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Research Keywords

X-ray and laser sciences; atomic, molecular, and optical physics; condensed matter physics; quantum sensing and quantum metrology; quantum optics; nonlinear optics; ultrafast science; imaging science; nanomaterials characterization.

Education

Ph.D.	Optical Sciences	University of Arizona, Tucson, Arizona, U.S.A.	2017
M.S.	Optical Sciences	University of Arizona, Tucson, Arizona, U.S.A.	2013
M.S.	Physics	National Central University, Taoyuan, Taiwan	2007
B.S.	Space Science	National Central University, Taoyuan, Taiwan	2005

Professional Experience

2021-present	Senior Research Associate JILA, University of Colorado Boulder & NIST, Boulder, Colorado, U.S.A. and Assistant Director of Research and Knowledge Transfer STROBE, NSF Science and Technology Center on Real-Time Functional Imaging, CU Boulder UCLA UC Berkeley UC Irvine FIU Fort Lewis College, U.S.A.
2017-2021	Postdoctoral Associate JILA, University of Colorado Boulder and NIST, Boulder, Colorado, U.S.A.
2012-2017	Graduate Research Associate Department of Physics, University of Arizona, Tucson, Arizona, U.S.A.
2011-2012	Graduate Research Assistant College of Optical Sciences, University of Arizona, Tucson, Arizona, U.S.A.
2009-2010	X-ray Project Engineer Dept. of Biomedical Imaging and Radiological Sciences, National Yang Ming Chiao Tung University, Taipei, Taiwan
2008-2009	Semiconductor Process Engineer United Microelectronics Corporation, Hsinchu, Taiwan
2004-2007	Graduate Research Assistant Department of Physics, National Central University, Taoyuan, Taiwan

Publications: Patents

- C.-T. Liao**, B. Wang, M. Tanksalvala, M. Murnane, H. Kapteyn. "Coherent Fourier Scatterometry Using Orbital Angular Momentum Beams." *Provisional Patent Application* App. No.: 62971735. 7 Feb 2020.
- H. Kapteyn, B. Wang, **C.-T. Liao**, M. Murnane. "Quantum-limited Extended Ultraviolet / Soft X-ray Coherent Diffraction Imaging." *International Patent* App. No.: PCT/US20/14140. 17 January 2020.

Publications: Invited book chapter and invited articles

- C.-T. Liao**, C. Hernández-García, and M. Murnane, "Switching the Twist in X Rays with Magnets," *Physics* 14, 34 (2021). DOI: <https://doi.org/10.1103/Physics.14.34> [Invited viewpoint article]
- H. Kapteyn, M. Murnane, Y. Esashi, M. Tanksalvala, J. Knobloch, **C.-T. Liao**, D. Hickstein, C. Bargsten, K. Dorney, J. Petersen. "Coherent EUV light sources based on High-Order Harmonic Generation—Principles and Applications in Nanotechnology." *Photon Sources for Lithography and Metrology*, edited by Vivek Bakshi, *SPIE Press*, in press (2021) [Invited Book Chapter]

Publications: Journal papers

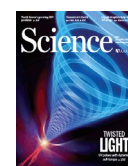
(19 articles in total, including 17 articles published, 2 manuscripts under review, and 2 manuscripts in preparation)
(h-index 9, total citations >400, as of 2021 Sep)

Manuscripts under review or in preparation

1. C. Gentry, **C.-T. Liao***, W. You, B. Varner, X. Shi, T. Gray, D. Temple, M. Raschke, K. Rossnage, H. Kapteyn, M. Murnane, and E. Cating-Subramanian*. "Super-resolved time-frequency measurements of Phonon Dynamics in 2D Quantum Material," *manuscript under review in a Nature research journal* (2021). [*Corresponding author]
2. A. Rana[†], **C.-T. Liao[†]**, E. Iacocca, J. Zou, M. Pham, E. Cating-Subramanian, Y. Lo, S. Ryan, X. Lu, C. Bevis, R. Karl Jr, A. Glaid, J. Rable, P. Mahale, Y. Yu, H. Ohldag, D. Shapiro, S. Yazdi, T. Mallouk, S. Osher, H. Kapteyn, V. Crespi, J. Badding, Y. Tserkovnyak, M. Murnane, J. Miao. "Creation and observation of topological magnetic monopoles and their interactions in a ferromagnetic meta-lattice," *manuscript under review in a Nature research journal* (2021). Preprint title in ArXiv: "Direct observation of 3D topological spin textures," <https://arxiv.org/abs/2104.12933> [*Equal contribution]

Peer-reviewed and published articles

3. G. Gui, N. Brooks, H. Kapteyn, M. Murnane, and **C.-T. Liao***. "Second-harmonic generation and the conservation of spatiotemporal orbital angular momentum of light," *Nature Photonics* 15, 608 (2021). DOI: <https://doi.org/10.1038/s41566-021-00841-8> [Impact factor 31.2] [*Corresponding author]
4. G. Gui, A. Adak, M. Dandapat, D. Carlson, A. Guggenmos, H. Kapteyn, M. Murnane, V. Pervak, and **C.-T. Liao***, "Measurement and control of optical nonlinearities in dispersive dielectric multilayers." *Optics Express* 29, 4947 (2021) DOI: <https://doi.org/10.1364/OE.409216>. [Impact factor 3.7] [*Corresponding author]
5. B. Wang, M. Tanksalvala, Z. Zhang, Y. Esashi, N. Jenkins, H. Kapteyn, M. Murnane, and **C.-T. Liao***. "Coherent Fourier scatterometry using orbital angular momentum beams for defect detection." *Optics Express* 29, 3342 (2021). DOI: <https://doi.org/10.1364/OE.414584> [Impact factor 3.7] [*Corresponding author]
6. M. Tanksalvala, C. Porter, Y. Esashi, B. Wang, N. Jenkins, Z. Zhang, G. Miley, J. Knobloch, B. Mcbennett, N. Horiguchi, S. Yazdi, J. Zhou, E. Hosler, M. Jacobs, C. Bevis, R. Karl Jr., P. Johnsen, G. Kuo, M. Chen, G. Gunjala, D. Ren, L. Waller, D. Adams, S. Cousin, **C.-T. Liao**, J. Miao, M. Gerrity, H. Kapteyn, and M. Murnane, "EUV ptychographic complex-imaging reflectometry." *Science Advances* 7, eabd9667 (2021). DOI: <https://doi.org/10.1126/sciadv.abd9667> [Impact factor 13.1]
7. X. Shi, **C.-T. Liao**, Z. Tao, E. Cating-Subramanian, M. Murnane, C. Hernandez Garcia, H. Kapteyn. "Attosecond light science and its applications for probing quantum materials." *Journal of Physics B: Atomic, Molecular and Optical Physics* 53 184008 (2020) DOI: <https://doi.org/10.1088/1361-6455/aba2fb> [Impact factor 1.7].
8. Y.H. Lo, **C.-T. Liao**, J. Zhou, A. Rana, C.S. Bevis, G. Gui, B. Enders, K. Cannon, Y.-S. Yu, R. Celestre, K. Nowrouzi, D. Shapiro, H. Kapteyn, R. Falcone, C. Bennett, M. Murnane, and J. Miao. "Multimodal x-ray and electron microscopy of the Allende meteorite," *Science Advances* 5, eaax3009 (2019). DOI: <https://doi.org/10.1126/sciadv.aax3009> [Impact factor 13.1]
9. **C.-T. Liao**, Y.H. Lo, J. Zhou, A. Rana, C.S. Bevis, G. Gui, B. Enders, K. Cannon, D. Shapiro, C. Bennett, H. Kapteyn, R. Falcone, J. Miao, and M. Murnane, "SQUARREL: scattering quotient analysis to retrieve the ratio of elements in x-ray ptychography." *Microscopy and Microanalysis* 25, 112 (2019). DOI: <https://doi.org/10.1017/S1431927619001296> [Impact factor 3.4]
10. L. Rego, K. Dorney, N. Brooks, Q. Nguyen, **C.-T. Liao**, J. S. Román, D. Couch, A. Liu, E. Pisanty, M. Lewenstein, L. Plaja, H. Kapteyn, M. Murnane, and C. Hernández-García. "Generation of extreme-ultraviolet beams with time-varying orbital angular momentum," *Science* 364, eaaw9486 (2019). DOI: <https://doi.org/10.1126/science.aaw9486> [Impact factor 41.8] [Featured on the cover of *Science* shown on the right].
11. K. Dorney, L. Rego, N. Brooks, J. Román, **C.-T. Liao**, J. Ellis, D. Zusin, C. Gentry, Q. Nguyen, J. Shaw, A. Picón, L. Plaja, H. Kapteyn, M. Murnane, and C. Hernández-García, "Controlling the polarization, divergence and vortex charge of attosecond high-harmonic beams via simultaneous spin-orbit momentum conservation," *Nature Photonics*, 13, 123 (2018). DOI: <https://doi.org/10.1038/s41566-018-0304-3> [Impact factor 31.2]
12. Y. Esashi, **C.-T. Liao***, B. Wang, N. Brooks, K. Dorney, C. Hernández-García, H. Kapteyn, D. Adams, and M. Murnane. "Ptychographic amplitude and phase reconstruction of bichromatic vortex beams," *Optics Express* 26, 34007 (2018). DOI: <https://doi.org/10.1364/OE.26.034007> [Impact factor 3.7] [*Corresponding author]
13. N. Harkema, J. E. Bækhoj, **C.-T. Liao**, K. B. Schafer, M. J. Gaarde, and A. Sandhu, "Controlling attosecond transient absorption with tunable, non-commensurate light fields," *Optics Letters* 43, 3357 (2018). DOI: <https://doi.org/10.1364/OL.43.003357> [Impact factor 3.7]
14. **C.-T. Liao** and A. Sandhu. "XUV Transient Absorption Spectroscopy: Probing Laser-Perturbed Dipole Polarization in Single Atom, Macroscopic, and Molecular Regimes." *Photonics* 4, 17 (2017). DOI: <https://doi.org/10.3390/photonics4010017> [Impact factor 2.1]



15. **C.-T. Liao**, X. Li, D. J. Haxton, T. N. Rescigno, R. R. Lucchese, C. W. McCurdy, and A. Sandhu. "Probing autoionizing states of molecular oxygen with XUV transient absorption: Electronic symmetry dependent lineshapes and laser induced modifications." *Physical Review A* 95, 4, 043427 (2017). DOI: <https://doi.org/10.1103/PhysRevA.95.043427> [Impact factor 2.8]
16. **C.-T. Liao**, A. Sandhu, S. Camp, K. J. Schafer, and M. B. Gaarde. "Attosecond transient absorption in dense gases: Exploring the interplay between resonant pulse propagation and laser-induced line-shape control." *Physical Review A* 93, 3, 033405 (2016). DOI: <https://doi.org/10.1103/PhysRevA.93.033405> [Impact factor 2.8]
17. **C.-T. Liao**, A. Sandhu, S. Camp, K. J. Schafer, and M. B. Gaarde. "Beyond the single-atom response in absorption line shapes: probing a dense, laser-dressed helium gas with attosecond pulse trains." *Physical Review Letters* 114, 14, 143002 (2015). DOI: <https://doi.org/10.1103/PhysRevLett.114.143002> [Impact factor 8.4]
18. **C.-T. Liao**, L.-W. Teng, C.-Y. Tsai, C.-W. Io, and I. Lin. "Lagrangian-Eulerian micromotion and wave heating in nonlinear self-excited dust-acoustic waves." *Physical Review Letters* 100, 18, 185004 (2008). DOI: <https://doi.org/10.1103/PhysRevLett.100.185004> [Impact factor 8.4]
19. H.-Y. Chu, **C.-T. Liao**, and I. Lin "Explosion dynamics of dusty plasma liquids induced by laser ablation on suspended dust particles." *Applied Physics Letters* 89, 10, 101503 (2006). DOI: <https://doi.org/10.1063/1.2348778> [Impact factor 3.6]

Honors & Awards

- 2019 R&D 100 Award (international team award): QM Quantum Microscope–Next Generation Microscopy & Analysis. Co-developed by KM Labs Inc. and JILA team through DoD DARPA STTR grants.
- 2019 Finalist (top 4), APS Carl E. Anderson Division of Laser Science Dissertation Award.
- 2018 Finalist (top3), WAGS-ProQuest Innovation in Technology Award.
- 2017 APS DLS Travel Grant Award.
- 2016 Arizona TRIF (Technology and Research Initiative Fund) Scholarship for PoW Workshop Series.
- 2015 Arizona TRIF (Technology and Research Initiative Fund) Photonics Fellowship Award.
- 2014 Arizona TRIF (Technology and Research Initiative Fund) Imaging Fellowship Award.
- 2014 Second-Place, University of Arizona GPSC Student Showcase in Physical Sciences.
- 2014 APS DAMOP Travel Grant Award.
- 2013 First-Place, University of Arizona GPSC Student Showcase in Physical Sciences.
- 2013 Taiwan Ministry of Education Technologies Incubation Scholarship Award.
- 2013 University of Arizona Optical Sciences Graduate Tuition Scholarship Award.
- 2010 University of Arizona Optical Sciences Graduate Tuition Scholarship Award.
- 2010 University of Arizona Optical Sciences Fellowship Award.
- 2007 Outstanding Poster Award of Physical Society Taiwan.
- 2005 Outstanding Poster Award of Physical Society Taiwan.
- 2005 First-Prize Scholarship in Admission to Physics at National Central University.

Synergistic Activities

Editorial Service / Journal Referee

- Science Advances (AAAS); Physics Review Letters (APS); Physics Review A (APS); Communication Physics (Springer Nature); Applied Optics (Optica, formerly OSA); Optics Letters (Optica, formerly OSA); Atoms (MDPI); Applied Sciences (MDPI); Crystals (MDPI); Sensors (MDPI); Journal of Physics B (IOP Publishing)

Professional Memberships

- American Physical Society (APS), number
- Optica, formerly Optical Society (OSA), number
- Society of Photo-Optical Instrumentation Engineers (SPIE), number
- Institute of Electrical and Electronics Engineers (IEEE), number

Recent Service and Outreach Activities

- Co-planned and conducted various education and outreach activities, events, and programs with STROBE and PEAQS. For example, several Summer Undergraduate Research Scholars Programs involving several students from minority-serving institutions (2021 May-Aug).
- Co-planned, conducted lab tours in JILA, Physics, and ECE departments at CU Boulder for the 2019 NSF STROBE site visit Meeting (Jun 2019)
- Co-planned, conducted lab tours at the University of Arizona for the 2016 Joint-Attosecond-MURI Annual Meeting (Nov 2016)

- Co-planned and conducted demonstrations and lab tours for new student orientation of the University of Arizona (Aug 2016)
- Co-planned and conducted demonstrations and lab tours on “Atomic demolition with high-power lasers” at Science City at Tucson Festival of Books (Mar 2016)
- Conducted demonstrations and lab tours at the University of Arizona Physics to promote STEM on the High School Day in Tucson (Oct 2015)
- Conducted demonstrations and lab tours on the Physics Event for Sunnyside High School (Apr 2015)
- Conducted demonstrations at 5th annual Laser Fun Day, themed after the International Year of Light 2015 (IYL2015) (Feb 2015)
- Co-planned and conducted demonstrations on Physics Open Day (Mar 2014) at the University of Arizona on “Blasting Atoms with Attosecond Photon torpedoes.”
- Conducted demonstrations and lab tours on the Physics Event for Walden Grove High School (Nov 2014)
- Conducted lab tours for undergraduate merit scholars (Oct 2014)
- Conducted demonstrations and lab tours for BASIS high school (Oct 2014)
- College of Optical Sciences recruitment representative in the Graduate School Fair at 2014 APS March Meeting in Denver (Mar 2014)
- Exhibit staff of the College of Optical Sciences for American Physical Society Graduate School Fair in Denver (Mar 2014)
- Co-planned and conducted demonstrations on Physics Open Day (Mar 2013) at the University of Arizona on “Blasting Atoms with Attosecond Photon Torpedoes.”
- Conducted demonstrations and lab tours on the Physics Event for Sonoran Science Academy Tucson (Feb 2013)
- Conference staff of The International OSA Network of Students (IONS-NA2) Conference in Tucson (Sep 2010)

Invited Oral Presentations (2017-)

1. **C.-T. Liao.** "Frontiers of X-ray Imaging Science for Nanomaterial Characterization," Physics & Engineering Science Seminar, Fort Lewis College. Oct-21, 2021. Durango, Colorado, U.S.A.
2. **C.-T. Liao.** "Frontiers of X-ray Imaging Science for Nanomaterial Characterization," Department of Physics & Materials Science Seminar, Norfolk State University. Sep-24, 2021. Norfolk, Virginia, U.S.A.
3. **C.-T. Liao,** A. Rana, and E. Cating-Subramanian, "Imaging Magnetic Materials: Structure and Texture - Practical solutions to complex imaging challenges From Table-Top to facility scales experiments." STROBE Research Seminar. Apr-2, 2020. Virtual at CU Boulder, UCLA, UC Berkeley, Florida International University, UC Irvine.
4. **C.-T. Liao,** S. Camp, X. Li, N. Harkema, D. Haxton, J. Bækhoj, T. Rescigno. R. Lucchese, K. Schafer, C. McCurdy, M. Gaarde, A. Sandhu. "Exploring Ultrafast Quantum Dynamics of Electrons by Attosecond Transient Absorption," LS Dissertation Award Presentations, Frontiers in Optics/Laser Science (FiO+LS 2019). Sep-16, 2019, Washington, DC, U.S.A.
5. **C.-T. Liao.** "Polarization-Shaped Extreme Ultraviolet Light Sources for Probing Quantum Materials," The 3rd annual EPIQS (The Gordon and Betty Moore Foundation's Emergent Phenomena in Quantum Systems) Postdoctoral Symposium. Jun-6, 2019. Beverly, Massachusetts, U.S.A.
6. **C.-T. Liao.** "Exploring Ultrafast Quantum Dynamics of Electrons by Attosecond Transient Absorption," Special Seminar in Department of Physics, Seminar in the Department of Physics, National Central University. Jun-5, 2017. Taoyuan, Taiwan.
7. **C.-T. Liao.** "Exploring Ultrafast Quantum Dynamics of Electrons by Attosecond Transient Absorption," Special Seminar in Institute of Photonics Technologies, Seminar in the Institute of Photonics Technologies & Department of Electrical Engineering, National Tsing Hua University, Jun-6, 2017. Hsinchu, Taiwan.