



# Karpur Shukla

 [https://centre.santafe.edu/thermocomp/Karpur\\_Shukla](https://centre.santafe.edu/thermocomp/Karpur_Shukla) •  [kshukla@alumni.cmu.edu](mailto:kshukla@alumni.cmu.edu) •  +1 646 580-5277

 <https://orcid.org/0000-0002-7775-6979> •  <https://scholar.google.com/citations?user=NxRloBgAAAAJ>

 300 Wedgewood Road, Morganville, New Jersey, 07751 •  U.S. Citizen (native-born), Overseas Citizen of India

## Education and Awards

<b>Doctor of Philosophy:</b> Department of Electrical and Computer Engineering, Brown University Center for Computing Research, Sandia National Laboratories	May 2026 (Anticipated)
<b>Master of Science:</b> Department of Electrical and Computer Engineering, Brown University	May 2023 (Anticipated)
<b>Master of Science:</b> Department of Physics, Carnegie Mellon University • GPA: 3.28 / 4.00 • Awards: Associate Member, Sigma Xi (Scientific Research Honors Society)	May 2016
<b>Bachelor of Science:</b> Department of Physics, Carnegie Mellon University • Awards: Science and Humanities Scholar Senior Leadership Award, Department of Physics, Carnegie Mellon University	May 2014

## Publications

*Reversible Computing and Thermodynamic Uncertainty Relations via the Geometry of Multiple Quantum Non-Equilibrium Steady States*

(Sandia Technical Report, tracking R&A #1068410, in preparation for publication through Sandia National Laboratories.)

**Karpur Shukla**, Michael P. Frank

*Synergistic Biophysical Techniques Reveal Structural Interactions of Engineered Cationic Antimicrobial Peptides with Membrane Mimics*

Accepted for publication in *Chemistry: A European Journal*; to be published shortly.

Frank Heinrich, Aria Salyapongse, Akari Kumagai, Fernando G. Dupuy, **Karpur Shukla**, Anja Penke, Daniel Husterd, Robert K. Ernst, Anna Pavlova, James C. Gumbart, Berthony Deslouches, Peter Y. Di, Stephanie Tristram-Nagle

## Invited, Workshop, and Conference Talks

<i>Nonequilibrium Dynamics and Superadiabatic Fluxon Motion for Reversible Computing</i> Invited talk [🔗] Host: Center for Computing Research, Sandia National Laboratories	Feb. 2020
<i>Pathfinding Thermodynamically Reversible Quantum Computation</i> Authors: <b>Karpur Shukla</b> , Michael P. Frank Invited talk, NSF Quantum Leap Challenge Institute Workshop on the Identification and Control of Fundamental Properties of Quantum Systems [🔗] Host: Department of Physics, Brown University	Jan. 2020

<p><i>Implementing the Asynchronous Reversible Computing Paradigm in Josephson Junction Circuits</i>  Authors: Michael P. Frank, Rupert M. Lewis, <b>Karpur Shukla</b>  Submitted talk, 21<sup>st</sup> U.S. Workshop on Superconductor Electronics, Devices, Circuits, and Systems [🔗]  Host: Department of Electrical and Computer Engineering, Stony Brook University</p>	Oct. 2019
<p><i>Review of Holographic Second Laws for Conformal Field Theories Out of Equilibrium</i>  Submitted talk, II Workshop on Quantum Information and Thermodynamics [🔗, 📄]  Host: International Institute of Physics, Federal University of Rio Grande do Norte</p>	Mar. 2019
<p><i>Nonequilibrium Disorder Operators and Topological Quantum Computation</i>  Invited talk, Thermodynamics and Computation: Towards a New Synthesis  Host: Thermodynamics of Computation Group, Santa Fe Institute</p>	Aug. 2017
<p><i>Physical Aspects of Topological Quantum Computation</i>  Invited talk  Host: Center for Computing Research, Sandia National Laboratories</p>	Aug. 2017

## Posters

<p><i>Thermodynamic Dissipation Bounds on Classical and Quantum Reversible Information Processing</i>  Authors: <b>Karpur Shukla</b>, Michael P. Frank  Submitted poster, 22nd Southwest Quantum Information and Technology Conference  Host: Center for Quantum Information and Control, University of New Mexico</p>	Feb. 2020
<p><i>Information Flows in Reversible Computing Out of Equilibrium, with Applications to Models of Topological Quantum Computing</i>  Authors: <b>Karpur Shukla</b>, Michael P. Frank  Submitted poster, 21<sup>st</sup> Southwest Quantum Information and Technology Conference [🔗]  Host: Center for Quantum Information and Control, University of New Mexico</p>	Feb. 2019

## Work and Research Experience

<p><b>Research Assistant:</b> Department of Electrical and Computer Engineering, Brown University; and  Center for Computing Research, Sandia National Laboratories</p> <ul style="list-style-type: none"> <li>• Currently examining thermodynamic uncertainty relations for systems described by Gorini-Kossakowski-Sudarshan-Lindbladian (GKSL) dynamics with multiple steady states, in terms of the quantum geometric tensor induced by GKSL superoperators.</li> <li>• Currently examining the dynamics and scattering of fluxons in long Josephson junctions under superadiabatic protocols, and finding conserved quantities of scattering processes via properties of classical conformal operator algebras and the sine-Gordon-modified-Korteweg-de-Vries hierarchy.</li> <li>• Currently examining applications of Floquet theory of topological insulators to the generation of high harmonic frequencies in graphene.</li> </ul> <p>[Some of this work continues work done at Flame University.]</p>	<p>Jun. 2020 –  Present</p>
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**Research Associate:** Centre for Mathematical Modeling, Flame University

Jul. 2018 –  
Jun. 2020

- Examined thermodynamic uncertainty relations for systems described by Gorini-Kossakowski-Sudarshan-Lindbladian (GKSL) dynamics with multiple steady states, in terms of the quantum geometric tensor induced by GKSL superoperators.
- Examined the dynamics and scattering of fluxons in long Josephson junctions under superadiabatic protocols, and finding conserved quantities of scattering processes via properties of classical conformal operator algebras and the sine-Gordon-modified-Korteweg-de-Vries hierarchy.

**Visiting Faculty:** Department of Applied Mathematics, Flame University

Dec. 2017 –  
Dec. 2019

- Faculty member for the Applied Mathematics major. As instructor and co-instructor, responsibilities involved lecturing; assigning required reading material, homework questions, and examination questions; and grading. For co-taught classes, each of these responsibilities was shared equally. As guest lecturer, responsibilities involved lecturing and assigning required reading material. Courses:
  - MATH202 (Linear Algebra)
    - Textbooks: *Matrix Analysis and Applied Linear Algebra* by C. D. Meyer  
*Introduction to Linear Algebra (5<sup>th</sup> Edition)* by G. Strang
  - MATH206 (Complex Analysis) [co-instructor]
    - Textbooks: *Complex Variables and Applications (8<sup>th</sup> Edition)* by J. Brown and R. Churchill
  - MATH303 (Partial Differential Equations) [co-instructor]
    - Textbooks: *Partial Differential Equations: An Introduction* by W. Strauss
  - PHYS101 (Introduction to Physics)
    - Textbooks: *University Physics (13<sup>th</sup> Edition)* by H. Young, R. A. Freedman, and A. Ford  
*Foundation Mathematics for the Physical Sciences* by K. F. Riley and M. P. Hobson
  - MATH331 (Mathematical Modelling) [guest lecturer]
    - Material: Markov processes, Monte Carlo simulations (integration, Markov chain Monte Carlo simulations, importance sampling, Metropolis-Hastings)

**Research Assistant:** Biological Physics Group, Carnegie Mellon University

Jan. 2016 –  
May 2016

- Examined phase transitions of DPPC lipid—antimicrobial peptide solutions via differential calorimetry spectroscopy. This included review of the electrical layout of equipment for optimizing data collection, and applying statistical techniques to examine collected data.
- Used multivariable linear regression, Fourier correlation analysis, and  $\chi^2$  analysis for composite curve fitting; and used the Akaike information criterion for model selection. All calculations were carried out in OriginLab 9.1 Pro, Python (via NumPy and SciPy), and Microsoft Excel.
  - Advisor (principal investigator): Stephanie Tristram-Nagle

**Research Assistant:** Quantum Condensed Matter Theory Group, Carnegie Mellon University

- Examined the electrical response of topological insulator (TI) surfaces to circularly polarized applied light, primarily in the optical wavelength. Particular emphasis was given to the surfaces of the topological insulators  $\text{Bi}_2\text{Se}_3$  and  $\text{MoS}_2$ .
- Used the techniques of weak-field quantum electrodynamics, finite-temperature (equilibrium) quantum many body theory, and nonlinear (quadratic) quantum response theory to analytically derive expressions for Berry curvature-dependent valley current transport on TI surfaces.
  - Advisor (principal investigator): Di Xiao

Aug. 2013 –  
Dec. 2013

**Research Assistant:** Computational Condensed Matter Group, Carnegie Mellon University

- Examined two- and four-point correlation functions
- Examined various two- and four-point correlation functions for a two-dimensional Ising model of quantum magnetism evolving over time.
- Used the analytic real-space renormalization group technique and Markov chain Monte Carlo simulations (applying the Metropolis-Hastings algorithm) to numerically calculate correlation functions and system values along spatial and time decimations.
  - Advisor (principal investigator): Robert Swendsen

Aug. 2010 –  
Dec. 2010

**Research Assistant:** Theoretical Biological Physics Group, Carnegie Mellon University

- Examined dynamical behavior of cell membrane surfaces and interactions between particles due to the effects of cell membrane geometry and composition.
- Used differential geometry and variational calculus techniques to find minimal shape equations, constraint equations, and corresponding force relations on the surfaces of cell membranes.
  - Advisor (principal investigator): Markus Deserno

Jan. 2009 –  
May 2009

## Programming Languages and Software Packages

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- Python (*with NumPy, SciPy, PyLab, and Matplotlib*) {fluent}
- Mathematica 10 {fluent}
- MATLAB / Octave {fluent}
- Origin 2020 {fluent}

## Natural Languages

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- English {fluent}
- Hindi {fluent}
- Gujarati {fluent}
- Spanish {fluent}