

Charles J. Law – Curriculum Vitae

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EDUCATION

Ph.D., Astronomy and Astrophysics Harvard University, Cambridge, MA Thesis: <i>Chemical Complexity at High Spatial Resolution during Star and Planet Formation</i> Advisor: Karin I. Öberg	2018 – Present
M.A., Astronomy and Astrophysics Harvard University, Cambridge, MA	May 2021
B.A., Physics and Astrophysics Secondary Concentration: Computer Science Magna Cum Laude with Highest Honors Harvard University, Cambridge, MA Thesis: <i>Carbon Chain Molecules Toward Embedded Low-Mass Protostars</i> Advisor: Karin I. Öberg	2013 – 2017

RESEARCH INTERESTS

I am broadly interested in exploring chemical complexity in space, with a particular focus on (sub)millimeter interferometry. I use high spatial resolution observations to understand the chemistry and physics of the star and planet formation process, including toward low-mass and embedded protostars, massive young stellar objects, and protoplanetary disks.

HONORS & AWARDS

Derek Bok Teaching Certificate, Harvard University	2021
Derek Bok Certificate of Excellence and Distinction in Teaching	Spring 2021
NSF Graduate Research Fellowship	2019 – Present
Smithsonian Astrophysical Observatory Research Fellowship	2017
Leo Goldberg Prize in Astronomy, Harvard University	2017
Thomas Temple Hoopes Prize, Harvard University	2017
Phi Beta Kappa, Harvard University	2017
Frederick Tarantino Memorial Scholarship Award, Universities Space Research Assoc.	2016
Harvard College PRISE Research Fellowship	2016
Detur Book Prize, Harvard University	2014
John Harvard Scholar, Harvard University	2014

PUBLICATIONS

Author of 32 publications (refereed or under review), including 8 as first author. A full listing of my publications can be found on [ADS](#).

First Author

1. **Law, C.J.**, Loomis, R. A., et al. (+33 coauthors). Molecules with ALMA at Planet-forming Scales (MAPS) III. Characteristics of Radial Chemical Substructures, *ApJS*, in press, [arXiv:2109.06210](https://arxiv.org/abs/2109.06210)

2. **Law, C.J.**, Teague, R., et al. (+33 coauthors). Molecules with ALMA at Planet-forming Scales (MAPS) IV. Emission Surfaces and Vertical Distribution of Molecules, *ApJS*, in press, [arXiv:2109.06217](#)
3. **Law, C. J.**, Zhang, Q., Öberg, K. I., Galván-Madrid, R., Keto, E., Liu, H., Ho, P. T. P. 2021, [Subarcsecond Imaging of the Complex Organic Chemistry in Massive Star-Forming Region G10.6-0.4](#), *ApJ*, 909, 214
4. **Law, C. J.**, Milisavljevic, D., et al. (+10 coauthors). 2020, [Three-dimensional Kinematic Reconstruction of the Optically-Emitting, High-Velocity, Oxygen-Rich Ejecta of Supernova Remnant N132D](#), *ApJ*, 894, 73
5. **Law, C. J.**, Zhang, Q., Ricci, L., Petitpas, G., M. J. Jiménez-Donaire, Ueda, J., Lu, X., Dunham, M. M. 2018, [Submillimeter Array Observations of Extended CO \(\$J = 2 - 1\$ \) Emission in Interacting Galaxy NGC 3627](#), *ApJ*, 865, 17
6. **Law, C. J.**, Öberg, K. I., Bergner, J. B., Graninger, D. 2018, [Carbon Chain Molecules Toward Embedded Low-Mass Protostars](#), *ApJ*, 863, 88
7. **Law, C. J.**, Ricci, L., Andrews, S. M., Wilner, D. J., Qi, C. 2017, [An SMA Continuum Survey of Circumstellar Disks in the Serpens Star-Forming Region](#), *AJ*, 154, 255
8. **Law, C. J.**, Milisavljevic, D., et al. (+9 coauthors). 2017, [TRES Survey of Variable Diffuse Interstellar Bands](#), *MNRAS*, 470, 2835

Second or Third Author

1. Teague, R., **Law, C. J.**, Jane Huang, Feilong Meng. disksurf: Extracting the 3D Structure of Protoplanetary Disks, submitted, *JOSS*
2. Zhang, K., Booth, A., **Law, C. J.**, et al. Molecules with ALMA at Planet-forming Scales (MAPS) V. CO Gas Distributions, *ApJS*, in press, [arXiv:2109.06233](#)
3. Guzmán, V. V., Bergner, J. B., **Law, C. J.**, et al. Molecules with ALMA at Planet-forming Scales (MAPS) VI. Distribution of the Small Organics HCN, C₂H, and H₂CO, *ApJS*, in press, [arXiv:2109.06391](#)

Other Co-Authored Publications

1. Sharda, P, et al. (incl. **Law, C. J.**). First extragalactic measurement of the turbulence driving parameter: ALMA observations of the star-forming region N159E in the Large Magellanic Cloud, submitted, [arXiv:2109.03983](#)
2. Anderson, A. R., et al. (incl. **Law, C. J.**). Protostellar and Protoplanetary Disk Masses in the Serpens-Aquila Region, under review
3. Martín Doménech, R., et al. (incl. **Law, C. J.**). Hot corino chemistry in the Class I binary source Ser-emb 11, in press, [arXiv:2109.11512](#)
4. Öberg K. I., et al. (incl. **Law, C. J.**). Molecules with ALMA at Planet-forming Scales (MAPS) I. Program Overview and Highlights, *ApJS*, in press, [arXiv:2109.06268](#)
5. Czekala, I., et al. (incl. **Law, C. J.**). Molecules with ALMA at Planet-forming Scales (MAPS) II. CLEAN Strategies for Synthesizing Images of Molecular Line Emission in Protoplanetary Disks, *ApJS*, in press, [arXiv:2109.06188](#)
6. Bosman, A. D., et al. (incl. **Law, C. J.**). Molecules with ALMA at Planet-forming Scales (MAPS) VII. Substellar O/H and C/H and Superstellar C/O in Planet-feeding Gas, *ApJS*, in press, [arXiv:2109.06221](#)
7. Alarcón, F., et al. (incl. **Law, C. J.**). Molecules with ALMA at Planet-forming Scales (MAPS) VIII. CO Gap in AS 209 – Gas Depletion or Chemical Processing?, *ApJS*, in press, [arXiv:2109.06263](#)
8. Ilee, J. D., et al. (incl. **Law, C. J.**). Molecules with ALMA at Planet-forming Scales (MAPS) IX. Distribution and Properties of the Large Organic Molecules HC₃N, CH₃CN, and c-C₃H₂, *ApJS*, in press, [arXiv:2109.06319](#)

9. Cataldi, G., et al. (incl. **Law, C. J.**). Molecules with ALMA at Planet-forming Scales (MAPS) X. Studying Deuteration at High Angular Resolution toward Protoplanetary Disks, *ApJS*, in press, [arXiv:2109.06462](#)
10. Bergner, J. B., Öberg, K. I., Guzmán, V. V., **Law, C. J.**, et al. Molecules with ALMA at Planet-forming Scales (MAPS) XI. CN and HCN as Tracers of Photochemistry in Disks, *ApJS*, in press, [arXiv:2109.06694](#)
11. Le Gal, R., et al. (incl. **Law, C. J.**). Molecules with ALMA at Planet-forming Scales (MAPS) XII. Inferring the C/O and S/H Ratios in Protoplanetary Disks with Sulfur Molecules, *ApJS*, in press, [arXiv:2109.06286](#)
12. Aikawa, Y., et al. (incl. **Law, C. J.**). Molecules with ALMA at Planet-forming Scales (MAPS) XIII. HCO⁺ and Disk Ionization Structure, *ApJS*, in press, [arXiv:2109.06419](#)
13. Sierra, A., Pérez, L. M., Zhang, K., **Law, C. J.**, et al. Molecules with ALMA at Planet-forming Scales (MAPS) XIV. Revealing Disk Substructures in Multiwavelength Continuum Emission, *ApJS*, in press, [arXiv:2109.06433](#)
14. Bosman, A. D., et al. (incl. **Law, C. J.**). Molecules with ALMA at Planet-forming Scales (MAPS) XV. Tracing Protoplanetary Disk Structure within 20 au, *ApJS*, in press, [arXiv:2109.06223](#)
15. Booth, A., et al. (incl. **Law, C. J.**). Molecules with ALMA at Planet-forming Scales (MAPS) XVI. Characterizing the Impact of the Molecular wind on the Evolution of the HD 163296 System, *ApJS*, in press, [arXiv:2109.06586](#)
16. Calahan, J., et al. (incl. **Law, C. J.**). Molecules with ALMA at Planet-forming Scales (MAPS) XVII. Determining the 2D Thermal Structure of the HD 163296 Disk, *ApJS*, in press, [arXiv:2109.06202](#)
17. Teague, R., et al. (incl. **Law, C. J.**). Molecules with ALMA at Planet-forming Scales (MAPS) XVIII. Kinematic Substructure in the Disks of HD 163296 and MWC 480, *ApJS*, in press, [arXiv:2109.06218](#)
18. Huang, J., et al. (incl. **Law, C. J.**). Molecules with ALMA at Planet-forming Scales (MAPS) XIX. Spiral Arms, a Tail, and Diffuse Structures Traced by CO around the GM Aur Disk, *ApJS*, in press, [arXiv:2109.06224](#)
19. Schwarz, K., et al. (incl. **Law, C. J.**). Molecules with ALMA at Planet-forming Scales (MAPS) XX. The Massive Disk Around GM Aurigae, *ApJS*, in press, [arXiv:2109.06228](#)
20. Sano, H., et al. (incl. **Law, C. J.**). 2020, [ALMA CO Observations of Gamma-Ray Supernova Remnant N132D in the Large Magellanic Cloud: Possible Evidence for Shocked Molecular Clouds Illuminated by Cosmic-Ray Protons](#), *ApJ*, 902, 53
21. Le Gal, R., et al. (incl. **Law, C. J.**). 2020, [A 3mm chemical exploration of small organics in Class I YSOs](#) *ApJ*, 898, 131

TALKS

I have given a total of 25 talks, including 5 **invited** talks and 5 *public* talks.

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| 1. Seminar, Exoplanet Pizza Lunch, CfA | September 2021 |
| 2. Contributed, Chemical processes in Solar-type star forming regions, Turin, Italy | September 2021 |
| 3. Invited , SSP Coffee Talk, CfA | July 2021 |
| 4. Contributed, Emerging Researchers in Exoplanet Science | May 2021 |
| 5. Invited , Origins Seminar, University of Arizona | May 2021 |
| 6. Contributed, Space Telescope, 2021 Spring Symposium | April 2021 |
| 7. Contributed, Five years after HL Tau: a new era in planet formation | December 2020 |
| 8. Contributed, Harvard-Heidelberg Star Formation Workshop | December 2020 |
| 9. Contributed, Astrochemical Frontiers | June 2020 |
| 10. <i>Public Talk</i> , North Shore Amateur Astronomy Club | June 2020 |

11. <i>Public Talk</i> , Gloucester Area Astronomy Club	May 2020
12. <i>Public Talk</i> , Beacon Hill Seminar	March 2020
13. Seminar, SMA Talk, CfA	February 2020
14. Contributed, New England Star Formation Meeting, UConn	January 2020
15. Contributed, 235 th AAS, Honolulu, HI	January 2020
16. <i>Public Talk</i> , Union County College/AAI, NJ	December 2019
17. Contributed, Science with the Submillimeter Array: Present and Future	October 2019
18. Contributed, ISMS, 74 th , Champaign-Urbana, IL	June 2019
19. Contributed, SNRs II, Chania, Crete, Greece	June 2019
20. Seminar, Exoplanet Pizza Lunch, CfA	May 2019
21. Invited , ALMA Community Day, MIT	April 2019
22. Invited , ALMA Community Day, CfA	April 2019
23. Seminar, High Energy Phenomena Seminar, CfA	February 2019
24. Invited , SMA Advisory Committee Meeting, CfA	July 2018
25. <i>Public Talk</i> , Gloucester Area Astronomy Club	September 2018

OBSERVING EXPERIENCE & PROPOSALS

PI of 7 programs and Co-I on an additional 30 programs for access to observing facilities such as the SMA, ALMA, VLA, 6.5m Magellan telescope, HST, Chandra, and JWST.

PI

1. Connecting scaling laws between exoplanets and young disks Submillimeter Array , 4 B-ranked Tracks	2020A+2021A
2. Jet-like, IR-bright Ejecta in O-rich LMC Supernova Remnant N132D Magellan Baade 6.5m , FIRE, 3 Nights	2021B
3. Jet-like, IR-bright Ejecta in O-rich LMC Supernova Remnant N132D Magellan Baade 6.5m , FIRE, 4 Nights	2020B
4. Searching for Ionized Accretion Flows around 0.1 pc Scale Clusters with O-Type Stars ALMA , 14.8 hours, C-ranked	Cycle 7
5. Jet-like, Si-rich ejecta in O-rich LMC Supernova Remnant N132D Magellan Baade 6.5m , FIRE, 3 Nights	2019B
6. Formation of O Stars by Accretion of Ionized Gas Very Large Array , 11 hours, A-ranked	2019A
7. Searching for Ionized Accretion Flows around 0.1 pc Scale Clusters with O-Type Stars Submillimeter Array , 8 B-ranked Tracks	2018B+2019A

Co-I

<i>Sub-mm/cm</i>	<i>Optical/IR</i>	<i>X-ray</i>
330.9 hours with ALMA	20.6 hours with JWST	50 ks with Chandra (HRC)
49.7 hours with IRAM 30m	3 orbits with HST	
56 hours with NOEMA	12 hours with VLT (Muse)	
13 tracks with SMA	10 nights with Lick/Shane 3m	
16.5 hours with VLA	5 hours with Gemini	
11.75 hours with GBT	1.5 nights with WIYN	
	0.5 nights with MMT	

Observing Experience:

SMA, 15 nights (2016 – 2018)
FIRE, Magellan Baade 6.5m, 2.5 nights (2019)
MMT, 1 night [*remote*] (2016)

Funding:

Harvard Data Science Initiative Research Fund, Regularized Maximum Likelihood Imaging: A New Method for Detecting Planets (**\$9,700**; Collaborator, PI: R. Teague)
NRAO Student Observing Support, VLA 2019A, 2019 (**\$33,601**; Advisor: Q. Zhang)
ALMA Student Observing Support, ALMA Cycle 4, 2016 (**\$9,000**; Advisor: Q. Zhang)

COLLABORATIONS

Molecules with ALMA at Planet-forming Scales (MAPS) 2018 – Present

PI: Karin I. Öberg; co-PIs: Yuri Aikawa, Edwin A. Bergin, Viviana V. Guzmán, Catherine Walsh

ALMA Cycle 6 Large Program to comprehensive survey the chemistry of five protoplanetary disks at high spatial resolution (~15 au)

N132D Chandra Legacy Team 2019 – Present

PI: Paul P. Plucinsky

Chandra Cycle 20 Large Program to obtain legacy observations of N132D at unprecedented depth/integration time (900 ks)

TEACHING

Teaching Fellow, Harvard University

Interstellar Medium and Star Formation (ASTRON 203). Spring 2021

Stellar and Planetary Astronomy (ASTRON 16). Spring 2020

Physics I (Lab): Mechanics, Elasticity, Fluids, and Diffusion (PHYS E-1axl). Fall 2017

Teaching Fellow, Harvard Summer School, Pre-College Program

Introduction to Scientific Programming in Python (CSCI P-14320). Summer 2019, 2020

Co-Instructor, Harvard Summer School, Pre-College Program

Introduction to Scientific Programming in Python (CSCI P-14320). Summer 2021

Instructor, Python Workshop, [SAO Latino Initiative Program](#)

Scientific Computing with SciPy Aug. 16, 2021

OUTREACH

Course Coordinator, Beacon Hill Seminar, [Unveiling the Cosmos](#) Spring 2021, Fall 2021

Contributing Author, [Astrobites](#) Jan 2019 – Present

AAS Astronomy Ambassador Jan 2019 – Present

Volunteer, CfA Observatory Night Fall 2017 – Present

Astronomy Advisor, Harvard Undergraduate Science Olympiad 2018 – 2020

Presenter, Flipped Science Fair, John F. Kennedy School June 2018, May 2019

Speaker, [Science Research Mentoring Program](#), Cambridge Rindge and Latin School Mar 2018

Seminar Leader, Harvard Summit for Young Leaders in China Aug 2017

SERVICE

Referee, A&A, A&A Letters, ApJ, ApJS	2018 – Present
Junior Member, American Astronomical Society	2017 – Present
Co-Organizer, CfA Star Formation Journal Club Series	Fall 2021 – Present
Member, CfA APS-IDEA, Accessibility & Sustainability Subcommittees	2021 – Present
Peer Mentor, Harvard Astronomy Department	2021 – Present
Co-Organizer, Grad School Visitation Days	Spring 2020
Co-Organizer, Student-Faculty Lunch Series	Spring 2020
Treasurer & Founding Member, Harvard Astrophysical Society	Nov 2015 – May 2017

MENTORING

Sage Crystian, Harvard Undergraduate Summer 2021 – Present

(co-advised with K. Öberg)

Summer research project mapping vertical gas structures in protoplanetary disks using ALMA data

Prabidhik KC, Harvard Undergraduate Spring 2020 – Present

(co-advised with Q. Zhang)

Independent research project on the chemistry of MYSOs and UC HII regions using SMA data

Devin Sullivan, Harvard Undergraduate Fall 2019

(co-advised with K. Öberg)

[Junior Thesis](#) (AY98) on the distribution of HCN gas in protoplanetary disks using ALMA data