Curriculum Vitae of

Patrick D. Sheehan

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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

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

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

- *"Are Embedded Disks with Substructures Hiding Young Binaries?"*
  2020B (29.5 hours)
- *"eDisk: Early Planet Formation in Embedded Disks - A Long Wavelength Perspective"*
  2020B (Co-PI; 32 hours)
- *"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)

W. M. Keck Observatory

- *"First Constraints on Pre-Main Sequence Evolutionary Tracks at* < 1 *Myr"*
  2020B (2 half-nights)

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 Science Foundation 2020 - 2023
NSF Astronomy & Astrophysics Postdoctoral Fellowship - $300,000
"Demographics of the Youngest Protostars and their Disks"

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

7 first authored; 7 second authored; 31 total; 2 white papers (1 first authored); See below under "Publication List"

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)

TriFT Fourier Transforms of Triangulated Unstructured Images
GitHub: https://github.com/psheehan/TriFT
(Under development and testing)

INVITED*/CONTRIBUTED TALKS

2020 *HLTau 2020: *Planet Formation in Embedded Disks*

2020 *IIT Colloquium: *Understanding Star and Planet Formation with Radio Observations*

2020 Thinkshop on Protoplanetary Disk Chemodynamics: *Protoplanetary Disk Chemodynamics as a Scale for Weighing Young Stars and Planets* (postponed due to COVID-19)

2020 Cores2Disks Workshop: *The Demographics of Protostellar Disks* (postponed due to COVID-19)

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: Graduate student, Northwestern University

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

Organizer of the CIERA Star & Planet Formation Journal Club 2020 - present
Member of the CIERA Seminar Committee 2020 - present
Referee for Nature, ApJ, A&A 2018 - present
ALMA Ambassador, North American ALMA Science Center 2018

PUBLICATION LIST

SIGNIFICANT CONTRIBUTIONS (*FIRST AUTHORED)

2020 *The VLA/ALMA Nascent Disk and Multiplicity (VANDAM) Survey of Orion Protostars IV. Unveiling the Embedded Intermediate-Mass Protostar and Disk within OMC2-FIR3/HOPS-370*, J. J. Tobin, **P. D. Sheehan**, N. Reynolds, S. T. Megeath, M. Osorio, G. Anglada, A. K. Diaz-Rodriguez, E. Furlan, K. M. Kratter, S. S. R. Offner, L. W. Looney, M. Kama, Z.-Y. Li, M. L. R. van 't Hoff, S. I. Sadavoy, and N. Karnath, ApJ, in press.

2020 *Constraining the Chemical Signatures and the Outburst Mechanism of the Class 0 Protostar HOPS 383*, R. Sharma, J. J. Tobin, **P. D. Sheehan**, S. T. Megeath, W. J. Fischer, J. K. Jorgensen, E. J. Safron, and Z. Nagy, ApJ, in press.

2020 **The VLA/ALMA Nascent Disk and Multiplicity (VANDAM) Survey of Orion Protostars. III. Substructures in Protostellar Disks*, **P. D. Sheehan**, J. J. Tobin, S. Federman, S. T. Megeath, and L. W. Looney, ApJ, in press.

2020 *ALMA Observations of Young Eruptive Stars: Continuum Disk Sizes and Molecular Outflows*, A. S. Hales, S. Pérez, C. Gonzalez-Ruilova, L. A. Cieza, J. P. Williams, **P. D. Sheehan**, C. López, S. Casassus, D. A. Principe, and A. Zurlo, ApJ, 900, 7.

2020 *ALMA 0.88 mm Survey of Disks around Planetary-mass Companions*, Y.-L. Wu, B. P. Bowler, **P. D. Sheehan**, S. M. Andrews, G. J. Herczeg, A. L. Kraus, L. Ricci, D. J. Wilner, and Z. Zhu, AJ, 159, 229.

2020 *The VLA/ALMA Nascent Disk and Multiplicity (VANDAM) Survey of Orion Protostars. II. A Statistical Characterization of Class 0 and Class I Protostellar Disks*, J. J. Tobin, **P. D. Sheehan**, S. T. Megeath, A. K. Díaz-Rodríguez, S. S. R. Offner, N. M. Murillo, M. L. R. 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.-Y. Li, I. Stephens, C. J. Chandler, E. Cox, M. M. Dunham, Ł. 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, 890, 130.

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, Submillimeter Opaque Structures in the Orion Molecular Clouds: Protostars within 10,000 yr of Formation?*, Karnath, N., S. T. Megeath, J. J. Tobin, A. Stutz, Z.-Y. Li, P. Sheehan, N. Reynolds, S. Sadavoy, I. W. Stephens, M. Osorio, G. Anglada, A. K. Díaz-Rodríguez, and E. Cox, ApJ, 890, 129.

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.

NON-REFEREED

2020 *Early onset of planet formation observed in a nascent star system*, **P. Sheehan**, Nature, 586, 205.

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