Clarke Hardy

PhD Candidate in Physics

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github.com/clarkehardy
clarkehardy.com

Education

PhD Candidate in Physics, *Stanford University* 2019 — PRESENT
Master of Science in Physics, *Queen's University* 2018 — 2019
Bachelor of Applied Science in Engineering, *Queen's University* 2014 — 2018

Skills

Languages & Computing	Python, TensorFlow, scikit-learn, pandas, C, C++, MATLAB, LabVIEW, ROOT, Git, Linux/Unix, HPC, LaTeX
CAD & Prototyping	Solidworks, Solid Edge, OrCAD, 3D printing, soldering
Simulation	COMSOL Multiphysics, Geant4, NEST, MCNP, PSpice
Hardware & Laboratory	DAQ, ultra-high vacuum, radioactive sources, cryogenics, machining, electronics
Data Science	Data processing/analysis/visualization, machine learning, image analysis, statistical modeling
Teaching	Syllabus design, course management, lesson planning, writing/grading assignments

Professional Development

Tri-Institute School on Elementary Particles (TRISEP) **JUN 2023**
Perimeter Institute for Theoretical Physics *Waterloo, Canada*

- Workshop spanning two weeks with sessions from invited researchers on the Standard Model, BSM physics, dark sector theory, amplitude techniques, EFT methods for gravity, gravitational wave theory, gravitational wave experiments, collider experiments, particle astrophysics observations, cosmology, and axions

Two Sigma PhD Symposium **JUN 2023**
Two Sigma *New York, NY*

- Symposium with invited presentations from eight PhD students and two professors along with social and networking sessions

Spring into Quant Finance **APR 2023**
G-Research *Saint-Jean-Cap-Ferrat, France*

- Week-long workshop on programming, statistics, finance, and machine learning taught by G-Research quant researchers

Awards

NSERC Postgraduate Scholarship - Doctoral, *National Sciences and Engineering Research Council of Canada (NSERC)* 2020
Alexander Graham Bell Canada Graduate Scholarship - Doctoral, *NSERC* (declined) 2020
Clarendon Scholarship, *University of Oxford* (declined) 2019
Queen's CAP Prize Examination Award, *Queen's University* 2019
R. Samuel McLaughlin Fellowship, *Queen's University* 2018
First Place, particle physics category, *Canadian Undergraduate Physics Conference* 2017
Ontario Professional Engineers Foundation Scholarship, *Queen's University* 2015
Principal's Scholarship, *Queen's University* 2014

Research Experience

GRADUATE RESEARCH ASSISTANT / OPTICALLY-LEVITATED MICROSPHERES LAB **AUG 2023 — PRESENT**
Stanford University *Stanford, CA*

- Developed a complete data analysis pipeline in Python to test for modifications to Newtonian gravity at short distances
- Designed a new statistical model to discriminate between signals and backgrounds and increase experimental sensitivity

GRADUATE RESEARCH ASSISTANT / nEXO NEUTRINOLESS DOUBLE BETA DECAY SEARCH **JUN 2020 — PRESENT**
Stanford University *Stanford, CA*

- Developed machine learning technique for detector light response calibration using Python & TensorFlow
- Designed xenon gas purifier to exceed stringent radiopurity requirements using Solidworks & COMSOL Multiphysics
- Demonstrated use of ^{127}Xe for charge calibration using Stanford liquid xenon time projection chamber (TPC) test facility
- Designed, constructed, maintained, & operated new liquid xenon TPC test facility for Stanford lab

GRADUATE RESEARCH ASSISTANT / LZ DARK MATTER SEARCH **SEP 2019 — JUN 2020**
SLAC National Accelerator Laboratory *Menlo Park, CA*

- Determined sensitivity to exotic dark matter using simulated detector response with Geant4 & NEST & statistical tools in ROOT
- Developed software for data analysis in C++/ROOT

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GRADUATE RESEARCH ASSISTANT / PICO DARK MATTER SEARCH **MAY 2017 — SEP 2019**
Queen's University / SNOLAB *Kingston, Canada*

- Designed, fabricated, & installed a retroreflector in the PICO-40L detector to achieve 75% increase in illuminated fraction
- Performed ray tracing simulations using MATLAB to optimize retroreflector geometry
- Assisted with commissioning of the PICO-40L detector at SNOLAB (underground science laboratory)
- Calculated event rate spectrum for backgrounds from coherent neutrino scattering in PICO detectors
- Determined sensitivity of the PICO-500 detector to annual modulations in a dark matter signal

UNDERGRADUATE RESEARCH ASSISTANT / NEWS-G DARK MATTER SEARCH **MAY 2016 — AUG 2016**
Queen's University *Kingston, Canada*

- Acquired & analyzed calibration data using a UV laser & radioactive sources
- Designed & constructed slow controls readout electronics & automated process of updating database
- Maintained & operated small test chamber & installed new larger test chamber

Teaching Experience

CO-INSTRUCTOR / SUMMER SCIENCE CIRCLE **JUL 2022**
Mount Tamalpais College *San Quentin, CA*

- Short lecture series offered to students incarcerated at San Quentin State Prison to introduce modern scientific research
- Served on a panel of scientists for a Q&A session with students
- Co-taught a session on how to read a scientific paper
- Co-taught a session on physics research that focused on Carl Anderson's 1933 paper "The Positive Electron." Conducted a demonstration with a cloud chamber as a supplement to the paper discussion

LEAD INSTRUCTOR / PHY 154: PHYSICS I WITH LAB **SEP 2022 — DEC 2022**
Mount Tamalpais College *San Quentin, CA*

- Introductory course on mechanics, waves, fluids, & heat offered to students incarcerated at San Quentin State Prison
- Designed syllabus & course materials to meet specific learning outcomes
- Coordinated with instruction team to organize class meetings, study group sessions, lab activities, & distribution/grading of assignments
- Adapted to COVID-19 quarantines by switching to teaching via correspondence at multiple points during the term

CO-INSTRUCTOR / MTH 220: PRECALCULUS I **JAN 2022 — JUN 2022**
Mount Tamalpais College *San Quentin, CA*

- Precalculus course offered to students incarcerated at San Quentin State Prison
- Prepared & delivered weekly lectures; wrote & graded weekly homework assignments & exams

TEACHING ASSISTANT / PH 41: MECHANICS **JAN 2022 — MAR 2022**
Stanford University *Stanford, CA*

- Introductory calculus-based mechanics course for undergraduate students taught in a flipped classroom
- Led small groups through practice problems; held office hours; graded assignments and exams; prepared review materials

TEACHING ASSISTANT / PH 25: MODERN PHYSICS **APR 2020 — JUN 2020**
Stanford University *Stanford, CA*

- Introductory algebra-based modern physics course for undergraduate students taught on Zoom
- Led tutorial sessions to review material and work through practice problems; held office hours; graded assignments and exams

TEACHING ASSISTANT / PH 23: ELECTRICITY, MAGNETISM, & OPTICS **JAN 2020 — MAR 2020**
Stanford University *Stanford, CA*

- Introductory algebra-based electricity, magnetism & optics course for undergraduate students
- Led tutorial sessions to review material and work through practice problems; held office hours; graded assignments and exams

TEACHING ASSISTANT / APSC 111: MECHANICS **MAY 2016 — AUG 2016**
Queen's University *Kingston, Canada*

- Introductory mechanics course for first-year engineering undergraduates
- Led tutorial sessions & review sessions; graded exams

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Conference Presentations

1. "Searching for new physics at the micron scale with optically levitated microspheres," APS April Meeting, Sacramento, CA, April 2024
2. "Optimizing energy reconstruction for nEXO" (poster), Topics in Astroparticle and Underground Physics (TAUP) 2023, Vienna, Austria, September 2023
3. "Searching for Neutrinoless Double Beta Decay with nEXO" (poster), TRISEP 2023, Waterloo, Canada, June 2023
4. "In Search of No Neutrinos: the nEXO Experiment and Detector Calibration" (invited talk), Two Sigma PhD Symposium, New York, NY, June 2023
5. "Development of a ^{127}Xe calibration source for nEXO," APS April Meeting, New York City, NY, April 2022
6. "Development of a high-purity zirconium purifier for nEXO," APS Division of Nuclear Physics Fall Meeting (virtual), MIT, October 2021
7. "Lightmap reconstruction in nEXO with an internal xenon 127 source," Light Detection In Noble Elements (virtual), UC San Diego, September 2021
8. "New Outreach Initiatives in Canada with the McDonald Institute," European Physical Society High Energy Physics Conference, Ghent, Belgium, July 2019
9. "Searching for Dark Matter with PICO-40L," European Physical Society High Energy Physics Conference, Ghent, Belgium, July 2019
10. "Determining the Physics Reach of the PICO Bubble Chamber Dark Matter Detectors," Canadian Association of Physicists Congress, Burnaby, Canada, June 2019
11. "Improving the Optics of the PICO Bubble Chamber Dark Matter Detector," Winter Nuclear & Particle Physics Conference, Mont Tremblant, Canada, January 2018
12. "Improving the Optics and Fiducial Volume of the PICO-40L Dark Matter Detector," Canadian Undergraduate Physics Conference, Ottawa, Canada, October 2017

Publications

1. R.H.M. Tsang [et al., including **C.A. Hardy**], "An integrated online radioassay data storage and analytics tool for nEXO," Nucl. Instrum. Methods Phys. Res. A 1055, 168477 (2023) [arXiv:2304.06180]
2. C. Adams [et al., including **C.A. Hardy**], "Neutrinoless Double Beta Decay," White Paper submitted for the Fundamental Symmetries, Neutrons, and Neutrinos Town Meeting (2022) [arXiv:2212.11099]
3. J. Aalbers [et al., including **C.A. Hardy**], "A Next-Generation Liquid Xenon Observatory for Dark Matter and Neutrino Physics," J. Phys. G: Nucl. Part. Phys. 50, 013001 (2023) [arXiv:2203.02309]
4. G. Gallina [et al., including **C. A. Hardy**], "Performance of novel VUV-sensitive Silicon Photo-Multipliers for nEXO," Eur. Phys. J. C 82, 1125 (2022) [arXiv:2209.07765]
5. B. G. Lenardo, **C. A. Hardy** et al., "Development of a ^{127}Xe calibration source for nEXO," JINST 17, P07028 (2022) [arXiv:2201.04681]
6. G Adhikari [et al., including **C A Hardy**], "nEXO: Neutrinoless double beta decay search beyond the 10^{28} year half-life sensitivity," J. Phys. G: Nucl. Part. Phys. 49, 015104 (2022) [arXiv:2106.16243]
7. D.S. Akerib [et al., including **C.A. Hardy**], "Projected sensitivities of the LUX-ZEPLIN (LZ) experiment to new physics via low-energy electron recoils," Phys. Rev. D 104, 092009 (2021) [arXiv:2102.11740]
8. M. Wagenpfeil [et al., including **C. A. Hardy**], "Reflectivity of VUV-sensitive Silicon Photomultipliers in Liquid Xenon," JINST 16, P08002 (2021) [arXiv:2104.07997]
9. M.G. Aartsen [et al., including **C. Hardy**], "Velocity independent constraints on spin-dependent DM-nucleon interactions from IceCube and PICO," Eur. Phys. J. C 80, 819 (2020) [arXiv:1907.12509]

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10. C. Amole [et al., including **C. Hardy**], "Data-Driven Modelling of Electron Recoil Nucleation in PICO C_3F_8 Bubble Chambers," Phys. Rev. D 100, 082006 (2019) [arXiv:1905.12522]

11. C. Amole [et al., including **C. Hardy**], "Dark Matter Search Results from the Complete Exposure of the PICO-60 C_3F_8 Bubble Chamber," Phys. Rev. D 100, 022001 (2019) [arXiv:1902.04031]