Charles J. Law – Curriculum Vitae

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EDUCATION

Ph.D., Astronomy and Astrophysics 2018 – Present
Harvard University, Cambridge, MA
Thesis: *Chemical Complexity at High Spatial Resolution during Star and Planet Formation*
Advisor: Karin I. Öberg

M.A., Astronomy and Astrophysics May 2021
Harvard University, Cambridge, MA

B.A., Physics and Astrophysics 2013 – 2017
Secondary Concentration: Computer Science
Magna Cum Laude with Highest Honors
Harvard University, Cambridge, MA
Thesis: *Carbon Chain Molecules Toward Embedded Low-Mass Protostars*
Advisor: Karin I. Öberg

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 study the chemistry and physics of star and planet formation, including toward low-mass 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., Teague, R., et al., 2021. ApJS, in press, arXiv:2109.06210
   MAPS III. Characteristics of Radial Chemical Substructures
2. **Law, C. J.**, Teague, R., Loomis, R. A., et al., 2021. ApJS, in press, arXiv:2109.06217

MAPS IV. Emission Surfaces and Vertical Distribution of Molecules

3. **Law, C. J.**, Zhang, Q., Öberg, K. I., et al., 2021. ApJ, 909, 214
   Subarcsecond Imaging of the Complex Organic Chemistry in Massive Star-Forming Region G10.6-0.4
4. **Law, C. J.**, Milisavljevic, D., Patnaude, D. J., et al., 2020. ApJ, 894, 73
   Three-dimensional Kinematic Reconstruction of the Optically-Emitting, High-Velocity, Oxygen-Rich Ejecta of Supernova Remnant N132D
5. **Law, C. J.**, Zhang, Q., Ricci, L., et al., 2018. ApJ, 865, 17
   Submillimeter Array Observations of Extended CO (J = 2 – 1) Emission in Interacting Galaxy NGC 3627
6. **Law, C. J.**, Öberg, K. I., Bergner, J. B., et al., 2018. ApJ, 863, 88
   Carbon Chain Molecules Toward Embedded Low-Mass Protostars
7. **Law, C. J.**, Ricci, L., Andrews, S. M., et al., 2017. AJ, 154, 255
   An SMA Continuum Survey of Circumstellar Disks in the Serpens Star-Forming Region,
8. **Law, C. J.**, Milisavljevic, D., Crabtree, K. N., et al. 2017. MNRAS, 470, 2835
   TRES Survey of Variable Diffuse Interstellar Bands

Second or Third Author

1. Teague, R., **Law, C. J.**, Huang, J., et al., 2021. JOSS, under review
   disksurf: Extracting the 3D Structure of Protoplanetary Disks
2. Zhang, K., Booth, A., **Law, C. J.**, et al., 2021. ApJS, in press, arXiv:2109.06233
   MAPS V. CO Gas Distributions
3. Guzmán, V. V., Bergner, J. B., **Law, C. J.**, et al., 2021. ApJS, in press, arXiv:2109.06391
   MAPS VI. Distribution of the Small Organics HCN, C_2H, and H_2CO

Other Co-Authored Publications

1. Anderson, A. R., et al. (incl. **Law, C. J.**), 2021. ApJ, under review
   Protostellar and Protoplanetary Disk Masses in the Serpens-Aquila Region
2. Sharda, P, et al. (incl. **Law, C. J.**), 2021. MNRAS, in press, arXiv:2109.03983
   First extragalactic measurement of the turbulence driving parameter: ALMA observations of the star-forming region N159E in the Large Magellanic Cloud
3. Martín Doménech, R., et al. (incl. **Law, C. J.**), 2021. ApJ, in press, arXiv:2109.11512
   Hot corino chemistry in the Class I binary source Ser-emb 11
4. Öberg, K. I., et al. (incl. **Law, C. J.**), 2021. ApJS, in press, arXiv:2109.06268
   MAPS I. Program Overview and Highlights
5. Czekala, I., et al. (incl. **Law, C. J.**), 2021. ApJS, in press, arXiv:2109.06188
   MAPS II. CLEAN Strategies for Synthesizing Images of Molecular Line Emission in Protoplanetary Disks
6. Bosman, A. D., et al. (incl. **Law, C. J.**), 2021. ApJS, in press, arXiv:2109.06221
   MAPS VII. Substellar O/H and C/H and Superstellar C/O in Planet-feeding Gas
7. Alarcón, F., et al. (incl. **Law, C. J.**), 2021. ApJS, in press, arXiv:2109.06263
   Molecules with ALMA at Planet-forming Scales (MAPS) VIII. CO Gap in AS 209 – Gas Depletion or Chemical Processing?
8. Ilee, J. D., et al. (incl. **Law, C. J.**), 2021. ApJS, in press, arXiv:2109.06319
   MAPS IX. Distribution and Properties of the Large Organic Molecules HC_3N, CH_3CN, and c-C_3H_2
9. Cataldi, G., et al. (incl. **Law, C. J.**), 2021. ApJS, in press, arXiv:2109.06462
   MAPS X. Studying Deuteration at High Angular Resolution toward Protoplanetary Disks
10. Bergner, J. B., et al. (incl. **Law, C. J.**), 2021. ApJS, in press, arXiv:2109.06694
    MAPS XI. CN and HCN as Tracers of Photochemistry in Disks
11. Le Gal, R., et al. (incl. **Law, C. J.**), 2021. ApJS, in press, arXiv:2109.06286
    MAPS XII. Inferring the C/O and S/H Ratios in Protoplanetary Disks with Sulfur Molecules

12. Aikawa, Y., et al. (incl. **Law, C. J.**), 2021. ApJS, in press, arXiv:2109.06419
    MAPS XIII. HCO^+ and Disk Ionization Structure
13. Sierra, A., et al. (incl. **Law, C. J.**), 2021. ApJS, in press, arXiv:2109.06433
    MAPS XIV. Revealing Disk Substructures in Multiwavelength Continuum Emission
14. Bosman, A. D., et al. (incl. **Law, C. J.**), 2021. ApJS, in press, arXiv:2109.06223
    MAPS XV. Tracing Protoplanetary Disk Structure within 20 au
15. Booth, A., et al. (incl. **Law, C. J.**), 2021. ApJS, in press, arXiv:2109.06586
    MAPS XVI. Characterizing the Impact of the Molecular Wind on the Evolution of the HD 163296 System
16. Calahan, J., et al. (incl. **Law, C. J.**), 2021. ApJS, in press, arXiv:2109.06202
    MAPS XVII. Determining the 2D Thermal Structure of the HD 163296 Disk
17. Teague, R., et al. (incl. **Law, C. J.**), 2021. ApJS, in press, arXiv:2109.06218
    MAPS XVIII. Kinematic Substructure in the Disks of HD 163296 and MWC 480
18. Huang, J., et al. (incl. **Law, C. J.**), 2021. ApJS, in press, arXiv:2109.06224
    MAPS XIX. Spiral Arms, a Tail, and Diffuse Structures Traced by CO around the GM Aur Disk
19. Schwarz, K., et al. (incl. **Law, C. J.**), 2021. ApJS, in press, arXiv:2109.06228
    MAPS XX. The Massive Disk Around GM Aurigae
20. Sano, H., et al. (incl. **Law, C. J.**), 2020. ApJ, 902, 53
    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
21. Le Gal, R., et al. (incl. **Law, C. J.**), 2020. ApJ, 898, 131
    A 3mm chemical exploration of small organics in Class I YSOs

TALKS

I have given a total of 27 talks, including 6 **invited** talks and 6 *public* talks.

1.	**Invited**, Leiden Astrochemistry Seminar	October 2021
2.	*Public Talk*, Beacon Hill Seminar	October 2021
3.	Seminar, Exoplanet Pizza Lunch, CfA	September 2021
4.	Contributed, Chemical processes in Solar-type star forming regions, Turin, Italy	September 2021
5.	**Invited**, SSP Coffee Talk, CfA	July 2021
6.	Contributed, Emerging Researchers in Exoplanet Science	May 2021
7.	**Invited**, Origins Seminar, University of Arizona	May 2021
8.	Contributed, Space Telescope, 2021 Spring Symposium	April 2021
9.	Contributed, Five years after HL Tau: a new era in planet formation	December 2020
10.	Contributed, Harvard-Heidelberg Star Formation Workshop	December 2020
11.	Contributed, Astrochemical Frontiers	June 2020
12.	*Public Talk*, North Shore Amateur Astronomy Club	June 2020
13.	*Public Talk*, Gloucester Area Astronomy Club	May 2020
14.	*Public Talk*, Beacon Hill Seminar	March 2020
15.	Seminar, SMA Talk, CfA	February 2020
16.	Contributed, New England Star Formation Meeting, UConn	January 2020
17.	Contributed, 235th AAS, Honolulu, HI	January 2020
18.	*Public Talk*, Union County College/AAI, NJ	December 2019
19.	Contributed, Science with the Submillimeter Array: Present and Future	October 2019
20.	Contributed, ISMS, 74th, Champaign-Urbana, IL	June 2019
21.	Contributed, SNRs II, Chania, Crete, Greece	June 2019

22. Seminar, Exoplanet Pizza Lunch, CfA — May 2019
23. **Invited**, ALMA Community Day, MIT — April 2019
24. **Invited**, ALMA Community Day, CfA — April 2019
25. Seminar, High Energy Phenomena Seminar, CfA — February 2019
26. **Invited**, SMA Advisory Committee Meeting, CfA — July 2018
27. *Public Talk*, Gloucester Area Astronomy Club — September 2018

TELESCOPE OBSERVING & PROPOSALS

PI of 7 programs and Co-I on an additional 31 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

Sub-mm/cm
330.9 hours with **ALMA**
49.7 hours with **IRAM 30m**
56 hours with **NOEMA**
20 tracks with **SMA**
16.5 hours with **VLA**
11.75 hours with **GBT**

Optical/IR
20.6 hours with **JWST**
3 orbits with **HST**
12 hours with **VLT** (Muse)
10 nights with **Lick/Shane 3m**
5 hours with **Gemini**
1.5 nights with **WIYN**
0.5 nights with **MMT**

X-ray
50 ks with **Chandra** (HRC)

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)

MAJOR 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 comprehensively 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 and 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 Public 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
Subject Matter Expert, NASA JWST Community Events 2021 – 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 College 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