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## EDUCATION

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### Ph.D. in Electrical Engineering, Jan. 2016 – Present

*Cumulative GPA: 3.9 out of 4*

*Duke University, Durham, NC, USA*

Research: Quantum Information and Computation, Information and Coding Theory, Statistical Inference Problems

Advisors: Prof. Henry D. Pfister and Prof. Robert Calderbank

Coursework: Quantum Information Science I & II, Quantum Error Correction and Architectures, Compressed Sensing, Information Theory and Statistical Mechanics, Convex Optimization, Machine Learning, Basic Analysis I & II, Detection and Estimation Theory

### M.S. in Electrical Engineering, Dec. 2015

*Cumulative GPA: 3.875 out of 4*

*Texas A&M University, College Station, TX, USA*

Thesis: On Cyclic Polar Codes and the Burst Erasure Performance of Spatially-Coupled LDPC Codes

Advisors: Prof. Henry D. Pfister and Prof. Krishna R. Narayanan

Coursework: Channel Coding, Statistical Communication Theory, Information Theory, Advanced Channel Coding, Computer Communication and Networking, Wireless Communications

### B.Tech. in Electronics and Communication Engineering, May 2013

*Cumulative GPA: 9.70 out of 10 (3.88/4)*

*Amrita University, Coimbatore, Tamilnadu, India*

Project: Wireless Electrocardiogram Monitoring for Cardiac Patients on Android Platform

Advisor: Prof. E. P. Sumesh

Advanced Coursework: Wireless Communications, OFDM for Broadband Wireless Communications, Agent Based Modeling, Pattern Recognition, Convex Optimization

## HONORS

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### DAAD RISE Professional Scholarship, 2015

*German Academic Exchange Service (DAAD)*

- One of the 34 scholarship recipients selected by the committee, among all the 184 applicants
- Funded the 3-month summer research internship in Alcatel-Lucent Bell Labs, Stuttgart, Germany

### Top Rank in Undergraduate Studies, May 2013

*Amrita University*

- Ranked first in the college, third in the university (among 3 engineering campuses)

### Ericsson Excel Certification in Telecommunications, 2012

*Amrita University*

- Attended leading Ericsson researcher's lectures, passed exam and completed an internship

### Central Board of Secondary Education (CBSE) Merit Scholarship 2010-11 & 2011-12

*Amrita University*

### Amrita TIDE Best Innovation Award, 2011-12

*Amrita University*

- As a team, developed an Integrated Village Development System; created a web portal for a job classifieds system
- Used Software Defined Radio (SDR) to demonstrate connectivity between places, with only partial internet dependence

## RESEARCH

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### Research Assistant, Prof. Henry Pfister's Group, Jan. 2016 – Present

*Duke University*

- Currently working on problems in quantum computation and quantum information
- Developed a systematic framework for synthesizing logical Clifford operators for arbitrary stabilizer codes
- Constructed a small unitary 2-design using the symmetries of classical Kerdock codes
- Software implementations of all algorithms available at <https://github.com/nrenga/symplectic-arxiv18a>
- Developed a simple characterization of diagonal unitaries in the Clifford hierarchy
- Studied and prepared notes for understanding duality of channels and codes, based on a recent paper

- Performed analysis on a recently proposed quantum belief propagation algorithm for pure-state channels
- Conducted research on construction of deterministic compressed sensing matrices and recovery of large supports of unknown sparse vectors; demonstrated strong empirical evidence that Kerdock matrices outperform other constructions

**Research Assistant, Prof. Henry Pfister's Group, Aug. 2014 – Dec. 2015** *Texas A&M University*

- Modified polar codes to produce cyclic polar codes of arbitrary blocklength, over appropriate Galois fields
- Achieved higher rates on the erasure channel than binary polar codes for a target block erasure rate

**Research Assistant, Prof. Gregory Huff's Group, Jan. 2014 – Aug. 2014** *Texas A&M University*

- Worked on the MUSIC algorithm to triangulate and localize the origin of an ocean wave through its interaction with a network of buoy sensors; developed a C++ utility with Qt Creator IDE for field sensing and analysis

## SKILLS

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Core: Information and Coding Theory, Signal Processing, Quantum Information and Computation, Graphical Models and Inference, Linear and Abstract Algebra, Combinatorics, Probability, Wireless Communication

General: Theoretical Research, Teaching, Programming, Technical and Formal Writing

Languages: MATLAB, C, C++, Python, Arduino, Mathematica

## TEACHING

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**Teaching Assistant, Error Correcting Codes, Fall 2017** *Duke University*

**Teaching Assistant, Digital Audio Processing, Spring 2017** *Duke University*

**Teaching Assistant, Capstone (Senior) Design, Spring and Fall 2015** *Texas A&M University*

**Student Lectures, Channel Coding, Fall 2015** *Texas A&M University*

## INDUSTRY EXPERIENCE

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**Graduate Research Intern, June – Aug. 2015** *Alcatel-Lucent Bell Labs, Stuttgart, Germany*

- Analyzed Spatially-Coupled Regular LDPC codes on burst erasure channels
- Proved that removal of 4-cycles and increasing left-degree can guarantee block erasure rates of  $O(10^{-15})$  for some codes

**Undergraduate Summer Intern, June – July 2012** *Ericsson India Global Services Private Limited, Chennai, India*

- Developed, with 5 fellow interns, a web portal (using Drupal and PHP) to facilitate the internal processing system of Ericsson's Revenue Management Division; prepared extensive documentation for the developed system

## SELECTED PROJECTS

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**Quantum Belief Propagation and CQ Polar Codes, Course Project, Spring 2019** *Duke University*

- Understood the recently introduced belief propagation algorithm that decodes classical binary linear codes on a pure-state channel by passing qubits as messages
- Constructed a 5-bit code example, performed full performance analysis for QBP on each bit, and compared to the optimal Helstrom strategy for each bit
- Summarized the connection to pure-loss optical channel and the capacity-achieving classical-quantum (CQ) polar codes

**Decoding the Surface Code, Course Project, Fall 2018** *Duke University*

- Built the minimum-weight perfect matching (MWPM) decoder from scratch using MATLAB's optimization routines
- Verified the well-known surface code thresholds via extensive simulations
- Partially built the recently introduced "Blossom-Belief Propagation" algorithm for MWPM
- Report online: <https://dx.doi.org/10.13140/RG.2.2.27511.47522>

**Efficient Classical Simulation of Quantum Circuits, Course Project, Fall 2018** *Duke University*

- Read and summarized the CHP simulator and the more recent stabilizer rank-based simulator
- Reviewed the symplectic representation of Clifford group and used it to succinctly describe the CHP simulator
- Report online: <https://dx.doi.org/10.13140/RG.2.2.20800.58887>

## Hands On, Course Project, Fall 2013

Texas A&M University

- As a team, developed a device for testing coordination of both hands simultaneously
- Developed a GUI using Qt Creator IDE to receive and visualize Inertial Measurement Unit (IMU) data real-time
- Performed real-time testing with voluntary participants on Demo Day

## Wireless Electrocardiogram (ECG) Monitoring, B.Tech. Project, Jul. 2012 – May 2013

Amrita University

- As a team, built hardware to transmit ECG (input from a reliable, mobile ECG extractor) to phone over Bluetooth
- Developed an Android application to receive signals from hardware in real-time and display it along with key parameters
- Processed the signals using the Pan-Tompkins algorithm to detect key parameters, and raised alerts when necessary via the Short Message Service (SMS)

## PROFESSIONAL ACTIVITIES

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### Project Manager for Duke Opportunities in Math (DOmath), June - July 2018

Duke University

- Mentored 3 students in a two-month project performing randomized benchmarking on IBM's *ibmqx4* device.
- Project lead by Prof. Robert Calderbank and Prof. Henry Pfister. Report: <https://math.duke.edu/domath2018>

### Quantum Group Meetings, Mar. 2017 – Present

Duke University

- Organizing weekly meetings on topics related to quantum information, computation, communications, algorithms
- Presented papers and my notes on several topics of common interest, most recently on our work on unitary 2-designs

### North American School of Information Theory, June 2016

Duke University

- Assisted in organizing the summer school, handled monetary responsibilities
- Developed an information-theory crossword puzzle (with a colleague) to illustrate iterative decoding

### Workshop on Software Defined Radio, Aug. 2012

Amrita University

- Learned to work with the Universal Software Radio Peripheral (USRP) Kit
- Developed simple communications system modules in GNU Radio Companion software

### Graduate Student Member of IEEE, since Nov. 2015

### Reviewer for IEEE Transactions on Information Theory, since 2016

### Reviewer for IEEE International Symposium on Information Theory, 2018

### Reviewer for IEEE Information Theory Workshop, 2018

### Reviewer for IEEE Transactions on Vehicular Technology, since 2019

## THESES

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1. N. Rengaswamy, “On Cyclic Polar Codes and the Burst Erasure Performance of Spatially-Coupled LDPC Codes,” Master’s thesis, Texas A&M University, 2015. [Online]. Available: <http://hdl.handle.net/1969.1/156244>.

## PEER-REVIEWED JOURNAL PAPERS

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1. V. Aref, N. R., and L. Schmalen, “Finite-Length Analysis of Spatially-Coupled Regular LDPC Ensembles on Burst-Erasure Channels,” *IEEE Trans. Inform. Theory*, vol. 64, no. 5, pp. 3431 – 3449, 2018. [Online]. Available: <https://arxiv.org/abs/1611.08267>.

## PREPRINTS

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3. T. Can, N. R., R. Calderbank, and H. D. Pfister, “Kerdock Codes Determine Unitary 2-Designs,” *Submitted to IEEE Trans. Inf. Theory, arXiv preprint arXiv:1904.07842*, 2019. [Online]. Available: <http://arxiv.org/abs/1904.07842>.
2. N. R., R. Calderbank, and H. D. Pfister, “Unifying the Clifford Hierarchy via Symmetric Matrices over Rings,” *Submitted to Phys. Rev. A, arXiv preprint arXiv:1902.04022*, 2019. [Online]. Available: <http://arxiv.org/abs/1902.04022>.
1. N. R., R. Calderbank, S. Kadhe, and H. D. Pfister, “Synthesis of Logical Clifford Operators via Symplectic Geometry,” *arXiv preprint arXiv:1803.06987*, 2018. [Online]. Available: <http://arxiv.org/abs/1803.06987>.

## PEER-REVIEWED CONFERENCE PAPERS

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5. T. Can, **N. R.**, R. Calderbank, and H. D. Pfister, “Kerdock Codes Determine Unitary 2-Designs,” in *Proc. IEEE Intl. Symp. Inf. Theory (accepted)*, 2019.
4. **N. R.**, R. Calderbank, S. Kadhe, and H. D. Pfister, “Synthesis of Logical Clifford Operators via Symplectic Geometry,” in *Proc. IEEE Int. Symp. Inform. Theory*, pp. 791–795, June 2018.
3. V. Aref, **N. R.**, and L. Schmalen, “Spatially Coupled LDPC Codes Affected by a Single Random Burst of Erasures,” in *Proc. Int. Symp. on Turbo Codes & Iterative Inform. Process.*, pp. 166–170, IEEE, 2016. [Online]. Available: <https://arxiv.org/abs/1607.00918>.
2. **N. R.**, L. Schmalen, and V. Aref, “On the Burst Erasure Correctability of Spatially Coupled LDPC Ensembles,” in *Proc. IEEE Intl. Zurich Seminar on Commun.*, pp. 155–159, 2016.
1. **N. R.** and H. D. Pfister, “Cyclic Polar Codes,” in *Proc. IEEE Int. Symp. Inform. Theory*, pp. 1287–1291, June 2015.

## TALKS, POSTERS AND WORKSHOPS

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12. Poster – “Kerdock Codes Determine Unitary 2-Designs”, *22nd Annual Conference on Quantum Information Processing*, University of Colorado Boulder, Jan. 14-18, 2019.
11. Poster – “Symplectic Matrices for Logical Clifford Synthesis and Diagonal Unitaries in the Clifford Hierarchy”, *22nd Annual Conference on Quantum Information Processing*, University of Colorado Boulder, Jan. 14-18, 2019.
10. Poster – “Synthesis of Logical Clifford Operators via Symplectic Geometry”, *13th Conference on the Theory of Quantum Computation, Communication and Cryptography*, University of Technology Sydney, Jul. 14-20, 2018.
9. Poster – “Synthesis of Logical Operators for Quantum Computers using Stabilizer Codes”, *North American School of Information Theory*, Texas A&M University, May 20-23, 2018.
8. Talk – “Synthesis of Logical Operators for Quantum Computers using Stabilizer Codes”, *Seminar, Department of Electrical Engineering*, Indian Institute of Technology Madras, Apr. 26, 2018.
7. Poster – “Logical Operators for CSS Codes: A Binary Perspective”, *Duke IBM Day*, Duke University, Oct. 31, 2017.
6. Workshop – *Beyond I.I.D. in Information Theory*, National University of Singapore, Jul. 24-28, 2017.
5. Poster – “Deterministic Compressed Sensing and Recovery of Large Supports”, *North American School of Information Theory*, Georgia Institute of Technology, Jun. 6-9, 2017.
4. Workshop – *Communications, Inference, and Computing in Molecular and Biological Systems*, University of Southern California, Dec. 3-4, 2015.
3. Talk – “The Burst Erasure Correctability of Spatially Coupled LDPC Ensembles”, *Information Sciences and Systems Seminar*, Texas A&M University, Nov. 4, 2015.
2. Talk – “Cyclic Polar Codes”, *Information Sciences and Systems Symposium*, Texas A&M University, Oct. 19, 2015.
1. Poster – “Cyclic Polar Codes: How to Achieve Higher Rates than Binary Polar Codes at Finite Blocklengths?”, *Eighth Annual Winedale Workshop*, Round Top, Texas, Oct. 9, 2015.

## REFERENCES

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1. **Prof. Henry D. Pfister**, Department of ECE, Duke University, <http://pfister.ee.duke.edu>
2. **Prof. Robert Calderbank**, Department of ECE, Duke University, <http://ece.duke.edu/faculty/robert-calderbank>
3. **Prof. Kenneth R. Brown**, Department of ECE, Duke University, <http://ece.duke.edu/faculty/kenneth-brown>
4. **Prof. Iman Marvian**, Department of ECE, Duke University, <http://ece.duke.edu/faculty/iman-marvian>
5. **Dr. Laurent Schmalen**, Nokia Bell Labs, Germany, <http://www.bell-labs.com/usr/laurent.schmalen>