

Kyle Kremer

1216 E. California Blvd, Pasadena, CA 91125 – kkremer@caltech.edu

www.kylekremer.com

Research Summary

My research program spans a wide spectrum of topics related to stellar dynamics and compact object physics. Broadly, the main question I aim to answer is: How do dynamical processes relevant in multibody systems lead to evolutionary outcomes not possible for isolated stars or binaries? I use computational and analytic methods to study dynamics in various contexts. I am especially interested in applications to current/upcoming gravitational wave detectors (e.g., LIGO & LISA) and transient observatories (e.g., Rubin).

Academic Positions

California Institute of Technology <i>NSF Astronomy & Astrophysics Fellow</i>	Pasadena, CA 2020–present
Carnegie Observatories <i>NSF Astronomy & Astrophysics Fellow</i>	Pasadena, CA 2020–present
Northwestern University <i>Postdoctoral Associate</i> <i>NSF Graduate Research Fellow</i>	Evanston, IL 2020 2015–2019

Education

Northwestern University <i>Ph.D. in Astronomy</i> – Thesis: The Role of Black Holes in Globular Cluster Dynamics – Advisor: Fred Rasio	Evanston, IL 2019
<i>Master of Science in Physics & Astronomy</i>	2017
Colburn Conservatory of Music <i>Master of Music</i>	Los Angeles, CA 2015
Northwestern University <i>Bachelor of Music; Double Major in Physics and Music Performance</i>	Evanston, IL 2012

Honors & Awards

NASA Einstein Fellowship	2022
NSF Astronomy & Astrophysics Postdoctoral Fellowship	2020
Carnegie Fellowship in Theoretical Astrophysics (deferred)	2020
Caltech Burke Fellowship (deferred)	2020
NSF Graduate Research Fellowship	2015
Winston Churchill Scholarship	2012
Barry M. Goldwater Scholarship	2011
National Undergraduate Fellowship, Princeton Plasma Physics Laboratory	2011
NASA Summer Research Program, Northwestern University	2009, 2010

52 total short-author publications, including 17 first-author, 30 co-author, and 5 proceedings/white papers

First-author publications:

17. **Formation of low-mass black holes and single millisecond pulsars in globular clusters**
Kremer, K., Ye, C.S., Kiroğlu, F., Lombardi, J., Ransom, S., Rasio, F.A. 2022, submitted to ApJL, 13 pp.
16. **Hydrodynamics of close encounters between main-sequence stars and black hole remnants**
Kremer, K., Lombardi, J., Lu, W., Piro, A.L., Rasio, F.A. 2022, submitted to ApJ, 21 pp.
15. **Dynamical formation channels for fast radio bursts in globular clusters**
Kremer, K., Piro, A.L., Li, D. 2021, ApJL, 917, L11, 11 pp.
14. **White dwarf subsystems in core-collapsed globular clusters**
Kremer, K., Rui, N.Z., Weatherford, N.C., Chatterjee, S., et al. 2021, ApJ, 917, 28–25 pp.
13. **Fast optical transients from stellar-mass black hole tidal disruption events in young star clusters**
Kremer, K., Lu, W., Piro, A.L., et al. 2021, ApJ, 911, 104, 18 pp.
12. **Populating the upper black hole mass gap through stellar collisions in young star clusters**
Kremer, K., Spera, M., Becker, D., Chatterjee, S., et al. 2020, ApJ, 903, 45, 25 pp.
11. **Modeling dense star clusters in the Milky Way and beyond with the CMC cluster catalog**
Kremer, K., Ye, C.S., Rui, N.Z., Weatherford, N.C., Chatterjee, S., et al. 2020, ApJS, 247, 48, 47 pp.
10. **Probing the survival of planetary systems in globular clusters with tidal disruption events**
Kremer, K., D’Orazio, D.J., Samsing, J., Chatterjee, S., Rasio, F.A. 2019, ApJ, 885, 2, 15 pp.
9. **Tidal disruptions of stars by black hole remnants in dense star clusters**
Kremer, K., Lu, W., Rodriguez, C.L., Lachat, M., Rasio, F.A. 2019, ApJ, 881, 75, 15 pp.
8. **Post-Newtonian dynamics in dense star clusters: Binary black holes in the LISA band**
Kremer, K., Rodriguez, C. L., Amaro-Seoane, P., Breivik, K., et al. 2019, PRD, 99, 063003, 12 pp.
7. **How initial size governs core collapse in globular clusters**
Kremer, K., Chatterjee, S., Ye, C. S., Rodriguez, C. L., Rasio, F. A., 2019, ApJ, 871, 38, 12 pp.
6. **Low-mass X-ray binaries ejected from globular clusters**
Kremer, K., Chatterjee, S., Rodriguez, C.L., Rasio, F.A. 2019, submitted to ApJ, arXiv: 1802.04895, 19 pp.
5. **How black holes shape globular clusters: Modeling NGC 3201**
Kremer, K., Ye, C. S., Chatterjee, S., Rodriguez, C.L., Rasio, F.A. 2018, ApJL, 855, L15, 7 pp.
4. **LISA sources in Milky Way globular clusters**
Kremer, K., Chatterjee, S., Breivik, K., Rodriguez, C.L., Larson, S.L., Rasio, F.A. 2018, PRL, 120, 191103, 6 pp.
3. **Accreting black hole binaries in globular clusters**
Kremer, K., Chatterjee, S., Rodriguez, C.L., Rasio, F.A. 2018, ApJ, 852, 29, 12 pp.
2. **Accreting double white dwarf binaries: Implications for LISA**
Kremer, K., Breivik, K., Larson, S.L., Kalogera, V. 2017, ApJ, 846, 95, 11 pp.
1. **Long-term evolution of double white dwarf binaries accreting through direct impact**
Kremer, K., Sepinsky, J., Kalogera, V. 2015, ApJ, 806, 76, 13 pp.

Co-author publications:

30. **Stellar graveyards: Clustering of compact objects in globular clusters NGC 3201 and NGC 6397**
Vital, E., Kremer, K., Libralato, M., Mamon, G., Bellini, A. 2022, submitted to MNRAS
29. **Gravitational Microlensing Rates in Milky Way Globular Clusters**
Kiroğlu, F., Weatherford, N.C., Kremer, K. et al. 2021, arXiv:2111.14866, submitted to ApJ
28. **Compact Object Modeling in the Globular Cluster 47 Tucanae**
Ye, C.S., Kremer, K. et al. 2021, arXiv:2110.05495, submitted to ApJ
27. **The Imprint of Superradiance on Hierarchical Black Hole Mergers**
Payne, E. Sun, L., Kremer, K., Lasky, P.D., Thrane, E. 2021, submitted to ApJ
26. **Implications of Eccentric Observations on Binary Black Hole Formation Channels**
Zevin, M., Romero-Shaw, I., Kremer, K., Thrane, E., Lasky, P.D. 2021, ApJ, 921, L43
25. **Modeling Dense Star Clusters in the Milky Way and Beyond with the Cluster Monte Carlo Code**
Rodriguez, C.L. et al. (including Kremer, K.), 2021, ApJS, 258, 22
24. **The Supersonic Project: SIGOs, a Proposed Progenitor to Globular Clusters, and their Connections to Gravitational Wave Anisotropies**
Lake, W., Naoz, S., Chiou, Y.S., Burkhardt, B., Marinacci, F., Vogelsberger, M., Kremer, K., 2021, ApJ, 922, 86
23. **Matching globular cluster models to observations**

- Rui, N.Z., **Kremer, K.**, Weatherford, N.C., Chatterjee, S., Rasio, F.A., Rodriguez, C.L., Ye, C.S., 2021, ApJ, 912, 102
22. **Intermediate-mass Black Holes from High Massive-star Binary Fractions in Young Star Clusters**
González, E., **Kremer, K.**, Chatterjee, S., Fragione, G., Roderiguez, C.L., et al. 2021, ApJ, 928, L29
 21. **Gravitational Waves as a Probe of Globular Cluster Formation and Evolution**
Romero-Shaw, I., **Kremer, K.**, Lasky, P., Thrane, E., Samsing, J. 2021, MNRAS, 506, 2362
 20. **Black hole mergers from star clusters with top-heavy initial mass functions**
Weatherford, N.C., Fragione, G., **Kremer, K.**, Ye, C.S., Rasio, F. A., 2021, ApJ, 907, 25L
 19. **Joint constraints on the field-cluster mixing fraction, common envelope efficiency, and globular cluster radii from a population of binary hole mergers via deep learning**
Wong, K., Breivik, K., **Kremer, K.**, Callister, T. 2021, PRD, 103, 083021
 18. **Neutron Star-Black Hole Mergers from Gravitational Wave Captures**
Hoang, B.-M., Naoz, S., **Kremer, K.** 2020, ApJ, 903, 8
 17. **Black Hole Mergers from Hierarchical Triples in Dense Star Clusters**
Martinez, M. A. S., Fragione, G., **Kremer, K.**, et al. 2020, ApJ, 903, 67
 16. **Demographics of triple systems in dense star clusters**
Fragione, G., Martinez, M. A. S., **Kremer, K.**, et al. 2020, ApJ, 900, 16
 15. **GW190412 as a third-generation black hole merger from a super star cluster**
Rodriguez, C. L., **Kremer, K.**, Grudić, M., Hafen, Z., et al. 2020, ApJ, 896, L10, 5 pp.
 14. **Illuminating black hole cusp populations in young star clusters**
Kaaz, N., **Kremer, K.**, Auchettl, K., Ramirez-Ruiz, E. 2020, accepted by ApJ, 13 pp.
 13. **Gravitational-wave captures by intermediate-mass black holes in galactic nuclei**
Fragione, G., Loeb, A. **Kremer, K.**, Rasio, F. A., 2020, ApJ, 897, 46, 10 pp.
 12. **A dynamical survey of stellar-mass black holes in 50 Milky Way globular clusters**
Weatherford, N.C., Chatterjee, S., **Kremer, K.**, Rasio, F. A., 2020, ApJ, 898, 162, 25 pp.
 11. **COSMIC variance in binary population synthesis**
Breivik, K., Coughlin, S.C., Zevin, M., Rodriguez, C.L., **Kremer, K.**, et al. 2020, ApJ, 898, 71, 17 pp.
 10. **On the rate of binary neutron star mergers in globular clusters**
Ye, C.S., Fong, W.-F., **Kremer, K.**, Rodriguez, C.L., Chatterjee, S., Fragione, G., Rasio, F.A., 2020, ApJ, 888, L10, 16 pp.
 9. **Gravitational-wave captures of single black holes in globular clusters**
Samsing, J., D’Orazio, D.J., **Kremer, K.**, Rodriguez, C.L., Askar, A. 2019, PRD, 101, 123010, 16 pp.
 8. **Can neutron-star mergers explain the r-process enrichment in globular clusters?**
Zevin, M., **Kremer, K.**, Siegel, D.M., Coughlin, S., Tsang, B.T.-H., Berry, C.P.L., Kalogera, V. 2019, ApJ, 886, 4, 16 pp.
 7. **Black holes: The next generation – Repeated mergers in dense star clusters and their gravitational-wave properties**
Rodriguez, C.L., Zevin, M., Amaro-Seoane, P., Chatterjee, S., **Kremer, K.**, et al. 2019, PRD, 100, 043027, 15 pp.
 6. **Probing the black hole merger history in clusters using stellar tidal disruptions**
Samsing, J., Venumadhav, T., Dai, L., Martinez, I., Batta, A., Lopez Jr., M., Ramirez-Ruiz, E., **Kremer, K.** 2019, PRD, 100, 043009, 12 pp.
 5. **In search of the thermal eccentricity distribution**
Geller, A.M., Leigh, N.W.C., Giersz, M., **Kremer, K.**, Rasio, F.A., 2019, ApJ, 872, 165, 14 pp.
 4. **Millisecond pulsars and black holes in globular clusters**
Ye, C.S., **Kremer, K.**, Chatterjee, S., Rodriguez, C.L., Rasio, F.A. 2019, ApJ, 877, 122, 10 pp.
 3. **Post-Newtonian dynamics in dense star clusters: Formation, masses, and merger rates of highly-eccentric black hole binaries**
Rodriguez, C.L., Amaro-Seoane, P., Chatterjee, S., **Kremer, K.**, et al. 2018, PRD, 98, 123005, 16 pp.
 2. **Characterizing accreting double white dwarf binaries with LISA and Gaia**
Breivik, K., **Kremer, K.**, Bueno, M., Larson, S.L., Coughlin, S., Kalogera, V. 2018, ApJL, 854, L1, 6 pp.
 1. **Spin tilts in the double pulsar reveal supernova spin angular-momentum production**
Farr, W.M., **Kremer, K.**, Lyutikov, M., Kalogera, V. 2011, ApJ, 742, 81, 5 pp.

Research notes, proceedings and white papers:

5. **No black holes in NGC 6397**
Rui, N.Z., Weatherford, N.C., **Kremer, K.**, et al. 2021, RNAAS, 5, 47
4. **The Observed Rate of Binary Black Hole Mergers can be Entirely Explained by Globular Clusters**
Rodriguez, C.L., **Kremer, K.**, et al. 2021, RNAAS, 5, 19
3. **The role of “black hole burning” in the evolution of dense star clusters**

Kremer, K., Ye, C.S., Chatterjee, S., Rodriguez, C.L., Rasio, F.A. 2020, Proceedings of the IAU, 351, 357, 10 pp.

2. Modeling pulsars in dense star clusters

Ye, C.S., Kremer, K., et al. 2020, Proceedings of the IAU, 351, 357, 4 pp.

1. Astro2020 Decadal Science White Paper: Gravitational Wave Survey of Galactic Ultra Compact Binaries

Littenberg, T.B., Breivik, K., Brown, W.R., Eracleous, M., Hermes, J.J., Holley-Bockelmann, K., Kremer, K., et al. 2019, arXiv:1903.05583, submitted to the Astro2020 call for science white papers, 5 pp.

Observing Programs as PI

• A KCWI Black Hole Search in Milky Way Globular Clusters

Keck-II/KCWI, 2022A, 3 half-nights, PI: K. Kremer

Students Mentored

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| • Riya Shrivastava (CASSI Summer Program at Carnegie) | 2021 - present |
| • Fulya Kiroğlu (Grad student at NU) | 2020 - present |
| • Elena González (CIERA REU program; now grad student at NU) | 2020 - present |
| • Devin Becker (CIERA REU program; now grad student at MIT) | 2019 |
| • Nicholas Rui (CIERA summer student; now grad student at Caltech) | 2019 |
| • Mitchell Lachat (CIERA REU program; now grad student at Univ of Rochester) | 2018 |

Invited Presentations

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| 16. AAS HEAD Meeting (special session), Pittsburgh, PA | March 2022 |
| 15. CIERA Science Happy Hour, Northwestern, Evanston, IL | September 2021 |
| 14. Niels Bohr Institute, Copenhagen, DK | November 2020 |
| 13. Michigan State Astro Seminar, East Lansing, MI | June 2020 |
| 12. CGCA Seminar, UW-Milwaukee, Milwaukee, WI | February 2020 |
| 11. Harvard-CfA, Cambridge, MA | December 2019 |
| 10. Carnegie Observatories Lunch Talk, Pasadena, CA | November 2019 |
| 9. Caltech Tea Talk, Pasadena, CA | November 2019 |
| 8. UCLA Astro Seminar, Los Angeles, CA | November 2019 |
| 7. UC-Santa Barbara Astro Lunch, Santa Barbara, CA | October 2019 |
| 6. UC-Santa Cruz FLASH Seminar, Santa Cruz, CA | October 2019 |
| 5. MODEST Meeting (Review talk), Bologna, IT | May 2019 |
| 4. Caltech TAPIR Seminar, Pasadena, CA | November 2018 |
| 3. University of Florida Theoretical Astrophysics Seminar, Gainesville, FL | September 2018 |
| 2. Harvard-CfA ITC Seminar, Cambridge, MA | May 2018 |
| 1. MIT Brownbag Seminar, Cambridge, MA | May 2018 |

Contributed Presentations

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| 18. IAU 361: Massive Stars Near & Far, Ballyconnell, IR | May 2022 |
| 17. Intermediate-mass Black Holes Meeting, San Juan, PR | April 2022 |
| 16. Dynamical Formation of Gravitational Wave Sources, Aspen, CO | January 2022 |
| 15. FRB 2021 Meeting (virtual) | July 2021 |
| 14. AAS Winter Meeting (dissertation talk), Honolulu, HI | January 2020 |
| 13. The Beginnings and Ends of Double White Dwarfs, Copenhagen, DK | July 2019 |
| 12. MODEST Meeting, Bologna, IT | May 2019 |
| 11. Gravitational-Wave Astrophysics with Populations, Aspen, CO | February 2019 |
| 10. LISA Astrophysics Working Group, Paris, FR | December 2018 |
| 9. Midwest Relativity Meeting, Milwaukee, WI | October 2018 |
| 8. 12th International LISA Symposium, Chicago, IL | July 2018 |
| 7. MODEST Meeting, Santorini, GR | June 2018 |
| 6. American Physical Society April Meeting, Columbus, OH | April 2018 |
| 5. Midwest Relativity Meeting, Ann Arbor, MI | October 2017 |

4. MODEST Meeting, Prague, CZ	September 2017
3. AAS Winter Meeting, Grapevine, TX	January 2017
2. AAS Summer Meeting, Anchorage, AK	June 2012
1. APS Division of Plasma Physics Meeting, Salt Lake City, UT	November 2011

Outreach & Community Engagement

Cosmos in Concert: Founder & Director (www.cosmosinconcert.com) 2015-present
 Educational outreach program combining classical music with astronomy education. Presents multimedia shows featuring live music performance, astronomy visuals, and narration. Presented 17 concerts in six states for audiences totaling over 6,000 people.

- Organize, fundraise, and direct annual concert series at Northwestern University presenting multimedia shows for symphony orchestra. Past concerts include *Solar System Symphony* (Spring 2016), *A Shout Across Time* (Spring 2017), and *Celestial Suite* (Fall 2017).
- Facilitate collaboration with professional orchestras (Boulder Philharmonic Orchestra), top U.S. music conservatories (Bienen School of Music, Colburn School), leading composers (James Stephenson, Matthew Fuerst, Ira Mowitz), and Chicago-area science organizations (Fermi National Lab, Adler Planetarium).
- Featured in local and national news outlets including *Popular Science*, *Splash Magazines*, and *WTTW Chicago Media*.

Science Sonification Project: Co-director 2016-2017
 Developed and led a cross-disciplinary collaboration at Northwestern that brought together doctoral students in music composition and the sciences to create original science-inspired music compositions that showcase scientific innovation in the Northwestern research community.

- Facilitated collaboration between six scientists from various departments and six composers from the Bienen School of Music throughout the Winter and Spring 2017 quarters, with each pair creating a unique piece of music.
- As culmination of this project, organized the Science Sonification Project Showcase in May 2017, which featured performances of these new pieces of music. Audience included Northwestern students, faculty, and staff as well as the general public.

The Nettelhorst School: Scientist/Musician-in-Residence 2015-2016
 Organized a six-week music/science residency at The Nettelhorst School (a GK-8 Chicago Public School) to develop curriculum that brought music/arts into the science classroom.

- Recruited and led a team of ten Northwestern graduate students from various departments at Northwestern, including the School of Education and Social Policy, Materials Science, and Physics & Astronomy.
- Worked directly with middle school science teachers and students.
- Organized two live music performances presented by musicians from Northwestern's Bienen School of Music.
- In total, the residency reached approximately 500 GK-8 students at Nettelhorst.

Northwestern Center for Talent Development 2016
 Developed curriculum and co-taught two-day course on astronomy for class of 20 middle school students.

CIERA Astronomer Evenings 2015-present
 Monthly public astronomy lectures at Dearborn Observatory at Northwestern

Professional Service

Conferences Organized:
 • CIERA Workshop on Black Hole Dynamics in Clusters December 2018

- Peer Reviewer for:**
- Nature Astronomy
 - Physical Review (PRD and PRL)
 - The Astrophysical Journal (and ApJ Letters)
 - Monthly Notices of the Royal Astronomical Society
 - Classical and Quantum Gravity

- Publications of the Astronomical Society of Australia

Other:

- Caltech TAPIR Seminar co-organizer 2021-2022
- Mentor/Lecturer for Carnegie Undergraduate Summer Program (CASSI) 2020, 2021
- CIERA Seminar co-organizer 2019

National and International Press

For: LISA sources in Milky Way globular clusters, Kremer, K., Chatterjee, S., Breivik, K., Rodriguez, C. L., Larson, S. L., Rasio, F. A. 2018, PRL, 120, 191103

- Phys.org: “Dozens of binaries from Milky Way globular clusters could be detectable by LISA”
<https://phys.org/news/2018-05-dozens-binaries-milky-globular-clusters.html>
- The Economic Times: “LISA can detect binaries from Milky Way’s globular clusters: Study”
<https://economictimes.indiatimes.com/news/science/lisa-can-detect-binaries-from-milky-ways-globular-clusters-study/articleshow/64135609.cms>
- Tech Source: “Binaries from Milky Way’s globular clusters could be detected by LISA”
<https://www.techsourceint.com/news/binaries-from-milky-ways-globular-clusters-could-detected-by-lisa>
- Inquistr: “LISA Observatory Might Be Able To Detect ‘Dozens’ Of Milky Way Binaries”
<https://www.inquistr.com/4897944/lisa-observatory-might-be-able-to-detect-dozens-of-milky-way-binaries/>
- Other: Technology Networks, Next Big Future, The Hans India, EurekAlert

For: How black holes shape globular clusters: Modeling NGC 3201, Kremer, K., Ye, C. S., Chatterjee, S., Rodriguez, C. L., Rasio, F. A. 2018, ApJL, 855, L15

- AASNOVA: “Shaping Globular Clusters with Black Holes”
<https://aasnova.org/2018/03/21/shaping-globular-clusters-with-black-holes/>

For: Cosmos in Concert

- Popular Science: “See The Planets Of Our Solar System While Listening To ‘The Planets’”
<https://www.popsci.com/see-planets-our-solar-system-while-listening-to-planets>
- Chicago WTTW: “Solar System Symphony Mends Music with Astronomy”
<https://chicagotonight.wttw.com/2016/05/23/solar-system-symphony-mends-music-astronomy>
- SPLASH Magazines: “‘A Shout Across Time’ Review – The Sun and the Moon and the Stars”
<https://splashmagazines.com/index.php/2017/05/16/a-shout-across-time-review-the-sun-and-the-moon-and-the-stars/>
- Boulder Weekly: “Infinite Space: Boulder Phil plays music about stars and astronomers and planets”
<https://www.boulderweekly.com/entertainment/infinite-space-boulder-phil-plays-music-stars-astronomers-planets/>