Curriculum Vitae of

Patrick D. Sheehan

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EDUCATION

University of Arizona, Tucson, Arizona 2017
Ph.D., Astronomy and Astrophysics
"Signposts of Planet Formation in the Early Stages of Star Formation"
M.S., Astronomy and Astrophysics
Advisor: Josh A. Eisner

University of Rochester, Rochester, New York 2011
B.S., Physics and Astronomy
B.A., Mathematics
Graduated *Summa Cum Laude* and with Highest Distinction

EMPLOYMENT

NSF Astronomy & Astrophysics Postdoctoral Fellow 2020 - present
Center for Interdisciplinary Exploration and Research in Astronomy (CIERA)
Northwestern University

CIERA Postdoctoral Fellow 2019 - 2020
Center for Interdisciplinary Exploration and Research in Astronomy (CIERA)
Northwestern University

Postdoctoral Scholar 2017 - 2019
National Radio Astronomy Observatory, Charlottesville (2018 - 2019)
Department of Physics and Astronomy, University of Oklahoma (2017 - 2018)
Supervisor: John J. Tobin

Research Assistant 2011 - 2017
NSF Graduate Research Fellow (2012 - 2015)
Department of Astronomy, University of Arizona
Advisor: Josh A. Eisner

HONORS & AWARDS

NSF AAPF Postdoctoral Fellowship, National Science Foundation 2020 - 2023

ALMA Ambassador, North American ALMA Science Center 2018

Service Award, Department of Astronomy, University of Arizona 2015

NSF Graduate Research Fellowship, National Science Foundation 2012 - 2015

Stoddard Senior Thesis Prize, Department of Physics & Astronomy, University of Rochester 2011

Fulbright Prize, Department of Physics & Astronomy, University of Rochester 2011

Phi Beta Kappa, Iota Chapter of New York 2011

Goldwater Scholarship, Barry M. Goldwater Scholarship and Excellence in Education Foundation 2009

PRINCIPAL INVESTIGATOR OBSERVING/COMPUTING PROPOSALS

Atacama Large Millimeter Array

- *"A Complete Survey of Protostellar Disk Gas and Dust Structure in Taurus"*
  Cycle 7 (20.9 hours - 12m Array; 41.3 hours Morita Array)
- *"Direct Mass Measurements of Pre-Main Sequence Stars in Upper Sco"*
  Cycle 7 (16.3 hours)
- *"What is Carving the Gaps in Young, Embedded Disks?"*
  Cycle 7 (13.5 hours)
- *"An ALMA/JCMT Study of the Time-Variable Class 0 Protostar HOPS 358 and Its (Warped?) Protostellar Disk"*
  Cycle 7 (2.5 hours)
- *"Disk Masses and Dust Grain Growth in Class I Protostars in Ophiuchus"*
  Cycle 3 (3.2 hours), Cycle 4 (1.2 hours)
- *"Resolving Structure in the Planet Forming Regions of the Compact Binary Protostar GV Tau"*
  Cycle 4 (1.7 hours)

Karl G. Jansky Very Large Array

- *"Constraints on Embedded Disk Structures and Masses"*
  2018B (9 hours), 2019A (18 hours)
- *"Characterizing the Radio Variability of Protoplanetary Disks in the ONC"*
  2016B (20 hours)

Combined Array for Research in Millimeter-wave Astronomy

- *"Measuring Envelope and Disk Masses Around Class I Protostars"*
  2012A (24 hours), 2012B (31.5 hours), 2013A (12 hours), 2014A (16 hours), 2014B (32 hours)

National Science Foundation XSEDE

- *"Constraints on the Structure of Embedded Protostellar Disks with Detailed Radiative Transfer Modeling"*
  2018 Q4 (Bridges - 3.6M SUs; Comet - 1.7M SUs)
  Startup Allocation (Bridges - 50k SUs; Comet - 50k SUs; Stampede2 1600 SUs),

PRINCIPAL INVESTIGATOR GRANTS

National Radio Astronomy Observatory 2019 - 2020
(Science PI) Student Observing Support, for Ms. Elizabeth Teng - $10,000
"Surrogate Modeling of Protoplanetary Disk Radiative Transfer Models"

National Radio Astronomy Observatory 2018
ALMA Ambassador Grant - $10,000

SCIENTIFIC COLLABORATION LEADERSHIP ROLES

Early Planet Formation In Disks (eDisks Team) 2019 - present
ALMA Large Program: 2019.1.00261.L
Core Team/Steering Committee member

PUBLICATIONS

6 first authored; 6 second authored; 27 total; 2 white papers (1 first authored); See below under "Publication List"

COMPUTER EXPERIENCE

OPEN SOURCE SOFTWARE

pdspy A MCMC Tool for Continuum and Spectral Line Radiative Transfer Modeling
GitHub: https://github.com/psheehan/pdspy
Zenodo: https://doi.org/10.5281/zenodo.2455079

mcrt3d Monte Carlo Dust Radiative Transfer in 3D
GitHub: https://github.com/psheehan/mcrt3d
(Under development and testing)

COMPUTER SKILLS

Python, Numpy, Scipy, Cython, C/C++, Fortran, IDL, OpenMP, Git
SLURM, Cluster computing
RADMC-3D and Hyperion Dust Radiative Transfer Codes
CASA Data Reduction Package

INVITED*/CONTRIBUTED TALKS

2019 *ALMA Workshop 2019: *Our Current Picture of Substructures in Protostellar Disks*

2019 Great Barriers in Planet Formation: *The Structures of Embedded Disks with ALMA*

2019 *NRAO Postdoc Symposium: *The Structures of Embedded Disks with ALMA/the VLA*

2019 *NRAO TUNA Lunch: *Know Thy Star Mass, Know thy Disk Mass, Know Thy Planet: Protoplanetary Disk and Stellar Mass Measurements with ALMA*

2018 *CIERA Theory Group: *Radio Observations of Disks, From Protostars to Protoplanets*

2018 Stars: From Birth to Death: *Constraints on Embedded Disk Structures and Masses as Seen by CARMA and ALMA*

2018 COSPAR Assembly: *Constraints on Embedded Disk Structures and Masses as Seen by CARMA and ALMA*

2018 Astrophysical Frontiers of the Next Decade and Beyond: *Constraints on the Structure of Embedded Disks with ALMA/the VLA: Setting the Stage for the ngVLA*

2018 Olympian Symposium: *Constraints on Embedded Disk Structures and Masses as*

Seen by CARMA and ALMA

2018 The Early Phase of Star Formation: *Constraints on Embedded Disk Structures and Masses as Seen by CARMA and ALMA*

2018 *CASA/JILA Friday Lunch Seminar: *Radio Observations of Disks, From Protostars to Protoplanets*

2017 *Leiden Embedded Disks Workshop: *Physical Structure of Class I Disks: Constraints on Disk Masses During the Embedded Phase*

2015 Star and Planet Formation in the Southwest 1: *Gauging the Potential for Planet Formation in Protoplanetary Disks*

2013 CARMA Symposium: *Measuring the Disk Masses of Class I Protostars*

2010 National Conference on Undergraduate Research: *Rainfall onto the Protostellar Disk of IRAS 13036*

STUDENTS SUPERVISED

Elizabeth Teng, NRAO REU Program and Senior Thesis (with Dr. Ryan Loomis) 2019 - 2020
Project: *"Surrogate Modeling of Protoplanetary Disk SEDs"*
Currently: Senior, Haverford College

TEACHING/OUTREACH

Program Director, CIERA High School Summer Research Program 2019 - present
Center for Interdisciplinary Exploration and Research in Astronomy
- Organized programming for 6-week summer program for high school students to be involved in CIERA research

Counselor, Astronomy Camp 2012 - present
Adult, Advanced, Beginner and Girl Scout Leader Educational Camps
- Led Advanced Teen Camp Bok 90" Spectroscopy, leading to astronomical telegrams on the classification of 5 supernovae
- Advised Camper Aliza Beverage for her IB Extended Essay project *"Hubble's Constant: A Spectrographic Study to Experimentally Determine the Rate of the Expansion of the Universe."*

Teaching Assistant 2015 - 2016
University of Arizona, Department of Astronomy
Astronomy 170B1: The Physical Universe (Fall 2015, Spring 2016)

Kepler Undergraduate Student Research Project 2012 - 2014
Project Leader (Fall 2013 - Spring 2014)
Graduate Student Advisor (Fall 2012 - Spring 2013)
University of Arizona Undergraduate Astronomy Club
Instructor for Astronomy 492: Directed Research (Fall 2013, Spring 2014)

OBSERVING EXPERIENCE

ALMA Scheduling Blocks

VLA Scheduling Blocks
CARMA Scheduling Blocks, on-site operations
University of Arizona, Kuiper 90" (Bok B&C Spectrograph)
University of Arizona, Kuiper 61" (Mont4K)
Apache Point Observatory, 3.5-meter (TripleSpec)

PROFESSIONAL/DEPARTMENTAL SERVICE

Referee for ApJ, A&A 2018 - present

ALMA Ambassador, North American ALMA Science Center 2018

PUBLICATION LIST

SIGNIFICANT CONTRIBUTIONS (*FIRST AUTHORED)

2020 *ALMA 0.8mm Survey of Disks Around Planetary-mass Companions*, Y. Wu, B. P. Bowler, **P. D. Sheehan**, S. M. Andrews, G. J. Herczeg, M. J. Ireland, A. L. Kraus, L. Ricci, D. J. Wilner, and Z. Zhu, ApJ, submitted.

2020 *The VLA/ALMA Nascent Disk and Multiplicity (VANDAM) Survey of Orion Protostars. A Statistical Characterization of Class 0 and I Protostellar Disks*, J. J. Tobin, **P. Sheehan**, S. T. Megeath, A. K. Diaz-Rodriguez, S. S. R. Offner, N. M. Murillo, M. van 't Hoff, E. F. van Dishoeck, M. Osorio, G. Anglada, E. Furlan, A. M. Stutz, N. Reynolds, N. Karnath, W. J. Fischer, M. Persson, L. W. Looney, Z. Li, I. Stephens, C. J. Chandler, E. Cox, J. Di Francesco, M. M. Dunham, L. Tychoniec, M. Kama, K. Kratter, M. Kounkel, B. Mazur, L. Maud, L. Patel, L. Perez, S. I. Sadavoy, D. Segura-Cox, R. Sharma, B. Stephenson, D. M. Watson, and F Wyrowski, ApJ, accepted.

2019 **High Precision Dynamical Masses of Pre-Main Sequence Stars with ALMA and Gaia* **P. D. Sheehan**, Y. Wu, J. A. Eisner, and J. J. Tobin, ApJ, 874, 136.

2018 *Exploring Protostellar Disk Formation with the ngVLA*, J. J. Tobin, **P. Sheehan** and D. Johnstone, Science With A Next-Generation Very Large Array, 189.

2018 *New Frontiers in Protostellar Multiplicity with the ngVLA*, J. J. Tobin, **P. Sheehan** and D. Johnstone, Science With A Next-Generation Very Large Array, 177.

2018 **Multiple Gaps in the Disk of the Class I Protostar GY 91*, **P. D. Sheehan** and J. A. Eisner, ApJ, 857, 18

2018 *The Orbit of the Companion to HD 100453A: Binary-driven Spiral Arms in a Protoplanetary Disk*, K. Wagner, R. Dong, **P. Sheehan**, D. Apai, M. Kasper, M. McClure, K. M. Morzinski, L. Close, J. Males, P. Hinz, S. P. Quanz, J. Fung, ApJ, 854, 130

2017 **Disk Masses for Embedded Class I Protostars in the Taurus Molecular Cloud*, **P. D. Sheehan** and J. A. Eisner, ApJ, 851, 45.

2017 *An ALMA Dynamical Mass Estimate of the Proposed Planetary Mass Companion FW Tau C*, Y. Wu and **P. D. Sheehan**, ApJL, 854, L26.

2017 **WL 17: A Young Embedded Transition Disk*, **P. D. Sheehan** and J. A. Eisner, ApJL, 840, 12.

2017 *An ALMA and MagAO Study of the Substellar Companion GQ Lup B: Constraints on the Accretion Disk Mass and Orbital Properties*, Y. Wu, **P. D. Sheehan**, J. R. Males, L. M. Close, K. M. Morzinski, J. K. Teske, A. Haug-Baltzell, N. Merchant, and E. Lyons, ApJ, 836, 223.

2016 **A VLA Survey For Faint Compact Radio Sources in the Orion Nebula Cluster*, **P. D. Sheehan**, J. A. Eisner, R. K. Mann, and J. Williams, ApJ, 831, 155.

2014 **Constraining the Disk Masses of the Class I Binary Protostar GV Tau*, **P. D. Sheehan** and J. A. Eisner, ApJ, 791, 19S.

SECONDARY CONTRIBUTIONS

2020 *Detection of Irregular, Sub-mm Opaque Structures in the Orion Molecular Clouds: Protostars within 10000 years of formation?*, N. Karnath, S. T. Megeath, J. Tobin, A. Stutz, Z.-Y. Li, **P. Sheehan**, S. Sadavoy, I. Stephens, M. Osorio, G. Anglada, A. Diaz-Rodriguez, E. Cox, ApJ, accepted.

2019 *The VLA/ALMA Nascent Disk and Multiplicity (VANDAM) Survey of Orion Protostars. I. Identifying and Characterizing the Protostellar Content of the OMC-2 FIR4 and OMC-2 FIR3 Regions*, J. J. Tobin, S. T. Megeath, M. van't Hoff, A. K., Diaz-Rodriguez, N. Reynolds, M. Osorio, G. Anglada, E. Furlan, N. Karnath, S. S. R. Offner, **P. D. Sheehan**, S. I. Sadavoy, A. M. Stutz, W. J. Fischer, M. Kama, M. Persson, J. Di Francesco, L. W. Looney, D. M. Watson, Z. Y. Li, I. Stephens, C. J. Chandler, E. Cox, M. M. Dunham, K. Kratter, M. Kounkel, B. Mazur, N. M. Murillo, L. Patel, L. Perez, D. Segura-Cox, R. Sharma, L. Tychoniec, and F. Wyrowski, ApJ, 886, 6.

2019 *New Spatially Resolved Imaging of the SR 21 Transition Disk and Constraints on the Small-Grain Disk Geometry*, S. Sallum, A.J. Skemer, J.A. Eisner, N. van der Marel, **P. D. Sheehan**, L.M. Close, M.J. Ireland, J.M. Males, K.M. Morzinski, V.P. Bailey, R. Briguglio, and A. Puglisi, ApJ, 883, 100.

2018 *Methanol and Its Relation to the Water Snowline in the Disk around the Young Outbursting Star V883 Ori*, M. L. R. van 't Hoff, J. J. Tobin, L. Trapman, D. Harsono, **P. D. Sheehan**, W. J. Fischer, S. T. Megeath, and E. F. van Dishoeck, ApJL, 864, 23.

2018 *Protoplanetary Disk Properties in the Orion Nebula Cluster: Initial Results from Deep, High-resolution ALMA Observations*, J. A. Eisner, H. G. Arce, N. P. Ballering, J. Bally, S. M. Andrews, R. D. Boyden, J. Di Francesco, M. Fang, D. Johnstone, J. S. Kim, R. K. Mann, B. Matthews, I. Pascucci, L. Ricci, **P. D. Sheehan**, and J. P. Williams, ApJ, 860, 77

2017 *An Explanation of the Very Low Radio Flux of Young Planet-mass Companions*, Y. Wu, L. M. Close, J. A. Eisner, and **P. D. Sheehan**, AJ, 154, 234.

2017 *Improved Constraints on the Disk Around MWC 349A from the 23-Meter LBTI*, S. Sallum, J. Eisner, P. Hinz, **P. Sheehan**, A. Skemer, P. Tuthill, and J. Young, ApJ, 844, 22.

2016 *Evolution of Mass Outflow in Protostars*, D. M. Watson, N. P. Calvet, W. J. Fischer, W. J. Forrest, P. Manoj, S. T. Megeath, G. J. Melnick, J. Najita, D. A. Neufeld, **P. D. Sheehan**, A. M. Stutz, J. Tobin ApJ, 828, 52.

2016 *Protoplanetary Disks in the Orion OMC1 Region Imaged with ALMA*, J. A. Eisner, J. M. Bally, A. Ginsburg, and **P. D. Sheehan**, ApJ, 826, 16E.

2013 *Anomalous CO_2 Ice toward HOPS-68: A Tracer of Protostellar Feedback*, C. A. Poteet, K. M. Pontoppidan, S. T. Megeath, D. M. Watson, K. Isokoski, J. E. Bjorkman, **P. Sheehan**, H. Linnartz, ApJ, 766, 117.

2012 *A Spitzer IRS Survey of NGC 1333: Insights into disk evolution from a very young cluster*, L. A. Arnold, Dan M. Watson, K. H. Kim, P. Manoj, I. Remming, **P. Sheehan**, L. Adame, W. J. Forrest, E. Furlan, E. Mamajek, M. McClure, C. Espaillat, K. Ausfeld, V. Rapson, ApJS 201, 12.

2012 *Spitzer Evidence for a Late Heavy Bombardment and the Formation of Urelites in η Corvi at 1 Gyr*, C.M. Lisse, M. C. Wyatt, C. H. Chen, A. Morlok, D.M. Watson, P. Manoj, **P. Sheehan**, T. M. Currie, P. Thebault, and M. L. Sitko, ApJ, 747, 93.

2009 *Solar System Analogs Around IRAS-Discovered Debris Disks*, Christine H. Chen, **Patrick Sheehan**, Dan M. Watson, Manoj Puravankara, Joan R. Najita, and William J. Forrest, ApJL, 701, 1367.

2009 *Abundant Circumstellar Silica Dust and SiO Gas Created by a Giant Hypervelocity Collision in the ∼12 Myr HD172555 System*, C.M. Lisse, C.H. Chen, M.C. Wyatt, A. Morlok, I. Song, G. Bryden, **P. Sheehan**, ApJ, 701, 2019.

WHITE PAPERS

2019 **Astro2020 Science Whitepaper: Protostellar Disks: The Missing Link Between Cores and Planets*, **P. D. Sheehan**, J. Tobin, I. Stephens, Z. Li, L. Looney, J. A. White, BAAS, 51, 244

2019 *Astro2020 Science Whitepaper: Measuring Protostar Masses: The Key to Protostellar Evolution*, J. J. Tobin, S. Offner, **P. Sheehan**, Z. Li, S. T. Megeath, L. Looney, N. Karnath, J. Green, R. Gutermuth, W. Fischer, I. Stephens, M. M. Dunham, Y. Yang, BAAS, 51, 187

REFERENCES

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Dr. John Tobin
Associate Scientist
National Radio Astronomy Observatory
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Dr. Giles Novak
Professor of Physics & Astronomy
Northwestern University
E-mail: g-novak@northwestern.edu
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Dr. Dan Watson
Professor of Physics & Astronomy
University of Rochester
E-mail: dmw@pas.rochester.edu
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