

# Dr. Charles R. Markus

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Laboratory Studies and Atmospheric Observations Group  
The Jet Propulsion Laboratory  
Pasadena, CA 91011

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## POSITIONS

### **NASA Postdoctoral Program Fellow, The Jet Propulsion Laboratory**

July 2023–Present Advisor: Dr. Carl Percival

### **Arnold O. Beckman Postdoctoral Fellow, California Institute of Technology**

July 2020–July 2023

Advisors: Prof. Mitchio Okumura and Dr. Stanley P. Sander

### **Visiting scholar, Universität zu Köln**

January 2020–July 2020

Advisor: Prof. Dr. Stephan Schlemmer

## EDUCATION

### **Ph.D. Chemistry**

**University of Illinois at Urbana-Champaign**, September 2013–December 2019

Advisor: Prof. Benjamin J. McCall

GPA 4.00/4

*Dissertation Title:* Sensitive and High-Precision Rovibrational Spectroscopy of Molecular Ions Relevant to Astronomical and Quantum Chemistry

*Dissertation research:* I improved the sensitivity of the sub-Doppler ion-sensitive technique Noise-Immune Cavity-Enhanced Optical Heterodyne Velocity Modulation Spectroscopy by more than an order of magnitude, which enabled the most extensive high-precision survey of  $\text{H}_3^+$  rovibrational transitions to date. This led to the most accurate predictions of the forbidden rotational spectrum, including a possible astrophysical maser. The derived ground-state energy levels are important benchmarks for *ab initio* theory, and my results will act as a stringent test for the foreseeable future. I also investigated the molecular ions  $\text{OH}^+$  and  $\text{D}_2\text{H}^+$  to accurately determine THz transition frequencies from their infrared spectra, which opens up the possibility for observations with modern THz observatories. This work resulted in 8 publications and 24 presentations.

## B.S. Mathematics and Chemistry with Honors

University of Wisconsin–Madison, 2008–2012

Certificate in Physics

GPA: 3.89/4

Undergraduate Research Advisor: Prof. Howard Zimmerman

## Undergraduate Researcher

The Jet Propulsion Laboratory, 2013

Research mentors: Dr. Robert Hodyss and Dr. Paul Johnson

*Research:* Carried out experiments using matrix isolation instrumentation to investigate the reactivity and stability of molecules trapped in water ices relevant to the surface chemistry of icy moons in the outer solar system. This work resulted in 1 publication.

## PUBLICATIONS

21. Cavity-enhanced dual-comb spectroscopy in the molecular fingerprint region using free-running quantum cascade lasers, **C. R. Markus**, J. Hayden, D. I. Herman, P. A. Kocheril, D. C. Ober, T. Bashiri, M. Mangold, M. Okumura, *submitted*, (2023).
20. Bimolecular Reaction of Methyl-Ethyl Substituted Criegee Intermediate with SO<sub>2</sub>, M. Zou, T. Liu, M. F. Vansco, C. A. Sojdak, **C. R. Markus**, R. Almeida, K. Au, L. Sheps, D. L. Osborn, F. A. F. Winiberg, C. J. Percival, C. A. Taatjes, S. J. Klippenstein, M. I. Lester, R. L. Caravan, *submitted*, (2023).
19. OH Roaming and Beyond in the Unimolecular Decay of the Methyl-Ethyl-Substituted Criegee Intermediate: Observations and Predictions, T. Liu, S. N. Elliott, M. Zou, M. F. Vansco, C. A. Sojdak, **C. R. Markus**, R. Almeida, K. Au, L. Sheps, D. L. Osborn, F. A. F. Winiberg, C. J. Percival, C. A. Taatjes, R. L. Caravan, S. J. Klippenstein, M. I. Lester, *J. Amer. Chem. Soc.*, (2023), **145**, 19405–19420. DOI: 10.1021/jacs.3c07126
18. Mid-Infrared Cross-Comb Spectroscopy, M. Liu, R. M. Gray, L. Costa, **C. R. Markus**, A. Roy, A. Marandi, *Nature Comm.*, (2023), **14**, 1044. DOI: 10.1038/s41467-023-36811-7
17. Cavity-Enhanced Vernier Spectroscopy with a Chip-Scale Mid-Infrared Frequency Comb, L. A. Sterczewski, T.-L. Chen, D. C. Ober, C. R. Markus, C. L. Canedy, I. Vurgaftman, C. Frez, J. R. Meyer, M. Okumura, M. Bagheri, *ACS Photonics*, (2022). DOI: 10.1021/acsp Photonics.1c01849
16. Reaction of methane and UV-activated perchlorate: Relevance to heterogeneous loss of methane in the atmosphere of Mars, X. Zhang, D. Berkinsky, C. R. Markus, S. R. Chitturi, F. J. Grieman, M. Okumura, Y. Luo, Y. L. Yung, S. P. Sander, *Icarus*, (2022), **376**, 114832. DOI: 10.1016/j.icarus.2021.114832

15. The fundamental rotational transition of  $\text{NO}^+$ , O. Asvany, **C. R. Markus**, A. R. Kobayashi, S. Schlemmer, C. Lauzin, *Journal of Molecular Spectroscopy*, (2021), **378**, 111447. DOI: 10.1016/j.jms.2021.111447
14. Pure Rotational Spectrum of  $\text{CCl}^+$ , O. Asvany, **C. R. Markus**, K. Nagamori, J. Furuta, K. Kobayashi, S. Schlemmer, S. Thorwirth, *The Astrophysical Journal*, (2021), **910**, 15. DOI: 10.3847/1538-4357/abe536
13. High-resolution infrared action spectroscopy of the fundamental vibrational band of  $\text{CN}^+$ , J. L. Doménech, O. Asvany, **C. R. Markus**, S. Schlemmer, S. Thorwirth, *Journal of Molecular Spectroscopy*, (2020), **374**, 111375. DOI: 10.1016/j.jms.2020.111375
12. Vibrational excitation hindering an ion-molecule reaction: The  $\text{c-C}_3\text{H}_2^+-\text{H}_2$  collision complex, **C. R. Markus**, O. Asvany, T. Salomon, P. C. Schmid, S. Brünken, F. Lipparini, J. Gauss, S. Schlemmer, *Physical Review Letters*, (2020), **124**, 233401. DOI: 10.1103/PhysRevLett.124.233401
11. High-resolution rovibrational spectroscopy of  $\text{c-C}_3\text{H}_2^+$ : The  $\nu_7$  C-H antisymmetric stretching band, O. Asvany, **C. R. Markus**, T. Salomon, P. C. Schmid, S. Banhatti, S. Brünken, F. Lipparini, J. Gauss, S. Schlemmer, *Journal of Molecular Structure*, (2020), **1214**, 128023. DOI: 10.1016/j.molstruc.2020.128023
10. High-resolution double resonance action spectroscopy in ion traps: vibrational and rotational fingerprints of  $\text{CH}_2\text{NH}_2^+$ , **C. R. Markus**, S. Thorwirth, O. Asvany, and S. Schlemmer, *Physical Chemistry Chemical Physics*, (2019), **21**, 26406–26412. DOI: 10.1039/C9CP05487A
9. Photochemistry of Ozone–Water Ices, P. V. Johnson, **C. R. Markus** and R. Hodyss, *ACS Earth and Space Chemistry* (2019). DOI: 10.1021/acsearthspacechem.9b00189
8. Highly accurate experimentally determined energy levels of  $\text{H}_3^+$ , **C. R. Markus** and B. J. McCall, *Journal of Chemical Physics* (2019), **150**, 214303. DOI: 10.1063/1.5099454
7. Sub-Doppler rovibrational spectroscopy of the  $\nu_1$  fundamental band of  $\text{D}_2\text{H}^+$ , **C. R. Markus**, P. A. Kocheril, and B. J. McCall, *Journal of Molecular Spectroscopy* (2019), **355**, 8–13. DOI: 10.1016/j.jms.2018.11.005
6. Extended sub-Doppler resolution spectroscopy of the  $\nu_3$  band of methane, P. A. Kocheril, **C. R. Markus**, A. M. Esposito, A. W. Schrader, T. S. Dieter, and B. J. McCall, *Journal of Quantitative Spectroscopy and Radiative Transfer* (2018), **215**, 9–12. DOI: 10.1016/j.jqsrt.2018.04.033
5. Improving cavity-enhanced spectroscopy of molecular ions in the mid-infrared with up-conversion detection and Brewster-plate spoilers, C. R. Markus, A. J. Perry, J. N. Hodges, and B. J. McCall, *Optics Express* (2017), **25**, 3709–3721. DOI: 10.1364/OE.25.003709
4. Well-Defined Cobalt(I) Dihydrogen Catalyst: Experimental Evidence for  $\text{CO(I)}/\text{CO(III)}$  Redox Process in Olefin Hydrogenation, K. Tokmic, **C. R. Markus**, L. Zhu, and A. R. Fout, *Journal of the American Chemical Society* (2016), **138**, 11907–11913. DOI: 10.1021/jacs.6b07066

3. HIGH PRECISION SPECTROSCOPY OF OH<sup>+</sup>, **C. R. Markus**, J. N. Hodges, A. J. Perry, G. S. Kocheril, H. S. P. Müller, and B. J. McCall, *The Astrophysical Journal* (2016), **817**, 138–142. DOI: 10.3847/0004-637X/817/2/138
2. High-precision *R*-branch transition frequencies in the  $\nu_2$  fundamental band of H<sub>3</sub><sup>+</sup>, A. J. Perry, J. N. Hodges, **C. R. Markus**, G. S. Kocheril, and B. J. McCall, *The Journal of Molecular Spectroscopy* (2015), **317**, 71–73. DOI: 10.1016/j.jms.2015.09.004
1. Communication: High precision sub-Doppler infrared spectroscopy of the HeH<sup>+</sup> ion, A. J. Perry, J. N. Hodges, **C. R. Markus**, G. S. Kocheril, and B. J. McCall, *Journal of Chemical Physics* (2014), **141**, 101101-1–101101-5. DOI: 10.1063/1.4895505

## FELLOWSHIPS AND AWARDS

### University of Illinois at Urbana-Champaign

- (2020) Arnold O. Beckman Postdoctoral Fellowship
- (2017) Graduate College Conference Travel Award
- (2016, 2017, 2018) NASA Earth and Space Science Fellowship – Astrophysics
- (2016) Turkey Run Analytical Chemistry Conference Best Poster Award
- (2015) Coleman Departmental Fellowship
- (2015) National Science Foundation Graduate Research Fellowship – Honorable Mention
- (2014) Walter Brown Departmental Fellowship
- (2013) G. L. Clark Recruitment Fellowship

### University of Wisconsin–Madison

- (2011) Hilldale Undergraduate Research Fellowship

## PRESENTATIONS

### Invited

5. Investigating the Photochemistry of Earth and Other Planetary Atmospheres Through Multiplexed Infrared Spectroscopy, **C. R. Markus**, S. P. Sander, M. Okumura, *Beckman Symposium*, California Institute of Technology, Pasadena, CA, 2022.
4. Sensitive and High-Precision Spectroscopy of Astronomically Important Molecular Ions, **C. R. Markus**, *Astrochemistry Discussions*, 2021.
3. Sub-Doppler Spectroscopy of Molecular Ions in the Mid-Infrared, **C. R. Markus** and B. J. McCall *Seminaire ISMO*, Institut des Sciences Moléculaires d’Orsay, Orsay, France.
2. Sensitive and precise mid-infrared spectroscopy of molecular ions relevant to interstellar chemistry, **C. R. Markus**, A. M. Esposito, A. Schrader, P. A. Kocheril, and

B. J. McCall, *Stratospheric Observatory for Infrared Astronomy Colloquium*, Ames Research Center, Mountain View, CA, 2017.

1. High-precision and high-accuracy rovibrational spectroscopy of molecular ions, J. N. Hodges, A. J. Pery, **C. R. Markus**, G. S. Kocheril, P. A. Jenkins II, and B. J. McCall, *Twenty Third High Resolution Molecular Spectroscopy*, Bologna, Italy, 2014.

## Contributed

33. Investigation of Gas-Phase Radical Chemistry by Cavity-Enhanced Frequency Comb Spectroscopy with Chip-Scale Interband Cascade Lasers, **C. R. Markus**, T.-L. Chen, L. A. Sterczewski, D. C. Ober, C. L. Canedy, I. Vurgaftman, C. Frez, J. R. Meyer, M. Bagheri, and M. Okumura. *Gordon Research Seminar: Molecular Interactions and Dynamics*, Stonehill College, North Easton, MA, 2022. (Oral)
32. Dramatic Conformer-Dependent Reactivity of Acetaldehyde-Oxide Criegee Intermediate with Dimethylamine Via a 1,2-Insertion Mechanism, M. F. Vansco, K. Zuraski, F. A. F. Winiberg, M. Anwar H. Khan, T. Liu, M. Zou, K. Au, **C. R. Markus**, N. Trongsiwat, Y.-L. Li, Y.-H. Lin, W. Chao, J. J.-M. Lin, P. J. Walsh, D. E. Shallcross, L. Sheps, D. L. Osborn, C. J. Percival, S. J. Klippenstein, C. A. Taatjes, M.I. Lester, and R.L. Caravan. *Gordon Research Seminar: Molecular Interactions and Dynamics*, Stonehill College, North Easton, MA, 2022. (Oral)
31. MID-INFRARED SPECTROSCOPY OF TRANSIENT SPECIES USING A CHIP-SCALE MID-INFRARED OPTICAL FREQUENCY COMB, **C. R. Markus**, T.-L. Chen, L. A. Sterczewski, D. C. Ober, C. L. Canedy, I. Vurgaftman, C. Frez, J. R. Meyer, M. Bagheri, and M. Okumura. *The Seventy Fifth International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2022. (Oral)
30. HIGH-RESOLUTION INFRARED SPECTRA OF THE OH-STRETCHING BANDS OF PROTONATED WATER DIMER,  $\text{H}_5\text{O}_2^+$ , T. Solomon, O. Asvany, **C. R. Markus**, and S. Schlemmer, *The Seventy Fifth International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2022. (Oral)
29. CAVITY RING-DOWN SPECTROSCOPY WITH INTERBAND CASCADE OPTICAL FREQUENCY COMBS, T.-L. Chen, **C. R. Markus**, L. A. Sterczewski, D. C. Ober, C. L. Canedy, I. Vurgaftman, C. Frez, J. R. Meyer, M. Bagheri, and M. Okumura. *The Seventy Fifth International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2022. (Oral)
28. Cavity-Enhanced Direct Frequency Comb Spectroscopy in the CH Stretching Region with Interband Cascade Lasers, **C. R. Markus**, T.-L. Chen, L. A. Sterczewski, D. C. Ober, M. Bagheri, and M. Okumura. *The Twenty Seventh Colloquium on High-Resolution Molecular Spectroscopy*, Online conference, Cologne, Germany, 2021. (Oral)

27. DIRECT FREQUENCY COMB CAVITY ENHANCED SPECTROSCOPY FOR TRACE GAS DETECTION USING MID-INFRARED INTERBAND CASCADE LASERS, C. R. Markus, T.-L. Chen, D. C. Ober, L. A. Sterczewski, M. Bagheri, and M. Okumura, *The 2020 Virtual International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2021. (Oral)
26. HIGH-RESOLUTION DOUBLE RESONANCE ACTION SPECTROSCOPY IN ION TRAPS: VIBRATIONAL AND ROTATIONAL FINGERPRINTS OF  $\text{CH}_2\text{NH}_2^+$ , C. R. Markus, S. Thorwirth, O. Asvany, and S. Schlemmer, *The 2020 Virtual International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2021. (Oral)
25. MEASUREMENT OF THE  $A \leftarrow X$  BAND OF 1- AND 2-METHYLLALLYL RADICALS USING CAVITY RINGDOWN SPECTROSCOPY, C. R. Markus, W. Chao, G. H. Jones, M. Okumura, *The Seventy Fifth International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2021. (Oral)
24. NOISE IMMUNE CAVITY ENHANCED OPTICAL HETERODYNE ZEEMAN MODULATION SPECTROSCOPY, A. C. Wannemacher, C. R. Markus, and K. N. Crabtree, *The Seventy Fifth International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2021. (Oral)
23. Inhibiting the Reaction  $\text{H}_2 + c\text{-C}_3\text{H}_2^+$  with Vibrational Excitation, C. R. Markus, O. Asvany, T. Salomon, P. C. Schmid, S. Banhatti, F. Lipparini, J. Gauss, S. Brünken, and S. Schlemmer, *APS March Meeting 2021*. (Oral)
22. HIGHLY ACCURATE EXPERIMENTALLY DETERMINED ENERGY LEVELS AND FORBIDDEN ROTATIONAL TRANSITIONS OF  $\text{H}_3^+$ , C. R. Markus and B. J. McCall, *Twenty Sixth Colloquium on High-Resolution Molecular Spectroscopy*, Université de Bourgogne, Dijon, France, 2019. (Poster)
21. HINDERING AN ION-NEUTRAL REACTION USING VIBRATIONAL EXCITATION: THE  $\nu_7$  ROVIBRATIONAL BAND OF  $\text{C}_3\text{H}_2^+$ , C. R. Markus, O. Asvany, T. Salomon, P. C. Schmid, S. Banhatti, F. Lipparini, J. Gauss, S. Brünken, S. Schlemmer, *Seventy Fourth International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2019. (Oral)
20. HIGHLY-ACCURATE EXPERIMENTALLY DETERMINED ENERGY LEVELS OF  $\text{H}_3^+$ , C. R. Markus and B. J. McCall, *Seventy Fourth International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2019. (Oral)
19. Sub-Doppler spectroscopy of  $\text{H}_3^+$  to accurately determine ground state energy levels, C. R. Markus and B. J. McCall, *Advances in hydrogen molecular ions:  $\text{H}_3^+$ ,  $\text{H}_5^+$  and beyond*, The Royal Society, London, United Kingdom, 2019. (Poster)
18. Cavity-enhanced spectroscopy of  $\text{H}_3^+$  and  $\text{D}_2\text{H}^+$  in the mid-infrared, C. R. Markus, P. A. Kocheril, and B. J. McCall, *Gordon Research Conference: Vibrational Spectroscopy*, Biddeford, MA, 2018. (Poster)

17. Indirect rotational spectroscopy of the  $D_2H^+$  molecular ion, C. R. Markus, P. A. Kocheril, and B. J. McCall, *Seventy Third International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2018. (Oral)
16. Sub-Doppler spectroscopy of the  $\nu_3$  band of methane, P. A. Kocheril, C. R. Markus, A. M. Esposito, A. W. Schrader, T. S. Dieter, and B. J. McCall, *Seventy Third International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2018. (Oral)
15. Sub-Doppler spectroscopy of the  $\nu_2$  fundamental band and first hot band of  $H_3^+$ , C. R. Markus, P. A. Kocheril, A. M. Esposito, A. W. Schrader, and B. J. McCall, *Seventy Third International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2018. (Oral)
14. Sub-doppler rovibrational spectroscopy of the  $H_3^+$  cation and isotopologues, C. R. Markus, J. E. McCollum, T. S. Dieter, P. A. Kocheril, and B. J. McCall, *Seventy Second International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2017. (Oral)
13. Cavity-enhanced spectroscopy of molecular ions in the mid-infrared with up-conversion detection and Brewster-plate spoilers, C. R. Markus, J. E. McCollum, T. S. Dieter, J. N. Hodges, A. J. Perry, and B. J. McCall, *Seventy Second International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2017. (Oral)
12. Cavity-enhanced spectroscopy of molecular ions in the mid-infrared with up-conversion detection and Brewster-plate spoilers, C. R. Markus, J. E. McCollum, T. S. Dieter, P. A. Kocheril, and B. J. McCall, *Twelfth International User Meeting on Cavity Enhanced Spectroscopy*, Radboud University, Nijmegen, Netherlands, 2017. (Oral)
11. Improving cavity-enhanced spectroscopy of molecular ions in the mid-infrared with up-conversion detection, C. R. Markus, A. J. Perry, and B. J. McCall, *The Sixty Fourth Pacific Conference on Spectroscopy and Dynamics*, Pacific Grove, CA, 2017. (Poster)
10. Improving the sensitivity of cavity enhanced spectroscopy of molecular ions, C. R. Markus, A. J. Perry, and B. J. McCall, *Turkey Run Analytical Chemistry Conference*, Marshall, IL, 2016. (Poster)
9. Highly accurate and precise infrared transition frequencies of the  $H_3^+$  cation, A. J. Perry, G. S. Kocheril, J. N. Hodges, C. R. Markus, and B. J. McCall, *Seventy First International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2016. (Oral)
8. Improved spectroscopy of molecular ions in the mid-infrared with up-conversion detection, C. R. Markus, J. N. Hodges, A. J. Perry, and B. J. McCall, *Seventy First International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2016. (Oral)

7. High precision and high accuracy spectroscopy of molecular ions, **C. R. Markus**, A. J. Perry, J. N. Hodges, G. S. Kocheril, and B. J. McCall, *Midwest Astrochemistry Meeting*, The University of Northern Iowa, IA, 2015. (Poster)
6. Progress Towards a High-Precision Infrared Spectroscopic Survey of the  $\text{H}_3^+$  Ion, **A. J. Perry**, J. N. Hodges, **C. R. Markus**, G. S. Kocheril, P. A. Jenkins II, and B. J. McCall, *Seventieth International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2015. (Oral)
5. High Precision Infrared Spectroscopy of  $\text{OH}^+$ , **C. R. Markus**, A. J. Perry, J. N. Hodges, G. S. Kocheril, P. A. Jenkins II, and B. J. McCall, *Seventieth International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2015. (Oral)
4. Advances in Sensitive, Accurate, Precise Ion Spectroscopy through Noise Immune Cavity Enhanced Optical Heterodyne Velocity Modulation Spectroscopy,, **J. N. Hodges**, A. J. Perry, **C. R. Markus**, P. A. Jenkins II, G. S. Kocheril, and B. J. McCall, *Eleventh International User Meeting on Cavity Enhanced Spectroscopy*, NIST / NOA, Boulder, CO, 2015. (Oral)
3. High Precision and High Accuracy Spectroscopy of Molecular Ions, **C. R. Markus**, A. J. Perry, J. N. Hodges, G. S. Kocheril, and B. J. McCall, *Turkey Run Analytical Chemistry Conference*, Marshall, IL, 2014. (Poster)
2. High-Precision Sub-Doppler Infrared Spectroscopy of  $\text{HeH}^+$ ,, A. J. Perry, J. N. Hodges, **C. R. Markus**, G. S. Kocheril, P. A. Jenkins II, and B. J. McCall, *Sixty Ninth International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2014. (Oral)
1. New High Precision Linelist of  $\text{H}_3^+$ , J. N. Hodges, A. J. Perry, **C. R. Markus**, P. A. Jenkins II, G. S. Kocheril, and B. J. McCall, *Sixty Ninth International Symposium on Molecular Spectroscopy*, University of Illinois at Urbana-Champaign, Urbana, IL, 2014. (Oral).

## TEACHING EXPERIENCE

### The California Institute of Technology

#### Mentoring

Caltech WAVE Fellow, Summer 2021

High school student, Summer 2021

### University of Illinois at Urbana-Champaign

Chemistry 104: General Chemistry II, Teaching Assistant (Spring 2014)

Chemistry 420: Instrumental Characterization, Teaching Assistant (Fall 2013)



**Mentoring**

REU student, Summer 2015

UIUC bachelors thesis students, 2016, 2017, 2018

**University of Wisconsin–Madison**

Chemistry 103: General Chemistry I, Faculty Assistant (Fall 2012): Oversaw two discussion and laboratory sections

**SERVICE AND COMMITTEES**

(2015–2018) International Symposium on Molecular Spectroscopy: Symposium Assistant

(2016–2018) Physical Chemistry Student Selected Seminar Committee

**EXTRACURRICULAR UNIVERSITY SERVICE**

(2021-2022) Okumura Group Careers in Science Series: Gave a seminar on presenting effective scientific presentations

(2014–2016) Women Chemists Committee Bonding With Chemistry Girls Day Camp: Group leader

(2011-2012) Volunteer tutor in chemistry, physics, and mathematics at the Greater University Tutoring Service at the University of Wisconsin-Madison