

Karthik Ramanathan

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Profile

I am a 5th year Physics Ph.D. candidate at the University of Chicago. I focus mainly on the DAMIC (*Dark Matter in CCDs*) experiment, a direct detection Dark Matter search using CCD sensors. I am broadly interested in leveraging new technologies at the “table-top” scale to investigate fundamental questions in particle physics.

Education

Ph.D. candidate in Physics, University of Chicago **2015-Present**

Advisor: Paolo Privitera

- KICP Research Assistantship (2016, 2017, 2018, 2019).
- Awarded departmental **Yodh Prize** for *outstanding research in experimental physics* (2019).
- Awarded APS-SBF travel grant to pursue collaborative research in Brazil (2019).

SM. (Masters) in Physics, University of Chicago **2015-2016**
Coursework based degree enroute to Ph.D.

MSc. in Finance, London School of Economics & Political Science **2010-2011**
Graduated with Merit

BASc. in Aerospace Engineering, University of Toronto **2005-2010**
Graduated with Honors

Physics/Applied Math Research Experience

University of Chicago, Kavli Institute for Cosmological Physics (KICP). **2015-Present**
Advisor: Paolo Privitera

- Investigated models of Dark Matter-electron scattering and used DAMIC at Snolab data to place world-leading interaction constraints for dark matter masses between 0.5-6 MeVc⁻² in certain parameter space (*see Publications section*).
- Characterized and implemented “Skipper” technology CCDs at UChicago, allowing for operation with single-electron energy resolution. These CCDs will form the basis of the next generation DAMIC-M experiment. Currently performing calibration studies with an eye towards measuring low-energy response of Silicon to energy deposition via nuclear and electronic interactions – vital for future low-energy searches.
- Performed low-energy Compton scattering calibration work with a UChicago test detector by exposing setup to gamma-ray sources and characterizing resultant

spectra. Identified several theoretically motivated, but heretofore unobserved in the literature, structural features of the energy spectrum (*see Publications section*).

- Used DAMIC Science Run data and a novel methodology developed at UChicago, interpreting dark current in the detector as originating from incident dark matter, to place limits on Hidden-Photons, culminating in PRL paper (*see Publications section*).
- Conducted calibration studies of CCD energy linearity and resolution based on LED exposure datasets, with results included in WIMP results publication (*see Publications section*).
- Developed MCNP, and to a lesser extent Geant4, particle simulations to assist in various internal and collaboration analyses.
- Deployed numerous analysis tools used by the collaboration for track reconstruction, parameter estimation, simulation, data processing, and visualization – primarily using ROOT, C++, Matlab, and Python for development.

London School of Economics

2010-2011

Advisor: Jean-Pierre Zigrand

Thesis: *Numerical option pricing under a combined Heston Volatility, Kou Jump, and Cox Intensity framework*

- Researched and constructed a novel quantitative option-pricing model utilizing stochastic volatility and doubly stochastic jump processes to better understand fat-tail “black-swan” events in financial markets.

University of Toronto

Summer 2008 & 2009

P. Lavoie Group, UofT Institute for Aerospace Studies

- Modeled vortex generator and plasma actuator behavior in fluid flows and summarized existing research for incoming postdoc. Assisted in design and simulation of actuators for laboratory use.

Weizmann Institute of Science

Summer 2005

N. Davidson Group

- Algorithmically cleaned up dust and diffraction artifacts in images of phonon excitations and collisions in Bose-Einstein Condensates. Published paper in Institute’s summer student publication (*see Non-Peer Rev. section*).

Publications

Peer Reviewed

- Aguilar-Arevalo, ... **K. Ramanathan**, ... [*alphabetical listing, 32 authors omitted*]. Constraints on Light Dark Matter Particles Interacting with Electrons from DAMIC

at SNOLAB. Accepted for publication in *Phys. Rev. Lett.* (Oct. 2019). DOI to be announced, available at arxiv:1907.12628

- Considered as first author within collaboration. Performed entirety of analysis and wrote first draft.
- **K. Ramanathan**, A. Kavner, ... [*9 authors excluded*]. Measurement of low energy ionization signals from Compton scattering in a charge-coupled device dark matter detector. *Physical Review D* 96, 042002 (2017) (DOI: 10.1103/PhysRevD.96.042002)
 - Conducted most of the experimental work, majority of the analysis, and wrote first draft.
- A. Aguilar-Arevalo, ... **K. Ramanathan**, ... [*alphabetical listing, 37 authors omitted*]. First Direct-Detection Constraints on eV-Scale Hidden-Photon Dark Matter with DAMIC at SNOLAB. *Phys. Rev. Lett.* **118** (2017) (DOI: 10.1103/PhysRevLett.118.141803)
 - Considered as first author within collaboration. Performed majority of analysis and wrote first draft.
- A. Aguilar-Arevalo, ... **K. Ramanathan**, ... [*alphabetical listing, 36 authors omitted*]. Search for low-mass WIMPs in a 0.6 kg day exposure of the DAMIC experiment at SNOLAB. *Phys. Rev. D* **94** (2016) (DOI: 10.1103/PhysRevD.94.082006)
 - Conducted analysis for Section IV. A. *Energy Response of a DAMIC CCD*

In preparation

- **K. Ramanathan**, N. Kurinsky Ionization Yield in Silicon (expected early 2020)
 - Investigating appropriate models to be broadly used by Silicon detector community for translating deposited energy into ionization charge.

Non-peer reviewed

- D. T. Nguyen, **K. Ramanathan**, S. Vohra. Design and Deployment of Aquaponic Grid Communities. *Royal Haskoning Innovative Solutions for the Delta; DeltaCompetition (2008)*
- Kovac, J., **Ramanathan, K.**, Pugatch, R., and Davidson, N. Anti-Polar Absorption Symmetry in Bose-Einstein Condensates. *Weizmann Institute of Science - International Summer Science Institute Journal*. (2005)

Workshop Participation (Selected)

- Universidade Federal do Rio de Janeiro (Sep. 2019) - collaborated with UFRJ scientists, thanks to APS travel grant (*see Awards section*), to research machine learning algorithms for particle track detection.

- New Directions in the Search for Light Dark Matter Particles (Jun. 2019) – collaborated with astroparticle community members in outlining immediate research goals for Light Dark Matter investigations.

Conference Presentations and Talks (Selected)

- APS Division of Particles and Fields Meeting, Boston, MA. (Aug. 2019) – presented DM-electron analysis and results using DAMIC at SNOLAB data.
- DAMIC-M Annual Collaboration Meeting (Jul. 2019) – presented on analysis and simulation work undertaken at UChicago.
- APS April Meeting, Denver, CO. (Apr. 2019) – presented on leakage current analyses using DAMIC at SNOLAB data
- APS April Meeting, Columbus, OH. (Apr. 2018) – presented on DAMIC-100 WIMP Search progress & DAMIC-M next generation detector.
- APS Canadian-American-Mexican Graduate Conference, Washington D.C. (Aug. 2017) – presented on Hidden Photon paper.
- TeVPA Conference, Columbus, OH. (Aug. 2017) – presented on Compton Scattering paper.
- SNOLAB Users Symposium (Sep. 2016) – presented on progress towards measurement of single scatter Compton electrons.

Awards, Fellowships, and Honors (Selected)

- UChicago Yodh Prize for outstanding research in experimental physics (2019)
- APS-SBF Brazil-U.S. Exchange Travel Grant of \$3,000 (2019)
- KICP Research Assistantship (2016, 2017, 2018, 2019)
- University of Toronto (Dean's List 2006, 2009, and 2010)
- RoyalHaskoning DeltaCompetition €10,000 Top Team Prize (2008)
- Queen Elizabeth II Aiming for the Top Scholarship (2005, 2006)
- Bessie F. Lawrence International Summer Science Institute Scholarship (2005)

Outreach and Extracurricular Activities (Selected)

- Graduate student mentor – Acted as a peer-mentor for incoming graduate students.
- Weekly Interactive Meeting of Particle Physicists (WIMPP) - Started a weekly journal club focused on discussing Experimental/Phenomenology papers where grad. students give 10-15 min. whiteboard talks.
- Bright Horizons Discovery Days – Participated in a monthly grad-student driven effort to present basic science topics in an interactive and playful manner to children ages 2-5 at a local Chicago preschool/daycare.

Other Research Experience (Selected)

University of Toronto 2010

Advisor: Chi-Guhn Lee

Thesis: *Optimization of Bidding Strategies in Electricity Markets*

- Studied behavior of electricity market auctions where bidders submit non-standard bids. Utilized Monte-Carlo methods in combination with linear programming toolkits to simulate large auctions.

DeltaCompetition 2008

Supervisor: James W. Davis (University of Toronto)

- External student competition/call for papers by Royal Haskoning, a Dutch environmental consulting firm.
- Co-author of prize-winning *Design and Deployment of Aquaponic Grid Communities* paper, which proposed engineering solutions to certain climate change problems affecting Deltaic regions around the world.

Non-Academic Professional Experience (Selected)

Viognier Capital Management 2011-2015

Quantitative Associate

- Was responsible for portfolio of ~\$2M USD invested using custom quantitative algorithms. Investigated new trading strategies and promising research avenues (e.g. validity of genetic algorithms for data mining).

Messier-Dowty Inc. 2008-2009

Systems Engineer

- Designed & programmed an alpha version of a Landing Gear Control Unit simulator for the Sukhoi SJ100 airplane and the Airbus A350 bid.