Andrew Casey-Clyde, Ph.D

Research Scientist

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Summary

Ph.D. Research Scientist 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 22 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.

Experience

Aug. 2023 – present **Visiting Research Assistant**, *Yale University*, New Haven, CT
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 SMBHB models to predict properties of individual SMBHBs and population.
- Simulated 1000 SMBHB populations and their gravitational wave signals to interpret observed data.
- Developed model of SMBHB progenitors to predict observations in censored telescope data.

Aug. 2019 – present **Graduate Research and Teaching Assistant**, *University of Connecticut*, Storrs, CT
Developed novel models of SMBHB populations, incorporating data from multiple, independent sources.
- Developed three hierarchical Bayesian models of SMBHB populations to predict population properties.
- Developed novel statistical method to efficiently sample multivariate probability distributions.

Sep. 2016 – Aug. 2019 **Graduate Research and Teaching Associate**, *San José State University*, San Jose, CA
Performed astrophysics research and data analysis, and taught undergraduate physics labs.
- Developed Bayesian data analysis to predict the location of newly observed gas in the galactic center.
- Developed convolutional neural network pipeline for galaxy classification.

Feb. 2015 – Aug. 2016 **Software Engineer**, *Salient Process, Inc.*, Sacramento, CA
Developed and maintained both internal and client-facing software.
- Lead developer for SPARK UI toolkit, which was later purchased by IBM.

Education

2019–2024 **Ph.D. Physics**, *University of Connecticut*, Storrs, CT, *GPA:* 3.823

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

Skills

Core	Statistics, data science, quantitative research, regression analysis, data modeling, classification
Technical	Python, SLURM, SQL, Git, Java, C++, C
Methods	Markov chain Monte Carlo, Hamiltonian Monte Carlo, kernel density estimation, k-nearest neighbors, artificial neural networks, convolutional neural networks, large language models
Software	NumPy, SciPy, Pandas, PyMC, Scikit-learn, Keras, TensorFlow, Jupyter, Spyder, Matplotlib, Seaborn
Soft skills	Problem solving, scientific writing, presentation, detail-oriented, project management, agile development, collaboration, organization

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.

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 ~ 1.6 pc of the central SMBH.

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

Selected Coursework

University of Connecticut

- Stars and Compact Objects
- General Relativity and Cosmology

San José State University

- Astronomy Data Analysis
- Statistical and Machine Learning Classification
- Computational Physics
- Deep Learning
- Numerical Analysis and Scientific Computing
- Methods in Mathematical Physics

University of California, Davis

- Astronomy Instrumentation & Data Analysis Lab
- Discrete Math for Computer Science
- Linear Algebra
- Intro to Programming & Problem Solving
- Computational Methods of Mathematical Physics
- Statistics through Computation
- Linear Algebra Computation Lab
- Software & Object Oriented Programming

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 Colombia, 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.

Grants

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

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.