
ANNA ELIZABETH ENGLE

NORTHERN ARIZONA UNIVERSITY
LOWELL OBSERVATORY

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EDUCATION

Ph.D., Astronomy & Planetary Science, Northern Arizona University, 2024

Dissertation title: “Experimental Studies Involving Mixtures of Methane, Ethane, Propane, and Nitrogen with Implications for Titan”

B.S., Astronomy, University of Maryland, 2018

Minor: Planetary Science

B.A., Studio Art, University of Maryland, 2011

HONORS & OPPORTUNITIES

Guest Researcher, Australian Nuclear Science and Technology Organisation, January 2025

Proposal title: “Identifying the crystal structure behaviour of propane under cryogenic conditions”

NASA FINESST Fellow, Northern Arizona University, *Dept. of Astronomy & Planetary Science*, 2021–2024

Grad Representative, Northern Arizona University, *Dept. of Astronomy & Planetary Science*, 2023–2024

Guest Researcher, Australian Nuclear Science and Technology Organisation, May 2022

Proposal title: “Probing the effects of methane on the solid phases of ethane”

Caltech Space Challenge Participant, California Institute of Technology, March 2022

Review Panel Executive Secretary

Dragonfly Mission Student Guest Investigator, Johns Hopkins University Applied Physics Laboratory, 2021–2023

Review Panel Executive Secretary

Outstanding Undergraduate TA Award, University of Maryland, *Dept. of Astronomy*, 2018

Senior Honors Student, University of Maryland, *Dept. of Astronomy*, 2017–2018

Maryland Space Grant Consortium Scholarship, 2017–2018

NSF REU Summer Student, Northern Arizona University, *Dept. of Physics & Astronomy*, 2017

PUBLICATIONS

A.E. Engle, S. Cupp, G.E. Lindberg (202X), L’appel du Vide: Attraction of Mobile Ions to a Polymer-Vacuum Interface. *In prep.*

S.M. Raposa, S.P. Tan, W.M. Grundy, J.K. Steckloff, J. Hanley, S.C. Tegler, **A.E. Engle**, C.L. Thieberger, G.E. Lindberg (2024), Deriving the N₂-CO Binary Phase Diagram Using Experimental Techniques and Thermodynamics. *The Planetary Science Journal*. 5, 12, 275.

A.E. Engle, J. Hanley, S.P. Tan, W.M. Grundy, S.C. Tegler, G.E. Lindberg, S.M. Raposa, J.K. Steckloff, C.L. Thieberger (2024), Ice Formation, Exsolution, and Multiphase Equilibria in the Methane–Ethane–Nitrogen System at Titan Surface Conditions. *The Planetary Science Journal*. 5, 10, 224.

- S.M. Raposa & **A.E. Engle**, W.M. Grundy, J. Hanley, S.P. Tan, O.M. Umurhan, J.K. Steckloff, C.L. Thieberger, S.C. Tegler (2024), Outbursts Upon Cooling of Low-Temperature Binary Mixtures: Experiments and Their Planetary Implications (*co-first authorship*). *Journal of Geophysical Research: Planets*. 129, e2024JE008457.
- S. Cupp, **A.E. Engle**, Hardin, A., G.E. Lindberg (2024), Identifying Local Interfaces. *Journal of Physical Chemistry, Part B*. 128, 6, 1527–1534.
- B.P. Blakley, W.M. Grundy, J.K. Steckloff, S.P. Tan, J. Hanley, **A.E. Engle**, S.C. Tegler, G.E. Lindberg, S.M. Raposa, K.J. Koga, C. Thieberger (2023), The Equilibrium Vapor Pressures of Ammonia and Oxygen Ices at Outer Solar System Temperatures. *Planetary & Space Science*. 244, 105863.
- S.C. Tegler, W.M. Grundy, M.J. Loeffler, P.D. Tribbett, J. Hanley, A.V. Jasko, H. Dawson, K.J. Koga, A.O. Madden-Watson, M.D. Gomez, J.K. Steckloff, G.E. Lindberg, S.P. Tan, S.M. Raposa, **A.E. Engle**, C.L. Thieberger (2024), Optical Constants of Ices Important to Planetary Science from Laboratory Reflectance Spectroscopy. *The Planetary Science Journal*. 5, 2, 31.
- W.M. Grundy, S.C. Tegler, J.K. Steckloff, S.P. Tan, M.J. Loeffler, A.V. Jasko, K.J. Koga, S.M. Raposa, **A.E. Engle**, C.L. Thieberger, J. Hanley, G.E. Lindberg, M.D. Gomez, A.O. Madden-Watson (2023), Laboratory Measurement of Volatile Ice Vapor Pressures with a Quartz Crystal Microbalance. *Icarus*. p. 115767.
- S.M. Raposa, S.P. Tan, W.M. Grundy, G.E. Lindberg, J. Hanley, J.K. Steckloff, S.C. Tegler, **A.E. Engle**, C.L. Thieberger (2022), Non-Isoplethic Measurement on the Solid-Liquid-Vapor Equilibrium of Binary Mixtures at Cryogenic Temperatures. *Journal of Chemical Physics*. 157, 064201.
- A.E. Engle**, J. Hanley, S. Dustrud, G.E. Lindberg, W.M. Grundy, G. Thompson, S.C. Tegler (2021), Phase Diagram for Methane–Ethane System and its Implications for Titan. *The Planetary Science Journal*. 2, 3, 118.
- J.K. Steckloff, J.M. Soderblom, K.K. Farnsworth, V.F. Chevrier, J. Hanley, A. Soto, J.J. Groven, W.M. Grundy, L.A. Pearce, S.C. Tegler, **A.E. Engle** (2020), Stratification Dynamics of Titan’s Lakes via Methane Evaporation. *The Planetary Science Journal*. 1, 2, 26.
- S.C. Tegler, T. Stufflebeam, W. Grundy, J. Hanley, G.E. Lindberg, S. Dustrud, **A. Engle**, T. Dillingham, D. Matthew, D. Trilling, H. Roe, J. Llama, G. Mace, E. Quirico (2019), A New Two-Molecule Combination Band as a Diagnostic of Carbon Monoxide Diluted in Nitrogen Ice on Triton. *Astronomical Journal*. 158, id. 17.

RESEARCH

NASA FINESST Fellow, 2021–2024

Northern Arizona University, *Dept. of Astronomy & Planetary Science*

Advisors: Drs. Jennifer Hanley and Stephen Tegler

Dissertation Title: Experimental Studies Involving Mixtures of Methane, Ethane, Propane, and Nitrogen with Implications for Titan

Graduate Research Assistant, 2019–2024

Northern Arizona University, *Dept. of Astronomy & Planetary Science*; Lowell Observatory

Advisors: Drs. Jennifer Hanley and Stephen Tegler

Dissertation Title: Experimental Studies Involving Mixtures of Methane, Ethane, Propane, and Nitrogen with Implications for Titan

Dragonfly Mission Student Guest Investigator, 2021–2023

Johns Hopkins University Applied Physics Laboratory; NASA Goddard Space Flight Center

Advisors: Drs. Patrick Peplowski and Ann Parsons

Topic: Tuning DraGNS’ interpretations to Titan’s surface

Graduate Research Assistant, PhD Research Rotation, 2020–2021

Northern Arizona University, *Dept. of Astronomy & Planetary Science, Dept. of Chemistry & Biochemistry*
Advisor: Dr. Gerrick Lindberg

Topic: Modelling interactions of polymer electrolytes with sites of delamination in supercapacitors

Research Specialist, 2018–2019

Northern Arizona University, *Dept. of Physics & Astronomy*

Advisors: Drs. Jennifer Hanley and William Grundy

Topic: Mapping the pure ethane solid-solid transitions and liquidus and solidus of the methane–ethane binary system at low temperatures

Honors Thesis Student, 2017–2018

University of Maryland, *Dept. of Astronomy*

Advisor: Prof. Jessica Sunshine

Topic: Removing terrestrial alteration from meteorite sample GRA 06128/9 through chemical leaching

NSF REU Student, Summer 2017

Northern Arizona University, *Dept. of Physics & Astronomy*

Advisor: Dr. William Grundy

Topic: Perturbing the nitrogen–methane binary system with carbon monoxide at Pluto conditions

Undergraduate Research Assistant, 2016–2017

University of Maryland, *Small Bodies Group*

Advisor: Prof. Jessica Sunshine

Topic: Characterizing the grains surrounding Comet 103P/Hartley 2

Undergraduate Research Assistant, Summer 2015

University of Maryland, *Small Bodies Group*

Advisor: Dr. Lori Feaga

Topic: Cataloging ultraviolet spectra of minerals commonly found in small bodies

CONFERENCE PROCEEDINGS

C. Thieberger, J. Hanley, **A. Engle**, W. Barea-Carrión, S. Tan, J. Steckloff, G. Lindberg, W. Grundy, and S. Tegler (2024), Laboratory Studies of Hydrocarbon Mixtures Relevant to Titan’s Lakes and Seas. *56th DPS Meeting*.

W. Barea-Carrión, C. Thieberger, J. Hanley, **A. Engle**, S. Tan, J. Steckloff, G. Lindberg, W. Grundy, S. Tegler (2024), The Effect of Propane on Two Liquid Systems in Titan’s lakes. *56th DPS Meeting*.

A.E. Engle, A.M. Parsons, P.N. Peplowski (2024), Nuclear spectroscopy on a new world: tuning the Dragonfly Gamma-ray and Neutron Spectrometer (DraGNS) for Titan’s surface environment. *4th Arizona Astrobiology Symposium*.

W.M. Grundy, S.M. Raposas, **A.E. Engle**, S. Tan, G.E. Lindberg, O.M. Umurhan, J. Hanley, C.L. Thieberger, J.K. Steckloff, K.J. Koga, and S.C. Tegler, and D.E. Trilling (2024), Pressure Outbursts from Cooling Volatile Liquid Mixtures. *LPSC LV*, Abstract #2092.

A.M. Parsons, M. Ayllon Unzueta, J.T. Wilson, P.N. Peplowski, Z.W. Yokley, **A.E. Engle**, J. Beechert, D.J. Lawrence, and R.D. Starr (2024), Experimental Study of Dragonfly/DraGNS’ Bulk Elemental Composition Measurement Capabilities for Titan-Like Materials. *LPSC LV*, Abstract #2184.

A.N. Morgan, R. Wochner, S.C. Tegler, W.M. Grundy, J. Hanley, K.J. Koga, J.K. Steckloff, G.E. Lindberg, S.P. Tan, S.M. Raposas, **A.E. Engle**, C.L. Thieberger, D.E. Trilling (2024), Spectral Analysis of CO₂/CO Ice Mixtures. *LPSC LV*, Abstract #1741.

S. Raposas, **A. Engle**, S. Tan, W. Grundy, S. Tegler, G. Lindberg, J. Hanley, J. Steckloff, C. Thieberger (2024), Laboratory Studies of Pluto’s Volatiles. *Laboratory Astrophysics Workshop (ICE 2024)*.

- S. Raposa, W. Grundy, S. Tan, S. Tegler, G. Lindberg, J. Hanley, J. Steckloff, **A. Engle**, C. Thieberger (2024), Phase Diagram Mapping of the N_2+CH_4+CO System to Better Understand Pluto's Glaciers. *55th DPS Meeting*.
- B.P. Blakley, W. Grundy, S. Tegler, S. Tan, A. Morgan, **A. Engle**, C. Thieberger (2024), Study of Uranian Satellite Volatiles. *55th DPS Meeting*.
- W.M. Grundy, S.C. Tegler, J.K. Steckloff, S.P. Tan, M.J. Loeffler, A.V. Jasko, K.J. Koga, S.M. Raposa, **A.E. Engle**, C.L. Thieberger, J. Hanley, G.E. Lindberg, M.D. Gomez, A.O. Madden-Watson (2023), Laboratory Measurement of Vapor Pressures of N_2 , CO , and CH_4 Ices. *ACM 2023*.
- A.E. Engle**, J. Hanley, C.L. Thieberger, S.C. Tegler, W.M. Grundy, S.P. Tan, G.E. Lindberg, S.M. Raposa, J.K. Steckloff (2023), Exsolution and other Phase Behaviors in the Methane–Ethane–Propane–Nitrogen System. *Titan Through Time VI*.
- C. Thieberger, J. Hanley, **A. Engle**, S. Tan, W. Grundy, S. Tegler, G. Lindberg, S. Raposa, J. Steckloff (2023), The Effects of Trace Species on Titan's Ternary System. *Titan Through Time VI*.
- A.E. Engle**, P.N. Peplowski, A.M. Parsons, M. Ayllon Unzueta, J.T. Wilson, Z.W. Yokley, S.M. MacKenzie, S.L. Murchie, E.P. Turtle, R.D. Lorenz, D.J. Lawrence, R.D. Starr (2023), Tuning DraGNS' Interpretations to Titan's Expected Surface Environment. *LPSC LIV*, Abstract #2545.
- J. Hanley, **A.E. Engle**, C. Thieberger, S. Tan, W.M. Grundy, G.E. Lindberg, S. Raposa, S.C. Tegler (2023), The Stability of Trace Species in the Liquids of Titan. *LPSC LIV*, Abstract #1849.
- W.M. Grundy, S.C. Tegler, J.K. Steckloff, M.J. Loeffler, A.V. Jasko, K.J. Koga, S.M. Raposa, **A.E. Engle**, C.L. Thieberger, J. Hanley, G.E. Lindberg, S. Tan, M.D. Gomez (2023), Laboratory Measurement of Vapor Pressures of Volatile Ices. *LPSC LIV*, Abstract #2281.
- A.E. Engle**, J. Hanley, C.L. Thieberger, W.M. Grundy, S.C. Tegler, G.E. Lindberg, S.P. Tan, S.M. Raposa, J.K. Steckloff (2023), Adding Propane to the Methane–Ethane–Nitrogen System at Titan-like Conditions. *1st Workshop on Ices in the Solar System*.
- W.M. Grundy, S.C. Tegler, J.K. Steckloff, A.V. Jasko, K.J. Koga, M.J. Loeffler, S.M. Raposa, **A.E. Engle**, C.L. Thieberger, J. Hanley, G.E. Lindberg, S.P. Tan, M.D. Gomez, A.O. Madden-Watson (2023), Laboratory Measurement of Volatile Ice Vapor Pressures Using a Quartz Crystal Microbalance. *1st Workshop on Ices in the Solar System*.
- S.M. Raposa, W.M. Grundy, S.P. Tan, G.E. Lindberg, J. Hanley, J.K. Steckloff, S.C. Tegler, **A.E. Engle**, C.L. Thieberger (2023), Phase Behaviors of Pluto's Volatiles. *1st Workshop on Ices in the Solar System*.
- M. Adang, A. Ainabe, A. Dave, A. Dumitrescu, **A.E. Engle**, S. Lamm, C. Liou, S.Y.W. Low, C. McClelland, G. Miceli, P. Patel, P. Salazar, L. Su, J. Todd, A. Vigneron, B. Wylie (2023), Searching for Life on Titan: The Undersea Retrieval Lake Extractions (TURTLE) Mission. *AIAA SCITECH 2023 Forum*.
- A.E. Engle**, J. Hanley, C.L. Thieberger, W.M. Grundy, S.C. Tegler, G.E. Lindberg, S.P. Tan, S.M. Raposa, J.K. Steckloff (2022), Adding Propane to the Methane–Ethane–Nitrogen System at Titan-like Conditions. *54th DPS Meeting*.
- S. Raposa, S. Tan, W. Grundy, G. Lindberg, J. Hanley, J. Steckloff, S. Tegler, **A. Engle**, C. Thieberger (2022), Phase Behaviors of Pluto's Volatiles. *54th DPS Meeting*.
- P.N. Peplowski, J.T. Wilson, M. Ayllon-Unzueta, **A. Engle**, R.D. Lorenz, S.M. MacKenzie, S.L. Murchie, D.J. Lawrence, A.M. Parsons, E.P. Turtle, Z.W. Yokley (2022), Neutron Spectroscopy at the Surface of Saturn's Moon Titan. *LPSC LIII*, Abstract #2329.
- A.E. Engle**, J. Hanley, S.P. Tan (2021), Mapping the Change in Temperature of the Methane–Ethane Freezing Points with the Addition of Nitrogen at Constant Vapor Pressure. *53rd DPS Meeting*.
- S. Raposa, W. Grundy, S. Tan, G. Lindberg, L. Libby, **A. Engle**, J. Steckloff, J. Hanley (2021), Path to the $N_2+CO+CH_4$ Equation of State: Results from Laboratory Experiments and Theoretical Modeling. *53rd DPS Meeting*.

- A.E. Engle**, J. Hanley, S.P. Tan (2021), Mapping the Change in Temperature of the Methane–Ethane Freezing Points with the Addition of Nitrogen at Constant Vapor Pressure. *Titan Through Time V*.
- B. Wing, J. Hanley, **A.E. Engle**, G.E. Lindberg, W.M. Grundy, S. Dustrud, S. Tan, S.C. Tegler (2021), The Effects of Propane on the Liquids of Titan. *Titan Through Time V*.
- A.E. Engle**, J. Hanley, S.P. Tan, S.C. Tegler, W.M. Grundy, G.E. Lindberg, J.K. Steckloff (2021), Mapping Changes in the Methane–Ethane System when adding Nitrogen at Titan Surface Conditions. *LPSC LII*, Abstract #1722.
- A.E. Engle**, J. Hanley, S. Dustrud, G. Thompson, G.E. Lindberg, W.M. Grundy, S.C. Tegler (2020), Phase Diagram for the Methane–Ethane System at Conditions Relevant to Titan. *52nd DPS Meeting*.
- A. Engle**, J. Hanley, W.M. Grundy, S. Dustrud, G.E. Lindberg, S.C. Tegler (2019). Identifying the Solid Phase Transitions of Ethane Using Raman Spectroscopy at Conditions Relevant to Titan’s Surface. *LPSC L*, Abstract #2509.
- J. Hanley, J.J. Groven, W.M. Grundy, S. Dustrud, **A. Engle**, G.E. Lindberg, S.C. Tegler (2019). Characterization of Possible Two Liquid System in Titan’s Seas. *LPSC L*, Abstract #1712.
- S.C. Tegler, T. Stufflebeam, W. Grundy, J. Hanley, G.E. Lindberg, S. Dustrud, **A. Engle**, T. Dillingham, E. Quirico (2018). A New, Unusual, and Diagnostic Band in Near-Infrared Spectra of Laboratory Ice Samples on Triton. *50th DPS Meeting*.
- A. Engle**, W. Grundy, S. Dustrud (2018). Raman Shop: Exploring the Carbon Monoxide–Nitrogen–Methane Ternary System of Sputnik Planitia via Raman Spectroscopy. *LPSC XLIX*, Abstract #2763.
- J.M. Sunshine, L.M. Feaga, T. Farnham, S. Protopapa, M.S. Kelley, **A. Engle** (2016). Characterizing the Large (cm-size) Grains Around Comet 103P/Hartley 2. *48th DPS Meeting*.

TEACHING AND MENTORING EXPERIENCE

NSF REU Graduate Assistant Mentor, Summer 2021

Northern Arizona University, *Dept. of Astronomy & Planetary Science*
Primary Mentor: Dr. Gerrick Lindberg

Graduate Teaching Assistant, Fall 2020

Northern Arizona University, *Dept. of Astronomy & Planetary Science*
Professors: Prof. Li-Hsin Chien and Dr. David Trilling

NSF REU Graduate Assistant Mentor, Summer 2019

Northern Arizona University, *Dept. of Astronomy & Planetary Science*
Primary Mentor: Dr. Jennifer Hanley

Undergraduate Teaching Assistant, 2017–2018

University of Maryland, *Dept. of Astronomy*
Professors: Prof. Jessica Sunshine and Dr. Drake Deming

PUBLIC TALKS

“Titan Underground: Karst Systems,” *Lowell Observatory Astronomy on Tap*, May 2023

“Experimental Studies of Phase Behaviors in Hydrocarbon+Nitrogen Mixtures at Titan Surface-like Conditions,” *LPI Seminar Series*, May 2023

“Experimental Studies of Hydrocarbons and Nitrogen at Titan-like Conditions,” *New Mexico State University Seminar Series*, April 2022

“Hydrocarbons in the Lakes of Titan,” *Phoenix Astronomical Society*, September 2021