi.org/10.1038/308434a0

Ochsenbein, F., Bauer, P., & Marcout, J. (2000). The VizieR database of astronomical catalogues. *Astronomy and Astrophysics, Supplement*, *143*, 23–32. https://doi.org/10.1051/aas:2000169

Olivares E., F., Greiner, J., Schady, P., Klose, S., Krühler, T., Rau, A., Savaglio, S., Kann, D. A., Pignata, G., Elliott, J., Rossi, A., Nardini, M., Afonso, P. M. J., Filgas, R., Nicuesa Guelbenzu, A., Schmidl, S., & Sudilovsky, V. (2015). Multiwavelength analysis of three supernovae associated with gamma-ray bursts observed by GROND. *Astronomy and Astrophysics*, *577*, A44. https://doi.org/10.1051/0004-6361/201321936

Pasham, D. R., & Velzen, S. van. (2018). Discovery of a Time Lag between the Soft X-Ray and Radio Emission of the Tidal Disruption Flare ASASSN-14li: Evidence for Linear Disk-Jet Coupling. *The Astrophysical Journal*, *856*, 1. https://doi.org/10.3847/1538-4357/aab361

Rees, M. J. (1988). Tidal disruption of stars by black holes of 106-108 solar masses in nearby galaxies. *Nature*, *333*, 523–528. https://doi.org/10.1038/333523a0

Shappee, B. J., Prieto, J. L., Grupe, D., Kochanek, C. S., Stanek, K. Z., De Rosa, G., Mathur, S., Zu, Y., Peterson, B. M., Pogge, R. W., Komossa, S., Im, M., Jencson, J., Holoien, T. W.-S., Basu, U., Beacom, J. F., Szczygieł, D. M., Brimacombe, J., Adams, S., … Yoon, Y. (2014). The Man behind the Curtain: X-Rays Drive the UV through NIR Variability in the 2013 Active Galactic Nucleus Outburst in NGC 2617. *The Astrophysical Journal*, *788*(1), 48. https://doi.org/10.1088/0004-637X/788/1/48

Smartt, S. J. (2009). Progenitors of Core-Collapse Supernovae. *Annual Review of Astronomy and Astrophysics*, *47*, 63–106. https://doi.org/10.1146/annurev-astro-082708-101737

Soto, K. M. de, Villar, V. A., Berger, E., Gomez, S., Hosseinzadeh, G., Branton, D., Campos, S., DeLucchi, M., Kubica, J., Lynn, O., Malanchev, K., & Malz, A. I. (2024). Superphot+: Real-time Fitting and Classification of Supernova Light Curves. *The Astrophysical Journal*, *974*, 169. https://doi.org/10.3847/1538-4357/ad6a4f

Stein, R., Mahabal, A., Reusch, S., Graham, M., Kasliwal, M. M., Kowalski, M., Gezari, S., Hammerstein, E., Nakoneczny, S. J., Nicholl, M., Sollerman, J., van Velzen, S., Yao, Y., Laher, R. R., & Rusholme, B. (2024). tdescore: An Accurate Photometric Classifier for Tidal Disruption Events. *The Astrophysical Journal Letters*, *965*(2), L14. https://doi.org/10.3847/2041-8213/ad3337

STScI Development Team. (2018). Synphot: Synthetic photometry using Astropy. *Astrophysics Source Code Library*, ascl:1811.001. https://ui.adsabs.harvard.edu/abs/2018ascl.soft11001S

Tonry, J. L., Denneau, L., Heinze, A. N., Stalder, B., Smith, K. W., Smartt, S. J., Stubbs, C. W., Weiland, H. J., & Rest, A. (2018). ATLAS: A High-cadence All-sky Survey System. *Publications of the Astronomical Society of the Pacific*, *130*(988), 064505. https://doi.org/10.1088/1538-3873/aabadf

van Velzen, Sjoert, Gezari, S., Cenko, S. B., Kara, E., Miller-Jones, J. C. A., Hung, T., Bright, J., Roth, N., Blagorodnova, N., Huppenkothen, D., Yan, L., Ofek, E., Sollerman, J., Frederick, S., Ward, C., Graham, M. J., Fender, R., Kasliwal, M. M., Canella, C., … Tachibana, Y. (2019). The First Tidal Disruption Flare in ZTF: From Photometric Selection to Multi-wavelength Characterization. *The Astrophysical Journal*, *872*(2), 198. https://doi.org/10.3847/1538-4357/aafe0c

Velzen, Sjoert van, Farrar, G. R., Gezari, S., Morrell, N., Zaritsky, D., Östman, L., Smith, M., Gelfand, J., & Drake, A. J. (2011). Optical Discovery of Probable Stellar Tidal Disruption Flares. *The Astrophysical Journal*, *741*, 73. https://doi.org/10.1088/0004-637X/741/2/73

Villar, V. A., Berger, E., Miller, G., Chornock, R., Rest, A., Jones, D. O., Drout, M. R., Foley, R. J., Kirshner, R., Lunnan, R., Magnier, E., Milisavljevic, D., Sanders, N., & Scolnic, D. (2019). Supernova Photometric Classification Pipelines Trained on Spectroscopically Classified Supernovae from the Pan-STARRS1 Medium-deep Survey. *The Astrophysical Journal*, *884*, 83. https://doi.org/10.3847/1538-4357/ab418c

Villar, V. Ashley, Cranmer, M., Berger, E., Contardo, G., Ho, S., Hosseinzadeh, G., & Lin, J. Y.-Y. (2021). A Deep-learning Approach for Live Anomaly Detection of Extragalactic Transients. *The Astrophysical Journal Supplement Series*, *255*, 24. https://doi.org/10.3847/1538-4365/ac0893

Villar, V. Ashley, Hosseinzadeh, G., Berger, E., Ntampaka, M., Jones, D. O., Challis, P., Chornock, R., Drout, M. R., Foley, R. J., Kirshner, R. P., Lunnan, R., Margutti, R., Milisavljevic, D., Sanders, N., Pan, Y.-C., Rest, A., Scolnic, D. M., Magnier, E., Metcalfe, N., … Waters, C. (2020). SuperRAENN: A Semisupervised Supernova Photometric Classification Pipeline Trained on Pan-STARRS1 Medium-Deep Survey Supernovae. *The Astrophysical Journal*, *905*, 94. https://doi.org/10.3847/1538-4357/abc6fd

Wenger, M., Ochsenbein, F., Egret, D., Dubois, P., Bonnarel, F., Borde, S., Genova, F., Jasniewicz, G., Laloë, S., Lesteven, S., & Monier, R. (2000). The SIMBAD astronomical database. The CDS reference database for astronomical objects. *Astronomy and Astrophysics, Supplement*, *143*, 9–22. https://doi.org/10.1051/aas:2000332

White, R. L., Becker, R. H., Helfand, D. J., & Gregg, M. D. (1997). A Catalog of 1.4 GHz Radio Sources from the FIRST Survey. *The Astrophysical Journal*, *475*(2), 479–493. https://doi.org/10.1086/303564

Woosley, S. E., & Weaver, T. A. (1995). The Evolution and Explosion of Massive Stars. II. Explosive Hydrodynamics and Nucleosynthesis. *The Astrophysical Journal Supplement Series*, *101*, 181. https://doi.org/10.1086/192237

Wright, E. L., Eisenhardt, P. R. M., Mainzer, A. K., Ressler, M. E., Cutri, R. M., Jarrett, T., Kirkpatrick, J. D., Padgett, D., McMillan, R. S., Skrutskie, M., Stanford, S. A., Cohen, M., Walker, R. G., Mather, J. C., Leisawitz, D., Gautier, T. N., III, McLean, I., Benford, D., Lonsdale, C. J., … Tsai, C.-W. (2010). The Wide-field Infrared Survey Explorer (WISE): Mission Description and Initial On-orbit Performance. *The Astronomical Journal*, *140*(6), 1868–1881. https://doi.org/10.1088/0004-6256/140/6/1868