

# Andrew Casey-Clyde

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## Summary

Ph.D. Research Assistant with 8+ years of data analysis, modeling, and research experience in astrophysics. Lead author of 3 research papers, including for a collaboration of 100+ scientists. Co-author of 17+ research papers and two white papers. Presented novel research at 27+ scientific meetings, conferences, and seminars. Gave 5 general public talks for non-technical audiences. Taught multiple multiple lab courses for students in engineering, bio-medical sciences, and non-STEM majors. Experience managing and advising undergraduate students.

## Experience

- Aug. 2023 – **Visiting Research Assistant, Yale University, New Haven, CT**  
present Analyzed astrophysical data to model supermassive black hole binary (SMBHB) populations.  
○ Led gravitational wave data analysis and modeling project for collaboration of 100+ scientists.  
○ Developed Bayesian, data-driven models of individual SMBHBs and SMBHB populations.  
○ Simulated 1000 SMBHB populations and their gravitational wave signals to interpret observed data.
- Aug. 2019 – **Graduate Research and Teaching Assistant, University of Connecticut, Storrs, CT**  
present Developed data-driven models of SMBHB populations.  
○ Developed three hierarchical Bayesian models of SMBHB populations to predict population properties.  
○ Developed novel statistical method to efficiently sample multivariate probability distributions.
- Sep. 2016 – **Graduate Research and Teaching Associate, San José State University, San Jose, CA**  
Aug. 2019 Performed astrophysics research and data analysis, and taught undergraduate physics labs.  
○ Developed Bayesian data analysis to model gas observed in the galactic center.
- Feb. 2015 – **Software Engineer, Salient Process, Inc., Sacramento, CA**  
Aug. 2016 Developed and maintained both internal and client-facing software.

## Education

- 2019–2024 **Ph.D. Physics, University of Connecticut, Storrs, CT, GPA: 3.823**
- 2019–2023 **M.S. Physics, University of Connecticut, Storrs, CT**
- 2016–2019 **M.S. Physics, San José State University, San Jose, CA, GPA: 3.791**  
Computational concentration
- 2010–2014 **B.S. Physics, University of California, Davis, Davis, CA, GPA: 2.945**  
Astrophysics emphasis

## Skills

Core	Statistics, data analysis, research	Technical	Python, SLURM, SQL, git
Software	Jupyter lab, NumPy, SciPy, PyMC, Pandas, Scikit-learn	Visualization	Matplotlib, ArviZ, Seaborn
Communication	Scientific writing, science presentation	Other	Project management, collaboration

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## Ph.D. Thesis

- Title *Multi-Messenger Constraints on Supermassive Black Hole Binaries*
- Advisors Chiara M. F. Mingarelli, Jonathan R. Trump, Daniel Anglès-Alcàzar
- Description The nanohertz gravitational wave background (GWB) is thought to be dominated by gravitational waves from supermassive black hole (SMBH) binaries (SMBHBs) – systems of two SMBHs which result from galaxy mergers. Quasars – i.e., bright, accreting SMBHs – have long been associated with galaxy mergers, suggesting a link with SMBHBs. In this work I developed novel models of the SMBHB population using observations of the GWB, quasars, and galaxies. Using these models I found the GWB implies SMBHBs may be eight times more numerous than previously expected. I further found that quasars may be up to seven times more likely to host a SMBHB than random galaxies. Finally, I found an excursion in the GWB spectrum at 16 nHz which is louder than the average expected signal from SMBHBs at  $\sim 2\sigma$  confidence.

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## Master's Thesis

- Title *Integrated Kinematic Fitting of Gas Streams in the Milky Way's Circumnuclear Disk*
- Advisors Elisabeth A. C. Mills, Aaron Romanowsky
- Description New observations of the galactic center have revealed a disk of dense molecular gas orbiting our galaxy's central SMBH. Using a leapfrog integration scheme I modeled the orbit of this gas. I then developed a Bayesian analysis pipeline to fit this model to observations, finding the gas must pass within  $\sim 1.6$  pc of the central SMBH.

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## Professional Development

### Vanderbilt University

- 2022 VIPER Summer School on Pulsar Timing Array Gravitational Wave Astrophysics

### Niels Bohr International Academy

- 2021 Summer School on Gravitational Wave Astrophysics

### Flatiron Institute, Center for Computational Astronomy

- Machine Learning

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## Selected Coursework

### University of Connecticut

- Stars and Compact Objects

- General Relativity and Cosmology

### San José State University

- Astronomy Data Analysis

- Deep Learning

- Statistical and Machine Learning Classification

- Numerical Analysis and Scientific Computing

- Computational Physics

- Methods in Mathematical Physics

### University of California, Davis

- Astronomy Instrumentation & Data Analysis Lab

- Computational Methods of Mathematical Physics

- Discrete Math for Computer Science

- Statistics through Computation

- Linear Algebra

- Linear Algebra Computation Lab

- Intro to Programming & Problem Solving

- Software & Object Oriented Programming

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## Publications

### Published

- [1] Johnson, Aaron D., [...], **Casey-Clyde, J. Andrew**, et al. May 2024. "NANOGrav 15-Year Gravitational-Wave Background Methods". *Physical Review D* 109, p. 103012.
- [2] Davis, Megan C., [...], **Casey-Clyde, J. Andrew**, et al. Apr. 2024. "Reliable Identification of Binary Supermassive Black Holes from Rubin Observatory Time-domain Monitoring". *The Astrophysical Journal* 965, p. 34.
- [3] Kelley, Luke Zoltan, [...], **Casey-Clyde, J. Andrew**, et al. Apr. 2024. "Nanograv/Holodeck: V1.5.2". *Zenodo*.
- [4] Agazie, Gabriella, [...], **Casey-Clyde, J. Andrew**, et al. Mar. 2024. "The NANOGrav 12.5 Yr Data Set: A Computationally Efficient Eccentric Binary Search Pipeline and Constraints on an Eccentric Supermassive Binary Candidate in 3C 66B". *The Astrophysical Journal* 963, p. 144.
- [5] Agazie, Gabriella, [...], **Casey-Clyde, J. Andrew**, et al. Mar. 2024. "The NANOGrav 12.5 Yr Data Set: Search for Gravitational Wave Memory". *The Astrophysical Journal* 963, p. 61.
- [6] Agazie, Gabriella, [...], **Casey-Clyde, J. Andrew**, et al. Mar. 2024. "The NANOGrav 15 Yr Data Set: Search for Transverse Polarization Modes in the Gravitational-wave Background". *The Astrophysical Journal* 964, p. L14.
- [7] Bécsy, Bence, [...], **Casey-Clyde, J. Andrew**, et al. Dec. 2023. "How to Detect an Astrophysical Nanohertz Gravitational Wave Background". *The Astrophysical Journal* 959, p. 9.
- [8] Agazie, Gabriella, [...], **Casey-Clyde, J. Andrew**, et al. Oct. 2023. "The NANOGrav 15 Yr Data Set: Search for Anisotropy in the Gravitational-wave Background". *The Astrophysical Journal* 956, p. L3.
- [9] Khusid, Nicole M., [...], **Casey-Clyde, J. Andrew**, et al. Sept. 2023. "Strongly Lensed Supermassive Black Hole Binaries as Nanohertz Gravitational-wave Sources". *The Astrophysical Journal* 955, p. 25.
- [10] Agazie, Gabriella, [...], **Casey-Clyde, J. Andrew**, et al. Aug. 2023. "The NANOGrav 15 Yr Data Set: Constraints on Supermassive Black Hole Binaries from the Gravitational-wave Background". *The Astrophysical Journal* 952, p. L37.
- [11] Agazie, Gabriella, [...], **Casey-Clyde, J. Andrew**, et al. July 2023. "The NANOGrav 15 Yr Data Set: Bayesian Limits on Gravitational Waves from Individual Supermassive Black Hole Binaries". *The Astrophysical Journal* 951, p. L50.
- [12] Arzoumanian, Zaven, [...], **Casey-Clyde, J. Andrew**, et al. July 2023. "The NANOGrav 12.5 Yr Data Set: Bayesian Limits on Gravitational Waves from Individual Supermassive Black Hole Binaries". *The Astrophysical Journal* 951, p. L28.
- [13] Falxa, M., [...], **Casey-Clyde, J. A.**, et al. June 2023. "Searching for Continuous Gravitational Waves in the Second Data Release of the International Pulsar Timing Array". *Monthly Notices of the Royal Astronomical Society* 521, pp. 5077–5086.
- [14] Koss, Michael J., [...], **Casey-Clyde, J. Andrew**, et al. Jan. 2023. "UGC 4211: A Confirmed Dual Active Galactic Nucleus in the Local Universe at 230 Pc Nuclear Separation". *The Astrophysical Journal* 942, p. L24.
- [15] Mingarelli, Chiara M. F. and **Casey-Clyde, J. Andrew**. Nov. 2022. "Seeing the Gravitational Wave Universe". *Science* 378, pp. 592–593.
- [16] Antoniadis, J., [...], **Casey-Clyde, J. A.**, et al. Mar. 2022. "The International Pulsar Timing Array Second Data Release: Search for an Isotropic Gravitational Wave Background". *Monthly Notices of the Royal Astronomical Society* 510, pp. 4873–4887.
- [17] **Casey-Clyde, J. Andrew** et al. Jan. 2022. "A Quasar-based Supermassive Black Hole Binary Population Model: Implications for the Gravitational Wave Background". *The Astrophysical Journal* 924, p. 93.

### Forthcoming

- [1] Agazie, Gabriella, [...], **Casey-Clyde, J. Andrew**, et al. July 2024. *The NANOGrav 15 Yr Data Set: Posterior Predictive Checks for Gravitational-Wave Detection with Pulsar Timing Arrays*.

- [2] Agazie, Gabriella, [...], **Casey-Clyde, J. Andrew**, et al. Apr. 2024. *The NANOGrav 15 Yr Data Set: Looking for Signs of Discreteness in the Gravitational-wave Background*.

### Submitted

- [1] Agazie, Gabriella, [...], **Casey-Clyde, J. Andrew**, et al. Nov. 2024. *The NANOGrav 15 Yr Data Set: Harmonic Analysis of the Pulsar Angular Correlations*.
- [2] Chen, Yifan, [...], **Casey-Clyde, J. Andrew**, et al. Nov. 2024. *Galaxy Tomography with the Gravitational Wave Background from Supermassive Black Hole Binaries*.
- [3] Laal, Nima, [...], **Casey-Clyde, J. Andrew**, et al. Nov. 2024. *Deep Neural Emulation of the Supermassive Black-hole Binary Population*.
- [4] Semenzato, Federico, **Casey-Clyde, J. Andrew** et al. Nov. 2024. *Cross-Correlating the Universe: The Gravitational Wave Background and Large-Scale Structure*.
- [5] Agazie, Gabriella, [...], **Casey-Clyde, J. Andrew**, et al. Aug. 2024. *The NANOGrav 15 Yr Data Set: Running of the Spectral Index*.
- [6] **Casey-Clyde, J. Andrew** et al. May 2024. *Quasars Can Signpost Supermassive Black Hole Binaries*.

### White Papers

- [1] Haiman, Zoltán, [...], **Casey-Clyde, J. Andrew**, et al. June 2023. *Massive Black Hole Binaries as LISA Precursors in the Roman High Latitude Time Domain Survey*.
- [2] Shen, Yue, **Casey-Clyde, J. Andrew** et al. June 2023. *Discovery and Characterization of Galactic-scale Dual Supermassive Black Holes Across Cosmic Time*.

## Presentations

### Talks

- [1] **Casey-Clyde, J. Andrew**. Nov. 2024. *Multi-Messenger Constraints on Supermassive Black Hole Binaries*. Dissertation Defense. Storrs, Connecticut.
- [2] **Casey-Clyde, J. Andrew**. Sept. 2024. *Multi-Messenger Constraints on Supermassive Black Hole Binaries*. Virtual.
- [3] **Casey-Clyde, J. Andrew**. Jan. 2024. *Quasars Can Signpost Supermassive Black Hole Binaries*. Contributed Talk. New Orleans, Louisiana.
- [4] **Casey-Clyde, J. Andrew**. Dec. 2023. *Multi-Messenger Constraints on Supermassive Black Hole Binaries*. Invited Talk. Pittsburgh, Pennsylvania.
- [5] **Casey-Clyde, J. Andrew**. Dec. 2023. *Quasars Can Signpost Supermassive Black Hole Binaries*. Contributed Talk. Miami, Florida.
- [6] **Casey-Clyde, J. Andrew**. Oct. 2023. *Interpreting Power-Law Excursions in Nanohertz Gravitational-Wave Background Spectra*. Contributed Talk. Vancouver, British Columbia, Canada.
- [7] **Casey-Clyde, J. Andrew**. July 2023. *How Many Quasars Host Supermassive Black Hole Binary Systems?* Contributed Talk.
- [8] **Casey-Clyde, J. Andrew**. June 2023. *How Many Quasars Host SMBHB Systems?* Contributed Talk. Port Douglas, Australia.
- [9] **Casey-Clyde, J. Andrew**. Mar. 2023. *How Many Quasars Host Supermassive Black Hole Binary Systems?* Contributed Talk.
- [10] **Casey-Clyde, J. Andrew**. Mar. 2023. *Interpreting Nanohertz Gravitational-Wave Background Spectra*. Contributed Talk. Corvallis, Oregon.
- [11] **Casey-Clyde, J. Andrew**. Feb. 2023. *How Many Quasars Host Supermassive Black Hole Binaries?* Invited Talk. Storrs, Connecticut.
- [12] **Casey-Clyde, J. Andrew**. Jan. 2023. *How Many Quasars Host Supermassive Black Hole Binaries?* Contributed Talk. Seattle, Washington.

- [13] **Casey-Clyde, J. Andrew.** Oct. 2022. *How Many Quasars Host Supermassive Black Hole Binaries?* Contributed Talk. Milwaukee, Wisconsin.
- [14] **Casey-Clyde, J. Andrew.** July 2022. *Quantifying the Relationship Between Supermassive Black Hole Binaries and Quasars Using Pulsar Timing Arrays.* Contributed Talk. Nashville, Tennessee, United States.
- [15] **Casey-Clyde, J. Andrew.** July 2022. *Quantifying the Relationship Between Supermassive Black Hole Binaries and Quasars Using Pulsar Timing Arrays.* Contributed Talk.
- [16] **Casey-Clyde, J. Andrew.** June 2022. *A Quasar-Based Supermassive Black Hole Binary Population Model: Implications for the Gravitational-Wave Background.* Contributed Talk. Pasadena, California, United States.
- [17] **Casey-Clyde, J. Andrew.** June 2022. *Quantifying the Relationship Between Supermassive Black Hole Binaries and Quasars Using Pulsar Timing Arrays.* Contributed Talk.
- [18] **Casey-Clyde, J. Andrew.** Apr. 2022. *A Quasar-Based Supermassive Black Hole Binary Population Model: Implications for the Gravitational-Wave Background.* Contributed Talk. New York, New York, United States.
- [19] **Casey-Clyde, J. Andrew.** Mar. 2022. *Quantifying the Relationship Between Supermassive Black Hole Binaries and Quasars Using Pulsar Timing Arrays.* Contributed Talk. New York, New York, United States.
- [20] **Casey-Clyde, J. Andrew.** Dec. 2021. *An AGN-based Supermassive Black Hole Binary Population Model: Implications for the Gravitational-Wave Background.* Contributed Talk.
- [21] **Casey-Clyde, J. Andrew.** Sept. 2021. *Anchoring Supermassive Black Hole Binaries to Quasars with the Gravitational-Wave Background.* Contributed Talk. Center for Computational Astronomy, Flatiron Institute, New York, New York.
- [22] **Casey-Clyde, J. Andrew.** July 2021. *Anchoring Supermassive Black Hole Binaries to Active Galactic Nuclei with the Gravitational-Wave Background.* Contributed Talk.
- [23] **Casey-Clyde, J. Andrew.** June 2021. *Anchoring Supermassive Black Hole Binaries to Active Galactic Nuclei with the Gravitational Wave Background.* Contributed Talk.
- [24] **Casey-Clyde, J. Andrew.** Apr. 2021. *Interpreting the Gravitational Wave Background in Terms of Supermassive Black Hole Binary Populations.* Contributed Talk.
- [25] **Casey-Clyde, J. Andrew.** Oct. 2020. *Interpreting the Gravitational-Wave Background in Terms of Supermassive Black Hole Binary Populations.* Contributed Talk.
- [26] **Casey-Clyde, J. Andrew.** Sept. 2020. *Constraining Supermassive Black Hole Binary Populations with PTAs.* Contributed Talk.
- [27] **Casey-Clyde, J. Andrew.** July 2020. *Constraining Supermassive Black Hole Binary Populations with PTAs.* Invited Talk.

### Posters

- [1] **Casey-Clyde, J. Andrew.** Nov. 2021. *A Quasar-Based Model of Supermassive Black Hole Binaries.* Poster. Windsor Locks, CT, USA.
- [2] **Casey-Clyde, J. Andrew.** July 2021. *Anchoring Supermassive Black Hole Binaries to Active Galactic Nuclei with the Gravitational-Wave Background.* Poster.
- [3] **Casey-Clyde, J. Andrew.** June 2021. *Interpreting the Gravitational Wave Background in Terms of Supermassive Black Hole Binary Populations.* Poster.
- [4] **Casey-Clyde, J. Andrew.** Jan. 2021. *Interpreting the Gravitational-Wave Background in Terms of Supermassive Black Hole Binary Populations.* iPoster.
- [5] **Casey-Clyde, J. Andrew, Thummar, H., and Donet, J.** Jan. 2019. *Galaxy Classification with Neural Networks in SDSS.* Seattle, WA, USA.
- [6] **Casey-Clyde, J. Andrew.** Jan. 2018. *Mapping Gas Orbits in the Circumnuclear Disk.* Poster. Washington, D.C., USA.
- [7] **Casey-Clyde, J. Andrew.** Aug. 2017. *Kinematics of the Eastern Arm in the Circumnuclear Disk.* Poster. Quy Nhon, Vietnam.

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## Grants

May 2021 – **PI: J. Andrew Casey-Clyde**, *NASA Connecticut Space Grant Graduate Research Fellowship*,  
Aug. 2021 \$8,000 USD, P-1709  
Multi-Messenger Detections and Constraints of Supermassive Black Hole Binaries

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## Outreach

May 2024 **Seagrave Observatory**, *Skyscrapers Amateur Astronomical Society*, North Scituate, RI  
Low Frequency Gravitational Waves: A New View of the Universe

Nov. 2023 **Hops 44**, *Astronomy on Tap*, Storrs, CT  
Gravitational Waves and Multi-Messenger Astronomy

Aug. 2023 **Hops 44**, *Astronomy on Tap*, Storrs, CT  
Supermassive Black Holes: A Crash Course on the Biggest Objects in the Universe

May 2023 **Ecotarium**, *Astrophysical Speaker Series*, Worcester, MA  
Low Frequency Gravitational Waves: A New View of the Universe

Jan. 2022 **Connecticut Invention Convention**, *Virtual Inventors Club*, Virtual  
Provided project mentorship to middle school-age student inventors.