

Curriculum Vitae

Jacob S. Higgins

JILA and University of Colorado Boulder
University of Colorado, Boulder
400 UCB, Boulder, CO 80309

jacob.higgins.@jila.colorado.edu
jakehigginsphd.com
Phone: (479) 252-2382

ACADEMIC APPOINTMENTS

JILA and University of Colorado Boulder

JILA Postdoctoral Fellow
Advisor: Prof. Jun Ye

Boulder, CO
June 2024 – present

National Institute of Standards and Technology (NIST)

NRC Postdoctoral Fellowship
Advisor: Prof. Jun Ye

Boulder, CO
June 2022 – June 2024

EDUCATION

The University of Chicago

Ph.D. in Physical Chemistry

M.S. in Physical Chemistry

NSF Graduate Research Fellow

Thesis Title: “Dynamic Mechanisms of Electronic-Vibrational Coupling in Photosynthetic Pigment-Protein Complexes”

Advisor: Prof. Gregory S. Engel

Chicago, IL

June 2022

December 2017

2018 – 2021

Hendrix College

B.A. in Chemical Physics with Honors, *Summa Cum Laude*

Thesis Title: “The Nature of Unidentified Infrared Emission Bands in Interstellar Space”

Advisors: Prof. Courtney D. Hatch, Prof. Andrew M. Schurko

Conway, AR

May 2016

AWARDS, HONORS, & FELLOWSHIPS

Research

- 2022-2024 NIST NRC Postdoctoral Fellowship: Awarded
- 2022 Schmidt Science Fellows, Finalist
- 2018-2021 NSF Graduate Research Fellowship Program (GRFP): Awarded
- 2016-2018 University of Chicago McCormick Fellowship
- 2016 Induction into Phi Beta Kappa
- 2016 American Chemical Society Undergraduate Environmental Chemistry Award
- 2015 Barry M. Goldwater Scholarship

Service

- 2023 JILA JEDI (JILA Excellence in Diversity & Inclusion) Award
- 2019 Joan Shiu Chemistry Department Student Service Award, University of Chicago
- 2019 Inclusive Pedagogy Grant, Office of the Provost, Diversity, Equity & Inclusion Initiative, University of Chicago

PUBLICATIONS

In Preparation

15. Non-perturbative exciton transfer rate analysis of the Fenna-Matthews-Olson photosynthetic complex under reduced and oxidized conditions
H. Ó. Gestsson, C. Nation, **J. S. Higgins**, G. S. Engel, A. Olaya-Castro

Submitted or Under Review/Revision

14. Temperature sensitivity of a Thorium-229 solid-state nuclear clock
J. S. Higgins, T. Ooi, J. F. Doyle, C. Zhang, J. Ye, K. Beeks, T. Sikorsky, T. Schumm, Submitted, *Physical Review Letters*, <https://arxiv.org/abs/2409.11590>
13. Fine-structure constant sensitivity of the Th-229 nuclear clock transition
K. Beeks, G. A. Kazakov, F. Schaden, I. Morawetz, L. Toscani De Col, T. Riebner, M. Bartokos, T. Sikorsky, T. Schumm, C. Zhang, T. Ooi, **J. S. Higgins**, J. F. Doyle, J. Ye, Under Revision, *Physical Review Letters*, <https://arxiv.org/abs/2407.17300>
12. $^{229}\text{ThF}_4$ thin films for solid-state nuclear clocks
C. Zhang, L. von der Wense, J. F. Doyle, **J. S. Higgins**, T. Ooi, H. U. Friebel, J. Ye, R. Elwell, J. E. S. Terhune, H. W. T. Morgan, A. N. Alexandrova, H. B. Tran tan, A. Derevianki, E. R. Hudson, Under Revision, *Nature*, <https://arxiv.org/abs/2410.01753>

In Press

11. Frequency ratio of the $^{229\text{m}}\text{Th}$ nuclear isomeric transition and the ^{87}Sr atomic clock
C. Zhang, T. Ooi, **J. S. Higgins**, J. F. Doyle, L. von der Wense, K. Beeks, A. Leitner, G. A. Kazakov, P. Li, P. G. Thirolf, T. Schumm, J. Ye, *Nature**, 633, 63–70 (2024) [*Cover Article]
10. Quantum Sensing Using Multi-Qubit Quantum Systems and the Pauli Polytope
I. Avdic, L. M. Sager-Smith, I. Ghosh, O. C. Wedig, **J. S. Higgins**, G. S. Engel, D. A. Mazziotti, *Physical Review Research*, 5, 043097 (2023)
9. Tunable itinerant spin dynamics with polar molecules
J.-R. Li, K. Matsuda, C. Miller, A. N. Carroll, W. G. Tobias, **J. S. Higgins**, J. Ye, *Nature*, 614, 70–74 (2023)
8. Leveraging Dynamical Symmetries in Two-Dimensional Electronic Spectra to Extract Population Transfer Pathways
J. S. Higgins, A. R. Dardia, C. J. Ndife, E. M. Bain, L. T. Lloyd, G. S. Engel, *Journal of Physical Chemistry A*, 126, 3594-3603 (2022)
7. Observation of Exciton Annihilation along Phycocyanin rods in the Phycobilisome of *Synechococcus elongates PCC 7942*
P. Navotnaya*, S. Sohoni*, L. T. Lloyd, S. M. Abdulhadi, P.-C. Ting, **J. S. Higgins**, G. S. Engel *Journal of Physical Chemistry B* 126, 23-29 (2022) [*Equal Contribution].
6. Redox conditions correlated with vibronic coupling modulate quantum beats in photosynthetic pigment-protein complexes
J. S. Higgins*, M. A. Allodi*, L. T. Lloyd, J. P. Otto, S. H. Sohail, R. G. Saer, R. E. Wood, S. C. Massey, P.-C. Ting, R. E. Blankenship, G. S. Engel, *Proceedings of the National Academy of Sciences*, 118 (49) e2112817118 (2021) [*Equal Contribution].
5. Photosynthesis tunes quantum mechanical mixing of electronic and vibrational states to steer exciton energy transfer,
J. S. Higgins, L. T. Lloyd, S. H. Sohail, M. A. Allodi, J. P. Otto, R. G. Saer, R. E. Wood, S. C. Massey, P.-C. Ting, R. E. Blankenship, G. S. Engel, *Proceedings of the National Academy of Sciences* 118 (11) e2018240118 (2021)

4. Quantum Coherence in Chemical and Photobiological Systems
J. S. Higgins, W. R. Hollingsworth, L. T. Lloyd, G. S. Engel, *Emerging Trends in Chemical Applications of Lasers* (American Chemical Society, 2021), Vol. 1398, Chap. 18 pp. 411-436
3. Sub-10 fs intervalley exciton coupling in monolayer MoS₂ revealed by helicity-resolved two-dimensional electronic spectroscopy
 L. T. Lloyd, R. E. Wood, F. Mujid, S. Sohoni, K. Ji, P.-C. Ting, **J. S. Higgins**, J. Park, G. S. Engel, *ACS Nano* 15, 6, 10253-10263 (2021)
2. Leveraging scatter in two-dimensional spectroscopy: passive phase drift correction enables a global phasing protocol,
 L. T. Lloyd, R. E. Wood, M. A. Allodi, S. Sohoni, **J. S. Higgins**, J. P. Otto, G.S Engel, *Optics Express* 28, 32869-328 (2020)
1. DNA scaffold supports long-lived vibronic coherence in an indodicarbocyanine (Cy5) dimer
 S. H. Sohail, J. P. Otto, P. D. Cunningham, Y. C. Kim, R. E. Wood, M. A. Allodi, **J. S. Higgins**, J. S. Melinger, G. S. Engel, *Chemical Science* 11, 8546-8557 (2020)

RESEARCH EXPERIENCE

NIST, University of Colorado Boulder Department of Physics, & JILA **Boulder, CO**
NRC Postdoctoral Fellow & JILA Postdoc 2022 – present

- Performed precision scans to find the low-lying transition energy of the thorium-229 nucleus
- Built vacuum ultraviolet frequency comb systems for precision measurement
- Prepared and characterized solid-state thorium oxide samples for spectroscopic scans
- Built tunable itinerant spin system in ultracold molecule apparatus

The University of Chicago, Department of Chemistry **Chicago, IL**
NSF GRFP Graduate Student, Engel Group 2016 – 2022

- Studied redox-dependence of excited state dynamics in photosynthetic pigment-protein complexes
- Performed ultrafast two-dimensional electronic spectroscopy experiments of biophysical systems
- Developed new data method to extract kinetic time constants from two-dimensional spectra

Hendrix College, Department of Chemistry **Conway, AR**
Research Assistant, Hatch Group 2015 – 2016

- Developed analytical method to study aerosols using gas chromatography/mass spectrometry to be implemented into undergraduate laboratory curriculum

Hendrix College, Department of Physics **Conway, AR**
Research Assistant, Tinsley Group 2015 – 2016

- Educational research studying gender differences between junior high students' perception of physical sciences and becoming a scientist

Hendrix College, Department of Biology **Conway, AR**
Research Assistant, Schurko Group 2013 – 2015

- Used bioinformatics, gene expression studies (qPCR), and protein mass spectrometry to study the role of histones in the DNA repair mechanism of bdelloid rotifers

Vanderbilt University, Department of Biomedical Engineering **Nashville, TN**
NSF REU Researcher 2013

- Studied the effects of shear stress and lipoprotein involvement in genetic regulation of human aortic endothelial cells using cone and plate device and qPCR
- Correlated presence and concentration of urine analytes in patients with bladder cancer using liquid chromatography/mass spectrometry data

PRESENTATIONS

Invited Talks

- Aug. 2024 “Building a nuclear clock with the thorium-229 nuclear transition using ultraviolet frequency combs,” *Massachusetts Institute of Technology Future Faculty Symposium*, Cambridge, MA
- April 2024 “Building a nuclear clock: Direct vacuum ultraviolet frequency comb spectroscopy for precision measurement and fundamental physics,” *National Institute of Standards and Technology*, Boulder, CO
- March 2024 “Building a clock with an atom’s nucleus,” *Hendrix College*, Conway, AR
- April 2022 “Tuning vibronic coupling within a photosynthetic complex,” *Big Quantum Biology Meetings*, UCLA Quantum Biology Tech Lab & University of Surrey Quantum Biology DTC, Online
- Feb. 2022 “Tuning vibronic coupling to steer energy transfer through photosynthetic proteins,” *University of Colorado Boulder*, Boulder, CO

Contributed Talks

- Aug. 2024 “Ultraviolet frequency combs for high resolution spectroscopy and quantum sensing,” *American Chemical Society Meeting, Fall 2024*, Denver, CO
- Aug. 2023 “The reach of ultrafast spectroscopy,” *Quantum Control of Light and Matter Gordon Research Seminar*, Newport, RI
- March 2022 “Coherent steering of photosynthetic excitons with redox-dependent vibronic coupling,” *American Physical Society March Meeting 2022*, Chicago, IL
- April 2021 “Steering of photosynthetic excitons with redox-dependent vibronic coupling,” *Department of Chemistry Tiger Talk*, University of Chicago, Chicago, IL.
- Oct. 2014 “Investigating the role of histone H2A variants in the unprecedented DNA repair system of bdelloid rotifers,” *Hendrix Biological Society Meeting*, Hendrix College, Conway, AR

Poster Presentations

- July 2024 “Ultraviolet frequency combs for precision measurement, quantum sensing, and the search for the $^{229\text{m}}\text{Th}$ nuclear transition,” *Electron Donor-Acceptor Interactions Gordon Research Conference*, Newport, RI
- Aug. 2023 “Building a nuclear clock: Direct vacuum ultraviolet frequency comb spectroscopy for precision measurement and fundamental physics,” *Quantum Control of Light and Matter Gordon Research Seminar*, Newport, RI
- Aug. 2023 “Tunable ultraviolet frequency combs for high resolution and ultrafast spectroscopy,” *Am. Chem. Society Conference*, San Francisco, CA
- April 2021 “Photosynthetic pigment-protein complexes steer excitons toward quenching sites using redox-dependent vibronic coupling,” *Am. Chem. Society Conference*, Online
- July 2019 “Extracting exciton energy transfer efficiency and system-bath interactions from two-dimensional spectroscopic signals,” *Photochemistry Gordon Research Conference*, Easton, MA
- May 2019 “Extracting exciton energy transfer efficiency and system-bath interactions from two-dimensional spectroscopic signals,” *Am. Chem. Society Great Lakes Regional Meeting*, Lisle, IL
- Oct. 2018 “Probing system-bath dynamics in pigment-protein complexes with two-dimensional electronic spectroscopy,” *Midwest/Southeast Photosynthesis Meeting*, Marshall, IN
- March 2016 “Method development to study atmospheric aerosols,” *Am. Chem. Society Conference*, San Diego, CA

- Nov. 2015 “Method development to study atmospheric aerosols,” *Arkansas IDeA Network of Biomedical Research Excellence Conference*, Fayetteville, AR
- July 2015 “Method development to study atmospheric aerosols,” *Central Arkansas Undergraduate Research Symposium*, Little Rock, AR
- Mar. 2015 “Evaluating the role of histone H2A variants and epigenetic modification in the DNA repair system of bdelloid rotifers,” *Experimental Biology Conference*, Boston, MA
- Nov. 2014 “Evaluating the role of histone H2A variants and epigenetic modification in the DNA repair system of bdelloid rotifers,” *Arkansas IDeA Network of Biomedical Research Excellence Conference*, Fayetteville, AR
- July 2014 “Investigating the role of histone H2A variants in the unprecedented DNA repair system of bdelloid rotifers,” *Central Arkansas Undergraduate Research Symposium*, Little Rock, AR

TEACHING EXPERIENCE

University of Colorado Boulder, Department of Physics Boulder, CO

- Spring 2023 Guest Instructor, *Physics Honors*

University of Chicago, Department of Chemistry Chicago, IL

- Spring 2019 Teaching Assistant and Grader, *Chemical Dynamics*
- Spring 2018 Grader, *Biophysical Chemistry*
- Fall 2016 – Spring 2017 Laboratory & Teaching Assistant, *General Chemistry I – III*

Hendrix College, Department of Chemistry Conway, AR

- Spring 2015, Spring 2016 Laboratory Assistant, *Organic Chemistry II Lab*
- Fall 2015 Laboratory Assistant, *Accelerated General Chemistry Lab*
- Fall 2013 Laboratory Assistant, *General Chemistry I Lab*

LEADERSHIP EXPERIENCE

JILA Postdoc Group Boulder, CO

Co-creator and co-leader 2023 – 2024

- Established the group as an organization dedicated to professional development and community events for postdocs at JILA
- Organized ~monthly events for postdocs including a faculty proposal panel, lab mentorship workshop, write-in workshop, grant writing panel, and job negotiations panel

JILA NSF Physics Frontier Center Boulder, CO

Postdoc Leader 2023 – 2024

- Developed professional development certificate for JILA postdocs and senior graduate students
- Trainings include mentorship, project management, proposal writing, and Diversity & Inclusion

Graduate Recruitment Initiative Team (GRIT), The University of Chicago Chicago, IL

Co-director of Recruitment, Physical Sciences Division (PSD) 2019 – 2020

- Headed a leadership team of graduate students across six PSD departments aimed at recruiting undergraduates from underrepresented backgrounds to graduate school
- Planned, organized, and secured funding for student recruitment trip to national *Society for the Advancement of Chicanos and Native Americans in Science (SACNAS)* conference in Honolulu, HI
- Coordinated diversity-themed events into graduate recruitment across six PSD departments
- Developed multiple Zoom-based undergraduate recruitment panels with student groups at Howard University, University of Illinois, and Columbia University

GRIT Chemistry Department Representative 2018 – 2019

- Secured funding for recruitment and retention events from the Chemistry Department
- Recruited undergraduate students at the national *SACNAS* meeting in San Antonio, TX
- Organized retention events focused underrepresented student experiences

Equity, Diversity, & Inclusion (EDI) Committee, UChicago Dept. of Chemistry Chicago, IL

Graduate Student Member 2020 – 2021

- Wrote and begin implementation of five-year EDI plan in the Department of Chemistry

@rtifice Tech Education, The University of Chicago

Chicago, IL

Leadership Board Member

2019 – 2021

- Organized board meetings & planned logistics for the year's activities

After-School Center Coordinator

2016 – 2019

- Volunteered at an after-school tech center in Chicago for middle school students

POPULAR PRESS

Nuclear Clocks

- NIST, "Major Leap for Nuclear Clock Paves Way for Ultraprecise Timekeeping," September 2024
- Quanta Magazine, "The First Nuclear Clock Will Test if Fundamental Constants Change," September 2024
- ScienceNews, "A nuclear clock prototype hints at ultraprecise timekeeping," September 2024
- Science, "Breakthrough promises new era of ultraprecise nuclear clocks," September 2024
- Optics & Photonics News, "Capturing the Tick of Future Nuclear Clocks," September 2024
- ScienceAlert, "Breakthrough: Scientists Create World's First Nuclear Clock Prototype," September 2024

Ultracold Molecules

- JILA Light + Matter, "Controlling a Quantum Classroom: New Insights into the Spin-Dynamics of Molecules," February 2023

Quantum Effects in Biology

- Science Alert, "Bacteria Could Be the First Organisms Found to Use Quantum Effects to Survive," March 2021
- PhysOrg, "Bacteria know how to exploit quantum mechanics, study finds," March 2021
- SciTechDaily, "Bacteria Know How to Exploit Quantum Mechanics to Steer Energy," March 2021
- Futuricity, "Bacteria use Quantum Mechanics for Protection," March 2021
- UChicago News, "Bacteria know how to exploit quantum mechanics, UChicago study finds," March 2021
- EurekAlert, "Bacteria know how to exploit quantum mechanics, UChicago study finds," March 2021
- Bioengineer.org, "Bacteria know how to exploit quantum mechanics, UChicago study finds," March 2021

Outreach

- Humans of JILA Podcast, "Episode 3 – JILA's Postdoc Group," October 2023
- UChicago Chemists Club, "GRIT: A student-led effort to enhance diversity, inclusion, and equity in Chemistry and Beyond," Fall 2021
- UChicago Chemistry, "Graduate Recruitment Initiative Team (GRIT) grows to the PSD and beyond," February 2019

ADDITIONAL SERVICE

Academic Service

- Undergraduate/post-baccalaureate research students mentored: Carlos Olivares, Nick Cleland, Danika Nimlos, James Hayman, Anna Dardia, Chidera Ndife, Malachi Elue
- Peer Referee for Academic Journals:
 - *AIP Advances*, September 2023
 - *Journal of the American Chemical Society*, November 2021
 - *Science*, May 2020
- Sep. 2021 Search Committee, UChicago Physical Sciences Division Director of Equity, Diversity, and Inclusion
- Winter 2020 UChicago Department of Chemistry Graduate Recruitment Committee
- Aug. 2019 Search Committee, UChicago Physical Sciences Division Dean of Students
- Summer 2019 Coordinator, UChicago “Chemistry Lunch and Learn” series for first year graduate students
- Winter 2019 UChicago Department of Chemistry Graduate Recruitment Committee

Advocacy

- April 2024 Panelist, Women and Gender Minorities in Physics Postdoctoral Panel, JILA
- June 2023 Interviewee, “Social Support for Nonbinary Scientists” research, online
- Nov. 2022 Volunteer, Community college outreach event, Q-SEnSE NSF center, JILA
- Aug. 2021 Panelist, UChicago Leadership Alliance Summer Program
- Jan. 2021 Panelist, Imposter Syndrome Workshop, UChicago Department of Chemistry
- Sep. 2020 Panelist, “Life During Grad School” series, UChicago Physical Sciences and Biological Sciences Division
- Feb. 2020 Panelist, First year graduate student workshop, “Candid Peer Conversations about the Graduate Student Experience,” UChicago Department of Chemistry
- Feb. 2020 Panelist, Graduate school information session for undergraduate students, UChicago Department of Chemistry
- May 2019 Volunteer, UChicago *Women in STEM symposium*, Chicago, IL
- April 2019 Volunteer, *Society for the Advancement of Chicanos and Native Americans in Science* regional conference, Chicago, IL
- July 2018 Volunteer, “Girls 4 Science” nonprofit event at UChicago, Chicago, IL