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Education

2000	Ph.D. Physics, University of Chicago
1999	M.S. Physics, University of Chicago
1993	B.A. Physics, *magna cum laude*, Rice University

Doctoral thesis

Composition and Spectrum of Cosmic Rays at the Knee as Measured by the CASA-BLANCA Experiment. **Advisor:** René Ong

Research and Teaching Appointments

Senior Research Associate, University of Colorado and NIST, 2010-present
Member of NIST's Quantum Sensors Project, working on TES-based microcalorimeters for high-precision spectroscopy of x rays and gamma rays. Leading the development of a high-throughput data analysis pipeline for microcalorimeter data. Developing new physics applications for microcalorimeters.

ARRA Fellow and Affiliate, NIST Boulder Labs, 2010-12
Member of NIST's Quantum Sensors Project, continuing to participate in two observational cosmology projects: ABS and ACTpol.

Assistant Professor of Physics, Princeton University, 2003-10
Led the data analysis pipeline and the site data acquisition software for the Atacama Cosmology Telescope (ACT). Led the optical design of ACT and the silicon lens development effort. Supervised students working on control software, analysis code, readout electronics, motion control, and analysis of radio point sources. Worked on instrument design, systematic errors, and observation strategy for the Atacama B-mode Search (ABS) and for ACT's polarization camera upgrade, ACTpol.

Robert H. Dicke Postdoctoral Fellow, Princeton University, 2000-03
Worked on the design and deployment of MINT, a millimeter interferometer for CMB studies, which observed in Chile in late 2001. Led the calibration and the analysis of MINT CMB data.

Graduate Research Assistant, University of Chicago, 1994-99
Designed, built, operated, and calibrated a new array of 144 atmospheric Cherenkov detectors, and determined properties of the cosmic ray composition in the 1 to 10 PeV range.

Graduate Teaching Assistant, University of Chicago, 1994-98
Assisted in the graduate particle physics course; taught introductory undergraduate physics labs.

Current Experiments

NIST Quantum Sensors Project including: x-ray metrology; tomography of integrated circuits;

synchrotron instruments at NSLS, SSRL, APS, BESSY; HOLMES; and energy-dispersive x-ray diffraction.

Past Experiments

Atacama Cosmology Telescope (ACT), ACT Polarization Camera (ACTpol), Atacama B-mode Search (ABS), Millimeter Interferometer (MINT), Chicago Air Shower Array (CASA-MIA), Broad Lateral Non-imaging Cherenkov Array (CASA-BLANCA).

Awards and Honors

Physical Measurement Laboratory Distinguished Associate Award, NIST, 2019
Physical Measurement Laboratory Distinguished Associate Award, NIST, 2017
Physical Measurement Laboratory Distinguished Associate Award, NIST, 2015
American Recovery and Reinvestment Act Fellowship, NIST, University of Colorado, 2010
Engineering Council Award for Excellence in Teaching, Princeton University, 2004
Robert Dicke Postdoctoral Fellowship, Princeton University, 2000
David Grainger Graduate Fellowship, University of Chicago, 1998
Nathan Sugarman Award for graduate research, University of Chicago, 1997
Valentine Telegdi Prize for the qualifying exam, University of Chicago, 1994
National Science Foundation Graduate Fellowship, University of Chicago, 1993
Robert McCormick Graduate Fellowship, University of Chicago, 1993
Phi Beta Kappa, Rice University, 1993
Tom Bonner Prize in Physics, Rice University, 1992

Research Interests

I develop techniques and software to analyze data generated by very high-resolution microcalorimeters for x-ray and gamma-ray detection. These techniques include energy calibration, real-time processing, and analysis beyond the standard optimal-filter approach. I have pioneered the use of cryogenic microcalorimeters for metrological x-ray measurements. I work to reduce or eliminate problems presented by sensor nonlinearity, pulse pile-up, cross-talk, and non-white sensor noise. I work on problems in the design of superconducting sensors and their multiplexed SQUID-based readout systems.

I also made observations of the cosmic microwave background radiation, working on experiments to measure both the small-scale secondary anisotropies (ACT and ACTpol) and the large-scale polarization signals (ABS). On the instrument side, I take a particular interest in controlling systematic errors, data acquisition and instrument control systems, optical design, and computer modelling of instruments. I directed the initial ACT data analysis pipeline.

Publications

J. W. Fowler, et al., "The potential of microcalorimeter x-ray spectrometers for measurement of relative fluorescence-line intensities," *Radiation Phys. and Chem.* **202**, 110487 (2023). arXiv:2208.07795

J. W. Fowler, et al., "Energy calibration of nonlinear microcalorimeters with uncertainty estimates from Gaussian process regression," *J. Low Temp. Phys.* **209**, 1047 (2022). arXiv:2204.08431

D. Yan, et al., "Absolute Energy Measurements with Superconducting Transition-Edge Sensors for Muonic X-ray Spectroscopy at 44 keV," *J. Low Temp. Phys.* **209**, 271 (2022). arXiv:2207.10845

Z. Levine, et al., "A Tabletop X-Ray Tomography Instrument for Nanometer-Scale Imaging: Reconstructions," *Nature Nanophotonics*, submitted 2022.

N. Nakamura, et al., "A Tabletop X-Ray Tomography Instrument for Nanometer-Scale Imaging: Integration of a Scanning Electron Microscope with a Transition-Edge Sensor Spectrometer," *Review of Scientific Instruments*, submitted 2022.

T. Hashimoto, et al., "Measurements of Strong-Interaction Effects in Kaonic-Helium Isotopes at Sub-eV Precision with X-Ray Microcalorimeters," *Physical Review Letters* **128**, 112503 (2022).

J. W. Fowler, et al., "Absolute energies and emission line shapes of the x-ray lines of lanthanide metals," *Metrologia* **58**, 015016 (2021). arXiv:2012.00130

L. Miaja-Avila, et al., "Valence-to-core x-ray emission spectroscopy of titanium compounds using energy dispersive detectors," *X-Ray Spectrometry* **50**, 9 (2021).

T. Okomura, et al., "Deexcitation Dynamics of Muonic Atoms Revealed by High-Precision Spectroscopy of Electronic X rays," *Physical Review Letters* **127**, 053001 (2021).

P. Szypryt, et al., "Design of a 3000-Pixel Transition-Edge Sensor X-Ray Spectrometer for Microcircuit Tomography," *IEEE Trans. Applied Superconductivity* **31**, 2100405 (2021).

S. Yamada, et al., "Broadband high-energy resolution hard x-ray spectroscopy using transition edge sensors at SPring-8," *Review of Scientific Instruments* **92**, 013103 (2021).

M. Durkin, et al., "Mitigation of finite bandwidth effects in time-division-multiplexed SQUID readout of TES arrays," *IEEE Trans. Applied Superconductivity* **31**, 1600905 (2021).

S. J. Smith, et al., "Performance of a broad-band, high-resolution, transition-edge sensor spectrometer for X-ray astrophysics," *IEEE Trans. Applied Superconductivity* **31**, 2100806 (2021).

G. C. O'Neil, et al., "Measurement of the $^2P_{1/2} - ^2 P_{3/2}$ fine-structure splitting in fluorinelike Kr, W, Re, Os, and Ir," *Phys. Review A* **102**, 032803 (2020).

S. Okada, et al., "X-ray Spectroscopy of Muonic Atoms Isolated in Vacuum with Transition Edge Sensors," *J. Low Temp. Phys.* **200**, 445 (2020).

J. W. Fowler, et al., "A robust principal component analysis for outlier identification in messy microcalorimeter data," *J. Low Temp. Phys.* **199**, 745 (2020). arXiv:1911.00423

M. B. Gralla, et al., "Atacama Cosmology Telescope: Dusty star-forming galaxies and active galactic nuclei in the equatorial survey," *Astrophysical Journal* **893**, 104 (2020). arXiv:1905.04592

Y.-I. Joe, et al., "Resonant Soft X-Ray Scattering from Stripe-Ordered $La_{2-x}Ba_xCuO_4$ Detected by a Transition-Edge Sensor Array Detector," *Physical Review Applied* **13**, 034026 (2020). arXiv:1907.07864

Z. Li, et al., "The cross correlation of the ABS and ACT maps," *J. Cosmology & Astroparticle Phys* **2020**, 010 (2020). arXiv:2002.05717

P. Szypryt, et al., "A transition-edge sensor-based x-ray spectrometer for the study of highly charged ions at the National Institute of Standards and Technology electron beam ion trap," *Review of Scientific Instruments* **90**, 123107 (2019). arXiv:2005.05483

D. T. Becker, et al., "Advances in analysis of microcalorimeter gamma-ray spectra," *IEEE Trans. Nuclear Science* **66**, 2355 (2019).

S.-J. Lee, et al., "Soft X-ray spectroscopy with transition-edge sensors at Stanford Synchrotron Radiation Lightsource beamline 10-1," *Review of Scientific Instruments* **90**, 113101 (2019).

D. T. Becker, et al., "Working principle and demonstrator of microwave-multiplexing for the HOLMES experiment microcalorimeters," *J. Instrumentation* **14**, P10035 (2019). arXiv:1910.05217

J. C. Weber, et al., "Configurable error correction of code-division multiplexed TES detectors with a cryotron switch," *Applied Physics Letters* **114**, 232602 (2019).

M. Durkin, et al., "Demonstration of athena X-IFU compatible 40-row time-division-multiplexed readout," *IEEE Trans. Applied Superconductivity* **29**, 2101005 (2019).

W. B. Doriese, et al., "Optimization of time-and code-division-multiplexed readout for athena x-ifu," *IEEE Trans. Applied Superconductivity* **29**, 2500305 (2019).

D. A. Bennett, et al., "Microwave SQUID multiplexing for the Lynx x-ray microcalorimeter," *J. Astro. Telescopes, Instruments, Systems* **5**, 021007 (2019).

D. Li, et al., "TES x-ray spectrometer at SLAC LCLS-II," *J. Low Temp. Phys.* **193**, 1287 (2018).

J. D. Gard, et al., "A scalable readout for microwave SQUID multiplexing of transition-edge sensors," *J. Low Temp. Phys.* **193**, 485 (2018).

C. G. Pappas, et al., "A highly linear calibration metric for TES x-ray microcalorimeters," *J. Low Temp. Phys.* **193**, 249 (2018). arXiv:1808.00623

C. J. Titus, et al., "Error-correcting codes for code-division multiplexed TES detectors," *J. Low Temp. Phys.* **193**, 556 (2018).

W. Yoon, et al., "Toward large field-of-view high-resolution x-ray imaging spectrometers: microwave multiplexed readout of 28 TES microcalorimeters," *J. Low Temp. Phys.* **193**, 258 (2018).

J. W. Fowler, et al., "Approaches to the optimal nonlinear analysis of microcalorimeter pulses," *J. Low Temp. Phys.* **193**, 539 (2018). arXiv:1803.02827

D. Yan, et al., "Microstructure analysis of bismuth absorbers for transition-edge sensor x-ray microcalorimeters," *J. Low Temp. Phys.* **193**, 225 (2018).

A. Kusaka, et al., "Results from the Atacama B-mode Search (ABS) experiment," *J. Cosmology & Astroparticle Phys* **2018**, 005 (2018). arXiv:1801.01218

C. J. Titus, et al., "L-edge spectroscopy of dilute, radiation-sensitive systems using a transition-edge-sensor array," *J. Chem. Phys.* **147**, 214201 (2017). arXiv:1706.09878

D. Yan, et al., "Eliminating the non-Gaussian spectral response of X-ray absorbers for transition-edge sensors," *Applied Physics Letters* **111**, 192602 (2017).

J. A. B. Mates, et al., "Simultaneous readout of 128 X-ray and gamma-ray transition-edge microcalorimeters using microwave SQUID multiplexing," *Applied Physics Letters* **111**, 062601 (2017).

J. W. Fowler, et al., "A reassessment of absolute energies of the x-ray L lines of lanthanide metals," *Metrologia* **54**, 494 (2017). arXiv:1702.00507

W. Guo, et al., "Counting near infrared photons with microwave kinetic inductance detectors," *Applied Physics Letters* **110**, 212601 (2017). arXiv:1702.07993

W. B. Doriese, et al., "A practical superconducting-microcalorimeter X-ray spectrometer for beamline and laboratory science," *Review of Scientific Instruments* **88**, 053108 (2017).

G. C. O'Neil, et al., "Ultrafast time-resolved X-ray absorption spectroscopy of ferrioxalate photolysis with a laser plasma X-ray source and microcalorimeter array," *J. Phys. Chem. Letters* **8**, 1099 (2017).

R. J. Thornton, et al., "The Atacama cosmology telescope: the polarization-sensitive ACTPol instrument," *Astrophys. J. Supplement* **227**, 21 (2016). arXiv:1605.06569

J. W. Fowler, et al., "When 'Optimal Filtering' Isn't," *IEEE Trans. Applied Superconductivity* **27**, 2500404 (2016). arXiv:1611.07856

L. Miaja-Avila, et al., "Ultrafast time-resolved hard X-ray emission spectroscopy on a tabletop," *Physical Review X* **6**, 031047 (2016).

K. M. Morgan, et al., "Code-division-multiplexed readout of large arrays of TES microcalorimeters," *Applied Physics Letters* **109**, 112604 (2016).

HEATES Collaboration, et al., "First application of superconducting transition-edge sensor microcalorimeters to hadronic atom X-ray spectroscopy," *Prog. Theor. Experimental Phys.* **2016**, 091D01 (2016).

M. R. J. Palosaari, et al., "Broadband ultrahigh-resolution spectroscopy of particle-induced X rays: extending the limits of nondestructive analysis," *Physical Review Applied* **6**, 024022 (2016).

E. Ferri, et al., "Pile-up discrimination algorithms for the HOLMES experiment," *J. Low Temp. Phys.* **184**, 405 (2016).

W. B. Doriese, et al., "Developments in time-division multiplexing of x-ray transition-edge sensors," *J. Low Temp. Phys.* **184**, 389 (2016).

B. Alpert, et al., "Algorithms for identification of nearly-coincident events in calorimetric sensors," *J. Low Temp. Phys.* **184**, 263 (2016). arXiv:1512.01608

J. W. Fowler, et al., "The practice of pulse processing," *J. Low Temp. Phys.* **184**, 374 (2016). arXiv:1511.03950

Y.-I. Joe, et al., "Observation of iron spin-states using tabletop x-ray emission spectroscopy and microcalorimeter sensors," *J. Phys B: Atomic, Molecular, Optical Phys.* **49**, 024003 (2015).

J. W. Fowler, et al., "Microcalorimeter spectroscopy at high pulse rates: A multi-pulse fitting technique," *Astrophys. J. Supplement* **219**, 35 (2015). arXiv:1503.05989

J. Uhlig, et al., "High-resolution X-ray emission spectroscopy with transition-edge sensors: present performance and future potential," *J. Synchrotron Radiation* **22**, 766 (2015).

R. Winkler, et al., "256-pixel microcalorimeter array for high-resolution γ-ray spectroscopy of mixed-actinide materials," *Nucl. Instr. Methods A* **770**, 203 (2015).

S. Naess, et al., "The Atacama cosmology telescope: CMB polarization at $200<\ell<9000$," *J. Cosmology & Astroparticle Phys* **2014**, 007 (2014). arXiv:1405.5524

J. W. Fowler, et al., "Maximum-likelihood fits to histograms for improved parameter estimation," *J. Low Temp. Phys.* **176**, 414 (2014). arXiv:1312.5622

M. R. J. Palosaari, et al., "Transition-edge sensors for particle induced X-ray emission measurements," *J. Low Temp. Phys.* **176**, 285 (2014).

A. S. Hoover, et al., "Uncertainty of plutonium isotopic measurements with microcalorimeter and high-purity germanium detectors," *IEEE Trans. Nuclear Science* **61**, 2365 (2014).

J. N. Ullom, et al., "Transition-edge sensor microcalorimeters for X-ray beamline science," *Synchrotron Radiation News* **27**, 24 (2014).

S. Das, et al., "The Atacama Cosmology Telescope: temperature and gravitational lensing power spectrum measurements from three seasons of data," *J. Cosmology & Astroparticle Phys* **2014**, 014 (2014). arXiv:1301.1037

R. Datta, et al., "Large-aperture wide-bandwidth antireflection-coated silicon lenses for millimeter wavelengths," *Applied Optics* **52**, 8747 (2013). arXiv:1307.4715

O. Noroozian, et al., "High-resolution gamma-ray spectroscopy with a microwave-multiplexed transition-edge sensor array," *Applied Physics Letters* **103**, 202602 (2013). arXiv:1310.7287

J. L. Sievers, et al., "The Atacama Cosmology Telescope: Cosmological parameters from three seasons of data," *J. Cosmology & Astroparticle Phys* **2013**, 060 (2013). arXiv:1301.0824

M. Hasselfield, et al., "The Atacama Cosmology Telescope: beam measurements and the microwave brightness temperatures of Uranus and Saturn," *Astrophys. J. Supplement* **209**, 17 (2013). arXiv:1303.4714

J. Dunkley, et al., "The Atacama Cosmology Telescope: likelihood for small-scale CMB data," *J. Cosmology & Astroparticle Phys* **2013**, 025 (2013). arXiv:1301.0776

M. Hasselfield, et al., "The Atacama Cosmology Telescope: Sunyaev-Zel'dovich selected galaxy clusters at 148 GHz from three seasons of data," *J. Cosmology & Astroparticle Phys* **2013**, 008 (2013). arXiv:1301.0816

B. K. Alpert, et al., "Operation of gamma-ray microcalorimeters at elevated count rates using filters with constraints," *Review of Scientific Instruments* **84**, 056107 (2013). arXiv:1212.1738

A. S. Hoover, et al., "Determination of plutonium isotopic content by microcalorimeter gamma-ray spectroscopy," *IEEE Trans. Nuclear Science* **60**, 681 (2013).

J. Uhlig, et al., "Table-top ultrafast x-ray microcalorimeter spectrometry for molecular structure," *Physical Review Letters* **110**, 138302 (2013).

M. J. Wilson, et al., "Atacama Cosmology Telescope: A measurement of the thermal Sunyaev-Zel'dovich effect using the skewness of the CMB temperature distribution," *Physical Review D* **86**, 122005 (2012). arXiv:1203.6633

R. Dünner, et al., "The Atacama cosmology telescope: data characterization and mapmaking," *Astrophys. J.* **762**, 10 (2012). arXiv:1208.0050

D. A. Bennett, et al., "A high resolution gamma-ray spectrometer based on superconducting microcalorimeters," *Review of Scientific Instruments* **83**, 093113 (2012).

N. Hand, et al., "Evidence of galaxy cluster motions with the kinematic Sunyaev-Zel'dovich effect," *Physical Review Letters* **109**, 041101 (2012). arXiv:1203.4219

K. D. Irwin, et al., "Advanced code-division multiplexers for superconducting detector arrays," *J. Low Temp. Phys.* **167**, 588 (2012). arXiv:1110.1608

W. B. Doriese, et al., "Optimization of the TES-Bias circuit for a multiplexed microcalorimeter array," *J. Low Temp. Phys.* **167**, 595 (2012).

J. W. Fowler, et al., "Optimization and analysis of code-division multiplexed TES microcalorimeters," *J. Low Temp. Phys.* **167**, 713 (2012). arXiv:1110.2531

B. K. Alpert, et al., "Predicted energy resolution of a running-sum algorithm for microcalorimeters," *J. Low Temp. Phys.* **167**, 582 (2012).

E. D. Reese, et al., "The Atacama Cosmology Telescope: high-resolution Sunyaev-Zel'dovich Array observations of ACT SZE-selected clusters from the equatorial strip," *Astrophys. J.* **751**, 12 (2012). arXiv:1108.3343

R. Hlozek, et al., "The Atacama Cosmology Telescope: a measurement of the primordial power spectrum," *Astrophys. J.* **749**, 90 (2012).

G. M. Stiehl, et al., "Code-division multiplexing for x-ray microcalorimeters," *Applied Physics Letters* **100**, 072601 (2012). arXiv:1201.6289

B. D. Sherwin, et al., "Evidence for dark energy from the cosmic microwave background alone using the Atacama Cosmology Telescope lensing measurements," *Physical Review Letters* **107**, 021302 (2011). arXiv:1105.0419

A. Hajian, et al., "Correlations in the (Sub) millimeter Background from ACT x BLAST," *Astrophys. J.* **744**, 40 (2011). arXiv:1101.1517

A. Hajian, et al., "The Atacama Cosmology Telescope: calibration with the Wilkinson microwave anisotropy probe using cross-correlations," *Astrophys. J.* **740**, 86 (2011). arXiv:1009.0777

J. Dunkley, et al., "The Atacama Cosmology Telescope: cosmological parameters from the 2008 power spectrum," *Astrophys. J.* **739**, 52 (2011).

T. A. Marriage, et al., "The Atacama Cosmology Telescope: Sunyaev-Zel'dovich-selected galaxy clusters at 148 GHz in the 2008 survey," *Astrophys. J.* **737**, 61 (2011).

N. Hand, et al., "The Atacama Cosmology Telescope: detection of Sunyaev-Zel'dovich decrement in groups and clusters associated with luminous red galaxies," *Astrophys. J.* **736**, 39 (2011).

B. D. Sherwin, et al., "Evidence for dark energy from the cosmic microwave background alone using the Atacama Cosmology Telescope lensing measurements," *Physical Review Letters* **107**, 021302 (2011).

S. Das, et al., "Detection of the power spectrum of cosmic microwave background lensing by the Atacama Cosmology Telescope," *Physical Review Letters* **107**, 021301 (2011).

D. S. Swetz, et al., "Overview of the Atacama Cosmology Telescope: receiver, instrumentation, and telescop systems," *Astrophys. J. Supplement* **194**, 41 (2011).

N. Seghal, et al., "The Atacama Cosmology Telescope: cosmology from galaxy clusters detected via the Sunyaev-Zel'dovich Effect," *Astrophys. J.* **732**, 44 (2011).

T. A. Marriage, et al., "The Atacama Cosmology Telescope: extragalactic sources at 148 GHz in the 2008 survey," *Astrophys. J.* **731**, 100 (2011).

S. Das, et al., "The Atacama Cosmology Telescope: a measurement of the cosmic microwave background power spectrum at 148 and 218 GHz from the 2008 southern survey," *Astrophys. J.* **729**, 62 (2011).

Invited Presentations

2019 Low-Temperature Detectors Conference, Milan
2017 Denver X-ray Conference, Big Sky, Montana
2016 X-ray Fundamental Parameters Workshop, Surrey, England
2013 Neutrino Mass Measurement Conference, Milan
2010 National Institute of Standards and Technology, Boulder
2010 CEA Paris-Saclay Seminar, France
2010 Université de Paris VII Astrophysics and Cosmology Colloquium
2010 University of Chicago Cosmology Seminar
2010 University of Michigan Astrophysics Seminar
2010 Texas A&M Cosmology Seminar
2009 Princeton University Physics Colloquium
2009 McGill-UM Joint Astrophysics Seminar
2008 University of Colorado Physics Colloquium
2006 University of Chicago Cosmology Seminar
2004 Division of Particles and Fields Plenary Session on Observational Cosmology, Riverside
2002 Princeton University Cosmology Seminar
2000 Goddard Space Flight Center High Energy Astrophysics Seminar
2000 McGill University High Energy Physics Seminar
1999 University of Chicago Sugarman Award Seminar

Professional Activities

- NASA reviewer for infrared and sub-millimeter proposals
- NSF reviewer for observational cosmology proposals

University and Department Service

- NIST Boulder Labs committee on contractor affairs 2021
- Academic adviser to Princeton undergraduates, 90 students from 2003-2010
- Princeton University Undergraduate Life Committee, 2005-07
- Princeton Physics Department Advanced Placement Officer, 2006-2010