

Michael A. Kuhn

Curriculum Vitae

Education

2007–2014 **PhD in Astronomy & Astrophysics**, *Penn State University*.

2003–2007 **BA in Astrophysics**, *Swarthmore College*, *High Honors*.

PhD thesis

title *The Spatial Structure of Young Stellar Clusters*

supervisors Eric Feigelson & Konstantin Getman

description My thesis was based on my contribution to the “Massive Young Star-Forming Complex Study in Infrared and X-ray” (MYStIX). I used our newly generated catalogs of young stellar objects to examine how these regions are structured, including statistical measures of stellar clustering, spatial correlations between stars and gas, mass segregation of stars, and stellar age spreads. One of my conclusions was that most of these systems must be dynamically expanding. Since the publication of the thesis, this conclusion has been directly confirmed via *Gaia* measurements.

Research interests

astronomy Star formation, young stellar objects, astronomical surveys

astrostatistics Statistical modeling, statistical classification, spatial point processes

Research experience

2018–present **Postdoctoral Scholar in Astronomy**, *Caltech*, Pasadena, CA.

Research under the supervision of Lynne Hillenbrand.

- Curation of a database of young stellar objects;
- Kinematic study of formation and dissolution of young star clusters and associations;
- Study of outbursts from young stars using *Gaia*, ZTF, and follow-up spectroscopy.

2014–2017 **FONDECYT Postdoctoral Fellow**, *Universidad de Valparaíso*, Valparaíso.

- Research on the assembly and dynamics of young star clusters;
- Study of young cluster demographics in the Milky Way.

2008–2014 **Graduate Research Assistant**, *Pennsylvania State University*, University Park.

- Study of young stellar clusters in the X-ray and infrared for the MYStIX project
- Development of statistical methods for modeling the structure of young stellar clusters;

2006–2007 **Undergraduate Research Assistant**, *Swarthmore College*, Swarthmore.

X-ray spectroscopy of a B-type star. Advisor: David Cohen.

2004,2005 **REU Student**, *Keck Northeast Astronomy Consortium*.

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☎ (814) 441-9510 • ✉ mkuhn@astro.caltech.edu

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Research skills

facilities used *Chandra X-ray Observatory, Spitzer Space Telescope, XMM Newton, Palomar P200/DBSP and TripleSpec, Blanco/ARCoIRIS, ESO/NTT, APEX, United Kingdom Infra-Red Telescope, Hobby Eberly Telescope, 2.1m telescope at KPNO*

Computer skills

languages R, Python, C, and many others

applications TOPCAT, CIAO, XSPEC, IRAF, numpy, pandas, scipy, astropy, scikit-learn, spatstat, and many others

Additional educational experiences

- 2015 Quality control training at the ALMA center in Santiago, Chile
- 2012 Saas-Fee Winter School in Star Formation
- 2010 Summer School in Statistics for Astronomers

Teaching experience

- 2019–2021 Research supervisor for students in Caltech's Freshman Summer Research Institute
- 2015–2021 Provided mentorship for undergraduate and graduate students at Valparaíso and Caltech
- 2017, 2018 La Serena School for Data Science
(http://www.aura-o.aura-astronomy.org/winter_school/content/2018-final-program)
- 2014 Certificate for completion of the course in college teaching (Penn State)
- 2011–2013 Guest lectures for astronomy and astrostatistics courses
- 2008–2009 Instruction and development of the syllabus for Astro 11 lab course

Approved Proposals (PI and select Co-I)

- 2021 PI SOFIA archive proposal (\$50,000)
- 2021 Co-I JWST/MIRI observations of YSOs in NGC 6357 (\$200,000)
- 2021 Co-I on a VLA large proposal (The VLA Orion A Large Survey)
- 2020 PI 45 ks *Chandra* Guest Observer observation of the North America Nebula (\$47,200)
- 2020 PI for 2 nights Caltech Palomar P200/DBSP
- 2019 PI archival *Chandra*/*NuSTAR* study of Orion (\$50,200)
- 2018 40 ks *XMM-Newton* DDT request granted to observe Gaia 17bpi
- 2018 PI 50 ks *Chandra* Guest Observer observation of Trifid North (\$54,860)
- 2015 PI 80 ks *Chandra* Guest Observer observation of W40 (\$27,377)
- 2014 PI 40 ks *Chandra* Guest Observer observation of IC 5146 (\$20,000)
- 2018 PI for 2 nights Caltech Palomar P200/TripleSpec
- 2017 PI APEX observation of massive protostars
- 2017 PI for 3 nights of observations of W40 with Blanco/ARCoIRIS

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- 2016 PI for 2 nights of observations of embedded massive stellar candidates with Blanco/ARCoIRIS
- 2015 PI for 3 nights of observations of RCW 38 cluster members with Blanco/ARCoIRIS
- 2010–2018 Co-I on a number of successful *Chandra* proposals
- 2014–2017 Co-I on successful CNTAC and ESO proposals

Awards

- 2014–2017 FONDECYT postdoctoral fellowship
- 2013 Downsbrough graduate fellowship in astrophysics
- 2012 Zaccheus Daniel fellowship travel grant

Invited talks

- 2021 Gaia's View of Young Stellar Clusters: Formation, Expansion, and Dispersal – Universitat de Barcelona, Spain
- 2021 The Life Cycles of Star Forming Regions in the Milky Way – Universidade Federal do Rio Grande do Sul – Porto Alegre, Brazil
- 2020 Statistical Models to Study Young Star Clusters and Associations – The Physical Challenges of Astro-Statistics (POSTPONED due to COVID-19) – Sesto, Italy
- 2019 The Early Evolution of Young Massive Clusters– From Gas to Stars – York, UK
- 2018 The Structure and Evolution of Young Star Clusters and Associations – JPL Summer Seminar Series talk
- 2017 The Young Star Cluster NGC 6231: Structure, Formation, and Fate – ESO, Chile
- 2017 Spatial Structure of Newly Formed Star Clusters – StarFormMapper Meeting – El Escorial, Spain
- 2016 Star Cluster Formation and Dissolution – Universidad Técnica Federico Santa María, Chile
- 2016 Mass Segregation in Young Stellar Clusters – Star Clusters: From Infancy to Teenagehood – Heidelberg, Germany
- 2014 MYStIX: Dynamical Evolution of Young Clusters – High Energy Astrophysics Division special session
- 2011 The Structure of Young Stellar Clusters – International Center for Radio Astronomy, Australia

Service

- 2021 Caltech Optical Observatories Time Allocation Committee member
- 2021 Reviewer for FONDECYT funding proposals
- 2012–present Referee for ApJ, ApJL, AJ, A&A, MNRAS, and PASP
- 2021 Referee for a Protostars & Planets VII review chapter
- 2018–2019 Organization of Caltech's Astronomy Tea Talks
- 2017 Seminar organization at the Universidad de Valparaíso

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Outreach

- 2019 Public lecture on star formation for Caltech STEM for Families
- 2019 Science for March outreach activities at Caltech
- 2008–2014 AstroFest outreach activities at Penn State

Press Releases

- 2021 “Astronomers Find a ‘Break’ in One of the Milky Way’s Spiral Arms” (PI) NASA/JPL press release
<https://go.nasa.gov/3C1SHOT>
- 2019 “Space Butterfly Is Home to Hundreds of Baby Stars” (PI), NASA/JPL image release
<https://go.nasa.gov/3E4iKX1>
- 2018 “Young Star Caught in a Fit of Growth” (co-I), joint Caltech/ESA press releases
<https://go.nasa.gov/38TzfqK>
- 2018 “NGC 6231: Stellar Family Portrait in X-rays” (PI), NASA/CXO image release (PI) NASA/JPL press release
<https://go.nasa.gov/2Vy6qgK>
- 2014 “NASA’s Chandra Observatory Delivers New Insight Into Formation of Star Clusters” (co-I), NASA/CXO press release
<https://go.nasa.gov/3jYseeU>
- 2007 Astronomers May Have Found a New Star in the Southern Cross” New York Times article featuring our AAS press release
<https://nyti.ms/3h191Ch>

Book chapters

1. **Kuhn, M. A.** & Feigelson, E. D., 2019, “Applications in Astronomy,” in *Handbook of Mixture Analysis*, ed. G. Celeux, S. Frühwirth-Schnatter, and C. P. Robert (Chapman & Hall/CRC)

First-authored peer-reviewed papers

1. **Kuhn, M. A.**, Benjamin, R., Zucker, C., et al. 2021, *A High Pitch Angle Structure in the Sagittarius Arm*, *A&A Letters*, 651, L10
2. **Kuhn, M. A.**, de Souza, R. S., Krone-Martins, A. et al. 2021, *SPICY: The Spitzer/IRAC Candidate YSO Catalog for the Inner Galactic Midplane*, *ApJS*, 254, 33
3. **Kuhn, M. A.**, Hillenbrand, L. A., Carpenter, J. M., & Avelar Menendez, A. R. 2020, *The Formation of a Stellar Association in the NGC 7000/IC 5070 Complex: Results from Kinematic Analysis of Stars and Gas*, *ApJ*, 899, 128
4. **Kuhn, M. A.** & Hillenbrand, L. A. 2019, *A Comparison of the X-ray Properties of FU Ori-type Stars to Generic Young Stellar Objects*, *ApJ*, 883, 117
5. **Kuhn, M. A.**, Hillenbrand, L. A., Sills, A., et al. 2019, *Kinematics in Young Star Clusters and Associations with Gaia DR2*, *ApJ*, 870, 32
6. **Kuhn, M. A.**, Getman, K. V., Feigelson, E. D., et al. 2017, *The Structure of the Young Star Cluster NGC 6231. II. Structure, Formation, and Fate*, *AJ*, 154, 214

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7. **Kuhn, M. A.**, Medina, N., Getman, K. V., et al. 2017, *The Structure of the Young Star Cluster NGC 6231. I. Stellar Population*, AJ, 154, 87
8. **Kuhn, M. A.**, Feigelson, E. D., Getman, K. V., et al. 2015, *The Spatial Structure of Young Stellar Clusters. III. Physical Properties and Evolutionary States*, ApJ, 812, 131
9. **Kuhn, M. A.**, Getman, K. V., & Feigelson, E. D. 2015, *The Spatial Structure of Young Stellar Clusters. II. Total Young Stellar Populations*, ApJ, 802, 60
10. **Kuhn, M. A.**, Feigelson, E. D., Getman, K. V., et al. 2014, *The Spatial Structure of Young Stellar Clusters. I. Subclusters*, ApJ, 787, 107
11. **Kuhn, M. A.**, Povich, M. S., Luhman, K. L., et al. 2013, *The Massive Young Star-Forming Complex Study in Infrared and X-Ray: Mid-infrared Observations and Catalogs*, ApJS, 209, 29
12. **Kuhn, M. A.**, Getman, K. V., Broos, P. S., Townsley, L. K., & Feigelson, E. D. 2013, *The Massive Young Star-forming Complex Study in Infrared and X-Ray: X-Ray Sources in 10 Star-forming Regions*, ApJS, 209, 27
13. **Kuhn, M. A.**, Getman, K. V., Feigelson, E. D., et al. 2010, *A Chandra Observation of the Obscured Star-forming Complex W40*, ApJ, 725, 2485

Other peer-reviewed papers

1. Cao, L., Pinsonneault, M. H., Hillenbrand, L. H., **Kuhn, M. A.** 2020, *Age Spreads and Systematics in λ Orionis with Gaia DR2 and the SPOTS Tracks*, ApJ, in press
2. Getman, K. V., Feigelson, E. D., **Kuhn, M. A.**, Broos, P. S., Garmire, G. P. 2019, *IRAS 09002-4732: A Laboratory for the Formation of Rich Stellar Clusters*, AJ, 158, 235
3. Getman, K. V., Feigelson, E. D., **Kuhn, M. A.**, Garmire, G. P. 2019, *Gaia Stellar Kinematics in the Head of the Orion A Cloud: Runaway Stellar Groups and Gravitational Infall*, MNRAS, 487, 2977
4. Herczeg, G. J., **Kuhn, M. A.**, Zhou, X., et al. 2019, *An initial overview of the extent and structure of recent star formation within the Serpens Molecular Cloud using Gaia Data Release 2*, ApJ, 878, 111
5. Graham, M. J., Kulkarni, S. R., Bellm, E. C., et al. 2019, *The Zwicky Transient Facility: Science Objectives*, PASP, 131, 078001
6. Borissova, J., Roman-Lopes, A., Covey, K., et al. 2019, *The G305 Star-forming Region. I. Newly Classified Hot Stars*, AJ, 158, 46
7. Hillenbrand, L. H., Contreras Peña, C., Morrell, S., et al. 2018, *Gaia 17bpi: An FU Ori-type Outburst*, ApJ, 869, 146
8. Borissova, J., Ivanov, V. D., Lucas, P. W., et al. 2018, *New Galactic star clusters discovered in the disc area of the VVVX survey*, MNRAS, 481, 3902
9. Medina, N., Borissova, J., Bayo, A., et al. 2018, *An Automated Tool to Detect Variable Sources in the Vista Variables in the Vía Láctea Survey*, ApJ, 864, 11
10. Richert, A. J. W., Getman, K. V., Feigelson, E. D., et al. 2018, *Circumstellar disc lifetimes in numerous galactic young stellar clusters*, MNRAS, 477, 5191
11. Getman, K. V., **Kuhn, M. A.**, Feigelson, E. D. 2018, *Young star clusters in nearby molecular clouds*, MNRAS, 477, 298
12. Getman, K. V., Feigelson, E. D., **Kuhn, M. A.** 2018, *Intracluster age gradients in numerous young stellar clusters*, MNRAS, 476, 1213
13. Smith, L. C., Lucas, P. W., Kurtev, R. 2017, et al. 2018, *VIRAC: The VVV Infrared Astrometric Catalogue*, Monthly Notices of the RAS, 474, 1826
14. Duronea, N. U., Cappa, C. E., Bronfman, L., et al. 2017, *Triggered massive star formation*

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- associated with the bubble Hii region Sh2-39 (N5), *Astronomy and Astrophysics*, 606, A8
15. Getman, K. V., Broos, P. S., **Kuhn, M. A.**, et al. 2017, *Star Formation In Nearby Clouds (SFINC)s: X-Ray and Infrared Source Catalogs and Membership*, *Astrophysical Journal, Supplement*, 229, 28
 16. Povich, M. S., Busk, H. A., Feigelson, E. D., Townsley, L. K., & **Kuhn, M. A.** 2017, *Candidate X-Ray-emitting OB Stars in MYStIX Massive Star-forming Regions*, *Astrophysical Journal*, 838, 61
 17. Kurtev, R., Gromadzki, M., Beamín, J. C., et al. 2017, *VVV high proper motion stars - I. The catalogue of bright $K_S \leq 13.5$ stars*, *Monthly Notices of the RAS*, 464, 1247
 18. Romine, G., Feigelson, E. D., Getman, K. V., **Kuhn, M. A.**, & Povich, M. S. 2016, *Young Stellar Populations in MYStIX Star-forming Regions: Candidate Protostars*, *Astrophysical Journal*, 833, 193
 19. Carballo-Bello, J. A., Ramírez Alegría, S., Borissova, J., et al. 2016, *Near-infrared photometry and spectroscopy of the low Galactic latitude globular cluster 2MASS-GC 03*, *Monthly Notices of the RAS*, 462, 501
 20. Borissova, J., Ramírez Alegría, S., Alonso, J., et al. 2016, *Young Stellar Clusters Containing Massive Young Stellar Objects in the VVV Survey*, *Astronomical Journal*, 152, 74
 21. Ramírez Alegría, S., Borissova, J., Chené, A.-N., et al. 2016, *Massive open star clusters using the VVV survey. V. Young clusters with an OB stellar population*, *Astronomy and Astrophysics*, 588, A40
 22. Pfalzner, S., Kirk, H., Sills, A., et al. 2016, *Observational constraints on star cluster formation theory. I. The mass-radius relation*, *Astronomy and Astrophysics*, 586, A68
 23. Chené, A.-N., Ramírez Alegría, S., Borissova, J., et al. 2015, *Massive open star clusters using the VVV survey. IV. WR 62-2, a new very massive star in the core of the VVV CL041 cluster*, *Astronomy and Astrophysics*, 584, A31
 24. Richert, A. J. W., Feigelson, E. D., Getman, K. V., & **Kuhn, M. A.** 2015, *No Evidence for Protoplanetary Disk Destruction By OB Stars in the MYStIX Sample*, *Astrophysical Journal*, 811, 10
 25. Townsley, L. K., Broos, P. S., Garmire, G. P., et al. 2014, *The Massive Star-Forming Regions Omnibus X-Ray Catalog*, *Astrophysical Journal, Supplement*, 213, 1
 26. Getman, K. V., Feigelson, E. D., & **Kuhn, M. A.** 2014, *Core-Halo Age Gradients and Star Formation in the Orion Nebula and NGC 2024 Young Stellar Clusters*, *Astrophysical Journal*, 787, 109
 27. Getman, K. V., Feigelson, E. D., **Kuhn, M. A.**, et al. 2014, *Age Gradients in the Stellar Populations of Massive Star Forming Regions Based on a New Stellar Chronometer*, *Astrophysical Journal*, 787, 108
 28. Broos, P. S., Getman, K. V., Povich, M. S., et al. 2013, *Identifying Young Stars in Massive Star-forming Regions for the MYStIX Project*, *Astrophysical Journal, Supplement*, 209, 32
 29. Povich, M. S., **Kuhn, M. A.**, Getman, K. V., et al. 2013, *The MYStIX Infrared-Excess Source Catalog*, *Astrophysical Journal, Supplement*, 209, 31
 30. Feigelson, E. D., Townsley, L. K., Broos, P. S., et al. 2013, *Overview of the Massive Young Star-Forming Complex Study in Infrared and X-Ray (MYStIX) Project*, *Astrophysical Journal, Supplement*, 209, 26
 31. Getman, K. V., Feigelson, E. D., Sicilia-Aguilar, A., et al. 2012, *The Elephant Trunk Nebula and the Trumpler 37 cluster: contribution of triggered star formation to the total population of an H II region*, *Monthly Notices of the RAS*, 426, 2917
 32. Cohen, D. H., **Kuhn, M. A.**, Gagné, M., Jensen, E. L. N., & Miller, N. A. 2008, *Chandra*

spectroscopy of the hot star β Crucis and the discovery of a pre-main-sequence companion, Monthly Notices of the RAS, 386, 1855

■ Papers under review

1. Hillenbrand, L. A., Kiker, T. J., Gee, M., et al. 2021, *A ZTF Look at Optical Variability of Young Stellar Objects in the North America and Pelican Nebulae Complex*, submitted
2. Hillenbrand, L. A., Isaacson, H., Rodriguez, A. C., et al. 2020, *LkH α 225 (V1318 Cyg) South in Outburst*, submitted
3. Zhou, X. Herczeg, G., Fang, M., Liu, Y., **Kuhn, M. A.** 2021, *The Ages of Optically Bright Clusters in the Serpens Star-Forming Region*, submitted

■ Research Notes

1. **Kuhn, M. A.** & Hillenbrand, L. A. 2020, *Distance and Tangential Velocity of the Main Ionizing Star in the North America/Pelican Nebulae with Gaia EDR3*, RNAAS, 4, 224

■ Conference proceedings and white papers

1. Siemiginowska, A. et al. 2019, *The Next Decade of Astrominformatics and Astrostatistics*, Astro2020 Science White Paper, BAAS, 51, 355
2. **Kuhn, M. A.**, & MYStIX Collaboration 2017, *Mass Segregation in Star-Forming Regions on Multi-Spatial Scales*, Star Formation from Cores to Clusters, 32
3. **Kuhn, M. A.**, Baddeley, A. J., Feigelson, E. D., et al. 2014, *MYStIX First Results: Spatial Structures of Massive Young Stellar Clusters*, The Labyrinth of Star Formation, 36, 453