Anthony Gómez-Fonseca

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Research Interests

My research interests lie in coding theory and graph theory. I have been interested in the construction of low-density parity-check (LDPC) codes, particularly protograph-based and quasi-cyclic (QC) LDPC codes, and in the optimization of their parameters. To solve problems in these areas, I use methodologies from algebra and applied algebra, combinatorics, discrete mathematics, and optimization. I am also interested in investigating broader families of error-correcting codes, such as generalized LDPC codes and codes from expander graphs, and quantum error correction.

Education

- **Ph.D., Mathematics, 2025, University of Notre Dame**
  Research area: Coding Theory, Graph Theory, Algebra, Applied Algebra
  Research interests: Quasi-Cyclic (QC) Low-Density Parity-Check (LDPC) Codes, Graph Cycle Structural Analysis, Generalized LDPC (GLDPC) Codes, Expander Codes
- **M.Sc., Mathematics, 2023, University of Notre Dame**
- **M.Sc., Mathematics, 2019, University of Puerto Rico, Río Piedras Campus**
  Research areas: Graph Theory and Ramanujan Graphs, Low-Density Parity-Check (LDPC) Codes.
  Qualifying Exams: Abstract Algebra (with honors/Ph.D. level), Topology, and Real Analysis.
- **B.Sc., Mathematics, 2016, University of Puerto Rico at Cayey**

Positions

- **University of Notre Dame**
  1. Graduate Fellowships for STEM Diversity (GFSD, formerly NPSC) Fellow (August 2019 – May 2025)
  2. Kinesis-Fernández Richards Fellow (August 2019 – May 2025)
  3. Instructor – Department of Mathematics
     – Calculus A (Fall 2023)
  4. Teaching Assistant – Department of Mathematics
     – Calculus B Tutorial (Spring 2021, Fall 2021, Spring 2022, Fall 2022)
     – Linear Algebra and Differential Equations Tutorial (Spring 2023)
     – Calculus A Tutorial (Fall 2024)
- **University of Puerto Rico, Río Piedras Campus**
  1. NASA Puerto Rico Space Grant Fellow (August 2018 – May 2019)
  2. Teaching Assistant – Department of Mathematics (August 2016 – August 2018)
- **University of Puerto Rico at Cayey**
  1. Research Assistant – Instituto de Investigaciones Interdisciplinarias (January 2015−May 2016)
     * Project: Modelos de cazador-presa: Una nueva estrategia de persecución (Advisor: Dr. Errol L. Montes Pizarro; Joint work with: Luis A. Molina Rodríguez)
  2. Mathematics Tutor – Colectivo Universitario para el Acceso (CUA – UPR Cayey) (August 2015 – May 2016, February 11, 2017)
     * As part of this educational justice program, I tutored and mentored socioeconomically disadvantaged students, helping them transition to the university lifestyle.

3. Mathematics Tutor – División de Educación Continua y Estudios Profesionales (DECEP) (May 2015)
4. Mathematics Tutor – Department of Mathematics-Physics (June 2014 and June 2016)
5. Mathematics Tutor – Programa de Servicios Educativos (PSE) (August 2013 – August 2015)
6. Mathematics Tutor – Centro de Apoyo al Estudiante (CAE) (August 2013 – August 2015)

Publications

In preparation

1. Roxana Smarandache, David G. M. Mitchell, and Anthony Gómez-Fonseca, "**Generalized Quasi-Cyclic LDPC Codes: Design and Efficient Encoding**." (submitted)
2. Anthony Gómez-Fonseca, "**An algebraic approach to construct QC-LDPC codes with girth g and shortest blocklength**."
3. Anthony Gómez-Fonseca, "**QC-LDPC Expander Codes**."

Published

8. Anthony Gómez-Fonseca, "**Construction of QC-LDPC Codes with Girth g from the Hermite Normal Form of a Matrix**," *2025 IEEE International Symposium on Information Theory (ISIT)*, Ann Arbor, United States, July 2025.
7. Roxana Smarandache, Anthony Gómez-Fonseca and David G. M. Mitchell, "**Generalized Quasi-Cyclic LDPC Codes: Design and Efficient Encoding**," *2024 IEEE International Symposium on Information Theory (ISIT)*, Athens, Greece, July 2024, pp. 434-439, doi: 10.1109/ISIT57864.2024.10619445.
6. Anthony Gómez-Fonseca, Roxana Smarandache and David G. M. Mitchell, "**A Low Complexity PEG-like Algorithm to Construct Quasi-Cyclic LDPC Codes**," *2023 12th International Symposium on Topics in Coding (ISTC)*, Brest, France, September 2023, pp. 1-5, doi: 10.1109/ISTC57237.2023.10273481.
5. Henry Chimal-Dzul and Anthony Gómez-Fonseca, "**Using Partial Orthomorphisms to Construct Short Quasi-Cyclic LDPC Codes with Girth at Least 6**," *2023 12th International Symposium on Topics in Coding (ISTC)*, Brest, France, September 2023, pp. 1-5, doi: 10.1109/ISTC57237.2023.10273465.
4. Anthony Gómez-Fonseca, Roxana Smarandache and David G. M. Mitchell, "**An Efficient Strategy to Count Cycles in the Tanner Graph of Quasi-Cyclic LDPC Codes**," in *IEEE Journal on Selected Areas in Information Theory*, vol. 4, September 2023, pp. 499-513, doi: 10.1109/JSAIT.2023.3315585.
3. Anthony Gómez-Fonseca, Roxana Smarandache and David G. M. Mitchell, "**On the Tanner Cycle Distribution of QC-LDPC Codes from Polynomial Parity-Check Matrices**," *2023 IEEE International Symposium on Information Theory (ISIT)*, Taipei, Taiwan, June 2023, pp. 2356-2361, doi: 10.1109/ISIT54713.2023.10207005.
2. Roxana Smarandache, Anthony Gómez-Fonseca and David G. M. Mitchell, "**Using Minors to Construct Generator Matrices for Quasi-Cyclic LDPC Codes**," *2022 IEEE International Symposium on Information Theory (ISIT)*, Espoo, Finland, June 2022, pp. 548-553, doi: 10.1109/ISIT50566.2022.9834862.
1. Anthony Gómez-Fonseca, Roxana Smarandache and David G. M. Mitchell, "**Necessary and Sufficient Girth Conditions for LDPC Tanner Graphs with Denser Protographs**," *2021 11th International Symposium on Topics in Coding (ISTC)*, Montreal, QC, Canada, August 2021, pp. 1-5, doi: 10.1109/ISTC49272.2021.9594176.

Teaching Experience

- **University of Notre Dame**
  1. Instructor – Department of Mathematics
     – Calculus A (Fall 2023)

2. Teaching Assistant – Department of Mathematics
   - Calculus B Tutorial (Spring 2021, Fall 2021, Spring 2022, Fall 2022)
   - Linear Algebra and Differential Equations Tutorial (Spring 2023)
   - Calculus A Tutorial (Fall 2024)

Awards and Honors

- Summer 2025 travel grant: International Symposium on Information Theory (ISIT)
- AMS Travel Grant - 2025 AMS Spring Southeastern Sectional Meeting, Clemson University, Clemson, South Carolina
- Summer 2024 travel grant: Department of Mathematics and International Symposium on Information Theory (ISIT)
- Summer 2023 travel grant: Department of Mathematics and International Symposium on Information Theory (ISIT)
- Summer 2022 travel grant: The Graduate School Professional Development Awards (GSPDA), International Symposium on Information Theory (ISIT), College of Science, and Department of Mathematics
- Graduate Fellowships for STEM Diversity (GFSD, formerly NPSC) Fellowship, 2019–2025
- Kinesis-Fernández Richards Fellowship, 2019–2025
- University of Puerto Rico, Río Piedras Campus – Magna Cum Laude, 2019
- NASA Puerto Rico Space Grant Fellowship, 2018–2019
- Beca por Mérito y Ejecutorias Excepcionales, 2018–2019 (not accepted)
- Programa de Experiencias Académicas Formativas (PEAF), 2016–2017 and 2017–2018
- University of Puerto Rico at Cayey – Magna Cum Laude, 2016
- University of Puerto Rico at Cayey – Cuadro de Honor (Honor Roll), 2013–2014, 2014–2015, and 2015–2016
- Travel award: 2015 Field of Dreams Conference (Birmingham, Alabama, United States)
- Recognition to the tutors, Centro de Apoyo al Estudiante (CAE), 2013–2014 and 2014–2015 (including summer sessions 2014 and 2015)

Presentations

25. Anthony Gómez-Fonseca, "**Construction of QC-LDPC Codes with Girth g from the Hermite Normal Form of a Matrix**," Mathematical Congress of the Americas 2025, InterContinental Miami, Miami, Florida, July 24, 2025.
24. Anthony Gómez-Fonseca, "**Construction of QC-LDPC Codes with Girth g from the Hermite Normal Form of a Matrix**," 2025 IEEE International Symposium on Information Theory (ISIT), University of Michigan, Ann Arbor, Michigan, June 26, 2025.
23. Anthony Gómez-Fonseca, "**Using Spectral Analysis to Optimize Certain Parameters of QC-LDPC Codes**," 2025 AMS Spring Southeastern Sectional Meeting, Clemson University, Clemson, South Carolina, March 8, 2025.
22. Anthony Gómez-Fonseca, "**QC-LDPC Codes from Expander Graphs**," 2024 AMS Fall Central Sectional Meeting, The University of Texas - San Antonio, San Antonio, Texas, September 15, 2024.
21. Roxana Smarandache, Anthony Gómez-Fonseca and David G. M. Mitchell, "**Generalized Quasi-Cyclic LDPC Codes: Design and Efficient Encoding**," 2024 IEEE International Symposium on Information Theory (ISIT), Athens, Greece, July 8, 2024.
20. Anthony Gómez-Fonseca, "**An algebraic approach to construct QC-LDPC codes with girth g and shortest block-length**," 2024 SIAM Spring Eastern Sectional Meeting, Howard University, Washington DC, April 6, 2024.
19. Anthony Gómez-Fonseca, Roxana Smarandache and David G. M. Mitchell, "**A Low Complexity PEG-like Algorithm to Construct Quasi-Cyclic LDPC Codes**," 2023 12th International Symposium on Topics in Coding (ISTC), Brest, France, September 5, 2023.

18. Henry Chimal-Dzul and Anthony Gómez-Fonseca, "**Using Partial Orthomorphisms to Construct Short Quasi-Cyclic LDPC Codes with Girth at Least 6**," 2023 12th International Symposium on Topics in Coding (ISTC), Brest, France, September 5, 2023.
17. Anthony Gómez-Fonseca, Roxana Smarandache and David G. M. Mitchell, "**On the Tanner Cycle Distribution of QC-LDPC Codes from Polynomial Parity-Check Matrices**," 2023 IEEE International Symposium on Information Theory (ISIT), Taipei, Taiwan, June 30, 2023.
16. Anthony Gómez-Fonseca, Roxana Smarandache and David G. M. Mitchell, "**A Low-Complexity PEG-like Algorithm to Construct Quasi-Cyclic LDPC Codes**," SIAM Southeastern Atlantic Section Annual Meeting, Virginia Tech, March 26, 2023.
15. Anthony Gómez-Fonseca, Roxana Smarandache and David G. M. Mitchell, "**An Efficient Strategy to Count Cycles in the Tanner Graph of Quasi-Cyclic LDPC Codes**," XXXVIII Seminario Interuniversitario de Investigación en Ciencias Matemáticas (SIDIM), University of Puerto Rico, Mayagüez Campus, February 25, 2023.
14. Anthony Gómez-Fonseca, "**Counting cycles in the Tanner graph of QC-LDPC codes**," Algebraic Geometry and Number Theory Seminar, Rice University, November 8, 2022.
13. Anthony Gómez-Fonseca, "**On the Tanner Cycle Distribution of QC-LDPC Codes from Polynomial Parity-Check Matrices**," Discrete Seminar, University of Nebraska-Lincoln, October 25, 2022. (virtual)
12. Anthony Gómez-Fonseca, "**On the Tanner Cycle Distribution of QC-LDPC Codes from Polynomial Parity-Check Matrices**," Postgraduate International Coding Theory Seminar (PICSeminar), October 20, 2022. (virtual)
11. Roxana Smarandache, Anthony Gómez-Fonseca and David G. M. Mitchell, "**Using Minors to Construct Generator Matrices for Quasi-Cyclic LDPC Codes**," IEEE International Symposium on Information Theory (ISIT), Espoo, Finland, June 27, 2022.
10. Anthony Gómez-Fonseca, Roxana Smarandache and David G. M. Mitchell, "**Necessary and Sufficient Girth Conditions for LDPC Tanner Graphs with Denser Protographs**," International Symposium on Topics in Coding (ISTC), Montreal, Canada, September 2, 2021 (virtual).
9. Anthony Gómez-Fonseca, "**Linear codes, graphs, and the projective special linear group $\mathbf{PSL}_2(\mathbb{F}_q)$**," XXXIV Seminario Interuniversitario de Investigación en Ciencias Matemáticas (SIDIM), University of Puerto Rico at Humacao, March 1, 2019.
8. Anthony Gómez-Fonseca, "**Linear Codes from Graphs Generated by the Projective Special Linear Group $\mathbf{PSL}_2(\mathbb{F}_q)$**," University of Puerto Rico, Río Piedras Campus, December 11, 2018.
7. Anthony Gómez-Fonseca, "**Cayley Graphs of $\mathbf{PSL}_2(\mathbb{F}_q)$ and Ramanujancy: Second Part**," University of Puerto Rico, Río Piedras Campus. June 13, 2018.
6. Anthony Gómez-Fonseca, "**Cayley Graphs of $\mathbf{PSL}_2(\mathbb{F}_q)$ and Ramanujancy: First Part**," University of Puerto Rico, Río Piedras Campus. May 21, 2018.
5. Anthony Gómez-Fonseca, "**Notes on Graph Theory and Ramanujan Graphs**," University of Puerto Rico, Río Piedras Campus. January 31, 2018.
4. Anthony Gómez-Fonseca, "**Notes on Continued Fractions**," Graduate Seminar, University of Puerto Rico, Río Piedras Campus, June 20, 2017.
3. Anthony Gómez-Fonseca, "**Simulacro del PEAU en Matemáticas**," Colectivo Universitario para el Acceso, University of Puerto Rico at Cayey, February 11, 2017.
2. Anthony Gómez-Fonseca, C. Torres-Rivera, L. Rodríguez-Rivera, J. Sosa-Díaz, "**El apoyo académico del CUA-UPR en Cayey: principios y retos**," Segundo Encuentro Estudiantil de Investigación, Creación y Servicio Comunitario, University of Puerto Rico at Cayey, December 7, 2015.
1. Anthony Gómez-Fonseca, L. Molina-Rodríguez, "**Modelos de cazador-presa: Una nueva estrategia de persecución**," Primer Encuentro Estudiantil de Investigación, Creación y Servicio Comunitario, University of Puerto Rico at Cayey, May 15, 2015.

Poster Presentations

2. Anthony Gómez-Fonseca and L. Molina-Rodríguez, "**Modelos de cazador-presa: Una nueva estrategia de persecución**," XXXI Seminario Interuniversitario de Investigación en Ciencias Matemáticas (SIDIM), University of Puerto Rico at Humacao, March 5, 2016.
1. Anthony Gómez-Fonseca and L. Molina-Rodríguez, "**Modelos de cazador-presa: Una nueva estrategia de persecución**," Mathematics Awareness Week, April 20–24, 2015.

Conferences and Workshops

20. Mathematical Congress of the Americas 2025, InterContinental Miami, Miami, Florida, July 21–25, 2025.
19. IEEE International Symposium on Information Theory (ISIT), University of Michigan, Ann Arbor, Michigan, June 22–27, 2025.
18. AMS Spring Southeastern Sectional Meeting, Clemson University, Clemson, South Carolina, March 8–9, 2025.
17. AMS Fall Central Sectional Meeting, The University of Texas - San Antonio, San Antonio, Texas, September 14–15, 2024.
16. IEEE International Symposium on Information Theory (ISIT), Athens, Greece, July 7–12, 2024.
15. SIAM Spring Eastern Sectional Meeting, Howard University, Washington DC, April 6–7, 2024.
14. 12th International Symposium on Topics in Coding (ISTC), Brest, France, September 4–8, 2023.
13. IEEE International Symposium on Information Theory (ISIT), Taipei, Taiwan, June 25–30 2023.
12. SIAM Southeastern Atlantic Section Annual Meeting, Virginia Tech, March 25–26, 2023.
11. XXXVIII Seminario Interuniversitario de Investigación en Ciencias Matemáticas (SIDIM), University of Puerto Rico, Mayagüez Campus, Puerto Rico, February 24–25, 2023.
10. Coding Theory and Cryptography: A conference in honor of Joachim Rosenthal's 60th birthday, Zurich, Switzerland, July 11–15, 2022.
9. Algebraic Coding Theory Summer School, University of Zurich, Switzerland, July 4–8, 2022.
8. IEEE International Symposium on Information Theory (ISIT), Aalto University, Espoo, Finland, June 26–July 1, 2022.
7. 11th International Symposium on Topics in Coding (ISTC), Montréal, Canada, August 30 – September 3, 2021 (virtual).
6. XXXIV Seminario Interuniversitario de Investigación en Ciencias Matemáticas (SIDIM), University of Puerto Rico at Humacao, Puerto Rico, March 1–2, 2019.
5. XXXIII Seminario Interuniversitario de Investigación en Ciencias Matemáticas (SIDIM), University of Puerto Rico, Río Piedras Campus, Puerto Rico, March 23–24, 2018.
4. New Graduate Students Summer Training. July 11–29, 2016. University of Puerto Rico, Río Piedras Campus.
    * Some of the workshops included in this training were: Processes of the verbal communication; Accessibility for all; Appraisal of student learning; Teaching strategies; Evaluation of aggression; Bullying; Bibliographic resources; Integrity and ethic in research; Security in the laboratories; and, CPR.
3. XXXI Seminario Interuniversitario de Investigación en Ciencias Matemáticas (SIDIM), University of Puerto Rico at Humacao, Puerto Rico, March 4–5, 2016.
2. 2015 Field of Dreams Conference, Sheraton Birmingham Hotel, Birmingham, Alabama, United States, November 6–8, 2015.
1. Taller de preparación de equipos de trabajo, Colectivo Universitario para el Acceso, University of Puerto Rico, Mayagüez Campus, Puerto Rico, August 22, 2015.

Professional Service

- Reviewer of papers for:
  - IEEE Transactions on Information Theory
  - IEEE Communications Letters
  - IEEE Information Theory Workshop (ITW)
  - IEEE International Symposium on Topics in Coding (ISTC)

  - Discrete Mathematics Days
  - Involve, a Journal of Mathematics

Skills

- Programming and Software:
  - SageMath, LaTeX, Python, Magma, MATLAB, Scilab.
- Languages:
  - Spanish (native language), English (fluent).